

**Gokhale Institute of Politics  
and Economics, Poona 4.**

**THE ELEMENTS OF  
VITAL STATISTICS**

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THE ELEMENTS  
OF  
VITAL STATISTICS  
IN THEIR BEARING ON SOCIAL  
AND PUBLIC HEALTH PROBLEMS

BY

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## PREFACE

THE first edition of this work, published in 1889, was written for the special use of medical officers of health and others engaged in public health and social work, who have to handle statistical data. It has evidently proved useful, for although the last revision was made in 1899, it is still called for both in this country and in America. The present re-written volume is intended for the same class of workers. It embodies much of the author's public health experience during the last forty years, and it must be regarded as showing the important purposes of administration and of administrative research to which statistics can be put, rather than as a guide to statistical technique.

I have endeavoured to utilize American as well as English vital statistics throughout the volume, in view of the great advance of America in the compilation of accurate figures and in their scientific use, and for the further reason that the most urgent requests for a new edition of this work have come from Americans.

The general plan of the book has not been altered greatly. I have not written a textbook of statistical method, though this aspect of the subject cannot be entirely avoided. But access to and study of the textbooks of statistics is assumed; and for the rest, with the exception of Chapters in Part II, methods are dealt with in their application to each subject as it arises.

It has been a chief aim to summarize available information on each subject dealt with, so that the volume may maintain its value as a ready source of trustworthy statistics, and may give references which will enable the student to pursue further inquiry into any subject on which fuller details are required. Methods of investigation and results on each subject are stated in the same or in contiguous chapters, and thus the student can at once appreciate the utility of the technical processes employed.

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Illustrations of practical problems are appended to many chapters. Some of these are only elementary in character, but experience has shown that they are needed for public health and other students.

Vital Statistics as a subject has developed greatly since 1889, and the introduction of the more elaborate mathematical processes into the study of biological problems—although representing an important advance in science—has repelled many hygienists from that fruitful study of their local or of other statistics which is practicable apart from advanced biometrical methods. The present volume is intended for those not equipped for higher mathematical investigations, which must remain the important function of a limited few. A few of these methods have been briefly indicated in order to make certain paragraphs comprehensible; but the special textbooks must be studied by those wishing to pursue this branch of statistics.

Apart from such mathematical complications, much valuable statistical investigation is practicable, for which no larger outfit is needed than accurate medical knowledge, a willingness to undertake laborious calculations, and sound judgment in the collection of facts and the interpretation of results. No better example of such possibilities exists than in the long and invaluable series of medical letters in the annual reports of the Registrar-General of England and Wales, each one of which contains information and deductions invaluable for every medical officer of health. These reports necessarily cannot exhaust the subjects of discussion, either nationally or still less locally; but they can be made the starting-point of important and extensive investigations into the distribution and the causation of special diseases. It is hoped that this volume may indicate lines for such investigations and encourage their pursuit.

The subjects embraced in the present volume are numerous, and it is almost certain that errors have crept in. The author will be grateful if the reader will communicate with him on any such points.

It will be noted that most of the statistical illustrations are taken from the official and other reports for England and for the United States. Only occasional reference is made to Scottish and Irish reports, or to the valuable

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Australasian and Canadian reports. This limitation was necessary to avoid excessive detail; but the student will have no difficulty in referring to the last report of each of these and of other series relating to foreign countries.

Owing to delay in issue of some of the English census returns for 1921, as for instance in dealing with migration, it has been necessary to utilise the 1911 census data. I wish to express my obligation to Mr. Vivian, the English Registrar-General, for allowing me to see and use advanced sheets of official reports on Occupational Mortality and on Fertility; also for permission from him and from H.M. Stationery Office to use a considerable number of official diagrams. The source of other diagrams is acknowledged throughout the text. I am also indebted to members of the staff of the General Register Office for assistance; and my special obligation to Dr. T. H. C. Stevenson, C.B.E., is of a character and on a scale which is evident throughout the volume, and for which formal thanks are entirely inadequate.

To Dr. William H. Davis, Chief Statistician for Vital Statistics of the Bureau of the Census of Washington, I wish to express my obligation for permitting the use of certain diagrams and for sending me advanced copies of official reports.

Mr. F. A. A. Menzler, F.I.A., B.Sc., of the Government Actuary's Department, has read many of the chapters, and has made many suggestions of great value. Dr. H. P. Newsholme and other friends have co-operated; but I am solely responsible for any errors in the volume and for the value or the reverse of any criticisms made within its covers.

In this respect I may compare my labours to those of the immortal Captain Graunt (p. 21), who suggested that, having completed his statistical analysis of the London Bills of Mortality, he was like a schoolboy who, coming to say his lesson to the world ("that peevish and techie master"), brought a bundle of rods wherewith to be whipped for every mistake he had committed.

ARTHUR NEWSHOLME.

ASHLEY HOUSE, SHALFORD, SURREY.  
March, 1923.

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**PART I**  
**VITAL STATISTICS**

## CHAPTER I

### INTRODUCTORY

VITAL statistics forms perhaps the most important branch of Statistics, as it deals with mankind in the aggregate. It is the science of numbers applied to the life-history of communities and nations; and in the following pages the more important statistical facts concerning the various phases and stages of life will be in turn presented. The subject naturally divides itself into three parts: the data to be considered, the methods of their compilation, and their interpretation. Thus we have to study—

1. The organization needed for the collection of facts, including the arrangement of schedules of inquiry or "questionnaires" and methods of registration.

2. The methods for examining, tabulating and analysing returns and registered facts.

3. The possible inferences from the facts when tabulated and analysed, including the principles governing comparison with other data, and the estimation of future probabilities.

There may be some difference of opinion as to the scope of vital statistics. In the broadest sense, it includes the whole study of man, as affected either by heredity or by environment, so far as the results of this study can be arithmetically stated. It deals with the conditions determining death, but there is no justification for the use of the redundant term "Mortal Statistics," relating to the last act of life; and it may be hoped that this ugly phrase will disappear from official reports. Vital statistics is concerned with marriages, births and deaths, with sickness in its many varieties, with accidents, drunkenness and crime, and with prosperity and poverty. It has its biological and its sociological side, both of supreme value to the community.

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In this volume the subjects discussed will be chiefly those of interest to public health and social workers, in the hope that assistance may be given in their important work.

The name **Demography** is used in approximately the same sense as the widest interpretation of vital statistics, and the name indicates the contrast between collective experience numerically expressed and a **monograph**, which literally means a more complete study of a single item, though commonly employed also to describe a demographic study of a particular subject. Some of the circumstances in which monographic rather than demographic investigation is more fruitful of result are discussed later (p. 532). M. Block defined Demography as "the science of man living in society, in so far as it can be expressed in numbers," which would serve also as a definition of vital statistics. As Professor Bowley has put it, the proper function of statistics is to enlarge individual experience. It is the science of averages.

The purpose of vital statistics, like that of statistics generally, is both scientific and utilitarian; under the first heading ascertaining and classifying facts and preparing the way for the investigation of causes, and under the second obtaining knowledge of evil conditions and their sources with a view to their amelioration or removal.

Much ink has been spilt in discussing whether there is a science of statistics as well as a statistical method. More correctly statistics must be regarded as an instrument of research, of great value, but having severe inherent limitations. It is the only method by which aggregates of units, as distinguished from units, can be measured. Thus in investigating height and weight in man, resort must be had to averages; and generally in investigating social, economic and biological phenomena, when scientific experimentation is impracticable, and when causation is complex and often largely unknown, the statistical is the only method of examination which can be pursued.

Statistics have a more limited range of application in the study of natural science, in which by means of experiment the number of variables can be limited, and accurate inference from a few facts is practicable. Facts in natural science are accurately measurable, and one can argue from single

case to single case. In social phenomena, on the other hand, similar isolation of causes is commonly unattainable. Mr. G. Udny Yule has stated this point as follows:—

The statistician cannot, like the physicist, narrow down the issue to the effect of one variation at a time. The problems of statistics are in this sense far more complex than the problems of Physics.—*Journal of the Royal Statistical Society*, Vol. LX., Part IV.

The object of statistics is to obtain a quantitative expression of facts. But in sociology differences of quality are even more important than of quantity, and thus heterogeneous items are liable to be treated in statistics as homogenous. A further point is that statistical inferences hold good for aggregates or averages, but not for individuals. Social phenomena when applied to the individual are subject to accidental and disturbing causes, but show a high degree of uniformity for large groups.

The limitations of application of statistics suggested above need to be borne in mind. Within these limits statistics can throw great light on various social and medical, including epidemiological problems; and they have the further value that they suggest lines of biological research, and test the errors of observation or experiment in such researches.

**Statistics.**—Statistics originally denoted inquiry into the condition of a State. The word is stated to have been first used by Achenwall (1719–92) of Gottingen in the middle of the eighteenth century. His disciple Schloezer defined statistics as history in repose, history being statistics in movement, and Moreau de Jannès defined statistics as the science of social facts expressed in numerical terms. Earlier statistics were merely descriptive, assembling the numerical facts of a given subject. Mathematical statistics order and compare these facts, introducing the process of induction.

The latter process was embodied in *Natural and Political Observations . . . upon the Bills of Mortality*, by Captain John Graunt, F.R.S. (Fourth Impression, 1665), and in Sir William Petty's *Five Essays in Political Arithmetic*, published in 1683.<sup>1</sup> In the dedication of his small volume to Lord

<sup>1</sup> John Graunt (1620–1674), William Petty (1623–1687). Petty appears to have co-operated with Graunt in the preparation of his *Observations*, etc., and the 5th edition appeared in 1676 after Graunt's death, with many additions by Petty.

Roberts (Lord Privy Seal), Graunt claimed to have succeeded in reducing large confused volumes of statistics of London into a few perspicuous tables, and to have abridged his observations thereon into a few succinct paragraphs, "without any long series of multiloquious deductions," an evident warning to later statisticians. Having noticed that most people who took in the "Weekly Bills" merely scanned the totals, Graunt proposed to himself the task of comparing one year, one season and one parish or other division with another in respect of burials, christenings, and of diseases and casualties in each of them.

Chapter I of Graunt's work informs us that the first continued weekly Bills extant began in 1603 in the first year of James I. There had been earlier Bills for 1592, 1593, and 1594 and some earlier years, but these were not continued. 1625 was the first year of complete returns for the City of London, the records of the City of Westminster being added next year. The information was obtained by searchers, usually "ancient matrons," sworn to their office, which included viewing the body and inquiry as to what disease or casualty had caused death. The return was made weekly and distributed to each family paying 4s. a year.

In Chapter II of Graunt's book the main object of the Bills in acquainting the public with the presence and the amount of Plague is revealed, and he emphasizes that for this purpose all deaths from all causes must be returned. (The wisdom of this is further illustrated in the case of Influenza, p. 401). Of the accuracy of returns under other headings he is relatively indifferent. Thus he says:—

As for consumptions, if the searchers do but truly report whether the dead Corps were very lean and worn away, it matters not to many of our purposes whether the disease were exactly the same as physicians define it in their books. . . .

I say it is enough if we know from the searchers but the most predominant symptoms; . . . if one died suddenly, the matter is not great, whether it is reported in the Bills, *Suddenly*, *Apoplexy*, or *Planet Strucken*, etc.

Graunt laid stress upon the proportion between acute and chronic fatal diseases, as on this would "seem to hang the judgment of the fitness of the country for long life." But he adds, we must come to the "more absolute standard" of longevity, and he states that the proportion of aged to the

total deaths was about 7 per cent. There was difficulty in defining "aged," owing to imperfect returns. Epidemic diseases in some were ten times as fatal as in other years, but chronic diseases were fairly steady causes of death.

In Chapter III is an interesting remark on syphilis:—

We find one casualty in our Bills, of which, though there be daily talk, there is little effect . . . and this casualty is the French pox.

He adds, however, that many deaths are returned as from ulcers and sores, and that

only hated persons and such whose noses were eaten off were reported by the searchers to have died of this too frequent malady.

We are informed that 3 in 200 died in childbirth. The remaining chapters of this pioneer work are concerned with Plague, with the balance between burials and christenings, with the excess of male over female births (stated to be 14 to 13), with the influence of season on mortality and with child mortality. "Of 100 quick conceptions, 36 die before they are six years old."

The first London Bills of Mortality were compiled in the reign of Henry VIII, about 1538. Their weekly resumption in 1603, mentioned above, was caused by the desire for information as to Plague, which was then prevalent. Thus Plague gave an impetus to vital statistics, just as the first invasion of cholera in 1831 hastened the establishment of national registration of deaths (p. 156).

John Howard's investigation (1774) into the conditions of prisons was statistical, the evidence being obtained by personal inspection. He was the first systematically to employ this double instrument of sanitary research in ascertaining the character and gravity of an evil; and he was phenomenally successful in securing early reform.

Achenwall's contemporary, Süßmilch (1707-67), hailed Graunt as a scientific Columbus; and the science of "Political Arithmetic" or statistics may be said to have been born in England, earlier statistics having been merely descriptive, while the English school subordinated description to explanation or an attempt at explanation. Süßmilch was both a descriptive statistician and a political arithmetician, and perceived the advantage of studying what Quetelet subsequently termed the law of large numbers.

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Other points in the history of statistics are given in the first volume of the *Statistical Journal* (London) and elsewhere in this volume. In 1832 the Statistical Department of the Board of Trade was established. In 1838 national registration of deaths began in England; in 1865 it included Great Britain and Ireland. In 1833 a statistical section was added to the British Association, and in 1834 the London Statistical Society was formed. At the London International Exhibition of 1851, the first International Statistical Congress was suggested. It met in Brussels in 1853, the opening address being made by Quetelet, who welcomed a new era of unity and combination in research. At the St. Petersburg meeting in 1872, a Permanent Commission of the International Statistical Congress was established (see also p. 177).

## CHAPTER II

### POPULATION. CENSUS

VITAL statistics are concerned with the members of a given community, and accurate information as to their number and their grouping in various respects is indispensable. Among the items with which vital statistics are chiefly concerned are: (a) Number, age, sex, mental condition, occupation; and (b) Marriages, births, deaths, migration, sickness.

For information as to these vital facts we depend on a census, or complete enumeration of the population; and on information furnished by complete and continuous registration of births and deaths, and of other important events in the life-history of individuals, as marriages and sickness, classified on the same basis as the statistics of population.

The first desideratum is a statement of population, as accurate as possible; for population forms the natural basis of all vital statistics. In comparing different communities it is necessary to state the deaths and other statistical data in terms of the population, otherwise no true comparison can be instituted.

The actual population is known only by census enumerations. For the years intervening between two census enumerations estimates of the population are made.

**English Census Enumerations.**—The first complete census of modern times was taken in the year 1751 in Sweden. In England the first census was in 1801, and then decennially, the twelfth being taken on June 19, 1921. The first census, in 1801, showed the number of males and females of each house and family, and the occupation, classified roughly as agricultural, trading, and others not comprised under these two heads. In 1821 information was first sought as to ages, but it was left optional whether this information should be furnished or not. The first census which could

## 26 THE ELEMENTS OF VITAL STATISTICS

be described as fairly complete was that of 1851, which was organized under Dr. Farr's supervision. It obtained information as to occupation, birthplace, relationship (husband, wife, etc.), marital condition (married, widow, bachelor, etc.), and the number of persons deaf and dumb or blind. At this census, under the powers given by the Census Act, the precise age at last birthday of each person in the country was first demanded.

In the census report of 1881 the age and sex distribution of the population of each urban and rural sanitary authority, as constituted that year, was given for the first time.

At the census of 1891 the schedule contained such new topics of inquiry as the number of rooms and of their occupants in all tenements with less than five rooms, and the important occupational distinction between employers, employees, and those working on their own account.

In 1901 no further additions were made to the subjects of inquiry; but in 1911 a number of additional items were included in the census schedule. The difficulty in defining what constitutes a "house" was avoided by the enumeration for each urban and rural district, of the number of various classes of buildings used as dwellings—ordinary dwelling-houses, blocks of flats and the separate flats or dwellings composing them, shops, institutions, etc., with the corresponding populations. The inquiry as to the number of rooms in tenements (dwellings), which in 1901 dealt only with tenements of less than five rooms, was extended to tenements of all sizes. The question as to duration of existing marriages, the number of children born of such marriages, and the number still living, which was entirely new, has enabled valuable information as to fertility to be tabulated (see p. 96).

The census enumeration of 1921 showed further changes. The Census Act, 1920, was passed authorizing each successive decennial census. It is thus applicable to all future censuses in Great Britain; it enables quinquennial censuses to be taken, if the Government decide on this course; and it provides for the taking of local censuses at the request and charges of the local authority for the area concerned.

Clause 5 of the Census Act, 1920, gives the following general powers and duties to the Registrar-General.

It shall be the duty of the Registrar-General from time to time to collect and publish any available statistical information with respect to the number and condition of the population in the interval between one census and another, and otherwise to further the supply and provide for the better co-ordination of such information, and the Registrar-General may make arrangements with any Government department or local authority for the purpose of acquiring any materials or information necessary for the purpose aforesaid.

The useful comparison as shown in the table on page 28 is taken from "The Census of 1921. Some Remarks on Tabulation," by F. A. A. Menzler, B.Sc., F.I.A. (*Journal of the Institute of Actuaries*, April, 1921).

The schedule for the 1921 census added a question as to the number and ages of children under 16, including an inquiry as to orphans, and a question as to place of work. The inquiry as to "infirmities," included in previous censuses, was omitted, it being generally recognized that information made by or on behalf of the individuals afflicted could not be expected to be reliable. The conclusion that the fertility inquiry of the 1911 census, and above all the question as to duration of marriage, could, notwithstanding its importance, be omitted "with less disadvantage than either of the new inquiries proposed," will be regretted by all who desire that this fundamental problem should continue to be studied with the aid of the completest possible information, though the Great War has profoundly modified fertility problems for some years; and the answer to the new dependency question gives the number of living children, information which is of value to the actuary in relation to pension and other cognate problems.

The substitution of "age in years and months" for "age last birthday and of age in months for children under one year of age," may conduce to accuracy for most ages; but its effect on the statement of age of infants is dubious.

The addition of the heading "divorced" is of doubtful value, though it gives logical completeness to the statement of matrimonial conditions. In the Scottish census volumes already issued divorced are included with widowed.

The Order in Council made under the Census Act, 1920, gives the schedule of particulars required to be stated in the Returns made in England and Wales, which is printed in Appendix A.

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### ENGLAND AND WALES.

*Comparison of Questions on Householder's Schedules of 1911 and 1921.*

1911.	1921.
Name.	Name.
Relation to head of family.	Relation to head of family.
Sex.	Sex.
Age last birthday: age in months for children under one year of age.	Age in years and months.
Whether unmarried, married, or widowed.	Whether unmarried, married, widowed or divorced.
For each married woman:— (a) Completed number of years marriage has lasted. (b) Of children born alive to present marriage:— (1) Total children born alive. (2) No. of children still living. (3) No. of children who have died.	For each married man, widower or widow, the number and ages of all living children and step-children under 16 years of age. In respect of persons under 15 years of age, whether both parents alive, mother dead, father dead, or both parents dead.
Particulars as to profession or occupation.	Particulars as to profession or occupation.
Whether employer, employee or working on own account.	Whether employer, employee or working on own account.
—	Whether employed or unemployed; present or last employer, and employer's business. <sup>1</sup>
Whether working at home.	Place of work, giving address.
—	Whether occupied in full-time or part-time attendance at an educational institution.
Birthplace.	Birthplace.
Nationality of persons not born in United Kingdom.	Nationality of persons not born in United Kingdom.
Infirmity.	—
Number of rooms.	Number of rooms.
Language spoken (Wales and Monmouth only).	Language spoken (Wales and Monmouth only).

<sup>1</sup> The employer's business was obtained in 1911 by the inquiry as to "Industry or service with which worker is connected," the direction given to the householder being that "this question should generally be answered by stating the business carried on by the employee."

Further remarks bearing on various items of the census schedule will occur in the chapters on fertility, housing, occupational mortality, and life-tables (pp. 96, 234, 302, and 311).

The 1921 census was postponed from April 24th to June 19th. A date in the third or fourth month of the year had at previous censuses been chosen, presumably because at this time of the year the effect of holidays, etc., in causing migration of the normal population of a place would be at its minimum. This is important, as the figures of local population, in the absence of any express inquiry as to each person's normal home, must be based on the residence at which he has been enumerated. Evidently, no one date would equally secure a minimum absence of non-residents from every locality.

**American Census Enumerations.**—The first general census of the United States was made in 1790, and the enumeration has been repeated at regular decennial intervals since that year. A permanent Census Bureau was created in 1902, which at present is in the Department of Commerce. The decennial census is made in virtue of Art. I, Sec. 3, of the Federal Constitution, which states:—

The actual enumeration shall be made within three years after the first meeting of the Congress of the United States, and within every subsequent term of ten years, in such manner as they shall by law direct.

The results of the first census of 1790 were comprised in a volume of 56 pages; for the census of 1910 the Census Bureau published twelve quarto volumes containing 11,456 pages.

**De facto and De jure Populations.**—In Great Britain the *de facto* population alone is enumerated, i.e. the population where and when the census is taken, while a *de jure* method of enumeration of births and deaths has recently (1911) replaced the simpler *de facto* enumeration previously accepted (p. 80). But to adopt a similar plan in census enumerations presents formidable difficulties of detail. Theoretically, it would be preferable to obtain the *de jure* population by referring to his own area the schedule of each person who was enumerated elsewhere than at his "usual place of residence"; but an attempt to do this might and probably would involve more numerous

inaccuracies than those occurring with the *de facto* method. It would be particularly difficult to define clearly and comprehensively what constitutes temporary and habitual residence respectively. Instances in which a family lived consistently in one home in the summer and in another in winter present difficulties which can only be overcome by a special local census. The *de facto* method is least satisfactory for health resorts and other districts in which transient waves of migration periodically occur. This method is probably the only practicable method when, as is the case in Great Britain, the responsibility for filling up the schedule is placed on the householder. In most areas, inasmuch as the census enumeration takes place everywhere on a single night, it is probable that the two populations do not differ greatly.

In the United States and Canada the enumerator is responsible for filling up each schedule, and the population is enumerated on the *de jure* principle.

**Workplace Population.**—The English census, 1921, will enable the workplace or day population of each area to be tabulated, so far as workers are concerned.

**The Limitations of Schedules.**—Merely to ask an additional question in the census schedule does not ensure a correct answer; and undue elaboration of the schedule may be associated with diminished accuracy in the most important items. A conservative attitude in adding items on which information is required from the householder is justified, though if the local and central machinery of census taking were duly organized and linked, it would be practicable from year to year to obtain special information, which would form a valuable supplement to the results of the decennial or quinquennial census.

The remarks as to limitation of inquiry by schedule apply with special force to this country, where each householder is required to fill up the schedule for his family. In the United States one enumerator at the census of 1910 was appointed on an average for about every 1,600 persons, and his duty was to fill up the schedules, the task to be completed within two weeks in cities and within 30 days elsewhere.<sup>1</sup>

<sup>1</sup> On this point and many others, see Professor G. C. Whipple's *Vital Statistics* (J. Wiley & Sons).

It seems clear, as the Registrar-General says in his General Report on the 1911 Census, that we have practically reached the limit of the questions that can usefully be asked unless, as in the United States, the duty of completing the schedule is thrown upon a more or less skilled enumerator.

**Errors in Census Data.**—Among the most common errors is that resulting from ignorance of adults as to their precise age. Many adults are ignorant of their exact age. Thus Dr. Ogle stated that “not improbably the greater number of adults do not know their precise age, and can only state it approximately.”<sup>1</sup> Although this is less true now than in 1891, this difficulty probably explains the tendency to return ages as some exact multiple of ten, when really a year or two on one side or other of the precise figure (30, 40, 50, etc.). For this reason decennial age-periods have been preferred by the Registrar-General in calculating death-rates, and 25–35, 35–45, etc., in preference to 30–40, 40–50, etc. This tendency does not appear until adult life, and quinquennia can therefore be safely used up to the age of 25 years. The ignorance of many adults as to their exact ages is illustrated by the following figure <sup>2</sup> (p. 32) which shows the consequent concentration on multiples of ten. The same diagram shows also some concentration on even numbers of age.

Among children under 5 years of age the vagueness with which parents use the terms “one year old,” “two years old,” etc., when the children are only in their first or second year respectively, is a cause of considerable error. The confusion between the age next birthday and the complete year of age is not uncommon; and from this has arisen some confusion in stating accurate statistics of mortality in early life. There appears to be also some failure to enumerate infants in the census. Mr. George King, F.I.A., in constructing the English Life-Table No. 6 (p. 235), began by assuming that the returns of children aged 0–5 at the two censuses of 1891 and 1901 were in the aggregate correct, but that they were wrongly distributed. On testing this point, further, in the construction of Life-Table No. 7, based on the results of 1901 and 1911 censuses, he

<sup>1</sup> General Census Report, 1891, vol. iv, p. 27.

<sup>2</sup> From the General Census Report, 1911, p. 87 (Cd. 8491).

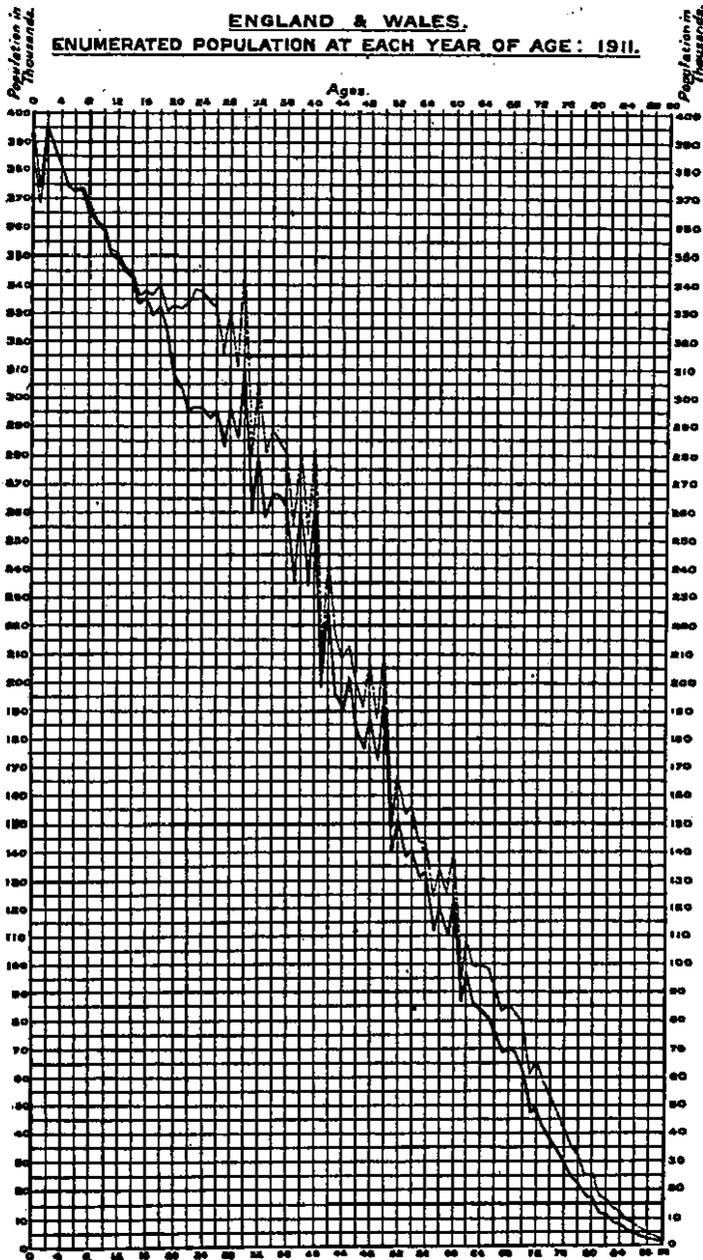


FIG. 1.—England and Wales: Enumerated Population at Each Year of Age, 1911. (From the Census Report.)

found that the mean populations at ages 2, 3 and 4, calculated from the two censuses, were very nearly the same as those calculated from excess of births over deaths for the same years; but that for ages 0 and 1, the populations given by the births and deaths alone largely exceeded the populations calculated from these two censuses. As there was no excess in the children aged from 2 to 4 last birthday—and as emigration is not likely to have affected greatly the infantile figures—"the conclusion seems inevitable that a large number of infants under 2 years of age escaped enumeration at both the censuses of 1901 and 1911, more especially so in 1911." For this reason, Mr. King, in constructing the English Life-Table No. 8, depended on statistics derived from births and deaths in calculating the death-rates for the first five years of life (see p. 342).<sup>1</sup>

Some wilful mis-statement of age occurs; thus at each census the young women of 20 to 25 years of age are stated to have been more numerous than were the girls aged 10 to 15 at the immediately preceding census.

There is also stated to have been some mis-statement of age in connection with the administration of old age pensions; and apart from monetary considerations, old persons appear to tend to overstate their ages. Reference to Fig. 1 shows that at the census of 1911 the number of females aged 20-25 and 25-30 was disproportionately high: After making allowance for the probable effect of migration of population into England, it is probable that there has been some transfer to these ages from the higher ages.

In the volume of the Census Report for 1911 dealing with Ages, it is concluded (p. xxxii) that the general effect of mis-statement appears to be inconsiderable, except among females in early adult life. Some doubt is thrown on the conclusion as to supposed mis-statement of age, especially in Ireland, to secure the old age pension at age 70, by a comparative examination of the figures of the Irish census in 1901, before old age pensions were available, with the figures of 1911 in the pension period.

<sup>1</sup> Supplement to the Seventy-Fifth Annual Report of the Registrar General, Part I, Life-Tables (Cd. 7513).

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Ages.	Males.		Females.	
	1901.	1911.	1901.	1911.
55	70,887	72,675	76,750	73,915
60	98,305	65,035	105,265	70,836
65	60,028	70,100	47,163	75,771
70	46,273	78,889	47,474	94,448
75	21,021	37,185	20,147	40,252

The figures in black type for 1911 show a marked increase of population, both male and female, at ages over 70; but in 1901 there was a corresponding anomaly at ages 10 years younger.

Occupational errors are perhaps the most serious in a census enumeration. The addition in 1891 of an inquiry, in respect of persons engaged in trade or industry, whether they were employers, employees, or were working on their own account, has reduced these errors. In 1911 further inquiry was made as to the service or industry in connection with which a given occupation was carried on. Thus a bricklayer employed by a brewer was required to enter both items; so also a carman would enter his particular work and the industry in which he was employed. The census schedule for 1921 gives further illustrations of this dual entry for clerks, engineers, railwaymen, textile workers, miners, labourers, etc. (p. 607).

## CHAPTER III

### POPULATION (*Continued*)

THE growth of the population of a community is determined by excess of births over deaths (*natural increase*) and by the balance between immigration and emigration. The rate of natural increase for a given period is the difference between the birth-rate and the death-rate for that period.

The percentage decennial increase of population in England and Wales as the result of natural increase and the actual percentage decennial increase are shown in the following table:—

ENGLAND AND WALES.

Inter-censal Period.	Increase per cent. by Births.	Decrease per cent. by Deaths.	Gain per cent. by Excess of Births over Deaths or Natural Increase.	Actual Decennial Increase per cent. of Population.
1861-71	37·56	23·98	13·58	13·21
1871-81	37·89	22·80	15·09	14·36
1881-91	34·24	20·27	13·97	11·65
1891-1901	31·57	19·18	12·39	12·17
1901-11	28·56	16·13	12·43	10·89
1911-21	23·03	14·65	8·38	4·93

The Board of Trade's returns do not determine completely the number of emigrants from or immigrants into England and Wales, but when the natural and the actual decennial increase of its population are compared, at each of the four censuses 1881 to 1911, England and Wales was found to have lost by excess of emigration over immigration part of its natural increase during the previous 10 years. In 1911 the enumerated population of 36,070,492 was 501,998 less than it would have been had its natural increase during 1901-11 of 4,044,647 persons been entirely retained in the country. In 1891-1901 the corresponding deficiency was 68,330, in 1881-91 it was 601,389, and in 1871-81 it was 164,307 (Census Report, 1911, p. 22).

In the inter-censal period 1911-21, in England and Wales,

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the gain by births was 8,275,400; the loss by deaths registered in England and Wales was of (a) civilians, 5,198,900, (b) non-civilians, 68,000; the loss due to excess of outward over inward migration was 1,193,750. The actual inter-censal increase was 1,814,750, or 4·9 per cent. The 1,193,750 includes 560,000 estimated to represent the deaths of non-civilians belonging to England and Wales which occurred outside the United Kingdom.

The actual, as distinguished from the natural, increase per cent. of the population of England and Wales in each successive inter-censal period 1801–11 to 1911–21 was as follows :

14·0,<sup>1</sup> 18·1, 15·8, 14·3, 12·7, 11·9, 13·2, 14·4, 11·7, 12·2, 10·9, 4·9<sup>2</sup>

In the interval 1911 to 1921 the rate of actual increase per cent. was less than half that in 1901 to 1911, and lower than in any period since censuses were taken. This was due to the loss of births during the Great War, and to the deaths of non-civilians during the same period.

During the inter-censal period 1911–21 the loss by migration was 37·6 per cent. of the total natural increase. This large loss is explained by the fact that war losses, except deaths occurring in England and Wales, not having been registered in this country, are counted as migration. Of the total natural increase in each decennial period, 4·8 per cent. was lost in 1871–81, and 16·6, 1·9, 12·4 and 37·6 per cent. of this natural increase in the succeeding inter-censal periods.

**Local Rates of Increase of Population.**—Considerable light is thrown on the distribution of increases in the last 20 years by the information given in the following table (from Preliminary Census Report, 1921, p. xi, Cd. 1485:—

### ENGLAND AND WALES.

	Increase per Cent. in Decennial Period.	
	1901–11.	1911–21.
Wales .. .. .	18·1	9·0
Central Counties .. .. .	11·2	5·9
Northern Counties .. .. .	10·3	4·9
London and Surrounding Counties .. .. .	11·0	4·4
Southern Counties .. .. .	9·5	3·9
Eastern Counties .. .. .	7·6	3·0

<sup>1</sup> 1801–11.

<sup>2</sup> 1911–21.

**Internal Migration.**—During 1901–11 the greatest gains by migration were experienced by the juxta-metropolitan counties of Middlesex (22·7 per cent.), Surrey (15·5 per cent.), Essex (8·5 per cent.), and Hertfordshire (8·9 per cent.) The South Wales mining counties also gained—Monmouthshire 10·9 per cent. and Glamorganshire 10·6 per cent. On the other hand, the predominantly agricultural counties lost by migration.

During 1911–21, the increase of population equalled or exceeded 10 per cent. in six counties, viz. Flintshire (14·8), Monmouthshire (13·9), Glamorganshire (11·8), Warwickshire (11·4), and the two juxta-metropolitan counties of Middlesex (11·2) and Surrey (10·0); Kent increased by 9·2 per cent. and Essex by 8·7 per cent.

**Increase of Population of United States.**—Excluding outlying possessions, in 1790, the population (Continental) was 3,929,214, in 1910 it was 91,972,266, and in 1920 it was 105,710,620. The rate of natural increase cannot be given, owing to defective birth registration in many States (see p. 74) and to a less degree of defective registration of deaths in a smaller number of States. The percentage increase of population over the preceding census in each decennium since 1800 (with corrections) was as follows :—

35·1,<sup>1</sup> 36·4, 33·1, 33·5, 32·7, 35·9, 35·6, 26·6, 26·0, 25·5, 20·7, 21·0, 14·9.<sup>2</sup>

The Indian population was included in the census for the first time in 1890. Approximately, it appears that while in successive decades 1801–1910 the population of England and Wales increased by one-seventh to one-eighth, that of the United States showed approximately an increase of one-third in each of the seven decades 1790–1860, of one-fourth during each of the three decades from 1860–90, of one-fifth during 1890–1910, and of a little over one-seventh in the last decade.

In the three decennial periods 1880–90, 1890–1900, and 1900–10, the white population increased 26·7, 21·2, and 22·3 per cent., the coloured population 13·5, 18·0, and 11·2 per cent.

At the three enumerations of 1900, 1910, and 1920 successively the negro population formed 11·6, 10·7, and 9·9

<sup>1</sup> Increase, 1790–1800.

<sup>2</sup> Increase, 1910–1920.

per cent. of the total, and the Indian population 0.3, 0.3, and 0.2 per cent. of the total population of the States. At the census of 1860 negroes formed 14.1 per cent. of the total population.

The high birth-rate of negroes is partially counter-balanced by their excessive mortality, especially in infancy; but the greater increase of whites is largely due to immigration from other countries. The percentage of increase for the white population has exceeded that for the negro population in every decade since 1790, except 1800-1810. In the fifty years 1860-1910 the white population increased 203.6 per cent. and the negro population 121.3 per cent. (Thirteenth Census Report, Abstract, p. 79). The share of excess of births over deaths in this result cannot be determined. If the recent restrictions on immigration into the United States continue to be enforced, the balance may change, and the proportion of negro to white population may even increase.

**England and Wales. Urban and Rural Populations.**—The rate of increase of population in 1911-21 varied greatly in towns. Thus among the large towns Blackpool's population increased 64.0 per cent., that of Hendon 44.3 per cent., and of Coventry 20.6 per cent., while in Blackburn a decrease of 4.8 per cent., in Bury of 4.4 per cent., Norwich of 1.1 per cent., and in London of 0.9 per cent. occurred. The decrease in the population of some large towns is accounted for largely, if not entirely, by the process of decentralization of the resident population, which has "swarmed" over into suburban and rural "dormitories" outside the municipal (or, in the case of London, the county) borders. The decrease in London was, however, probably not greater than could be accounted for by seaside visitors, the 1921 census having been taken in June instead of April, and by war losses. Of the 29 divisions of London in the period 1911-21, 14 showed some decrease of population, the increase in the other divisions being relatively small.

One of the most characteristic and persistent features of population during the last hundred years is its steadily increasing aggregation in towns. This feature is not confined to any one country. It is seen, for instance, in Australia as well as in Great Britain, and is marked in the United States.

For England and Wales it is difficult to express numerically the trend of the population to towns. Frequent changes occur in the administrative areas known as urban and rural districts. The large towns (especially the county boroughs) obtain Parliamentary powers to absorb within their areas surrounding rural districts, thus diluting their urbanization. Similarly, large villages and larger aggregations of rural population are granted the additional powers of urban districts and are transferred from the rural to the urban group; while, on the contrary, there are many so-called rural

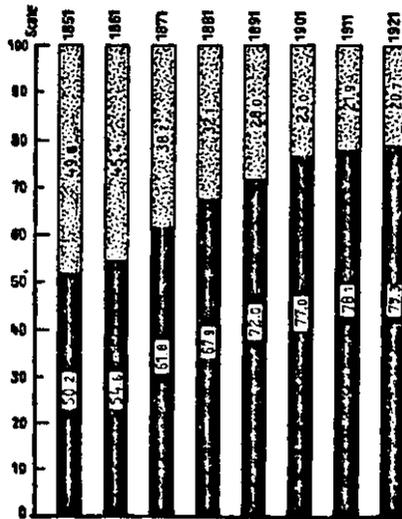


FIG. 2.—Relative Proportions of Urban and Rural Populations at Each Census, 1851 to 1921.

districts which, in parts, show denser aggregation of population than some of the urban districts. The above diagram shows, subject to the above precautionary remarks, the increasing proportion of urban population during the last 70 years. (See also page 302.) In the Census Report for 1911 it is stated that if small towns with populations not exceeding 5,000 are included among the rural areas, the proportion of "rural" population is increased from 21.9 to 25.3 per cent.; while if 10,000 be taken as the limiting population, the rural proportion becomes 30.3 per cent.

A further indication of the extent of urbanization of England and Wales is given in the following table, which

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relates to 28,162,936 persons out of 30,034,385 living in urban districts, and out of a total population of 37,885,242 in 1921. The second column gives corresponding data for the United States. The proportion per cent. of the total population living in towns of various sizes was as follows:—

PERCENTAGE OF TOTAL POPULATION IN TOWNS.

Living in Towns with a Population	England and Wales, 1921.	United States, 1920.
Over 1,000,000 .. .. .	11.8	9.6
Under 1,000,000 and over 500,000 .. .. .	6.5	5.9
Under 500,000 and over 250,000 .. .. .	7.3	4.3
Under 250,000 and over 100,000 .. .. .	13.6	6.2
Under 100,000 and over 50,000 .. .. .	10.2	5.0
Under 50,000 and over 10,000 .. .. .	22.5	11.4
10,000 and less .. .. .	7.8	9.0
	79.7	51.4
In other Urban Districts .. .. .	20.3	48.6

The degree of parallelism between the degree of urbanization in England and in the United States shown in the above table is striking.

**Urbanization in the United States.**—The Census Bureau classifies as urban a population which resides in cities and other incorporated places of 2,500 inhabitants or more. In New England towns it has been found necessary to include with the urban population the population of all towns having 2,500 inhabitants or more. Thus classified, the population of the United States was divided as follows at each of the 5 censuses 1880–1920:—

POPULATION OF THE UNITED STATES.

*Proportion per Cent.*

	1880.	1890.	1900.	1910.	1920.
Urban ..	28.6	35.4	40.0	45.8	51.4
Rural ..	71.4	64.6	60.0	54.2	48.6
	100.0	100.0	100.0	100.0	100.0

**Estimates of Population.**—Comparison between different countries and parts of countries, in respect of their healthiness and social conditions, are only practicable when the

facts concerning these are stated in terms of the respective populations. Hence estimates of population are necessary in inter-censal years. Such estimates, especially for localities within a country, involve a large element of uncertainty, owing to the varying local growth of population. When only a decennial census is taken, the doubtfulness of death-rates, etc., for the later portion of an inter-censal period is correspondingly great. In France and Germany, in some divisions of the Australian Commonwealth and of Canada, and in the Union of South Africa a quinquennial census is required; while in this country and still more in the United States the possibility of accurate statement of rates of vital interest is seriously handicapped by permitting the continuance of decennial intervals between censuses. The Census Act, 1920, makes a more frequent census practicable in Great Britain; and it may be hoped that erroneous regard for economy will not prevent an intermediate census in 1926. An intermediate modified census was taken in London in 1896, on the initiative of the London County Council, though its value was lowered by absence of information as to the age and sex of the population. Local censuses will, it is hoped, become common in the next few years under the powers conferred by the above-named Act.

Several methods of estimating inter-censal populations have been proposed. None of these is satisfactory under all circumstances, and the best method to be adopted for any given area and at any given interval after the last census must be determined after careful consideration of all available data.

(1) The natural increase, that is, the excess of births over deaths since the last census, being known, it becomes possible, if one knows the amount of emigration and immigration, to state the population in any given year. This method of estimating the population of England and Wales as a whole has been employed from 1914 onwards (p. ix, Annual Report of the Registrar-General, 1914), and in 1921 it yielded a result within 33,000 of the census total, whereas the method of estimation by geometrical increase would have gravely over-estimated the 1921 population, as it would have made no allowance for the war or for the decreasing birth-rate. The accuracy of method (1) depends

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on the completeness of migration statistics. Given this, the method has the great merit that its results are based on recent events, and that it does not involve the supposition that the rate of increase of the last is continuing in the present decennium.

The method obviously is unsuitable for local estimates of population, as in their case migration statistics do not exist. But the balance of births and deaths for every area is known, and from this and the auxiliary information indicated on page 44, fairly good local estimates of population are possible.

(2) The population at the two most recent census enumerations being known, it is frequently assumed that the rate of increase is in *arithmetical progression*; i.e. that the *same annual increase* continues during each year. Thus, given a population in April, 1911, of 32,000, in April, 1921, of 36,000, to find the mean population in 1925.

$$\frac{36,000 - 32,000}{10} = 400 = \text{annual increase.}$$

$$\frac{400}{4} = 100 = \text{increase from April to Midsummer.}$$

Therefore mean population in 1925 = 36,000 + (400 × 4)  
+ 100 = 37,700.

This method gives populations for all the areas in England and Wales which when added together equal the population of the entire country estimated by the same method.

The method is theoretically unsound, as it makes no allowance for the increased number of parents year by year, owing to steadily increasing numbers who year by year attain marriageable age. It assumes, in other words, simple interest when compound interest is in action.

This method is used in American statistics, and appears to be the most satisfactory available in the circumstances of that country.

(3) The theoretical source of error indicated above is avoided by the next method, in which it is assumed that the *same rate of increase* holds good in one as in the preceding inter-censal period, that is, that the population increases in *geometrical progression*.

Thus, if the census population of a town is 32,000 in 1911, and 36,000 in 1921, what is the mean population in 1925?

(a) Find the rate of increase in 1911-21.

$P_{1911}$  = population at census 1911,

$P_{1921}$  = population at census 1921,

R = annual rate of increase of the population, then

$$\begin{aligned} P_{1921} &= P_{1911} \times R^{10} \\ \log P_{1921} &= \log P_{1911} + 10 \log R \\ \log R &= \frac{1}{10} (\log P_{1921} - \log P_{1911}) \\ &= \frac{4.556303 - 4.505150}{10} = .0051153 \end{aligned}$$

(b) Apply this to the increase in the next  $4\frac{1}{4}$  years.

Here  $P_{1925} = P_{1921} R^{\frac{17}{4}}$

$$\begin{aligned} \log P_{1925} &= 4.556303 + \frac{17}{4} (.0051153) \\ &= 4.578043. \end{aligned}$$

By consulting the table of logs, the population corresponding to this number will be found to be 37,848 = population at the middle of 1925.

The mean population of the year is taken as the basis of mortality and other rates, which until 1921 has involved an estimate, even in the census year, for the quarter between the census and midsummer. (In the above example, it has been assumed, contrary to fact, that the census of 1921 was taken at the end of the first quarter of the year.)

Estimates made by this method may be very erroneous, even for the entire country, and still more when applied to special districts. Thus the decennial rate of increase of the population of England and Wales in 100 years has varied from 18.1 per cent. in 1811-21 to 4.9 per cent. in 1911-21. Serious anomalies occur when this method is applied to all great towns. In one decennium such a town may, owing to brisk trade, have a rapid increase of working population with many children, and in the next decennium, in consequence of emigration or transmigration, there may be little or no increase. The declining birth-rate, which is having a greater effect on the number of population than the declining death-rate, is another cause of disturbance which increases

the difficulty in forming a correct estimate of the population in inter-censal periods by this method.

Estimates of local population based on geometrical progression appear to have been used in official reports up to 1900. From 1901-10 the method of estimation given on pages ix-x of the Annual Report of the Registrar-General, 1909, was employed. From 1911-14 Mr. Waters' later method was adopted, as described by him in the Annual Report, 1901, and in the Annual Report for 1913 (p. xii). In the report for 1911 factors of correction were published for each of the years 1911-20, by the application of which to the 1901-11 increase in population of any community in England and Wales its estimated population for the year in question could be obtained. But active emigration in the years 1911-13 and then the war made the underlying assumption of these corrections inapplicable. Hence the assumption of geometrical progression was abandoned, and estimates were made based on births, deaths and migration. The Waters' method had assumed continuous change in arithmetical progression in the proportion borne by each local to the total population, and this assumption also became untenable with the abandonment of the assumption of increase in geometrical progression of the entire population.

(4) The Great War and the uncertainty as to the local source of emigrants having rendered estimates of population based on accepted methods useless, it became necessary to substitute estimates based on local information. For this purpose there became available first the National Register of 1915 for recruiting purposes, then the Food Cards in England (1917), and for the future there will be available the list of parliamentary electors which the law requires to be prepared annually. It appears inevitable that in future local estimates of population will be based more extensively on local information, of which the *list of parliamentary electors* will form an important part. Thus the number of electors being ascertained, it may be assumed that their proportion to the entire population remains approximately the same from one census to another. This assumption may be checked by ascertaining from local records for rating purposes the *number of inhabited houses*,<sup>1</sup> as ascertained from the assessment books,

<sup>1</sup> This number in a census year is not identical with the number ascertained at the census. This need not cause serious difficulty if it be assumed

this number being multiplied by the average number of inhabitants in each house, as ascertained at the last census.

In Table 7 of the Census Report for London (Tables, Part I) is given a table of the population of each Parliamentary Borough in London, and the number of electors as ascertained when the Register of autumn 1921 was made. The proportion of the total male and total female population who are electors is shown in the following table. Male electors at present become such at the age of 21, female at the age of 30.

	Electors per 1,000 of Population of Both Sexes at all Ages.	
	Males.	Females.
Parliamentary County of London ..	26.1	20.8
Battersea { N. Division .. ..	27.6	19.8
{ S. Division .. ..	29.4	22.4
Bethnal Green { N.E. .. ..	25.7	19.3
{ S.W. .. ..	21.4	15.7
Hampstead .. ..	23.5	21.2
Lambeth { Brixton Division .. ..	28.1	23.5
{ North Division .. ..	24.1	19.3
Westminster { St. George's .. ..	24.1	19.8
{ Abbey .. ..	32.5	23.0
Woolwich { E. Division .. ..	29.1	21.3
{ W. Division .. ..	25.9	19.4

Only sample constituencies have been taken. The contrasts in proportion of electors to total population, as between the different divisions of the above-named boroughs, illustrate the fact that in the less well-to-do divisions the population is to a greater extent below the age of parliamentary representation than in other divisions of London.

(5) Until the marked and steady decline in the birth-rate began, it was possible when the *number of registered births* in a district was known for a given year, to calculate approximately the population among which these births had occurred. The birth-rate still gives a useful clue to errors in the estimated populations of large towns. If the deviation from the birth-rate of the preceding 5 or 10 years is greater in any given year than in the immediately preceding years, there is reason to suspect that the estimate of population is incor-

that the proportion between the census enumeration of inhabited houses and the number in the census year in the assessment books holds good in inter-censal years.

rect, unless great changes in the industrial condition of a community can be adduced in explanation of the anomaly.

(6) A useful discussion of the different methods of estimating populations is given in a paper on "The Application of the Method of Multiple Correlation to the Estimation of Post-Censal Populations," by E. C. Snow, M.A. (*Journal of the Royal Statistical Society*, May 1911).

Following experiment on local statistics, Mr. Snow claims that the use of multiple correlations gives better results than other methods of estimation. The method has the advantage shared with method (1), but not to the same extent, of taking into account the current events in changing populations, as to births, deaths, marriages, and the number of houses. It is desirable that a method for national purposes should, when applied to local areas, give for the aggregate of local areas the same grand total as is obtained when the method is applied to the whole country, which is impracticable for a method based on local sources of information, but this defect of locally based estimates is met by multiplying the sum of estimates for the individual districts by the factor:—

$$\frac{\text{Estimate for whole country}}{\text{Sum of estimates for individual districts.}}$$

(7) An estimate is required not only of the total population but also of persons of each sex at different age-periods. This in the past has been effected upon the basis of the age and sex distribution of the previous census, the number in each age-group being increased to the same percentage extent as it is estimated that the population at all ages has increased. With the acceleration in the decline of the birth-rate this involves some error in age distribution of the estimated population; but no alternative method of estimation appears to be practicable. For this reason death-rates according to age and sex based on the census populations 1911 and 1921 and dealing with deaths in each age period in 1910-11-12 and in 1920-21-22 are more trustworthy than are rates for intermediate years.

In the Registrar-General's Annual Report for 1916 a "group survivorship" method of estimating the numbers living at various ages was adopted. It is only applicable to

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England and Wales as a whole, inasmuch as it requires tabulation of deaths by single years of age, and because the necessary migration returns are not available for different localities. It is based on correction of the census figures at each age-period for migrants and deceased at corresponding ages, allowing for the interval between the census year and the year for which the estimate is made.

## CHAPTER IV

### NATIONALITY AND RACE

SOME indication of the extent of emigration from Great Britain is given on page 35, but the available information is incomplete, and fails to show the influence of migration on the age constitution of the population. No complete data appears to be available showing the amount and sources of the immigration into Great Britain, apart from that portion which is *en route* to the Western Hemisphere. A register of aliens was kept during the war, and may be continued. Valuable clues as to migration are obtainable from the census returns of birthplaces. The figures for 1911 are quoted, those for 1921 being not yet published. As stated in the census report, the birthplace columns of the census schedule were designed to show for every person :—

- (a) If born in the United Kingdom, the name of the county, and town or parish.
- (b) If born in any other part of the British Empire, the name of the dependency, colony, etc., and of the province or state,
- (c) If born in a foreign country, the name of the country.
- (d) Whether born at sea.

Persons born elsewhere than in England and Wales were asked to state whether they were residents or visitors in this country, and persons born in foreign countries whether :—

- (1) British subjects by parentage.
- (2) Naturalized British subjects ; or
- (3) Of foreign nationality.

Naturalized British subjects were also asked to state the year of naturalization, and foreigners the nationality to which they belonged.

Of the total population of England and Wales in 1911 nearly 96½ per cent. were born within its borders, a further 2½ per cent. were born in Scotland or Ireland, or in some other part of the British Empire, leaving only 1 per cent. born abroad.

**Foreign Population.**—Tested by birthplace, it was found at the census of 1911 that in 11 of the 62 total administrative counties of England and Wales, more than 75 per cent. of the population was born within the county in which they were enumerated; and in 11 counties this proportion was less than 60 per cent., the remaining counties occupying an intermediate position, as regards birthplace of their inhabitants. In only 6 of the large towns was the proportion of natives as high as 70 per cent., while in 35 it was less than 50 per cent. The circumstances of London are special. Only 68 per cent. of its population in 1911 was native, its population being replenished from all parts of the British Isles and abroad. It is noteworthy, however, that only 3·4 per cent. of its population consisted of foreigners. There were 1·1 per cent. of Scots and 1·1 per cent. of Irish, most of the remaining non-natives being derived from English counties, and especially from counties around London.

At the census of 1921, of every 1,000 of the population of London, 921 were born in England, 17 in Scotland or Wales, 12 in Ireland, and 10 in other parts of the British Empire, the remaining 40 having been born in foreign countries. Of this number 27 were foreigners.

On page 217 of the Census (General) Report, 1911, is given a table which is summarized below:—

ENGLAND AND WALES, 1911.

*Persons at the Census Returned as Born Abroad per 1,000 of Total Population.*

Census.	British Subjects Born Abroad.	Foreigners.
1851	0·6	2·8
1861	0·9	4·2
1871	1·7	4·4
1881	2·2	4·5
1891	1·2	6·8
1901	2·8	7·6
1911	2·5	7·9

In 1911 the number of foreign residents and visitors in England and Wales at the date of the census was 285,060, of whom 33·5 per cent. were born in Russia (including Russian Poland), 18·7 per cent. in Germany, 10·1 per cent. in France,

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7.2 per cent. in Italy, 4.8 per cent. in the United States, and the remainder were of various nationalities.

**Nativity and Parentage.**—The American census returns give valuable information as to the nativity and parentage of the total white population, which enables the investigator to trace the course and the geographical distribution of the greatest and most rapid commingling of nationalities in the world's history.

At each successive census, 1850 to 1910, the percentage of foreign born to the total population of the United States was :—

1850. 1920.  
9.7, 13.2, 14.4, 13.3, 14.7, 13.4, 14.5, 13.0.

Evidently there has been no great change in this percentage since 1860. The proportion of foreign-born population is higher in urban than in rural districts. At the three last censuses, including 1920, the proportion of foreign born to total population in urban districts was 22.2, 22.6, and 19.1 per cent. respectively. In the following table is shown the increase in successive decennial periods respectively of foreign born white persons, of white persons of completely foreign parentage, and with one parent foreign born :—

UNITED STATES.  
*Increase per Cent. of*

	Foreign-Born Whites. (1)	Persons of Foreign Parentage. (2)	Persons of Mixed Parentage. (3)	Native White Population. (4)
1870-80	19.4	52.7	65.2	—
1880-90	39.1	27.0	78.9	—
1890-1900	12.0	31.5	46.7	23.1
1900-1910	30.7	21.5	19.3	20.8

It may be surmised that in their desire to be regarded as "100 per cent. Americans" many fail accurately to fill up the census information from which columns (2) and (3) are derived.

The proportion of males to females is much higher in the foreign born than in the native American population. This is shown in the following table, which also gives the proportion of males to female negroes.

UNITED STATES.

*Proportion of Males to Females (= 100) at Successive Censuses.*

	1900.	1910.	1920.
Total white .. .. .	102·8	102·7	101·7
Foreign born .. .. .	117·4	129·2	121·7
Negroes .. .. .	104·9	106·6	104·4

In 1910 whites constituted 98 per cent. of the total population in the North, 95·9 per cent. in the West, and 69·9 per cent. in the South of the United States. In the West the non-white population consists chiefly of Indians, Chinese, and Japanese. Native whites of foreign or mixed parentage formed 28·6 per cent. of the total population in the North, 24·5 per cent. in the West, and only 4·3 per cent. in the South. Foreign born white formed 20·3 per cent. of the total population in the North, 19 per cent. in the West, and only 2·5 per cent. in the South.

The chief sources of the foreign born white population as enumerated at the 1920 United States census were as follows, the figures giving the percentage of total immigration coming from each country named (*post-bellum* boundaries):—

Germany .. .. .	12·3
Russia, Lithuania, and Finland .. .. .	12·3
Italy .. .. .	11·7
Norway, Sweden, and Denmark .. .. .	8·7
Poland.. .. .	8·3
Ireland .. .. .	7·6
England .. .. .	5·9
Austria and Hungary .. .. .	5·5

and smaller proportions from other European countries.

A marked change has taken place in the chief sources of the foreign-born population of the States. In 1900 southern and eastern Europeans formed only 17·7 per cent. of the total foreign-born, in 1910 they formed 37·4 per cent.; and the above table shows which countries have led in immigration in 1911-20. The course of American immigration has been changed and its volume diminished by the Great War.

**International Aspects of Population.**—The population of the different parts of the British Isles is shown in the following table:—

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	1821.	1921.
England .. .. .	11,281,957	35,678,530
Wales .. .. .	718,279	2,206,712
Scotland .. .. .	2,091,521	4,882,288
Ireland .. .. .	6,801,827	4,390,219 (1911)
Other British Islands .. .. .	89,508	149,852
	20,983,092	47,307,601

In England the decennial percentage increase of population varied from 16.0 per cent. in 1821-31 to 4.8 per cent. in 1911-21; in Wales from 13.3 per cent. in 1891-1901 to 9.0 per cent. in 1911-21; in Scotland from 13.0 per cent. in 1821-31 to 2.5 per cent. in 1921. In Ireland the course of population is indicated by the following percentage figures, the first relating to the period 1821-31 and the last to 1901-11, no census having been taken in 1921.

1821-31. 1901-11.  
 +14.2, +5.5, -19.8, -11.8, -6.7, -4.4, -9.1, -5.2, -1.5.

The course of the population of Ireland has been determined chiefly by the amount of emigration in successive periods to America.

The following data are taken from the English Census Report, 1911 (Vol. of Summary Tables, Cd. 7929) :—

BRITISH EMPIRE.

*Population Enumerated or Estimated at or about the Year 1911.*

		Number who were Natives of Great Britain or Ireland.
British Empire .. .. .	420,582,535	46,209,660
India .. .. .	315,156,396	122,860
Other parts of Asia .. .. .	8,176,474	13,176
Union of South Africa .. .. .	5,973,394	182,006
Other parts of Africa .. .. .	29,715,237	9,441
Dominion of Canada .. .. .	7,206,643	781,666
Other parts of America .. .. .	2,295,084	6,961
Commonwealth of Australia .. .. .	4,472,282	590,722
New Zealand .. .. .	1,058,445	228,684
Other parts of Australasia and Oceania .. .. .	630,041	1,437

In 1921 the enumerated population of Great Britain was 42,767,530, an increase of 4·7 per cent. in 10 years; that of the Australian Commonwealth<sup>1</sup> 5,426,008, an increase of 21·8 per cent. in 10 years; that of New Zealand<sup>1</sup> 1,218,270 (increase 20·8 per cent.); of the Indian Empire 319,075,132 (increase 1·2 per cent.); of the Union of South Africa 1,521,635 (Europeans only: increase 19·2 per cent.).

**Further International Data.**—In 1789 the populations of the Great European Powers were as follows:—

	Millions.
France .. .. .	26
Great Britain and Ireland .. .. .	12
Russia .. .. .	25
German Empire .. .. .	28
Of which Austria .. .. .	18
Prussia .. .. .	5

In 1815 the relative populations were as follows:—

	Millions.
France .. .. .	29·5
Great Britain and Ireland .. .. .	19
Austria .. .. .	30
Prussia .. .. .	10
Russia .. .. .	45
German Confederation (in which were included parts of Austria and Prussia) .. .. .	30

In 1890 the relative populations were stated by M. Jacques Bertillon to be as follows:—

	Millions.
France .. .. .	38·3
Great Britain and Ireland .. .. .	38·1
Austro-Hungary .. .. .	43·2
German Empire .. .. .	49·4
Russia in Europe .. .. .	100·2
Italy .. .. .	30·5

The most remarkable contrast shown in the preceding tables is between Great Britain and Ireland, with a population of 12 millions in 1789 and of 38 millions in 1890, and France with a population of 26 millions in 1789 and of only 38 millions in 1890, not reckoning external colonies in either instance.

The relative populations of the chief European countries in 1880 and in 1910 or thereabouts are shown in the

<sup>1</sup> Excluding Maories, etc.

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following table published by the International Statistical Institute :—

OF THE TOTAL POPULATION OF EUROPE (= 100) THE PROPORTION IN EACH COUNTRY IN THE YEAR.

	1880.	1910.
England and Wales .. ..	7.77	8.08
Scotland .. ..	1.12	1.06
Ireland .. ..	1.55	0.98
France .. ..	11.20	8.78
Germany .. ..	13.54	14.52
Austria .. ..	6.63	6.38
Belgium .. ..	1.65	1.66
Hungary .. ..	4.71	4.67
Italy .. ..	8.52	7.75
Russia .. ..	25.82	29.13
All other countries .. ..	17.49	17.03
	100.00	100.00

## CHAPTER V

### SEX AND AGE DISTRIBUTION OF POPULATION

CORRECT vital statistics for any community necessitate an adequate analysis of the age and sex distribution of its population. This is important whether marriage-rates, birth-rates, sickness-rates, or death-rates are studied; hence the following paragraphs are a necessary preface to subsequent chapters.

**Proportion of Sexes—(a) England and Wales.**—The census reports give the number of males and females, and of each of these in different age groups for counties and for the larger administrative areas; and in inter-censal years the estimated numbers in these groups are usually given in each Annual Report of the Registrar-General. For individual towns and counties they may be estimated as explained on page 46. The number living at any year of age under five may be considered to be the excess of births over deaths at lower ages. If the population at ages 0–5 in the year 1922 is required, this is the balance of local births over deaths during the five years ending in the middle of 1922.

As the corresponding English census data for 1921 are not yet completely published, the valuable study of the age and sex distribution of the population in the 1911 Census Report is utilized here.

In successive census years the number of females in the population to 1,000 males has varied from 1,057 in 1801 to 1,068 in 1911 and 1,095 in 1921, the lowest proportion of females having been 1,036 in 1821. In some counties at the Census of 1911 there was a great excess of females; in Sussex 1,256, in Surrey 1,166, in London 1,127 to 1,000 males; while in other counties there were fewer females than males, as for instance in the mining counties of Wales, in Durham, and in Derbyshire. Large excess of females in the population implies a higher social status with an excess of unoccupied females

and many domestic servants. Internationally it may be noted that for every 1,000 males there were in censuses at or near the year 1911, in Norway 1,099, in Italy 1,037, in France 1,034, in the German Empire 1,026, in the Australian Commonwealth 926, and in Canada 886 females.

The excess of females is found in nearly every age period. In England and Wales during 1838-1918, on the average 1,040 male births occurred to every 1,000 female births. The proportion has varied at different times, and is not the same in different countries; but in all countries for which records exist more male than female infants are born. The greater mortality among male children may be inferred from the fact that at the time of the English Census of 1911, there were living at ages 0-5, 502 males to 498 females. At ages 5-10 the two sexes were equal in numbers; and at subsequent ages the excess of females markedly increased. At ages 65-70 there were only 454 males to every 546 females. At ages 20-25 and 25-30 there were 473 males to 527 females, and at 30-35 the proportion had become 478 to 522, and at ages 35-40, 483 to 517, the male proportion then steadily decreasing. There may be some understatement of ages by females, but two factors are probably chiefly concerned in the sudden drop in the proportion of males at ages 20-25, viz. emigration and foreign service of young males.

(b) United States.—In 1820 there were 1,033 males to every 1,000 females in the population; in 1910 the proportion was 1,060 to 1,000, thus showing an increased preponderance of males over females. As might be anticipated, the excess of males was greatest among foreign born, being 1,292 in 1910, as compared with 1,027 for the native population. These figures, it will be noted, are not exactly comparable with the English ratios, in which the male element in the proportion is stated as 1,000. Thus in 1910 in England and Wales the proportion of females to males was 1,068 to 1,000; in the United States the proportion of females per 1,000 males was 974 for natives and 774 for the foreign born. The largest excess of males, as shown by a map on page 98 of the Abstract of the Thirteenth Census of the United States, is in the Western States.

The negro population, which is but little affected by migration, in 1910 consisted of 989 males to 1,000 females;

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or to make the ratio comparable with the ratio for England, of 1,012 females to 1,000 males.

**Age-Proportions—(a) England and Wales.**—In the phrase of the Census Report for 1911, the age-constitution of the population is the key which alone can furnish an explanation of many of the phenomena associated with different populations. It is by utilization of this information

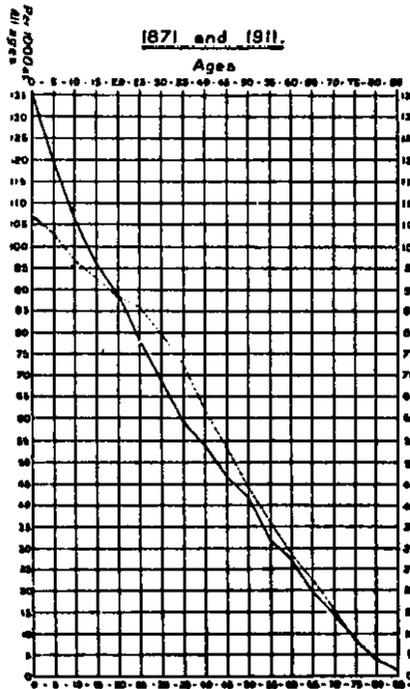


FIG. 3.—England and Wales: Proportion per 1,000 Persons at all Ages Living at Each Age-Period, 1871 and 1911.....  
 ●—●—● 1871  
 ..... 1911

that death-rates truly comparable with corresponding rates for other areas can be stated.

Statements of ages are needed also, because of legislative enactments applicable only to prescribed age-limits, for educational purposes, and for many economic reasons.

Of the total population of England and Wales in 1911,

- More than one-tenth was under 5 years of age.
- More than one-fifth was under 10 years of age.
- Nearly two-fifths was under 20 years of age.
- At ages 20-55 nearly one-half was comprised.
- At ages over 55 a little over one-tenth was comprised.

There are marked divergencies from the average age-distribution of population in town and country, in mining districts, in areas of textile industry, in "dormitory" or suburban residential areas, and in other sections of the country. These are made the subject of an elaborate and valuable study in pages 66 to 85 of the General Census Report, 1911 (Cd. 8491.)

**Changes in Age-Proportions.**—Striking changes have occurred in the age-distribution of the population, as may be seen at a glance in Fig. 3.

These changes have been brought about chiefly by the fall in the national birth-rate since 1877 (p. 115). In 1881, for every 1,000 persons at all ages there were 136 children under 5, and about the same number at previous censuses. In 1891 this proportion had become 123; it was 114 in 1901, and 107 in 1911. As the generation born since 1876 has grown up, the proportion of older children has also been lessened, though more slowly. It follows that, with the diminished proportion of children, there is an increased proportion of persons at higher ages. If this process continues the future age-distribution of the population of England and Wales will approximate to that of France, which has a practically stationary population. In 1911 as shown in Fig. 4, the population of France on the average was much older than that of England.

A comparison of Fig. 4 and Fig. 5 brings out the resemblances and the differences between Ireland and France. In both there is a small proportion of children and adolescents, in both an excess of old people; but in Ireland there is a gap in early adult life which does not appear in the experience of France. In one instance, that of Ireland, we see the combined result of a low crude birth-rate and of a high rate of emigration; in the curve for France is seen the almost unmixed result of a persistently low birth-rate.

Although it anticipates what will be discussed more fully in Chapters XVIII and XIX, it may be stated here that, inasmuch as the death-rate (i.e. the number of deaths at a given age-period per 1,000 living at that age-period) at the two extremes of life is the heaviest, the present distribution of population in England and Wales is favourable to a low crude death-rate for all ages in the aggregate; but the course

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of events shows that as time goes on this effect will be reversed.

The change in the age-distribution of the population

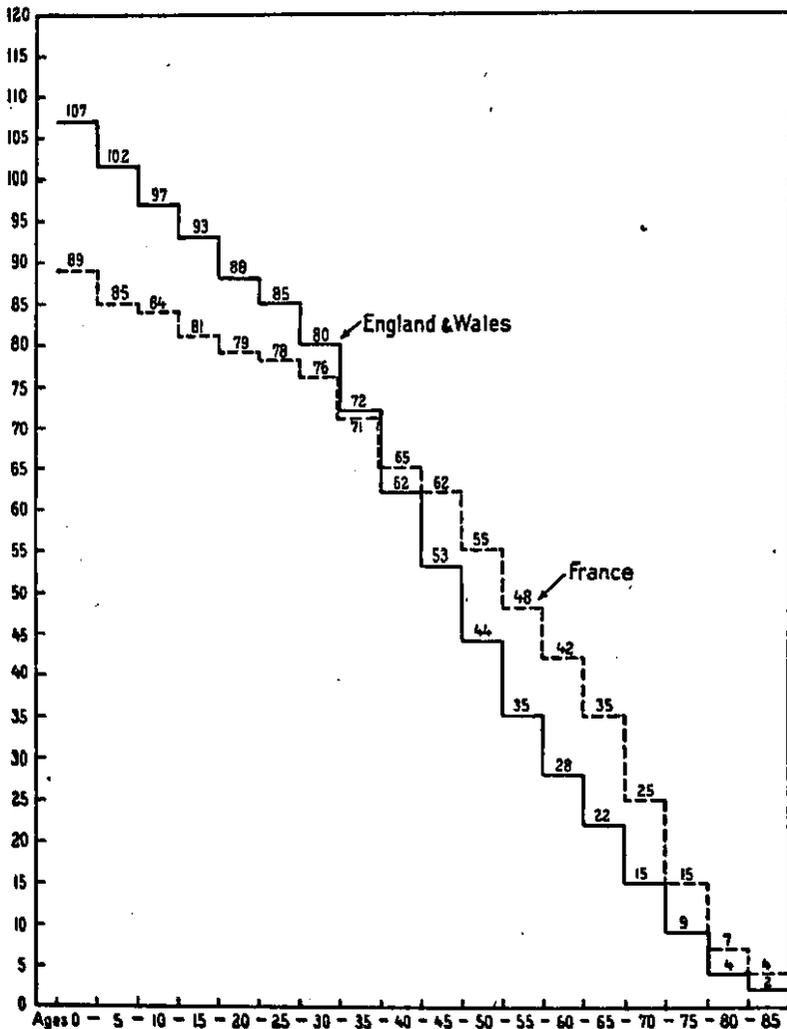


FIG. 4.—Comparison of Proportion Living in Quinquennial Age-Periods 0-, 5-, 10-, etc., in 1,000 at all Ages.  
 ..... France, 1911.  
 ●—●—● England and Wales, 1911.

(The figures overlying each rectangle show the number living at each age-period out of 1,000 at all ages. The age-period is indicated horizontally.)

described above has been brought about chiefly by the decline in the birth-rate; the greater fall in the death-rate

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in childhood and adolescence than at older ages and fluctuations in immigration has also borne some share in producing the result.

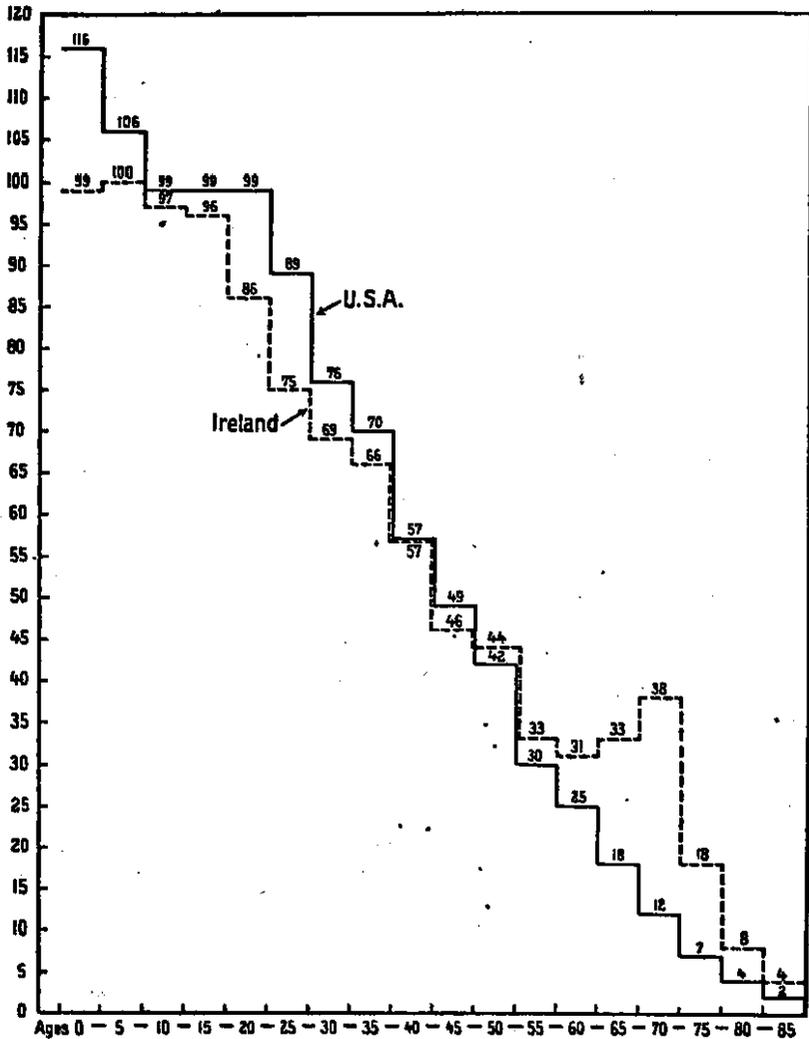


FIG. 5.—Comparison of Proportion living in Quinquennial Age-Periods 0-, 5-, 10-, etc., in 1,000 at all Ages.  
 ●—●—● United States,  
 ..... Ireland.

(b) Differences in Age-Proportions in Other Countries.—A table on page 63 of the English General Report (Census) 1911 gives the proportion of persons at

## SEX AND AGE DISTRIBUTION OF POPULATION 61

quinquennial age-periods for a number of countries; and from the data in this table Fig. 4 comparing England and France, and Fig. 5 comparing Ireland (1911) and the United States (1910), have been prepared.

The following table, extracted from the same source, shows the proportion of the total population of a number of countries at ages under 5, 5-15, 15-25, 25-45, and 45 and over, and indicates which countries have relatively young and which relatively old populations:—

PROPORTION OF PERSONS AT DIFFERENT AGES IN OR ABOUT THE YEAR 1911.

	Under 5.	5-15.	15-25.	25-45.	45 and over.	All Ages .
England and Wales ..	107	199	182	299	213	1,000
Scotland .. ..	112	210	185	282	211	1,000
Ireland .. .. .	99	197	182	287	255	1,000
Australia .. ..	119	199	202	288	192	1,000
New Zealand .. .	117	196	183	323	181	1,000
Canada .. .. .	124	207	193	289	187	1,000
Union of South Africa	150	247	195	277	131	1,000
United States .. .	116	205	197	292	190	1,000
France .. .. .	89	169	160	291	291	1,000
Germany .. .. .	120	220	183	273	204	1,000

It will be noted that at ages 15-25, when promise is becoming fulfilment in life, South Africa, Australia, the United States and Canada have the fullest life, partly owing to immigration from older countries; while England, Scotland, Ireland, New Zealand and Germany have about an equal standing, and France is the poorest. At the chief working years of life (25-45) France is rather richer than Germany; other countries occupy a fairly equal position, excepting New Zealand. As old age approaches Ireland and France show a large excess of population, in the first of these the result of emigration, in the second due to a low birth-rate protracted over many years. A disproportionate number of aged persons is one of the penalties of a persistently low birth-rate.

The preceding proportions must have been markedly modified by the war; but no recent international figures can yet be given.

It is unlikely that increase of population in civilized countries will continue at the rate effective during the nine-

## 62 THE ELEMENTS OF VITAL STATISTICS

teenth century ; and it is not unlikely that white populations, especially in Western Europe, in continental America, in Australasia and South Africa, will tend to the French position of stationariness.

So far the total age-distribution for the two sexes has been discussed. When standardized death-rates (see p. 216) are calculated, it is necessary to know the proportion at

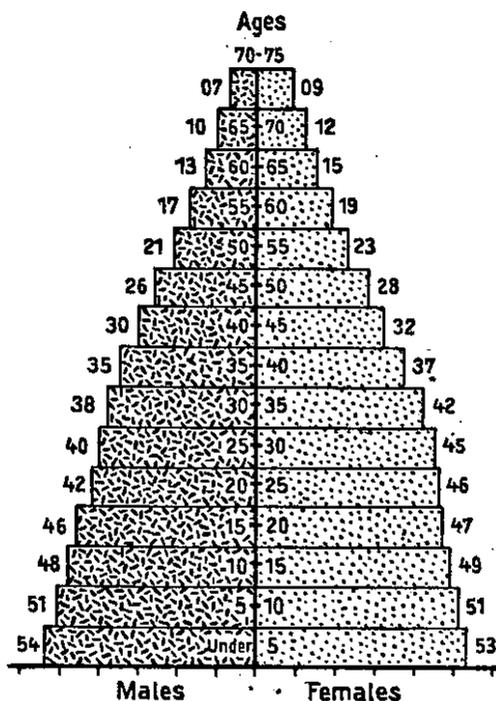


FIG. 6.—England and Wales, 1911 Proportion per 1,000 Persons of Both Sexes of Males and Females Living at Each Quinquennial Age-Period up to 75. (The number after this age is too small to be stated in the diagram.)

each age-period of the two sexes separately. For England and Wales this is shown in Fig. 6 for the year 1911.<sup>1</sup>

For the United States it is necessary to divide the population into four groups to bring into relief the differences in age and sex distribution of the white and the coloured population, and especially of the foreign-born population. Dia-

<sup>1</sup> The provisional figures of estimated age-distribution of the population of England and Wales in June 1921 are given in the Registrar-General's

## SEX AND AGE DISTRIBUTION OF POPULATION 63

grams showing these proportions are given in the American Census Report.

*Annual Statistical Review, 1921* (Text, page 91), and from these the following proportional figures have been calculated :—

Ages.	Males.	Females.	Ages.	Males.	Females.
0—	454	442	60—	157	166
5—	489	482	65—	114	129
10—	494	491	70—	77	97
15—	} 2,230 }	468	75—	41	59
20—		447	80—	17	26
25—		445	85 and	} 7 }	12
30—		426	upwards		
35—		400	Total ..	4,777	5,223
40—		356	Total	10,000	
45—	263	both sexes			
50—	235				
55—	199				

## CHAPTER VI

### MARRIAGES

VARIOUS methods may be employed in stating marriage-rates.

(1) A common method is to state the proportion of marriages to 1,000 of the total population, and such crude marriage-rates are usually employed for comparing conditions as to marriage in different countries. Evidently this method cannot give comparable results, on account of the varying age-constitution of different populations, causing corresponding variations in the number of marriageable persons. Particularly it cannot be trusted for international comparisons.

(2) The number of marriages can be stated in terms of the marriageable persons, which may approximately be taken as the number 15 years old and over, who are bachelors, spinsters, widowers, widows, or divorced. These numbers can be ascertained for the whole country and for each chief division of it from census reports, and can be estimated for inter-censal years by the method indicated on page 46. For England and Wales the marriage-rates thus calculated are given for both males and for females on page 5, Annual Report, Registrar-General, 1920. In the table at the top of page 65 they are given for males and females over 15 years of age in groups of years for the last 65 years, the corresponding crude marriage-rates also being given.

The difference between these figures and the proportion of each sex which is married, given on page 68, will be noted. This last-named proportion represents the aggregate number of married persons, not the number married in a given year. It furthermore gives the proportion to the population at all ages.

# MARRIAGES

65

	1851-60.	1861-70.	1871-80.	1881-90.	1891-1900.	1901-10.	1911-15.
<i>England and Wales—</i>							
No. of males married per annum per 1,000 single and widowed males aged 15 and over.. . . .	59.3	60.9	59.7	53.7	53.6	51.6	54.4
No. of females married per annum per 1,000 single and widowed females aged 15 and over.. . . .	51.7	51.8	50.7	45.3	44.9	43.2	45.5
Number of persons married per 1,000 living at all ages..	16.9	16.6	16.2	14.9	15.6	15.5	16.6 <sup>1</sup>

<sup>1</sup> 1911-20. In 1921 this rate was 16.9.

**Proportion of Population Married.**—The proportions in England and Wales, Census 1911, and in the United States, Census 1910, were as follows :—

**PROPORTION PER 1,000 OF EACH SEX AGED 15 AND UPWARDS.**

	Unmarried.		Married.		Widowed.		Divorced.	
	Male.	Fem.	Male.	Fem.	Male.	Fem.	Male.	Fem.
England and Wales ..	403	390	545	506	52	104	not	given
United States .. ..	387	297	558	589	45	106	5	6

On page 146 *et seq.* of Abstract of the American Census, 1910, will be found elaborate statistics of marital conditions in the United States.

For an elaborate study of marriages the reader may be referred to the volume by Mr. G. H. Knibbs, the statistician of the Commonwealth of Australia, on *The Mathematical Theory of Population* (Appendix A, vol. i, of the Census of the Commonwealth), which gives an exhaustive investigation of all aspects of the population problem.

**Age at Marriage.**—This is an important consideration, as fertility is a function of age and of duration of marriage (see p. 100). Of the total marriages in England and Wales, about 90 per cent. of male marriages are of bachelors and 88 to 90 per cent. of female marriages are of spinsters. The

distribution of marriage-ages of bachelors and spinsters, therefore, has special importance. These are stated for 1920 on pages 72-86 Annual Report of the Registrar-General, 1920. In the following diagram this distribution is displayed:—

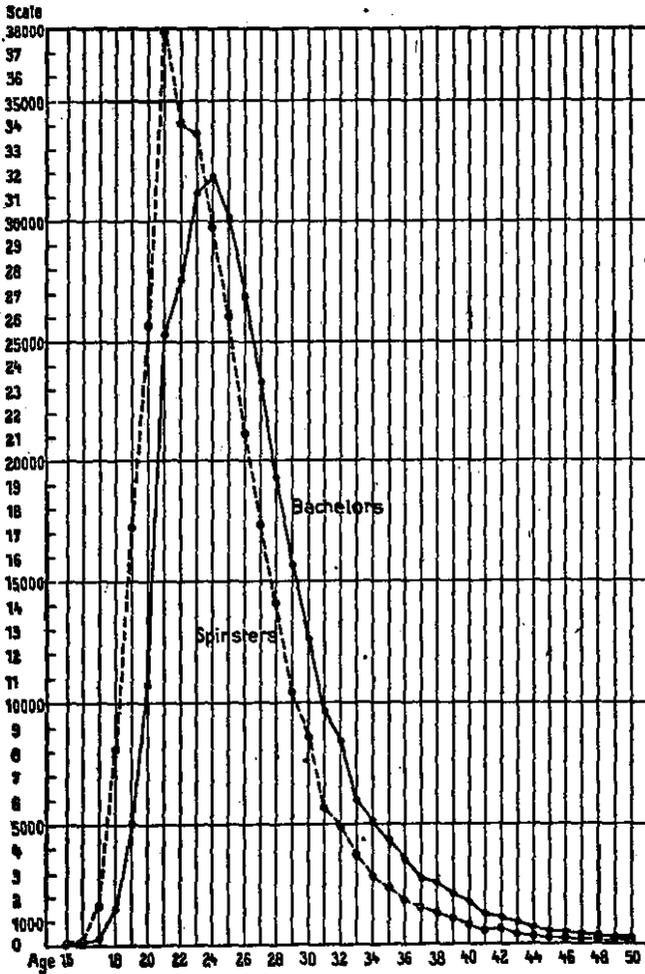


Fig. 7.—England and Wales: Marriages of Bachelors with Spinsters, and of Spinsters with Bachelors, 1920, at Various Ages.

The *mean age at marriage* in 1920 was 27·51 years for bachelor bridegrooms, and for spinster brides 25·54 years, representing an average postponement of marriage since 1896 of 0·88 year for bachelors and of 0·40 year for spinsters.

The most usual ages of marriage are 24 for men and 21 for women.

The *marriages of minors* have steadily decreased. In 1876-80 they numbered 7·8 per cent. of total marriages for husbands and 21·7 per cent. for wives; the proportion for husbands reached its minimum in 1915, when it was 3·5 per cent. for husbands, and in 1918 for wives, when it was 12·9 per cent. In 1920, 4·7 per cent. of the total marriages at all ages were of minors for husbands and 14·3 per cent. for wives.

**Marriage and National Prosperity.**—Farr described the marriage-rate as the barometer of prosperity (present in part, but future anticipated prosperity in still greater part), just as the Funds are the barometer of credit. So the marriages of England increased as “the result of peace after war, abundance after dearth, high wages after want of employment, speculation after languid enterprise, confidence after distrust, national triumphs after national disasters.”

The same conclusion is borne out by the fact, frequently alluded to in the earlier reports of the Registrar-General, that the marriage-rate for many years varied in the same direction as the value of British exports, the average price of wheat, and the amount per head of population cleared out at the Bankers' Clearing House. The coincidence was one in direction, but not in degree. The subject is discussed in a paper by Dr. W. Ogle (*Journal of the Royal Statistical Society*, vol. liii, part ii, 1890).

The general course of the male and female marriage-rates (per 1,000 of each sex aged 15 and upwards, can be seen in Table 3 of the Registrar-General's Annual Report, 1920. The marriage-rate in successive decennia stated per 1,000 persons living at all ages has been as follows:—

1841-50.	1911-20.
16·1, 16·9, 16·6, 16·2, 14·9, 15·6, 15·5, 16·6.	

The statement in this form conceals the oscillations from year to year.

The special influence of the Great War on the marriage-rate can be seen in the following table, in which the marriage-rate is given for the years 1914-19: A, the crude rate for persons per 1,000 living at all ages; B, the rate for males per 1,000 single and widowed, and C, the rate for

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females per 1,000 single and widowed, aged 15 years and upwards.

ENGLAND AND WALES.

*Marriage-rates.*

Year.	A.	B.	C.
1914	15.9	53.0	44.4
1915	19.4	64.4	53.6
1916	14.9	49.5	41.0
1917	13.8	46.2	36.3
1918	15.3	51.5	39.2
1919	19.7	65.1	50.6
1920	20.2	—	—

Some rush into matrimony occurred during the second year of the war under the influence of the uncertainty of life in war and of the pensions for war widows.

**Influence of Age at Marriage and Duration of Marriage on Fertility.**—This subject is important as bearing on the standardization of birth-rates discussed in Chapter VIII. The English law unfortunately does not require a statement of age of father and mother of the infant, and registration data in this country do not, therefore, throw light on these points. But the birth-statistics for Scotland for the single year 1855 gave the data needed for the study of this problem; and, supplementing Matthews Duncan's work, Dr. C. J. Lewis and Mr. J. N. Lewis (*Natality and Fecundity*, 1906) have made an exhaustive analysis of the Scottish figures.

Ages.	Number of Wives-Mothers to 100 Wives.
15-19	51.12
20-24	42.70
25-29	36.60
30-34	30.24
35-39	24.20
40-44	11.33
45-49	1.81
50-54	0.09
55-59	0.03

Total Wives, year 1855 = 398,307.

Total Wives-Mothers, year 1855 = 84,971.

Number of Wives-Mothers to 100 Wives, year 1855 = 21.3.

Number of Wives, aged 15-44 = 293,687.

Number of Wives-Mothers to 100 Wives aged 15-44 = 28.6.

During that year there were 84,971 wives-mothers in Scotland. The ages of 1·2 per cent. of these were unstated. Of the rest 1·9 per cent. were under 20, 18·9 per cent. between 20 and 24, 28·1 per cent. aged 25-29, 24·2 per cent. aged 30-34, 17·4 per cent. aged 35-39, 7·3 per cent. aged 40-44, and 1·0 per cent. over 45 years old.

The fertility of wives at different ages was as shown in the table at foot of page 68. It is concluded from this table that the fertility of wives is greatest in the early years of the child-bearing period of life, that this fertility steadily diminishes, and very rapidly diminishes towards the end of this period of life.

From the same volume is taken the following table, the female fertility at different ages in which may be compared with the above figures for Scotland in 1855:—

NUMBER OF WIVES-MOTHERS TO 100 WIVES AT QUINQUENNIAL GROUPS OF AGES.

Age of Mother.	Berlin (Boeckh).	Buda-Pesth (Korösi).	Sweden (Sidenblad).	New South Wales (Royal Commission).	
	1887-90.	1889-92.	1891.	1871.	1901.
15-19	50·34	42·80	51·81	50·10	56·28
20-24	45·55	35·80	45·14	44·15	39·70
25-29	33·60	29·20	37·53	40·75	29·87
30-34	22·50	20·60	31·18	33·67	22·68
35-39	14·50	14·70	25·04	27·04	17·25
40-44	6·03	5·90	14·23	13·41	8·81
45-49	0·74	0·70	2·00	0·71	0·43

The Swedish fertility-rates were utilized in calculating the standardized birth-rates as described on page 86, illustrations of which are given on page 102. Two possible sources of error may conceivably arise in using these rates to standardize birth-rates:—

(a) Later marriages in more recent years would, it may be said, disturb the factor. The "weighting" of different proportions of wives at higher age-periods would be corrected by the application of the Swedish rate of fertility at these higher ages, and no error would arise assuming that the Swedish rates accurately represent comparative fertility at different ages.

(b) But if more recent marriages at any given age are

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females per 1,000 single and widowed, aged 15 years and upwards.

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(b) But if more recent marriages at any given age are

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more fecund than marriages of longer duration at the same age, then an older would have an undue advantage as against a younger married population. Statistics on this point are not entirely satisfactory. The effect of alteration in age at marriage on fertility in early married life is probably not great, and it appears likely that the excess of fertility of the newly married over others does not represent a natural law, but is chiefly, if not entirely, the result of ante-nuptial conception. Thus in the Scottish statistics for 1855, in 1·6 per cent. of the 16,176 mothers of first-born children the birth preceded marriage; further, in 21·3 per cent. the birth occurred within 7 months of marriage, and in an additional 13·5 per cent. the birth of first-born children occurred within 7-9 months of marriage. Coghlan's investigations in New South Wales point to the conclusion that 30 per cent. of the legitimate first births are the product of ante-nuptial conceptions.

## CHAPTER VII

### THE REGISTRATION OF BIRTHS

REGISTRATION of baptisms, marriages and deaths dates back to 1538, in the reign of Henry VIII, when the clergy in every parish were required to keep a weekly record of these events, and were made responsible for the safe keeping of the register. From these records in various parishes, and especially from the records for London, much valuable information has been extracted from time to time. Pursuant to the Civil Registration Act, the office of Registrar-General was established in 1836, and registration of births and deaths was begun July 1, 1837.

**Births.**—Under the Act of 1836 the registration of births was optional, unless on being requested to register by the Registrar; and no penalty was authorized for refusal to register. Registration was made compulsory by the Births and Deaths Registration Act of 1874 (see also p. 156). At the present time the failure to register is almost negligible. During the 39 years ending with 1876, the deficiency in birth registration was estimated by Dr. Farr at 5 per cent.

Under the Act of 1874 it is required that the father and mother of every child born alive, or in their default "the occupier of the house in which to his knowledge" a child is born, "and each person present at the birth, and of the person having charge of the child, to give to the Registrar within 42 days next after such birth information of the particulars required to be registered."

These are as follows:—

1. When and where born.
2. Name, if any.
3. Sex.
4. Name and Surname of Father.
5. Name and Maiden Surname of Mother.
6. Rank or Profession of Father.
7. Signature, Description, and Residence of Informant.

8. When Registered.
9. Signature of Registrar.
10. Baptismal Name, if added after Registration of Birth.

The putative father is not required to furnish such particulars concerning the birth of his illegitimate child, and his name is not to be entered in the Register except at the joint request of himself and of the mother. The Registrar is required to keep himself informed of the occurrence of births, and may require the attendance of any of the persons mentioned above to give him the needed particulars for registration. The official instructions to registrars, however, enjoin upon them not to call upon medical practitioners or other persons present at the birth until they have failed to obtain the information both from the parents and the occupiers.

**Birth Registration in United States.**—In the United States there were many early local attempts at registration,<sup>1</sup> Massachusetts having a very early system; and in Dr. Trask's pamphlet will be found a copy of a model Bill for the registration of births and deaths, endorsed by various medical and Government authorities. The essential features of this law have been adopted by a number of States, each State being autonomous in legislative enactments dealing with matters within its own area. The information asked for in birth certificates is shown on page 79.

The American form requires fuller information than the English. It does not, however, require a statement of the date and duration of marriage, the importance of which in the study of fertility problems is recognized in Australian statistics.

A permanent Census Act was passed by the Federal Legislature in 1902, and this authorized the collection of birth and death statistics from such States and municipalities as in the judgment of the Director of the Census had satisfactory records. Since then the Census Bureau of the Federal Government has made annual collections of mortality statistics from a steadily increasing area, which for 1920 comprised 82.2 per cent. of the population of the United States. Until recently relatively few States have maintained

<sup>1</sup> For particulars see the publication of the United States Public Health Service on *Vital Statistics*, 1914, by Dr. J. W. Trask.



the Children's Bureau of the Federal Government has taken an active part in similar work. It realizes—what is especially true in a new country with many immigrants—that enforcement of the law must go hand in hand with appreciation by the public of the end aimed at by the law. It may be doubted, however, whether more systematic enforcement of registration by fines on default, with publication of cases in which this course has been adopted, should not be employed to supplement the educational propaganda.

In some States there is adequate legal provision for birth registration, but the law is not enforced. This is illustrated by facts given in a paper by Dr. Louis Dublin,<sup>1</sup> who lays down as a first test of the accuracy and completeness of birth registration that in any community the number of births registered shall be greater in the census year than the number of living children enumerated under one year old. Replies from 144 cities were analysed, and in 15·9 per cent. of these this criterion failed. Thus in Baltimore, Maryland, the enumerated population under one year in 1910 exceeded the births in that year by 3·7 per cent., in Jersey City, N.J., by 26·7 per cent., and in Chicago by 50·3 per cent. The second test is constituted by variations of the birth-rate year by year. Some gradual decrease in the birth-rate might be expected; but increases or violent oscillations in the crude birth-rate (p. 84), whether of increase or decrease, suggest intermittent neglect or fulfilment of birth registration. It was found that in 142 of the 144 cities investigated, the birth-rate had apparently increased, while in Philadelphia and New York City, where birth registration has been fairly reliable since 1910, the birth-rate had decreased. A third test is to ascertain whether the recorded birth-rate is below the likely minimum of a city, say 20 per 1,000 inhabitants.

Since the date of Dr. Dublin's paper, rapid improvement in birth registration has occurred; but the three tests indicated above remain of value in checking the completeness of birth registration in any given community.

**Disadvantages of Defective Birth Registration.**—The absence of birth registration is liable to be detrimental both

<sup>1</sup> "The Present Status of Birth Registration," etc., L. I. Dublin (*Quarterly Publication of the American Statistical Association*, March 1917).

to the State and to the individual, for such registration is the primary means of personal identification, it determines when compulsory school attendance shall be enforced, and when industrial employment may be permitted. It is the best evidence of citizenship, and the only satisfactory evidence in cases of inheritance, etc.

The failure to secure prompt notification or registration of births may lead to the neglect to treat cases of ophthalmia of the new born, or neglect to visit and give needed advice and aid for mothers and new-born infants. In England the notification within 36 hours of all births has been enforced, in order to enable early visits to be made to aid in child hygiene work.

Not less important is the fact that in the absence of complete records of births it is impracticable to assess the position in respect of infant mortality of a given community and of its poorer and richer sections, or to compare the position of one community with that of others. The following illustration is taken from Dr. Dublin's paper. Baltimore now possesses good registration of births; but in 1910 its registration was demonstrably defective, as seen below:—

Year.	Registered Birth-rate per 1,000 Population.	Infant Mortality per 1,000 Registered Births.
1910 ....	17.6	217.7
1915 ....	23.3	119.8

There was an apparent increase in births of 38.3 per cent. But the population of Baltimore increased only 4.3 per cent. in the same period, which is not consistent with the great increase in births; furthermore, a birth-rate of 17.6 is improbable. If we assume, as is likely, that the birth-rate in 1910 was as high as in 1915, then the births in 1910 were 13,037, and not 9,858, the number actually registered, and the infant mortality rate in 1910 requires to be reduced in the proportion  $\frac{9,858}{13,037}$ , when it becomes 164.6 instead of 217.7. Under such circumstances as the above, it is almost impracticable to say to what extent the infant death-rate is declining. The infant mortality rates

given above, based on official records, were a reason for enforcing better birth registration, not for relaxing efforts to reduce infant mortality.

**Notification of Births.**—The registration of births has been long regarded by medical officers of health as opening up valuable possibilities of hygienic work in the interest of mother and infant; but the six weeks' delay in registration permitted in Great Britain, and the fact that registration is not in the hands of public health administrators, have made it difficult to undertake prompt visiting of homes where births have occurred. Huddersfield obtained a local Act to secure early notification of births to the medical officer of health, and this was followed by "An Act to provide for the Early Notification of Births, 1907." The Act was "adoptive," only becoming operative on adoption by a local authority; but its adoption was rapid, and in 1915 a further Act was passed making early notification of births universally compulsory. The object of this Act is administrative and hygienic, not the improvement of registration, though it may occasionally be a useful check on the completeness of registration of births.

Under this Act it is—

the duty of the father of the child, if he is actually residing in the house where the birth takes place at the time of its occurrence, and of any person in attendance upon the mother at the time of, or within six hours after, the birth, to give notice in writing of the birth to the medical officer of health of the district in which the child is born.

Notice is required to be given by posting a prepaid letter or post-card addressed to the medical officer of health, giving the necessary information of the birth within thirty-six hours after the birth, or by delivering a written notice of the birth at the office or residence of the medical officer within the same time; and the local authority is required to supply without charge addressed and stamped post-cards containing the form of notice to any medical practitioner or midwife residing or practising in their area, who applies for the same.

The duty of notification falls equally on the father and on the professional attendant at the birth; but notification by the latter is not enforced if the parent discharges his duty. It is well, therefore, for the doctor or midwife to see that he does so. No fee is paid for notifications.

The notification of births to the medical officer of health has led to the inauguration in all sanitary areas of important work in child hygiene. Evidently, however, there is over-

lapping in requiring notification and registration, and much to be said for a fusion of the two duties. This could only be done satisfactorily by insisting on registration within, say, four days of birth. In practice hygienic visits by public health nurses are only exceptionally made at an earlier date than this, and the compulsory notification of ophthalmia of the new born provides partial protection against a chief risk of delayed notification of births.

Registration of births in Great Britain is substantially complete for live-births, and the notification of births has given some additional safeguard against omission of registration. Registration operates much more efficiently as a check on the completeness of notification.

**Still-births.**—In Great Britain there is no official registration of still-births, but under the Notification of Births Act the birth of any child “which has issued forth from its mother after the expiration of the twenty-eighth week of pregnancy, whether alive or dead,” is required to be notified to the medical officer of health.”

The rule of the Central Midwives Board, England, prescribes that an infant is to be regarded as still-born if after complete birth it “has not breathed or shown signs of life,” and this is the definition generally adopted in this country and used for registration purposes. The notification of still-births under the Act of Parliament is limited as stated above; but midwives are required by the Central Midwives Board to notify still-births without any defined limitation to ages over the twenty-eighth week. This introduces a source of lack of comparability in local statistics, when comparing, for instance, the still-birth rate in two districts in which confinements are attended to a preponderant extent by doctors or by midwives respectively.

Apart from the practical difficulty of determining the exact period of gestation, there are international differences of practice as to still-births. It is not clear for each country whether an arbitrary limit of foetation is taken below which notification or registration is not required; and there is much discrepancy in the definition of still-birth. In Prussia (*Annuaire Internationale de Statistique, II, Office of the International Statistical Institute, 1917*) “still-born” include infants born at term and without life, and a foetus born

without life and having a length of 0.32 metres, after 180 days of gestation or more than this. In Belgium "on entend par enfant présenté sans vie celui dont la naissance n'a pas été enregistrée et qu'est présenté sans vie à l'officier de l'état-civil" (Décret du 4 Juillet, 1806); and still-born include also any infant born after the 180th day of pregnancy without sign of life. In Denmark any fœtus born without sign of life after the twenty-ninth week of pregnancy is regarded as a still-born infant; abortions in earlier pregnancy are not registered. In France all infants born without sign of life, and those born alive which die before registration, are regarded as still-born. As registration may be made at any time within three days after birth, evidently many infants having had extra-uterine life are entered as still-born.

In view of the above quoted and similar facts, the greatest possible caution is required in accepting comparisons of international statistics of still-birth (see also p. 83). Full particulars as to still-births are given in a report of the Royal Statistical Society, of which Dr. R. Dudfield was chairman.

**Registration of Births in United States.**—The Model State Law recommended for adoption in each State as given on page 83 of Dr. Trask's pamphlet on *Vital Statistics* (Washington, Government Post Office) provides in Section 6 that—

a still-born child shall be registered as a birth and also as a death, and separate certificates of both the birth and the death shall be filed with the local registrar, in the usual form and manner, the certificate of birth to contain in place of the name of the child, the word "still-birth": *Provided*, That a certificate of birth and a certificate of death shall not be required for a child that has not advanced to the fifth month of utero-gestation.

In Section 13 it is required that—

within ten days after the date of each birth there shall be filed with the local registrar of the district in which the birth occurred a certificate of such birth, which certificate shall be upon the form adopted by the State Board of Health with a view to procuring a full and accurate report with respect to each item of information enumerated in Section 14 of this Act.<sup>1</sup>

In each case where a physician, midwife, or person acting as midwife was in attendance upon the birth, it shall be the duty of such physician,

<sup>1</sup> A proviso may be added that shall require the registration, or notification, at a shorter interval than ten days of births that occur in cities.

midwife, or person acting as midwife to file in accordance herewith the certificate herein contemplated.

By Section 14 it is required that—

the certificate of birth shall contain the following items, which are hereby declared necessary for the legal, social, and sanitary purposes subserved by registration records<sup>1</sup> :—

(1) Place of birth, including State, county, township or town, village, or city. If in a city, the ward, street, and house number; if in a hospital or other institution, the name of the same to be given, instead of the street and house number.

(2) Full name of child. If the child dies without a name, before the certificate is filed, enter the words "Died unnamed." If the living child has not yet been named at the date of filing certificate of birth, the space for "Full name of child" is to be left blank, to be filled out subsequently by a supplemental report, as hereinafter provided.

(3) Sex of child.

(4) Whether a twin, triplet, or other plural birth. A separate certificate shall be required for each child in case of plural births.

(5) For plural births, number of each child in order of birth.

(6) Whether legitimate or illegitimate.<sup>2</sup>

(7) Date of birth, including the year, month, and day.

(8) Full name of father.

(9) Residence of father.

(10) Colour or race of father.

(11) Age of father at last birthday, in years.

(12) Birthplace of father; at least State or foreign country, if known.

(13) Occupation of father. The occupation to be reported if engaged in any remunerative employment, with the statement of (a) trade, profession, or particular kind of work; (b) general nature of industry, business, or establishment in which employed (or employer).

(14) Maiden name of mother.

(15) Residence of mother.

(16) Colour or race of mother.

(17) Age of mother at last birthday, in years.

(18) Birthplace of mother; at least State or foreign country, if known.

(19) Occupation of mother. The occupation to be reported if engaged in any remunerative employment, with the statement of (a) trade, profession, or particular kind of work; (b) general nature of industry, business, or establishment in which employed (or employer).

It will be noted that among the other conditions of registration named above is one that still-births should be registered both as births and deaths. It is important to keep these statistics separate from those of infant mortality

<sup>1</sup> The following items are those of the United States standard certificate of birth, approved by the Bureau of the Census.

<sup>2</sup> This question may be omitted if desired, or provision may be made so that the identity of parents will not be disclosed.

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among live-born children. This is done in the American "Birth Statistics," which give tables of still-births in different States, including tables showing the number of child in order of birth, by colour and age of mother, and by country of birth of mother.

The details of registration both of births and deaths vary in different States, but a certain standard of birth registration is required before a given State is admitted into the "Birth Registration Area" (see p. 72).

**Allotment of Births in Institutions.**—Rates of infant mortality based on the number of births in a given district will only be trustworthy when infants live during the first year after the infant's birth in the district in question; or when, as is usually the case, it may reasonably be assumed that on an average inward and outward migration will balance. Large maternity hospitals in the past have been a cause in some areas of misleading birth-rates.

The English Registrar-General's rule now is identical with that for deaths. All births of infants in an area other than that of the mother's residence are transferred to that area, whether they occur in an institution or at a private address.

## CHAPTER VIII

### BIRTHS

**MARRIAGE** in civilized life is the institution by which the population is chiefly replenished, and the study of the birth-rate and of the conditions which determine and modify the fertility of marriage forms an essential part of vital statistics. We may first consider the chief available facts as to the birth-rate in this and other countries.

Births may be of living or of so-called still-born or dead-born infants, which in Great Britain are defined as dead infants born after the end of the twenty-eighth week of pregnancy; besides these there are numerous abortions at an earlier stage of pregnancy. It is convenient to consider first these mishaps in reproduction.

**Still-births.**—In Great Britain there is no civil registration of still-births, but they are required to be notified (p. 77). This requirement began to be enforced in various districts at different times, and the following table relating to a period prior to general enforcement, taken from evidence given by me to the Royal Commission on Venereal Diseases, 1915, shows the range of variation of notification of still-births in various areas.

The still-births are stated as a percentage to registered (live) births, which is the nearest approximation possible to a basis rendering comparison between different areas practicable.

	1910.	1911.	1912.	1908 to 1912 or Other Period.	Range of Percentages for 3 Years, 1910-12.
In 74 County Boroughs and Towns with over 50,000 population ..	3.01	3.18	2.98	3.06	1.08-5.52
In 67 Towns with populations between 20,000 and 50,000 ..	3.21	3.07	3.34	3.34	1.19-7.82
In the 29 Metropolitan Boroughs ..	2.14	2.21	2.46	2.18	0.31-5.83

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In the following table the range of variation of notifications in each group of towns is given separately for each year from 1909 onwards:—

	No. of Areas.	Average Percentage of Still-births to Registered Births.	Range.
	1908.		
Metropolitan boroughs .. ..	7	1.43	0.36-2.54
Large towns .. .. .	17	3.04	0.72-5.06
Smaller towns .. .. .	12	4.02	1.17-7.31
	1909.		
Metropolitan boroughs .. ..	17	2.08	0.61-3.34
Large towns .. .. .	46	3.10	0.62-9.65
Smaller towns .. .. .	24	3.61	1.58-8.07
	1910.		
Metropolitan boroughs .. ..	28	2.14	0.73-3.33
Large towns .. .. .	52	3.01	1.18-7.65
Smaller towns .. .. .	34	3.21	1.65-6.70
	1911.		
Metropolitan boroughs .. ..	27	2.21	0.69-3.44
Large towns .. .. .	58	3.18	1.24-5.95
Smaller towns .. .. .	40	3.07	0.96-7.01
	1912.		
Metropolitan boroughs .. ..	27	2.46	0.31-3.30
Large towns .. .. .	60	2.98	1.24-5.32
Smaller towns .. .. .	54	3.40	0.92-8.40

It will be noted that the still-births are stated in terms of the number of registered, (i.e. live) births. Live-births are the subject of registration which is practically complete, and these births form a much more satisfactory denominator than the population of each area. It is, indeed, only by this method that the statistics of different areas can be fairly compared. It must not, however, be assumed that all still-births (defined as above) are notified. By comparison of notified live-births with registered births, it can be shown that not all live-births are notified, and the deficiency of notification is likely to be greater for still-births.

The above table shows great variation in the proportion of still-births. Some part of this variation is caused by varying degree of compliance with the obligation to notify

still-births, but it is unlikely that this completely explains the variations. The real proportion of still-births varies in different medical practices and in the practice of different midwives ; there are also local or social differences due among other causes to the varying prevalence of syphilis.

For the year 1919 (Annual Report of the Chief Medical Officer, Ministry of Health, 1920, Cd. 1397) the number of still-births per 100 registered live-births showed variations of which the following are examples :—

Counties—		County Boroughs—	
Northamptonshire .. ..	1.3	Oldham .. ..	7.2
East Suffolk .. ..	5.0	Rochdale .. ..	6.8
<i>Metropolitan Boroughs—</i>		Wolverhampton .. ..	1.5
Lambeth .. ..	3.7	Grimsby .. ..	1.1
Deptford .. ..	1.6		

These variations on the minimum side are almost certainly too great to correspond to facts.

It has been suggested that in stating the maternal rate of mortality from child-bearing by the most accurate measure of exposure to risk, viz. confinements at term and prematurely, the number of still-births should be added to live-births, and the deaths of mothers stated in terms of these together. It would, however, be folly to do this in view of the imperfect and variable degree of certification of still-births at present obtained, and of the differing definition of "still-birth" in various communities.

Still-births have a varying signification in different countries : (a) as regards the period of pregnancy covered by the returns ; and (b) as regards the definition of live-birth. This subject is summarized in a special report of a Committee of the Royal Statistical Society (1912), and this Committee reported—

- (1) That it is desirable that an international definition of "still-births" should be adopted ;
- (2) That still-births should be registered ; and
- (3) That where the definition of "still-birth" does not exclude from such category the births of children born alive but dying before registration, official inquiries should be instituted on the occasion of registration with a view to discriminating between such form of pseudo still-birth (Bertillon's *dit mort-né*) and the genuine (*mort-né*).

**Live-births.**—In the discussion of natural increase of population, the terms fertility and fecundity have been employed in varying senses by different authors. Matthews Duncan<sup>1</sup> defines *fertility or productiveness* as “the amount of births as distinguished from the capability to bear,” a quality of chief interest to the statistician and the political economist. By *fecundity* he means “the demonstrated capability to bear children,” a quality of interest especially to the physiologist and physician. Fertility implies fecundity, and introduces also the idea of number of progeny; fecundity “indicates the quality without any superadded notion of quantity.”

Birth-rates are a measure of fertility, which may be stated in terms of the total population, or of the possible parents, i.e. the number living in marital relationship at child-bearing ages. In the important Fertility Report, issued as part of the official English Census Report for 1911, “fertility” means the children born or surviving in proportion to married couples, both parents being returned on the same census schedule. It represents the whole family born, and so differs from fertility in the sense of annual births per 1,000 women aged 15–45. Fertility being employed in these different senses, it is important to define precisely in each statement the exact measure of fertility in use.

**Birth-rates.**—The various methods of stating the birth-rate in common use may now be stated:—

(1) The birth-rate is reckoned as a rate per 1,000 of the population living at all ages in the middle of the year. This is the *crude birth-rate*. It is fairly satisfactory when used for the same community in a short series of years, or in comparing the birth-rates of communities whose populations are known to be nearly, if not quite, equal in their age and sex-composition and in marital condition. If, however, the number of women, especially of married women, living at child-bearing years differs in two populations, the birth-rate per 1,000 of the total population will vary from this cause, apart altogether from varying fertility of the two populations.

(2) The proportion which the births registered bear to the women living at child-bearing years—i.e. roughly between

<sup>1</sup> *Fecundity, Fertility, and Allied Topics*, 1866.

about 15 and 45 years of age—may be calculated. These are shown by the census returns for each urban and rural sanitary district; and as the age and sex-composition, except in abnormal cases, is not likely to vary greatly in an inter-censal period, the same proportion of women aged 15-45 to the total population may be regarded as holding good throughout the intervening period between any two census enumerations.

This method is no more accurate than the first, as a measure of fertility, for it ignores the great differences in proportion of married women aged 15-45 which may exist between two populations.

(3) A more accurate method is to subdivide the births into legitimate and illegitimate, stating the former per 1,000 of married women aged 15-45, and the latter per 1,000 of unmarried women aged 15-45.

The following example shows the relative accuracy of the three methods, as a measure of fertility, for the legitimate and illegitimate birth-rates in two areas of sharply different social status. In Kensington there is a high proportion of female unmarried domestics, who scarcely contribute to the birth-rate; in Stepney these are relatively few. It is likely also that in Stepney there is little, and in Kensington much, "birth-control." The legitimate birth-rate by the most accurate method of the three in 1921 was 27 per cent. higher in Stepney; and it will be noted that the crude birth-rate approximates more nearly to this than the birth-rate calculated by method B. On the other hand, the excess of illegitimacy in Stepney is greatly exaggerated by the crude method A, and to a less but still great extent by method B.

LEGITIMATE BIRTH-RATES IN KENSINGTON AND STEPNEY, 1921.

	Kensington.	Stepney.	Percentage Excess of Birth-rate in Stepney over that in Kensington.
A, Birth-rate per 1,000 inhabitants	18.1	24.2	33
B, Birth-rate per 1,000 women aged 15-45 years	55.7	98.8	77
C, Birth-rate per 1,000 married women aged 15-45 years	163.0	207.4	27

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## ILLEGITIMATE BIRTH-RATES IN KENSINGTON AND STEPNEY, 1921.

	Kensington.	Stepney.	Percentage Excess of Birth-rate in Kensington over that in Stepney.
A, Birth-rate per 1,000 inhabitants	1.34	0.59	127
B, Birth-rate per 1,000 women aged 15-45 .. .. .	4.12	2.40	72
C, Birth-rate per 1,000 unmarried women aged 15-45 years ..	6.26	4.58	37

At this point a distinction may be drawn between birth-rate and fertility-rate. The figures given in line A show the relative rates of increase by births in the two communities, and from a national and economic standpoint this is the information desired. Such crude birth-rates will always possess a special value of their own. But to ascertain to what extent the difference between the two is caused by differences in fertility of the married women in the populations compared, line C must be consulted, or the nearer approximation to an accurate determination of fertility described in the next paragraph may be used.

(4) A full description of this more accurate method is given in a paper on "An Improved Method of Calculating Birth-rates," by A. Newsholme and T. H. C. Stevenson (*Journal of Hygiene*, vol. v, Nos. 2 and 3, 1905).

As this method of birth-rate standardization is seldom necessary in practice, the following brief summary of it, which has been extracted from p. xviii of Part III of the Decennial Supplement to the Seventy-fifth Report of the Registrar-General, will suffice to show the principle of the method:—

Briefly, the method is analogous to the "indirect" method of standardizing death-rates. Taking the calculation of the standardized birth-rate of England and Wales in 1911 as an example, the following description, adapted from the paper referred to, will show the method of calculation: Standard fertility rates, those of Sweden in 1891<sup>1</sup> being adopted, are applied to the wives of the community whose true birth-rate is to be ascertained, and the births at each age period 15-20, 20-25, 25-30, 30-35, 35-40, and 40-45, which according to this standard ought to occur are thus ascertained. Thus, in England and Wales in 1911, according to the Swedish standard, 1,243,585

<sup>1</sup> These rates are: Per 1,000 wives aged 15-20, 518; 20-25, 451; 25-30, 375; 30-35, 312; 35-40, 250; and 40-45, 142.

births should have occurred in its (enumerated) population of 36,070,492, and the birth-rate corresponding to this figure, which may be termed the "index" birth-rate, since its use is to indicate the degree in which the constitution of the population favours fertility, is therefore 34.48 per 1,000. The index birth-rate of England and Wales in 1901, similarly calculated, is 34.91, and this is employed as the standard with which other index birth-rates are compared. As the index birth-rate in 1911 was lower than the standard, the recorded birth-rate in 1911 has to be increased in proportion to the difference between the two index birth-rates, or by  $\frac{34.91}{34.48}$  (= 1.0125), to compensate for the degree by which the population at the later date was less favourably constituted for fertility.

The legitimate birth-rate of England and Wales in 1911, calculated upon the estimated population in the middle of the year, being 23.31, its standardized birth-rate becomes  $23.31 \times 1.0125 = 23.60$ .

The method of obtaining the standardized illegitimate birth-rates is as follows: The proportion per 1,000 total population of women aged 15-45 who were not wives was ascertained, and the proportion 132.7 per 1,000 in England and Wales in 1901 was taken as a standard. The crude illegitimate birth-rate per 1,000 of total population in each community was then reduced or increased in accordance with the excess or deficiency of the proportion of women not wives at child-bearing ages. The proportion in England and Wales in 1911 was 130.3 per 1,000, and the standardization factor is therefore  $\frac{132.7}{130.3} = 1.018$ . The illegitimate birth-rate in England and Wales in 1911 being 1.04, its standardized illegitimate birth-rate becomes  $1.04 \times 1.018 = 1.06$ . Finally, the addition of the standardized legitimate and illegitimate birth-rates gives the standardized total birth-rate, viz. 24.66.

**Proportion of Male to Female Births.**—This proportion has sometimes been called its *Masculinity*. Its course since registration began in England and Wales can be seen in Table 3 on page 5 of the Annual Report of the Registrar-General, 1920. The highest proportion of male to 1,000 female live-births since 1870 was 1,060 in 1919. Prior to 1915, from 1870 it was never higher than 1,043 (in 1875), the lowest figures being 1,033 in 1888 and in 1890, and 1,032 in 1898. The proportion of male to female births varies in different countries. In Scotland it is rather higher than in England. The proportion was 1,056 in Germany in 1914, 1,059 in Austria in 1913, and 1,040 in Belgium, in Denmark 1,052 in 1915, in France 1,041 in 1911, in Ireland 1,048 in 1912, in Italy 1,051 in 1914.

There does not appear to be a consistent difference between the sex proportion of nuptial and ex-nuptial births. Much further information as to masculinity and on the general

question of "Natality and Fecundity," is given in a work by C. J. Lewis and J. N. Lewis.<sup>1</sup>

Dr. Stevenson (Annual Report of the Registrar-General, 1919) draws attention to the close parallelism during the last 50 years of the movement in prices and of the sex ratio, as shown in the following diagram from the above report. It would appear that the association between the great proportional increase of male births in 1916-19 and prices was not

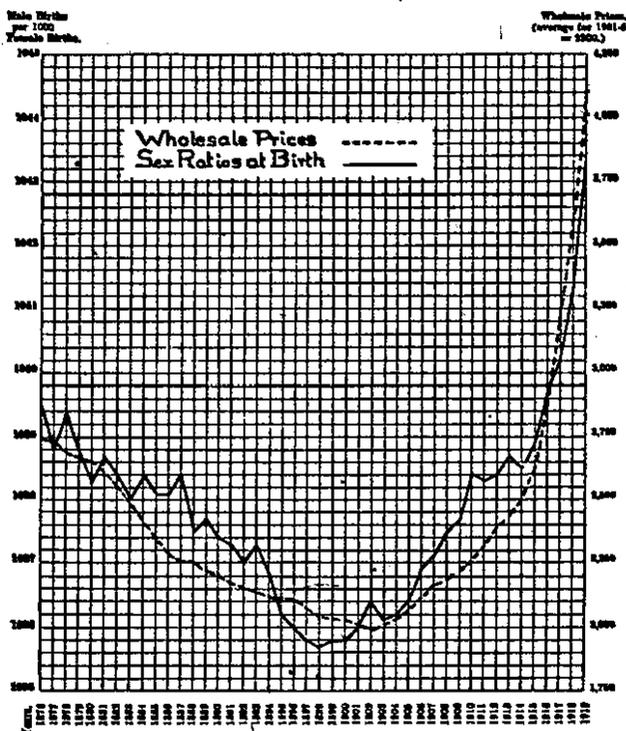


FIG. 9.—Sex Ratios at Birth and "Economist" Index Numbers of Wholesale Prices (Smoothed Curves).

merely accidental, as it approximately holds good to a large extent during the whole period shown in Fig. 9. The method of smoothing is to plot against each year the average figures for that year and the nine preceding years. The explanation of this close coincidence is obscure. It may or may not be significant that there was a marked increase of masculinity of legitimate, and not a consistent increase

<sup>1</sup> *Natality and Fecundity*, 1906.

of masculinity of illegitimate births in the recent years of war.

**Plural Births.**—In the first year of civil registration in Scotland, 1855, much more comprehensive detail was asked for in respect of each birth than has ever since been obtained in Great Britain, on the lines indicated as now desirable (p. 68). After the first year the schedule of inquiry was curtailed, but the more complete records for one year remained, and these have been made the subject of valuable analysis, of which the results were published by Dr. Matthews Duncan in his book on *Fertility, Fecundity and Sterility* (1871), and more recently in Messrs. Lewis's work (see p. 68). According to these early Scottish returns, one mother out of 8,497 had triplets, and there was one twin birth to 87·1 births. Nuptial multiple births are more frequent than ex-nuptial, which may be explicable by the fact that a higher proportion of twin births occurs in women of older years. Knibbs gives the ratio of twin to total births in Switzerland (1881–1900) as 1 to 79·3, in Germany (1901–2) as 1 to 78·7, and in Belgium (1890–1900) as 1 to 90·0.

**Illegitimacy.**—Illegitimacy has great social importance, among other reasons because of the excessive child-mortality associated with it. *Primâ facie* it may be regarded as a measure of the sacredness of family life, and possibly it has some utility in this respect in comparison between countries. Rural communities in England have more illegitimacy than urban; but it is likely that this is explicable as much by less effective contraceptive precautions as by less chastity.

The illegitimate birth-rate may be stated,

(1) Like the total birth-rate, in terms of the general population, which gives but a poor index of its amount.

(2) A more accurate method is to state it as a proportion to the number of unmarried women at child-bearing ages.

(3) For certain purposes a further subdivision may be required, on the lines indicated for total birth-rate on page 86.

(4) The illegitimate birth-rate is often stated as a proportion to the total births. This method is fallacious, especially when it is employed to compare the experience of one year or of one community with that of other years or of other communities; for the legitimate birth-rate is steadily declining,



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and therefore a stationary rate of illegitimacy would show an increase, if stated in proportion to total births, unless the total birth-rate was decreasing exactly in the same proportion; and the interpretation of a diminishing proportion of illegitimacy would similarly be ambiguous. Thus in 1876-80 the illegitimate births in England and Wales formed 4.8 per cent. of the total births; in 1896-1900 this proportion had fallen to 4.0 per cent.; and it then rose in 1911-15 to 4.3 per cent., and in 1918 under war and *post-bellum* conditions to 6.3 per cent. of the total births. But when the illegitimate births are stated as a rate per 1,000 unmarried and widowed females aged 15-45 years, the rate was 14.4 in 1876-80, fell to 7.8 in 1911-15, and only rose to 8.2 in 1918 and 8.3 in 1919. The fallaciousness of the statement of illegitimacy in proportion to total births is still more clearly illustrated by the following table from p. xxxv of the Annual Report of the Registrar-General, 1919.

	1876-80.	1911-15.	1916.	1917.	1918.	1919.
Proportion of illegitimate births to total births (= 100 in 1876-80) ..	100.0	90.7	101.1	117.1	131.8	127.4
Proportion of illegitimate births to unmarried females aged 15-45 (= 100 in 1876-80) ..	100.0	54.2	52.8	51.4	56.9	57.6

If the preceding ratios between two variables shown above were to be trusted, it would appear that illegitimacy had increased; whereas, as shown in the second line of the above table, and more clearly in the following table, the illegitimate has declined more than the legitimate birth-rate.

	1876-80.	1911-15.	Percentage Decline of Birth-rate.
Legitimate birth-rate per 1,000 married women aged 15-45 .. ..	296.3	189.7	36.0
Illegitimate birth-rate per 1,000 unmarried women aged 15-45 ..	14.4	7.8	45.9

Whether this decrease in illegitimacy is due to greater chastity or to the increased use of contraceptive measures is doubtful.

## BIRTHS

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In England the proportion of illegitimate births per 1,000 births in 1918 was 63. It was 16·7 in the same year for the entire birth registration area of the United States, varying from 6·3 in Kansas to 50·7 in Virginia. The proportion is highest among the coloured population. According to the official report for 1918, "the very low rates of illegitimacy . . . suggest that accurate information regarding illegitimacy may not be given on birth certificates."

## CHAPTER IX

### THE DECLINE IN THE BIRTH-RATE

A most significant feature of the history of western civilization, European and American, is the decline in the birth-rate which has occurred during recent decades. This began earlier or later in various countries, and its distribution among various sections of the population varies in different countries, though it is rapidly becoming general (p. 102). The history of this movement and of its consequence on the relative magnitudes of nationalities, races, religions and social strata of society forms an essential study in sociology and demography.

The effect of births on population is measured by the *crude birth-rate*, and a comparison of these birth-rates in different countries is first necessary before the causes of changes in the birth-rate are discussed.

AVERAGE ANNUAL CRUDE BIRTH-RATES OF DIFFERENT COUNTRIES.

	1871-75.	1891-95.	1911-13.	Percentage Decline between	
				1871-75 and 1911-13.	1891-95 and 1911-13.
England and Wales ..	35.5	30.5	24.1	32	21
Scotland ... ..	35.1	30.5	25.7	27	16
Ireland.. .. .	27.1	23.0	23.0	15	0
France .. .. .	25.5	22.3	18.8	38	16
Prussia.. .. .	38.8	37.0	28.8	26	22
Italy .. .. .	36.8	36.1	31.9	13	11
Sweden .. .. .	30.7	27.5	23.6	23	14
Australia .. ..	37.0	32.4	28.1	12	13

See also table on page 102.

The comparison is confined to years prior to the Great War, and it will be noted that there is a general decline of birth-rate, though greater in some countries than in others.

— Reference to the table on page 5 of the Annual Report of the Registrar-General, 1920, shows that the highest crude birth-rate, or to 136.3, was registered in 1876. It had risen slightly

up to that year, but little importance can be attached to this, as, although the registration of births had nominally been compulsory since civil registration began, no penalty followed discovered infraction of the law prior to the Act of 1874. From 1876 the English birth-rate has declined steadily.

In Scotland the decline in birth-rate began in 1878. In Ireland the decline in the crude rate has been small (on this see p. 94). In France the birth-rate was already as low as 26.2 per 1,000 in 1860. From 1877 onwards a further slow decline began, and in 1913 the birth-rate was 19.0 per 1,000. In Prussia the birth-rate was 35 to 38 per 1,000 until 1903. In 1912 it had become 28.9. Italy's birth-rate was nearly always over 35.0 per 1,000 prior to 1895; in 1912 it was 32.4. The Swedish birth-rate was about 30 prior to 1884. In 1913 it had fallen to 23.1. Australia had a birth-rate usually over 35 until 1891; since then it has declined somewhat irregularly, being 28.2 in 1913.

These crude birth-rates when considered along with corresponding crude death-rates show the extent to which each country is replenishing its population by natural increase.

The next stage in the inquiry is to ascertain the factors producing the decline in birth-rate. The following table illustrates the course of events in England, as ascertained by several tests:—

ENGLAND AND WALES.  
*Mean Annual Birth-rates.*

	Per 1,000 Living at All Ages.	Per 1,000 Women aged 15-45 Years.	Legitimate Birth-rate per 1,000 Married Women aged 15-45.	Illegitimate Birth-rate per 1,000 Single and Widowed Women aged 15-45.
1851-60	34.1	144.9	281.0	18.3
1861-70	35.2	151.0	287.3	18.2
1871-80	35.4	153.6	295.5	15.1
1881-90	32.4	138.7	274.6	12.6
1891-1900	29.9	122.7	250.3	9.3
1901-10	27.2	109.0	221.6	8.2
1911-15	23.6	94.4	189.7	7.8
	A	B	C	D

Between 1871-80 and 1901-10, if the birth-rate for the earliest period = 100, that for the last period = 66.7 (col. A), a reduction of 33.3 per cent.; = 71.0 (col. B), a reduction of 29.0 per cent.; = 75.0 (col. C), a reduction of 25.0 per cent.; = 54.0 (col. D), a reduction of 46.0 per cent.

As already explained, correction for variation in the proportion of married women at child-bearing ages, and for variation in the number of women at these ages who are married, can be carried further by the calculation of standardized birth-rates (p. 86). When the birth-rates for England and Wales are thus treated, the following are the results.

The standardized birth-rates<sup>1</sup> were as follows:—

	1861.	1871.	1881.	1891.	1901.	1911.
	34·80	35·40	34·65	32·62	28·41	24·70
Percentage increase or decline in 10 years ..	—	+ 2 %	— 2 %	— 6 %	— 13 %	— 13 %

In the Registrar-General's Decennial Supplement for 1901-10 the following standardized rates are given:—

	1881-90.	1891-1900.	1901-10.
	33·45	30·46	27·37
Percentage decrease in 10 years ..	—	— 9 %	— 10 %

In the above comparison of decline of birth-rate in successive periods, the rate of actual addition to the population by births, which is the essential point from an economic and political standpoint, has been abandoned, and birth-rates have been substituted which compare the fertility of marriages at child-bearing ages. The results thus stated coincide fairly closely with those derived from crude birth-rates, which show a decline of 8 per cent. between 1881-90 and 1891-1900, and of 10 per cent. in the next decennium.

A large number of comparisons between standardized birth-rates in 1881 and 1903 are given in the paper referred to below.<sup>2</sup> As indicating that crude do not everywhere give the same indication as standardized birth-rates, the special example of Ireland may be quoted.

In that country the crude birth-rate was 24·5 in 1881, as compared with 33·9 in England and Wales, and was 23·1 in 1901, as compared with 28·4. Standardized rates in Ireland and England respectively were 35·2 and 34·7 in 1881, 36·1 and 28·4 in 1901. Thus Ireland, whose crude birth-rate was approximately as low as that of France, had a true rate of fertility as high in 1881 as, and much higher in 1901 than, England. The reason for this remarkable change

<sup>1</sup> For particulars, see paper referred to on page 86.

<sup>2</sup> *Loc. cit.*, p. 86.

in the relative position of the two countries produced by arithmetical corrections is that while in England in 1901 the number of females aged 15-45 per 1,000 of the total population was 250, and in Ireland 235, the wives at ages 15-45 in England formed 46·8 per cent., and in Ireland only 32·5 per cent. of the females of the same age. The case of Connaught in 1901 is even more striking.<sup>1</sup> Its crude birth-rate was 21·3 as compared with 28·4 in England; while its standardized birth-rate was 38·1 as compared with 28·4 for England.

The facts so far adduced and further facts contained in the paper referred to above show that the changes in the birth-rate in various countries are due only to a limited extent to causes other than decline in fertility, viz. postponement of marriage and limitation in the number of marriages. The following table from the Annual Report of the Registrar-General for 1912 further brings out the greater importance of what the late Dr. Jacques Bertillon called "Natalité pathologique," true lowered fertility of the marriage relationship. Line A shows that the increased proportion of wives and of spinsters, etc., in the population should have meant a higher birth-rate in 1912 than in 1876-80; while the extent of reduction ascribable to fewer married women is stated in Line B, and the true effect of diminished fertility in line C.

ENGLAND AND WALES.

*Factors tending to Increase or Reduce the Birth-rate per 1,000 Living between 1876-80 and 1912.*

	Birth-rate.		
	Total.	Legitimate.	Illegitimate.
A, Potential effect of increased proportion of women aged 15-45 in the population .. ..	+ 2·86	+ 2·72	+0·14
B, Potential effect of decreased proportion of married women aged 15-45 .. .. .	- 1·10	- 1·16	+0·06
C, Effect of diminished fertility .. ..	-13·29	-12·43	-0·86
Recorded fall 1876-80 to 1912 .. ..	-11·53	-10·87	-0·66
	(from 35·3 to 23·8)	(from 33·6 to 22·8)	(from 1·7 to 1·0)

<sup>1</sup> *Loc cit.*, p. 86.

Since the above data were published further official English information has become available, which is summarized in the next paragraph.

**English Fertility Data, 1911.**—At the census of 1911, questions as to the duration of marriages and the number of children born and surviving were asked, thus enabling the changes in fertility to be analysed by social class, occupation, birthplace, locality of residence, and according to the duration of marriage. Some of the results were published in 1917 (Census Report, 1911, England and Wales, vol. xiii, part i), and a second volume summarizing and commenting on these results is on the point of publication.<sup>1</sup> Preliminary results have been published by Dr. T. H. C. Stevenson, C.B.E., of the General Register Office.<sup>2</sup> Tables were prepared dividing the total population into sections of similar duration of marriage and wife's age at marriage, and standardized fertility rates per million families were obtained for marriages similar as regards duration, but of all marriage ages, and for those similar as regards age but of all durations, and for all marriages of whatever duration or marriage age. It was found that some 50,000 marriages from 1851 to 1860 were still in existence in 1911, and comparisons of a long series of marriages were practicable. Groups were formed according to occupation, the population being divided into eight social classes. Of these classes I-V are in descending order of the social scale, Class I including the upper and middle classes and Class V unskilled labour. Classes VI, VII and VIII are special groups, consisting of textile workers, miners and agricultural labourers respectively. Some of the results are shown in the following table, in which four groups have been selected from those detailed by Dr. Stevenson:—

<sup>1</sup> The published tables contain an analysis for the whole population by ages of the husband and wife at census and at marriage, duration of marriage, and numbers born and dead. The "Fertility Report" will contain an analysis by marriage age of the wife, duration of marriage, and number of children born and dead for sections of the population classified by (1) size of tenement, (2) occupation (a) of husband, (b) of wife, (3) social class as deduced from occupation, (4) area of enumeration, and (5) birthplace of husband and of wife.

<sup>2</sup> "The Fertility of Various Social Classes in England and Wales from the Middle of the Nineteenth Century to 1911," by T. H. C. Stevenson, M.D., C.B.E. (*Journal of the Royal Statistical Society*, vol. lxxxiii, part iii).

# THE DECLINE IN THE BIRTH-RATE

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CHILDREN BORN PER 100 FAMILIES—STANDARDIZED RATES.

Date of Marriage.	Duration of Marriage in Years.	Upper and Middle Classes.	Textile Workers.	Miners.	Unskilled Labourers.
1906-11	0-5	70	76	105	100
1901-06	5-10	171	185	263	242
1896-1901	10-15	242	275	399	362
1891-96	15-20	303	359	517	463
1886-91	20-25	357	435	610	541
1881-86	25-30	413	501	671	596
1871-81	30-40	497	567	717	652
1861-71	40-50	607	648	777	715
1851-61	50-60	662	696	797	763
	over 60	682	732	870	781
	Total ..	277	319	433	392

The table gives the total fertility, i.e. number of children, per 100 families in each group, classified according to duration of marriage. Each of the rates has been standardized in a manner comparable to that for birth-rates and death-rates (pp. 86 and 221). The method is thus summarized by Dr. Stevenson :—

The standard used is one million families divided as in the total population into sections of similar duration of marriage and wife's age at marriage. The rates of total and effective fertility<sup>1</sup> established for the population under examination are multiplied into these sections of the standard million, and the sums of the results form standardized total and effective fertility rates per million families. Standardized rates for all marriages of each duration whatever the age of wife at marriage, and for all of each age at marriage whatever the duration, are easily obtained at the same time. . . .

By this method it is possible to measure and compare the fertility experience of any sections of the population from 1851-60 to 1911. Similarly standardized fertilities for periods of different duration can be compared with others of corresponding dates. In the preceding table, if a comparison is made between the standardized fertility rates of marriages dating from 1871-81 and from 1901-6 respectively, the following comparative figures are obtained, the fertility rate for upper and middle class for each period being stated as 100 :—

<sup>1</sup> By "effective fertility" is meant the surviving children per 100 couples.

Duration of Marriage.	Upper and Middle Class.	Unskilled Workers.	Textile Workers.	Miners.
30-40 years .. ..	100	132	114	145
5-10 years .. ..	100	142	108	150

It will be seen that in recent marriages unskilled workers are relatively more and textile workers are relatively less prolific than the upper and middle class than they were in earlier marriages, and that miners are also relatively more prolific in recent years.

The following diagram constructed from Table II in Dr. Stevenson's paper compares the fertility of marriages in various social classes, and according to duration of marriage. Classes I to V in the diagram run in descending order down the social scale, while the curves for Classes VI and VII give the separate experience of textile workers and miners respectively. Note that the figures given in the diagram are *relative values*, stated in proportion to the corresponding rates for occupied persons of all classes jointly, each of which is taken as 100.

For marriages of longest duration (50-60 years) the variation of fertility was from 11 per cent. below (Class I) to 8 per cent. above the average (in miners). The relative course of fertility for each class in successive decennial or quinquennial periods is shown in Fig. 10. Agricultural labourers (Class VIII) have been omitted from the diagram for the sake of clearness, but the curve for them is similar to that for Class V (unskilled labour). Miners, with a decline in average fertility, show increasing relative fertility, reaching a maximum in 1891-6, and then declining somewhat. The class of unskilled labour (Class V) 50-60 years ago had little more than the average fertility for all classes, but its relative fertility then increased until 1896-1901. The intermediate classes, III and IV, have retained a fairly consistent position throughout the entire period. Classes I and II have run an almost parallel course. Until 1886-91 they both showed a greater relative decline in the birth-rate than all other classes, except that of textile workers. Since then their relative position has approached the mean line, and there appears to be evidence of a process which perhaps is tending

towards equality of decline of birth-rate in all classes. The textile workers' case is especially interesting. The decline in their birth-rate has not been followed by any appreciable rise in relative position in recent years.

It would appear, in view of a consideration of the aggregate of the curves in Fig. 10, that the class divergence in fertility

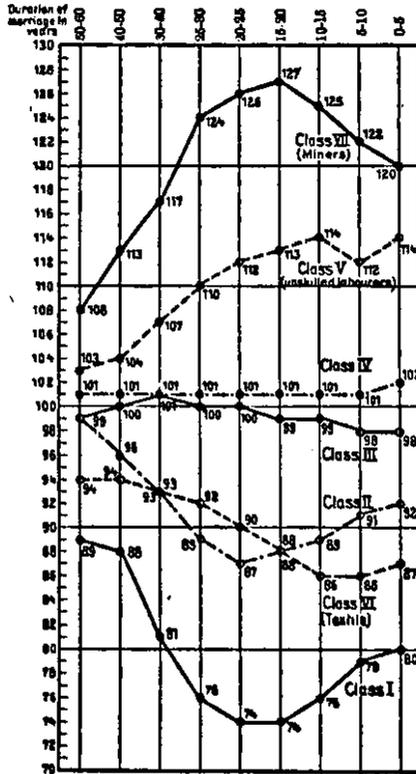


FIG 10.—Standardized total Fertility of Marriages of various dates in different social classes, each stated as a percentage of the corresponding rates for occupied persons of all classes jointly, for the same duration of marriage.

ceased to continue after the end of the nineteenth century, except for the class of unskilled labourers.

The differences continued more or less, but ceased to increase. This change in the course of events is, however, regarded by Dr. Stevenson as perhaps due to the fact that in recent years we are concerned only with the fertility of early married life, and it is known that the least fertile classes are

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relatively more fertile in the early years of their marriage than later.

Another method of comparison can be employed, as in the following examples.<sup>1</sup> Thus, if the comparative fertility of marriages of all durations in the general population be stated as 100, it is 126·4 for coal-miners, only 64·7 for doctors; it is 113·4 for agricultural labourers, 70·3 for teachers; 100·5 for farmers, and 72·0 for clergymen (Church of England); 91·9 for cotton spinners, 81·2 for cotton weavers, and 79·8 for Nonconformist ministers.

The important question as to the relation between the number of children in a family and the prospect of survivorship will be discussed in Chapter X.

**Fertility—(a) Males.**—The Registrar-General's report on "Fertility" (census of 1911) should be consulted for details. It summarizes the experience of 6,014,319 out of the 6,630,284 married women enumerated at the 1911 census. In 13 per cent. of all couples the ages of husband and wife were equal, 63 per cent. of the husbands were returned as older, and 24 per cent. as younger than their wives. Early marriage, as is well known, increases in frequency down the social scale, 7 per cent. of the husbands in Class Ia (professional) being married at ages under 25, against 57 per cent. for coal-miners.

When the wife is of child-bearing age, the size of the family obviously depends on the duration of marriage as well as on the marriage ages of the parents, and safe comparison can only be made for marriages of equal duration in each case. The results in the smoothed curves in the above-named report show that the decline with the wife's marriage age in the number of children born is very similar whatever the husband's marriage age. Thus wives of each age have distinctly higher average fertility where the husband is under 25, and lower where he is over 45 at marriage, but between these ages there is comparatively little variation. A number of anomalies in the result just quoted are pointed out in the official report. Thus the younger husbands are apt to be drawn from a more fertile class, or at least a class in which natural fertility is thwarted to the smallest extent. This gives rise to a sort of spurious excess of fertility for young

<sup>1</sup> From Dr. Stevenson's evidence in *The Decline of the Birth-rate*, p. 15.

husbands. In coal-miners, in whom it appears most likely that unfettered fertility is manifested, there is the smallest evidence of decline of fertility with advancing age of the father. The conclusion stated in the report is that "it appears that much of the apparent decline with increase of age in male fertility is certainly unreal, and that until middle life is passed it may all be so."

**Fertility—(b) Females.**—The official figures show a maximum fertility at marriage age 17 or 18, with a progressive decline in fertility with advancing age at marriage. The decline is especially great from marriage age 20 to 25, followed by a more gradual decline lasting till about 30–35, and afterwards again becoming more rapid. Professor Tait in his contribution to Matthews Duncan's work on Fertility (1866) summarized the relation between age at birth of progeny and fertility in the law that the fertility at different ages varies directly as the difference between these ages and 50, and Yule (reference p. 106) has shown the general applicability of Tait's formula, even though it only gives a working approximation, in the standardization of the birth-rates of many populations.

**Fertility and Duration of Marriage.**—The facts bearing on this should be consulted in the "Fertility Report." The influence of duration of marriage in decreasing fertility has been overstated. This effect is not of such a magnitude as to be likely to have much effect on the standardized birth-rate (p. 86).

**Local Distribution of Decline of Birth-rate.**—Examples of variations in this respect have already been given, and many more, in which so-called arithmetical factors of variation have been eliminated, are given in the joint paper quoted on page 86. A few of these may be adduced. They have bearing on the problem as to whether the decline may be regarded as chiefly or largely due to cyclical variations in fertility beyond the range of voluntary control. If in a given country examples of greater and less decrease, or of increase and decrease, or of decrease and no decrease, contemporaneously occur, these coincidences at least do not lend support to such a hypothesis, although it may be considered remotely conceivable that different sections of a given population might be at different stages of a cyclical develop-

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ment! The standardized birth-rates to be quoted are for the years 1881 and 1901-3 respectively.

	1881.	1901-3.	Increase + or Decrease—, per Cent.
<i>Increases of Standardized Birth-rate—</i>			
Connaught .. .. .	33·81	38·08	+13
Ulster .. .. .	35·15	35·13	± 0
Dublin .. .. .	32·24	35·39	+10
Ireland .. .. .	35·17	36·08	+ 2
<i>Decreases—</i>			
Belfast .. .. .	34·69	33·97	— 2
Liverpool .. .. .	32·47	30·83	— 5
Scotland .. .. .	39·29	33·38	—15
London .. .. .	32·21	26·83	—17
England, selected rural counties	36·30	29·39	—19
County of Durham .. .. .	36·91	32·95	—11
Bradford .. .. .	30·63	21·95	—28
Burnley .. .. .	35·66	23·71	—34

The earlier figures for Ireland, especially for Connaught, may be open to doubt, as registration of births might be imperfect in remote rural parts for some years after its establishment. But if not, then it would appear that during the same period, in neighbouring countries in both of which economic conditions were improving, one showed a stationary or even an increasing, another a declining birth-rate; and that in England Liverpool showed a decline of birth-rate which was only about one-seventh of that experienced by Burnley, another town in the same county.

**International Distribution of Decline of Birth-rate.**— Still utilizing the same source of accurately ascertained standardized birth-rates, the following comparisons are significant:—

	1881.	1901 (or near Years).	Decline per Cent.
<i>Australasia—</i>			
New South Wales .. .. .	38·80	26·47	—32
New Zealand .. .. .	36·68	29·63	—19
Victoria .. .. .	36·02	27·04	—25
<i>Europe—</i>			
Belgium .. .. .	40·76	31·01	—24
France .. .. .	25·06	21·63	—14
German Empire .. .. .	40·37	35·34	—12
Sweden .. .. .	38·49	36·19	— 6
Berlin .. .. .	33·11	21·89	—34
Hamburg .. .. .	34·98	25·40	—27
Paris .. .. .	23·27	16·65	—28

It will be seen that in 1881 the birth-rates of London, Berlin and Hamburg were as high as or higher than that for Dublin; in 1901 the contrast is marked. The Paris birth-rate was lowest both in 1881 and in 1903, but that of Berlin was rapidly approximating it, with Hamburg, and it may be added some other German towns following in the same track.

The British illustrations already given do not show any marked preponderance of urban over rural decline of birth-rate. Between 1881 and 1903 the standardized birth-rate of London declined 16 per cent., that of Berkshire 21 per cent. and of Sussex 26 per cent.

Illustrations bearing on the possible influence of industrial conditions have been given. The marked reduction shown in textile areas has followed—with what degree of causal connection is debatable—enforcement of a longer school life and the curtailment and now the abolition of half-time work in factories for school-children. The persistently high birth-rate in mining districts has not been associated with any special local change in the employment of children.

**Religion and Race and Birth-rate.**—There is no clear evidence of differences of race-fertility in the figures already quoted, or in other available figures for civilized countries. France has areas in which a high birth-rate persists, especially in Brittany; but the evidence points to religion rather than race as the explanation. The same view is supported by the high fertility of French Canadians, and of Irish in most parts of the world. The importance of religion in this connection consists in the fact that for Roman Catholics the use of contraceptives is banned. In the words of Monsignor Canon W. F. Brown:<sup>1</sup> “the (Roman Catholic) Church forbids the destruction of the product of conception even when the life of the mother is at stake; and also all anti-physiological methods of preventing conception.” The low birth-rate now experienced in many countries is the resultant of two forces, viz. natural fertility and artificial measures against it. That contraceptives are increasingly used in most countries is an accepted fact; but it is doubted by many whether these give the chief explanation of the reduced birth-rate in those countries, and whether there is not

<sup>1</sup> Report of Birth-rate Commission, p. 81.

also in operation some physiological or economic factor producing reduced fertility. It is convenient here to summarize some of these explanations of lowered birth-rate.

**Supposed Influence of Increased Nutrition.**—The statement by Doubleday (*True Law of Population*, 1841), that throughout both the animal and vegetable kingdoms “over-feeding checks increase, whilst, on the other hand, a limited or deficient nutriment stimulates and adds to it,” may comprise an element in the problem; but it is improbable that it accounts for more than a fraction of the present difference between communities, or of the difference between the past and current experience of the same communities. It does not appear likely that the average nutrition of French wives is so much greater than that of Irish wives as to account for a difference of standardized birth-rates of 21·6 and 36·1, or that the difference between 35·7 (Prussia) and 28·4 (England) is explicable by this “law.”

Nor is it at all likely that in the dietary of vast masses of population some element may be lacking affecting fertility, explaining the social and national differences illustrated in previous paragraphs.

**Inverse Relation between Individuation and Genesis.**—Herbert Spencer<sup>1</sup> criticized Doubleday’s hypothesis and advanced another, which is equally dubious. According to him, as a necessity of evolution, fertility diminishes with that intellectual and moral development of the race which is comprised within the meaning of the word civilization. Darwin similarly concluded that changed conditions of life have a remarkable and specific power of acting repressively on the reproductive system. It is, however, doubtful if, on a general scale, any inverse relationship whatever exists between cerebral development and the capacity of men and women to procreate.

In sample experiences derived from Peerage and Baronetage lists, a reduction of families is shown in recent periods. Whetham<sup>2</sup> gives the results of a hundred fertile marriages for each decade from 1831 to 1890, taken consecutively from

<sup>1</sup> *A Theory of Population deduced from the General Law of Animal Fertility*, by Herbert Spencer, 1852.

<sup>2</sup> *The Family and the Nation*, by W. C. D. and G. D. Whetham, 1909, p. 139.

those families who have held their title to nobility for at least two preceding generations :—

Period.	No. of Births to Each Fertile Couple.
1831-40 .. ..	7.1
1841-60 .. about	6.1
1871-80 .. ..	4.4
1881-90 .. ..	3.1

Thus during sixty years a stable upper class have reduced their fertility by more than one-half. It can scarcely be argued reasonably that the state of nutrition or the intellectual capacity of parents so circumstanced had so increased as to account for this result.

**Cyclical Variations in Fertility.**—Brownlee, on the basis largely of pre-registration statistics, has advanced the hypothesis that there are true cyclical changes in fertility, the cycle being a long one, possibly round about 200 years. The subject may be studied in the two papers mentioned below.<sup>1</sup> He summarizes his conclusions as follows: (1) At two epochs centring about the years 1600 and 1800 high birth-rates existed in England and Wales as a whole. (2) During the intervening period centring about 1700 the birth-rate was considerably lower, a phenomenon again observed at the present day. (3) "In my opinion a considerable part of this oscillation in the birth-rate is an expression of race physiology."

The subject cannot be discussed with any confidence in the figures involved; but Dr. Brownlee's papers are an interesting adventure in speculative statistics. If such a cycle exists, neither the longer series in Sweden nor English official statistics go back far enough to verify or disprove the contention. Meanwhile the hypothesis does not fit in well with the simultaneous stationary character, small decline, or arge decline of the birth-rate in different countries, and in

<sup>1</sup> "Germinal Vitality: A Study of the Growth of Nations as an Instance of a hitherto undescribed Factor in Evolution," by J. Brownlee, M.D., D.Sc. (*Proceedings of the Philosophical Society, Glasgow, 1908*).

"The History of the Birth- and Death-Rates in England and Wales . . . from 1570 to the Present Time," by Dr. Brownlee (*Public Health, June and July, 1916*).

different sections of the same country, associated with differences of social position and religion. Such statistics as are given for pre-registration periods necessarily fail to distinguish accurately as regards growth of population between excessive death-rates due to pestilence, etc., and low birth-rates; and the analogy between cyclical changes in the incidence of microbic invasions of disease and periodic increases of racial energy is not strongly supported. It is not denied, and is not unlikely, that there may be variations in fertility from time to time, and at the same time in different sections of a community; nor is it improbable that these may have dietetic associations. But that volitional limitation of families is practised largely in most civilized communities, and that the reduction in the birth-rate is greatest where this practice is most in vogue, is, I believe, generally admitted, though this does not, of course, exclude the possibility of the existence of unknown factors at work—not necessarily, and not probably, periodic.

**Economics and the Birth-rate.**—Mr. Udny Yule<sup>1</sup> has advanced reasons for not resting contented with the view that the reduction in the birth-rate is due in the main to prudential control of conception; and it is obvious to all that strong parental motives lie behind the adoption of such methods. "Contraceptive measures are a means not a cause" (Yule). Even as a means their complete influence is challenged, and Mr. Yule advances the illustration of Connaught, in which fertility was 35 to 39 per cent. greater in 1911 than in 1881, and some 6 per cent. greater in 1871 than in 1881, as calculated by Tait's coefficient (p. 101). Other instances of increasing fertility where registration is known to be approximately accurate appear to be unknown. Mr. Yule gives curves of prices (Sauerbeck's index numbers) showing for each year the average of this index number for the current and several preceding years, and of percentage increase of population in each decade. The result is shown in the following figure copied from Mr. Yule's brochure by courtesy of the Cambridge University Press. The coefficient of correlation between the inter-censal increase-rate and the

<sup>1</sup> "On the Changes in the Marriage- and Birth-rates in England and Wales during the Last Half-century, with an Inquiry as to their Probable Causes," by G. U. Yule (*Journal of the Royal Statistical Society*, vol. lxi., 1916, p. 34).

index number of prices of the eleven years preceding the decade is 0.91, and Mr. Yule, with some reason, regards the two curves as being too similar for the similarity to be accidental. His view is that migration, marriage-rate and fertility are only three forms of response to demand for population. The demand

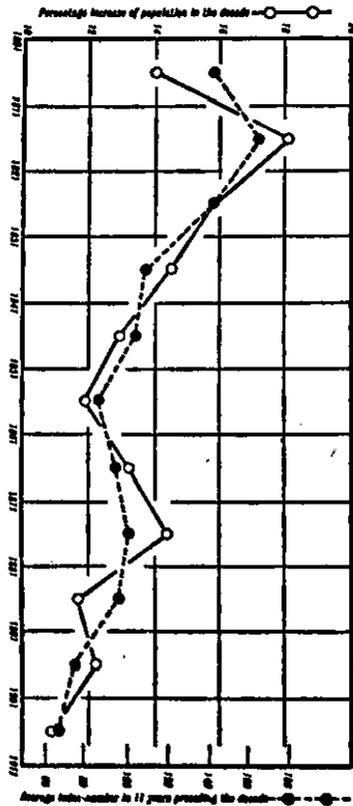


Fig. 11.—Chart showing the inter-censal increase of population in England and Wales for each decade from 1801-11 to 1901-11 (full line and scale on left), and the average price-level in the 11 years preceding that inter-censal date (dotted line and scale on right).

is for adults; and, as he says, “if there is any truth in this economic theory of population, this lag in response must end to give rise to a swing in population of a very long period.”

The method by which the suggested influence of prices on the marriage-rate and on fertility is exercised is unknown. As Yule says: “I am at a loss to suggest the precise nature

of the nexus. That the nexus is economic, and that it probably operates *via* psychology rather than directly through physiology is my view; and I doubt—in fact I disbelieve—its being wholly conscious, or as the phrase now goes ‘volitional.’”

Events in more recent years do not conform to the view that the marriage-rate (p. 67), and through it the birth-rate, varies with the activity of trade. The birth-rate has steadily decreased since 1880, whereas trade fluctuates. If there be an obscure relation between economic conditions and birth-rate, this view does not compete or conflict with the generally adopted view as to the causation of reduced birth-rate; it only suggests a possible communal and unconscious motive for inhibition of conception, in addition to the more active immediate family motive. Nor is there excluded the possibility of cyclical changes in the birth-rate, for which a *prima facie* case has not, in my view, been established. Furthermore, the possibility that a portion of the reduced birth-rate is caused by obscure nutritional differences between families and communities is not excluded.

**Fertility in Relation to Social Status.**—Some of the most important facts bearing on the distribution of births in social strata in England have been already quoted (p. 99). Many studies of this aspect of the problem have been published. Thus Dr. D. Heron, in a paper published in 1906,<sup>1</sup> found positive correlations (see p. 517) between the birth-rate and the proportion of males in different parts of London engaged in the lowest type of labour ( $+0.517 \pm 0.095$ ), and for overcrowding ( $+0.697 \pm 0.067$ ), and a similar relationship in other respects between adverse social circumstances and the largest families. These correlations were consistent with the conclusion previously stated by Pearson and Powys, that 25 per cent. of the married population produces 50 per cent. of the next generation. Heron concluded that this higher fertility of a section of the population is very markedly correlated with the most undesirable social factors.

In the “Fertility Report,” the most fertile part of the total population having been graded by occupations, it was

<sup>1</sup> “On the Relation of Fertility in Man to Social Status, etc.” by D. Heron, M.A. (*Draper's Company Research Memoirs*, 1906).

found that the most fertile 25 per cent. of the population produce not 50 per cent. but 31·4 per cent. of children born, and 30·5 per cent. of children surviving to marriages where the wife was under 45 years old at the census. For older wives the proportion of children born was 29·6 per cent. The most fertile 25 per cent. included unskilled and agricultural labourers, miners, and a number of skilled trades, especially in metals.

In mitigation of the somewhat gloomy conclusions which may appear to be suggested by the above quoted inquiries and others which resemble them, we may suggest that (1) the increasing proportion of the replenishment of the population coming from families living under relatively unfavourable circumstances may continue for a limited period only. If the present rate of decline in the birth-rate continues, in two or three generations every married couple will have become familiar with contraceptive methods. In at least one European country official stations have been established for instructing married women on these; and in other countries, whether wisely or unwisely, voluntary agencies for the same purpose are rapidly increasing. Whether the very poor, for whom the incentive to avoid impoverishment by increase of family is greatest, will all learn these practices remains to be seen. They are already widely adopted in the textile and in some other wage-earning communities, and it is, I think, likely that they will become general, unless the economic or the moral outlook is unexpectedly changed. The only exception may be in populations on which the Roman Catholic Church retains its hold. This may carry with it strange changes in the racial constitution of the western world; Irish and Italian, for instance, predominating over Anglo-Saxon, with a vast increase in the Slavonic races, in which a high birth-rate appears likely to continue for several generations.

Meanwhile it is clear that in families least able to support a large number of dependents these are most numerous, and that this may imply for some of the children (see p. 346) stunted growth and defective mental and physical adult life. It may be urged, however, that the remedy does not necessarily consist in limited families, but in a more equitable distribution of the rewards of labour, in more satisfactory

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expenditure of present wages, and in greater extension of co-operative effort to secure for every child born the fulfilment of its potentialities in life. The conditions of the poorest classes have greatly improved in the last two generations, and better environment has not exhausted its capacity to produce still more important improvements.

But, it may be suggested, the differences between rich and poor are largely inherent, and are therefore more or less irremovable. That there are essential differences in family qualities is undoubted; the doubt is as to the social distribution of these superior mental and physical qualities. Neither mental nor physical superiorities are a class characteristic; statistics appearing to point to this conclusion are never free from the errors due to varying environment, ante-natal and post-natal. The only statement that is certainly true is that both initial intellectual superiority and physical superiority are a function of stock and not necessarily of class. It may, of course, be argued that the best stock naturally comes to the top, and so forms the upper class, a view which assumes that the impediments to "rising" for a large proportion of the total young are not sufficiently great to prevent the success of potential talent. This subject is further discussed by me elsewhere,<sup>1</sup> but I may quote here one statement from this fuller discussion: "The time spent on bemoaning the disproportionate contribution to the population of the very poor were better spent in promoting the more efficient prevention of destitution (see p. 294), while preventing the multiplication of the small minority having definitely heritable defects, and of those who will not or cannot support themselves and their families."

The international aspects of neo-Malthusianism, the advocacy and practice of means for artificial prevention of conception, have not been adequately considered. Personal and family comfort are increased by a limited family; but nationally this is no compensation, for instance to France, whose stationary population is replenished from outside nations. As the international situation is at present developing, Germany is following the example of France and England in control of its birth-rate. There is little evidence

<sup>1</sup> *The Declining Birth-rate: Its National and International Significance*, by A. Newsholme, 1911.

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so far of progress of this movement eastward, and the next few generations may see an increasing preponderance in Europe of Slavonic people, with a large admixture of Asiatic blood. In America similar and even more striking changes are occurring. The native-born Americans, chiefly of Anglo-Saxon origin, have a birth-rate which commonly exceeds but little the death-rate; while immigrants and Americans of Celtic origin or who are derived from eastern and southern Europe, and a large Hebraic contingent are populating the continent.

Forecasts are notoriously untrustworthy; but if the present policy of large restriction of families becomes universal in western communities, our present civilization may become bankrupt and be replaced eventually by that of the Chinese or other eastern races, who in their turn, possibly earlier than now appears likely, may resort to "birth control," as an alternative to war, pestilence, and famine, if these checks to population are inhibited. The facts and trends of events indicated above show the fundamental importance of strengthening the relationship between the organized community and the family in regard to child-bearing and child-rearing. Money is required to be spent on nurseries and schools rather than on armies.

## CHAPTER X

### THE RELATION BETWEEN BIRTH-RATE AND INFANT MORTALITY

**Net or Effective Fertility.**—Hitherto it may have been assumed that additions by birth to a given population consisting of different races or different classes in society give an accurate index of their relative contribution to the increase of the population; and generally it is true that populations with the highest and the lowest birth-rates make respectively the greatest and the least contribution to increase, though not usually in exact proportion to their birth-rates. It is conceivable, however, that a high birth-rate might form, so to speak, a desperate effort to make good the losses produced by a high general death-rate, or might be associated with such a heavy loss of life (in the first two years after birth), that what may be called the net fertility would be greatest in the population having a low birth-rate.

The influence of high and low birth-rates on the age constitution of the population is discussed in Chapter V. Here we are concerned with the relation, if any, between the magnitude of the birth-rate and that of the rate of loss of life in the early years after birth. Of course, if more infants are born more infants will die, though it is equally true that more infants will survive. But unless the rule that death-rates should be stated in terms of the population at risk is observed, serious errors of statement may result (see p. 340).

The most complete statement of effective or net fertility is contained in the "Fertility Report" and in Dr. Stevenson's paper, from which the following quotation is made. The method of standardizing to obtain total fertility for different durations of marriages is indicated on page 97, as stated by Dr. Stevenson's paper:—

The standardized child mortality rate is easily obtained from the standardized rates of total and effective fertility. The difference

## BIRTH RATE AND INFANT MORTALITY 113

between the number born and the number surviving to the standard million in any instance is evidently the number of deaths of children which the standard population would have suffered under the operation of the total and effective fertility rates experienced by the population under examination; and the ratio of these standardized rates to the standardized total births yields the standardized rate of child mortality.

Information as to the number of children surviving out of a given number born per marriage was obtained from the census schedules in 1911, and for the social classes distinguished in the text and table on page 97 the net fertility is given in the following table:—

STANDARDIZED TOTAL AND NET FERTILITY OF MARRIAGES OF VARIOUS DATES IN EACH SOCIAL CLASS PER CENT. OF THE CORRESPONDING RATES FOR OCCUPIED PERSONS OF ALL CLASSES JOINTLY.<sup>1</sup>

		Social Class.							
		I.	II.	III.	IV.	V.	VI.	VII.	VIII.
Marriages 40-50 years ago (1861-71)	Total fertility (children born) . . .	88	96	101	100	104	94	113	104
	Net fertility (children surviving)	91	99	100	100	100	88	105	111
Marriages 10-15 years ago (1896-1901)	Total fertility	76	89	99	101	114	86	125	114
	Net fertility	80	92	99	101	109	83	119	119

In the older marriages in Groups I-V the range of total relative fertility is between 88 and 104, and of net fertility between 91 and 100; in the more recent marriages the corresponding ranges are between 74 and 113 and between 81 and 109. It will be seen that in both periods the miner (VII) loses by heavy child mortality more of his high fertility than the agricultural labourer (VIII); the textile worker's position (VI) is changed comparatively little. It may be inferred generally that the social and occupational differentiation of the birth-rate is greater than it was half a century ago, though, as suggested on page 109, it does not follow that this differentiation will continue. Greater survivorship in families with a low birth-rate does not go far to compensate for their

<sup>1</sup> It will be noted that in the more favourable classes net fertility is represented by higher figures than total fertility. This is because the figures represent *relative values only*, and are not rates of fertility.

lower fertility. The surplus of births over deaths decreases when the number of births decreases, although in such circumstances the deaths of infants, and so also usually the *death-rate* among infants, also decrease. The general result is that the influences producing a lowered birth-rate are gradually decreasing the supply of increased life in the community.

**Relation between Birth-rate and Infant Mortality Rate.**—Measures for the reduction of infant mortality sometimes have attributed to them the power to compensate for lowering of the birth-rate. Although this is obviously absurd, the error may be illustrated as showing the relative force of birth and death in determining the total volume of life.

Let us assume that in a town having a population of 100,000 the annual birth-rate is 25 per 1,000, and the infant mortality (i.e. under one year) equals 100 per 1,000 births. There will be 2,500 births and 250 infant deaths in a year, leaving a net increase in a year of 2,250. By reducing the rate of infant mortality to 50 per 1,000 births, the net increase becomes 2,375. But if we assume that the birth-rate becomes 30 per 1,000, and that the reduced infant mortality of 50 per 1,000 births continues, then the increase of population at the end of a year will be 2,850 instead of 2,375. The merits of child welfare work cannot be fully expressed arithmetically as above; for deaths are merely an end-product, and if results are to be assessed, account must be taken of the improved health of survivors which is associated with a lowered infant mortality.

**Correlation between Birth-rate and Infant Mortality Rate.**—The course of events in England and Wales is shown in Fig. 12.

The illegitimate birth-rate is not included in the above curve; but as such births during the above period have never formed more than 6.5 per cent. (in 1856-60), and in more recent years form only 4 per cent. of the total births, the general course of the curve is not materially affected by their omission. The apparent slight rise in the curve prior to 1876 may be ascribable to leakage in birth registration. From 1876 onwards a steady fall in the birth-rate set in. The quinquennial percentage decline in the birth-

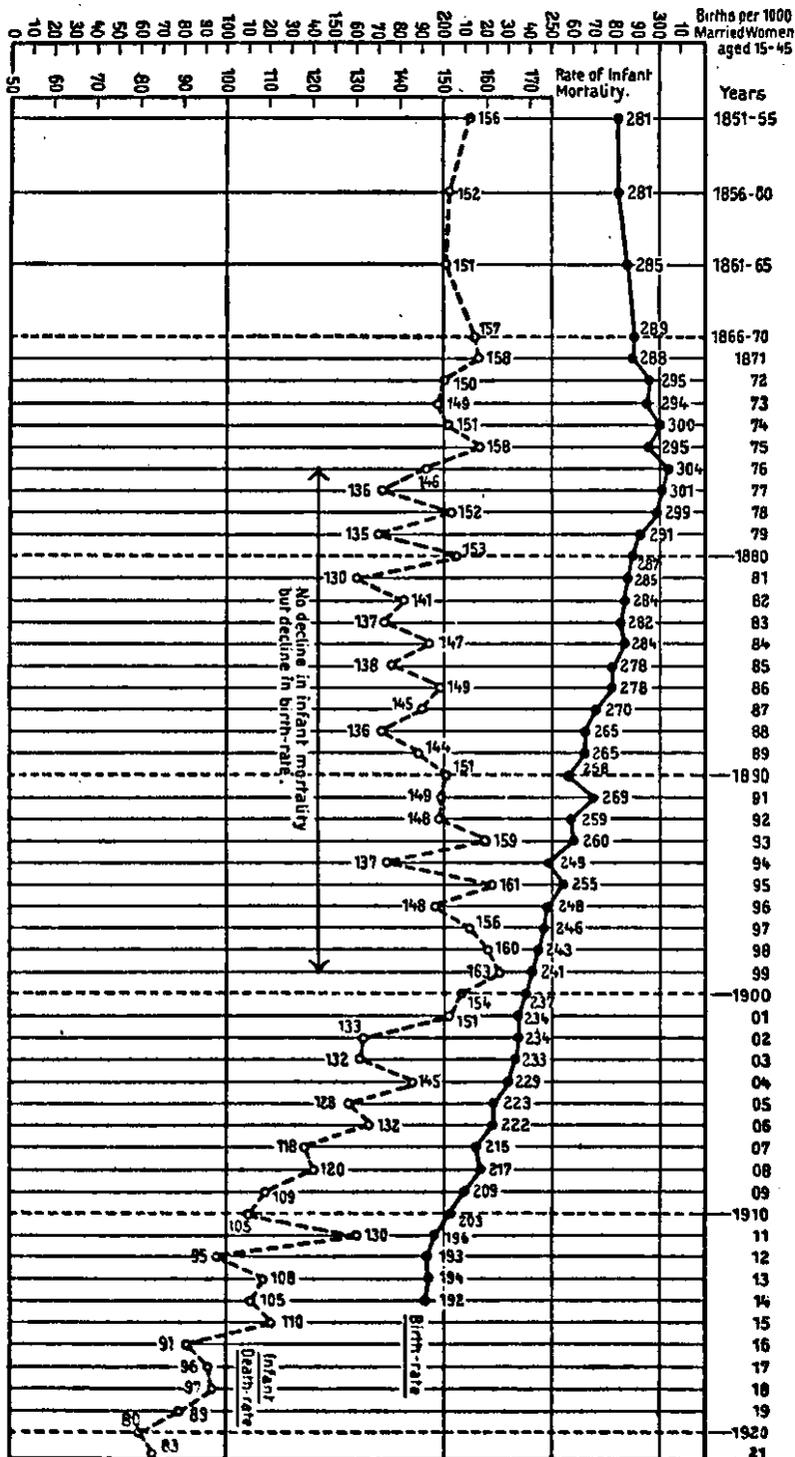


FIG. 13.—Course of Legitimate Birth-rate (per 1,000 Married Women Aged 15-45) and of Rate of Total Infant Mortality (per 1,000 Births), in Quinquennial Averages, 1851-1870, afterwards for Single Years.

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rate, on the basis of the rates given in the above diagram, has been :—

	Percentage Decline in 5 Years.
1876-80 to 1881-85	5
1881-85 to 1886-90	6
1886-90 to 1891-95	3
1891-95 to 1896-1900	4
1896-1900 to 1901-05	4
1901-05 to 1906-10	7
1906-10 to 1911-15	10

A comparison of the two curves is instructive. The birth-rate began to decline in 1877, and has continued to do so almost continuously. The rate of infant mortality has varied greatly from year to year, but on the average it manifested no tendency to decline until 1900. This is shown by the average decennial infant death-rates 1851-60 to 1891-1900 as follows :—

154, 154, 149, 142, 153.

For the four first quinquennia of this century the corresponding rates were

138, 117, 110, 90,

and the more recent part of the curve shows no indication of return to infant death-rates on the former scale. It is significant that in 1899 the birth-rate was 20 per cent. lower than in 1876, but that in the intervening 23 years the infant death-rate showed no tendency to decline; while the birth-rate in 1914 was 17 per cent. lower than in 1900, and the infant death-rate had declined 31 per cent. in 14 years. It may be argued that in the last 14 years a much higher proportion of the total births than in the previous 23 years occur under the assumed more favourable circumstances of smaller families, rendering the effect visible in the reduced infant mortality in England; but this leaves it still open to doubt whether nationally the reduced birth-rate has influenced greatly or only to a minor degree the course of the infant death-rate. Further facts must be adduced on this problem. I have drawn attention to it in a series of official reports on child mortality, from which the following facts are taken :—

In a report published in 1910<sup>1</sup> statistics were given showing that in the twelve counties of England and Wales having an infant death-rate equal to or greater than that of England and Wales, the birth-rate varied from 5 per cent. below to 21 per cent. above that of England and Wales; while among the twelve counties having each of them an infant death-rate more than 20 per cent. below that of England and Wales, the birth-rate varied from 12 per cent. below to 17 per cent. above that of England and Wales.

In single counties the contrast was even greater. Thus, in the chiefly urban county of Lancashire the birth-rate was 1 per cent. below and its infant death-rate 22 per cent. above the average for the whole country. In the chiefly rural county of Shropshire the birth-rate was 17 per cent. above, its infant death-rate 25 per cent. below, the average. Perhaps the most striking exception to the relationship between high birth-rate and low rate of infant mortality is Ireland, which in 1901 had a standardized birth-rate of 36·1 as compared with 28·4 for England; its infant death-rate being 101 per 1,000 births as compared with 151 in England. The coefficient of correlation between the standardized birth-rate for the 46 registration counties of England and Wales and the infant death-rate for 1901-5 in the same counties was represented by the fraction 0·36 (see p. 517).

Results in that report were summed up as follows:—

Large families evidently do not necessarily imply a high infant mortality. The connection commonly observed between a high birth-rate and a high rate of infant mortality probably is due in great part to the fact that large families are common among the poorest classes, and these classes are specially exposed to the degrading influences producing excessive infant mortality.

In my second report, written in the light of experience up to the year 1913, after quoting the above statement, I added:—

There should be added to this the further statement that if a large family implies such a degree of poverty as to produce deficient nutrition of mother or infant, it must tend to reduce the infant's prospect

<sup>1</sup> Report by A. Newsholme to the Local Government Board on Infant and Child Mortality, 1910 (Cd. 5263).

Second Report by A. Newsholme on Infant and Child Mortality, 1913 (Cd. 6909).

Third Report on Infant Mortality, dealing with Infant Mortality in Lancashire, by Drs. Newsholme, Copeman, Manby, Farrar, and Lane-Clayton, 1914 (Cd. 7511).

Report on Child Mortality at Ages 0-5 in England and Wales, by A. Newsholme, 1916 (Cd. 8496).

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of health and life. Short of this extreme poverty, it may also be agreed that if a large family implies maternal overwork and insufficient attention to domestic cleanliness, especially in relation to the infant's food, it must favour the same result.

There are very marked variations in birth-rate in the 241 urban areas dealt with in the present report, and a low birth-rate and a high infant mortality are not uncommonly found in association.

It appears unlikely that the change in the birth-rate has played more than a minor part in aiding the reduction of infant mortality experienced in the last twelve years, and that such effect as it may have had has, as indicated above, been chiefly indirect.

In a third report (ref. p. 117) the following comparative figures for towns in Lancashire appeared:—

	Birth-rate.	Infant Death-rate.		Birth-rate.	Infant Death-rate.
Burnley.. ..	23·0	177	Stretford .. ..	17·1	95
Farnworth .. ..	23·3	180	Wigan .. ..	27·9	165
Colne .. ..	20·6	130	Widnes .. ..	31·4	140
Nelson .. ..	17·5	87			

In wards of the same town, Stretford, two wards with an approximately equal infant death-rate (108–111), had birth-rates of 17·8 and 31·0 respectively. The lessons of the experience of Lancashire were summarized as follows:—

A large family is not incompatible with a low rate of infant mortality, and infant mortality may be excessive in communities having small families. The relationship between the two is complex. The chief influence appears to be more that of the circumstances leading to a higher standard of family life than of the smaller number of children. In so far as the low birth-rate is the expression of a higher standard of comfort it is likely to have associated with it a low infant mortality. In communities in which, as in Farnworth, Burnley, and Wigan, the standards of municipal sanitation and of domestic life are of the low type found in many homes of miners and in some homes of textile workers, a high birth-rate and an excessive infant mortality are usually associated; but the experience of Burnley shows that the birth-rate may decline, while the rate of infant mortality remains excessive.

In a later report (ref. p. 118) on child mortality 0–5, the relative rates shown in the figure on page 119 were given.

It will be seen that there is a fairly close parallelism between the death-rate among all children under 5 and the birth-rate in successive periods; but, as shown more in

detail in Fig. 12, the same relationship between birth-rate and infant death-rate only appears in the three most recent quinquennia.

Furthermore, the three curves represent the resultant of multifarious experiences. They show the general trend of

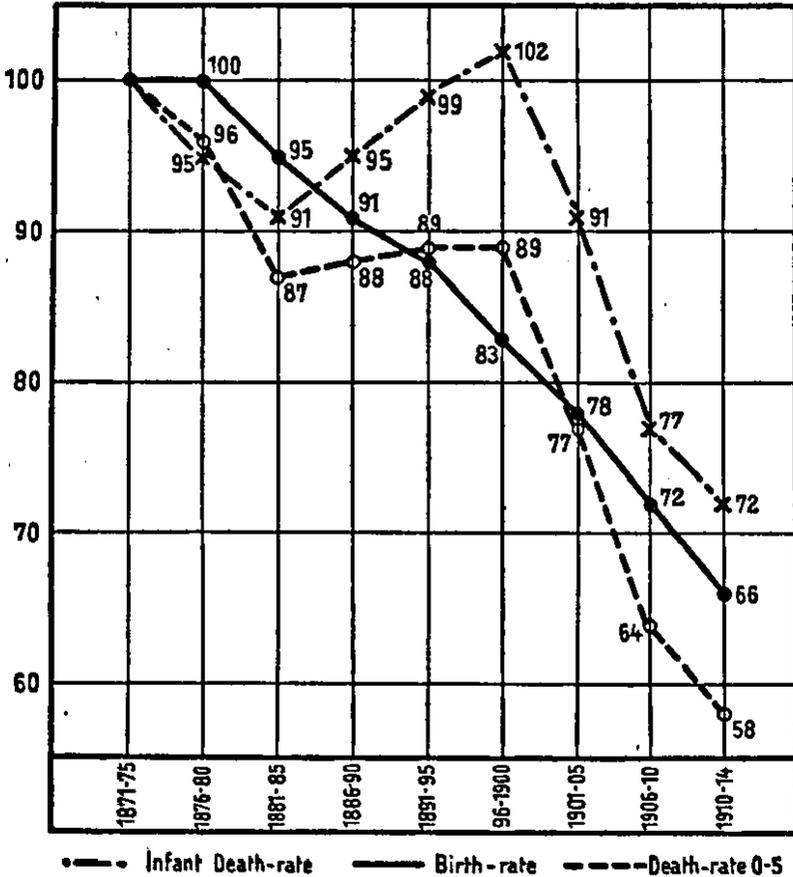


FIG. 13.—England and Wales: Comparable Relative Figures of Legitimate Birth-rate, Death-rate under 5 Years, and Infant Death-rate.

NOTE.—In this figure, (a) 294·6, the legitimate birth-rate per 1,000 married women 15-45 in 1871-75 = 100, (b) the death-rate, same period, 64·0, under 5 years of age per 1,000 of population aged 0-5 = 100, and (c) the deaths of infants under one year old, 153 per 1,000 births = 100, are taken as starting-points, subsequent rates being given as proportional figures.

experience; but that this trend is not inevitable is indicated by the following examples from the same report:—

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NOTE.—The death-rates quoted in the next lines are deaths 0-5 per 1,000 births. The birth-rates are per 1,000 of total population.

High Birth-rate with High Child Death-rate.			Low Birth-rate with High Child Death-rate.		
	Death-rate.	Birth-rate.		Death-rate.	Birth-rate.
Ince-in-Makerfield	288	35.7	Bolton .. ..	200	21.8
Bilston .. ..	237	34.5	Blackburn .. ..	202	21.8
Tipton .. ..	222	34.2	Burnley .. ..	257	22.8
Shoreditch .. ..	241	31.5	Preston .. ..	225	23.9

The towns named in the second column are textile towns, in which special causes of high child mortality prevail.

In the report just quoted I remarked :—

Notwithstanding the general coincidence between declining birth-rate and declining child mortality in recent years, the numerous exceptions to this association do not justify the conclusion that restriction of the birth-rate should play a part in the prevention of excessive child mortality. There is no reason to doubt that in the residential towns and suburbs in which the association between low birth-rate and low child mortality is most obvious, larger families would be associated with a continuance of relatively low child mortality.

The preceding statistics have been quoted somewhat fully, because they illustrate facts which health officers and social workers will have to utilize in framing judgments. They carry us as far as this: Mass statistics, like the above, dealing with the whole country, with a single town, or even a single ward of a large town, are not finally conclusive in determining whether there is intrinsic relationship between large families and a high child death-rate. They show, on the other hand, that any influence of large families in causing an excessive child death-rate often is submerged in the greater effect of other influences causing reduced child mortality.

The nearest approach to trustworthy figures on this point is in Dr. Stevenson's statistics (ref. p. 96). His preliminary results were published in the Annual Report of the Registrar-General, 1911, and are summarized in the table on page 121. In the first five of these groups fertility rates and infant death-rates vary in the same direction. These are average results, to which, as already indicated, many exceptions occur. But as remarked by me

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in the Annual Report of the Medical Officer of the Local Government Board, 1913-14, p. xxix :—

In the textile industries, employing 3·4 per cent. of the total male and 4·4 per cent. of the total female population of England and Wales, aged 10 and upwards, fertility and infant mortality vary widely in opposite directions; and among agricultural labourers, who number 4·6 per cent. of the total male population aged 10 and upwards, the infant mortality is very low, with a nearly average rate of fertility. Miners, who compose 6·7 per cent. of the total male population aged 10 and upwards, have an excessive infant mortality, and a fertility exceeding to a still greater extent the average for the whole country. The figures quoted above appear to be consistent with the view that, outside the range of extreme poverty, there is no unavoidable relationship between a high birth-rate and a high rate of infant mortality.

**FERTILITY RATES AND RATES OF INFANT MORTALITY IN DIFFERENT SOCIAL STRATA.—(PERCENTAGE DEVIATION FROM CORRESPONDING RATES FOR ENGLAND AND WALES.)**

Number.		Fertility Rates.	Rates of Infant Mortality.
		Per Cent.	Per Cent.
I.	Upper and middle class .. ..	-27	-39
II.	Intermediate class .. ..	-19	-15
III.	Skilled workmen .. ..	- 6	-10
IV.	Intermediate class .. ..	- 2	- 3
V.	Unskilled workmen .. ..	+31	+22
VI.	Textile workers .. ..	-23	+19
VII.	Miners .. ..	+42	+28
VIII.	Agricultural labourers .. ..	- 1	-22
	All classes .. ..	100	100

Dr. Stevenson (ref. p. 96) considers the relationship of child mortality to fertility as both close and complex, and regards it as in some measure reciprocal: "It seems probable that in many cases children die because many are born, and that many are born because comparatively few survive."

**Summary.**—Although numerous facts have been adduced pointing to the conclusion that the relation between large families and excessive infant mortality is not inevitable, the two in actual experience *en masse* are associated. Thus the massed statistics of the Fertility Census Report show a mortality about five times as high for the largest families as for the smallest: and M. March has shown that in France the rate of mortality of the first-born in families which subsequently become large families is much greater than that of

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the first-born of relatively small families (*Journal of the Royal Statistical Society*, May 1920, p. 402). (But on this see p. 562.) The contention in the preceding pages is that, given satisfactory social and sanitary conditions, including arrangements for adequate care of young children, and assuming the higher standard of knowledge and conduct which is rapidly being secured, the difference in mortality experienced by smaller and larger families should cease. The factors involved are numerous and as in the analogous problem of poverty, it is possible, by removing some elements in the complex of factors, to reduce materially, if not to remove entirely, the relationship between a high birth-rate and a high rate of child mortality.

## CHAPTER XI

### REGISTRATION OF SICKNESS

THE registration of sickness as well as of deaths is required in the interest of public health, and to determine the risks in sickness insurance schemes.

A necessarily imperfect as well as a belated view of the prevalence of disease is obtained from the registration of deaths alone. The medical officer of health would have an increased power of protecting the public health if he could by early information of every case of preventible disease track its development and progress, and adopt measures of prevention. Dr. Lyon Playfair in 1874 emphasized the importance of registration of sickness in these words: "The record of deaths only registers, as it were, the wrecks which strew the shore, but it gives no account of the vessels which were tossed in the billows of sickness, strained and maimed as they often are by the effects of recurrent storms. Registration of sickness would tell us of the coming storms, and enable us to trim our vessels to meet them."

Mortality statistics necessarily "ignore all that precedes the close of life," and the medical officer of health, who only knows of fatal cases of preventible diseases, is to a large extent in the impotent position of a mere recorder of events. The prevalence of a given disease cannot be gauged with absolute accuracy in the absence of registration of each case of the disease, except when, as in hydrophobia, the disease is always fatal.

It is fallacious to assume any fixed ratio between sickness and mortality. The *fatality of a given infectious disease varies greatly* in different outbreaks under varying circumstances. The highest ratio of sickness is occasionally found associated with a favourable rate of mortality. Thus cholera may be less fatal towards the end of an epidemic than at its beginning; so a conclusion drawn simply from the death

returns might easily exaggerate the diminution in the prevalence of the disease. Scarlet fever, again, varies greatly in fatality in different places and at different periods in the same place. There are some diseases, again, the knowledge of which is desired (because they may simulate more serious conditions or for other reasons), but which are seldom fatal (except in some cases, through secondary consequences), as quinsy, mumps, chicken-pox.

Mortality statistics necessarily ignore everything that precedes the close of life. They are silent about the large mass of common sickness, which, although it may disable a man, is not "unto death." From the standpoint of the commonwealth and the common health, sickness is more important than death; for it is the amount and duration of sickness rather than the mortality from it which have most importance as influencing the prosperity of a community. Or as Charles Dickens has stated it: "It concerns a man more to know the risk of the fifty illnesses that may throw him on his back than the possible date of the one death that must come. We must have a list of killed *and of the wounded too!*"<sup>1</sup>

Local returns of disabling sickness of every description would not only enable us to deal promptly with epidemic disease, but would also throw light on the influence of season and climate, of social conditions, and of trades and manufactures on health.

It is evident that even were it possible it is not requisite to know of every case of sickness. The lines of demarcation between health and sickness are ill-defined, and it would be necessary to limit returns to disabling sickness.

**The History of Attempts to Establish Registration of Sickness.**—The complete history of the various stages of advocacy of a national system of registration of sickness, and the local attempts that have been made to carry it into effect, has never been written, though a brief outline will be found in a paper by me on "A National System of Notification and Registration of Sickness," and in a more recent paper by Dr. Dudfield (*Journal of the Royal Statistical Society*, vol. lix, part i, and vol. lxxxvi, part ii).

Proposals for the public registration of disease were made

<sup>1</sup> *All the Year Round*, vol. iv, pp. 227-8.

at the beginning of the eighteenth century, and were urged by Dr. Rumsey and others in later years. Sir B. W. Richardson appears to have been the first to initiate a system on voluntary lines in 1855, and the Metropolitan Association of Health Officers in 1857 organized returns of sickness attended at the public expense. In 1860 Dr. A. Ransome and others organized a similar system in Manchester and Alford. Various other attempts followed, with some partial success; and Dr. Farr, in the Supplement to the Registrar-General's Thirty-fifth Annual Report, made the following remarks which summarize the benefits then regarded as likely to be derived from registration of sickness:—

The reports of the existing medical officers are of great practical value, and will become more valuable every day. What is wanted is a staff officer in every county or great city, with clerks, to enable him to analyse and publish the results of weekly returns of sickness, to be procured from every district; distinguishing, as the Army returns do, the new cases, the recoveries, the deaths reported weekly, and the patients remaining in the several hospitals, dispensaries, and work-houses. These compiled on a uniform plan, when consolidated in the metropolis, would be of national concern. It has been suggested that the returns of sickness should, to save time, be sent to London, and there analysed on a uniform system, as the causes of death are. That with the present postal arrangements is quite practicable. The thing to aim at ultimately is a return of the cases of sickness in the civil population as complete as is now procured from the Army in England. It will be an invaluable contribution to therapeutics, as well as to hygiene, for it will enable the therapeutists to determine the duration and the fatality of all forms of disease, under the several existing systems of treatment, in the various sanitary and social conditions of the people. Illusion will be dispelled, quackery, as completely as astrology, suppressed, a science of therapeutics created, suffering diminished, life shielded from many dangers. The national returns of cases and of causes of death will be an arsenal which the genius of English healers cannot fail to turn to account.

The subject of a "National System of Registration of Disease" appears to have gradually dropped into abeyance. It was blessed by medical men and sanitarians and Secretaries of State, but no practical steps were taken.

**The Compulsory Notification of Infectious Diseases.**  
—The leaven of the protracted agitation in favour of such registration was, however, at work. Medical officers of health in various parts of the country complained that their preventive measures were belated, owing to the fact that epidemic diseases had obtained a firm foothold before the

occurrence of fatal cases brought them under their cognizance. Gradually the idea of compulsory notification of infectious diseases, as the most urgent branch of a national system of registration of diseases, came to the front. Such notification of infectious diseases became actual fact in a characteristically British fashion. The experiment was allowed to be made by those towns desiring to make it. In September 1877 the first local Act for enforcing the compulsory notification of the chief infectious diseases came into operation in Bolton, Lancashire. This example was followed by other towns, and the adoptive enactment of the Infectious Diseases (Notification) Act in 1889 was followed by a rapid adoption of the Act by urban and rural sanitary authorities throughout England.

**Information now Available, or that could be made Available.**—1. A complete statement of *notifiable infectious and other diseases*, more fully described in the next chapter, is now obtainable.

2. It is desirable that *all cases of sickness occurring among the parochial poor* in each district should be periodically reported to the medical officer of health, and tabulated summaries of these statistics prepared for use according to a scheme, the scope of which might gradually be extended.

At first it would probably be wise to limit the return to total new cases treated in the period, whether at home or in one of the many Poor Law institutions; but there are obvious advantages in obtaining by this means information respecting the amount and localization of special diseases like rheumatic fever or pneumonia, to be made the subject of special investigation.

3. There is needed the imposition of the duty to send periodically to the medical officer of health a statement of the number of new in-patients and out-patients treated at every medical institution, with particulars limited as suggested above for parochial patients. This would necessitate making it obligatory on the managing bodies of all voluntary institutions for the treatment of the sick to keep accurate records of all cases treated at these institutions, in readiness for the returns to be made as above.

A useful step in this direction has been taken in an interim report issued in July 1922 by the Voluntary Hospitals Com-

mission on "Uniform Systems of Accounts," which recommends that in future no hospital shall be recommended for a grant under King Edward VII Hospital Fund, unless the Committee of Management undertake to keep such form of account as the local Hospital Committee may require. They give the following form, in addition to a detailed form for expenses under various categories. The form gives a useful basis for more detailed medical statistics, which we may hope will gradually be supplied.

## STATEMENT AS TO BEDS AND PATIENTS.

*For the Year ended December 31, 19 .*

	Preceding Year 19 .	Year under Review 19 .
(1) Number of beds available for use at 31st December .. .. .		
(2) Average number of Patients resident daily (as counted and recorded daily, totalled, and divided by number of days in the year) .. .. .		
(3) Number of In-Patients in the Hospital at beginning of year .. .. .		
(4) Number of In-Patients admitted during year .. .. .		
(5) Number of In-patients in the Hospital at the end of the year .. .. .		
(6) Total number of New Out-Patients during the year .. .. .		
(7) Total number of Out-Patient attendances during the year .. .. .		

**Tabulation of Information in Relation to Population at Risk.**—Although the tabulation of hospital statistics is desirable, they cannot be regarded as useful in comparing the vital conditions of one community with those of another, unless in each instance the population from which the patients are drawn is known and unless the extent to which hospital provision is utilized and the methods of selecting patients are fairly equal in the two communities. The non-surgical part of a hospital experience gives a useful clue to the chief

acute disabling illnesses, while that of a Poor Law infirmary shows the chronic disabling illnesses of a community. The Army and Navy Medical Statistics present the ideal from the standpoint of exact knowledge of lives at risk and complete knowledge of cases of illness.

It does not follow that when the population served by a hospital cannot be ascertained these statistics have no epidemiological or social value. On this point see the reference to Dr. Guy (p. 314). In the Milroy lectures given by me (*Lancet*, March 1895) on "The Natural History of Rheumatic Fever," the annual statistics of this disease as treated in hospitals for a series of years in this and other countries were utilized on the assumption that the proportion

$$\frac{\text{Number of cases of rheumatic fever} \times 1,000}{\text{Total medical cases admitted}}$$

would form a rough index year by year of the amount of this disease in a given district. The assumption was not strictly accurate, but it sufficed to enable important conclusions to be reached concerning special epidemic years, as to the inverse relation between the amount of rheumatic fever and the annual rainfall in a number of countries, and as to the parallelism of the curves of chorea and rheumatic fever, etc. One could distrust the ratio as an accurate index of the sickness-rate, while having confidence in it for acute annual differences in the curve plotted from the rates, especially when the year of these differences coincided in a number of curves.

**National Insurance Statistics.**—In 1921 the number of insured persons in England and Wales entitled to medical benefit was about 12,680,000, or 33·5 per cent. of the total population. These insured persons when sick are entitled to such medical services requiring only ordinary competence and skill as the 12,079 doctors whose names are on the panel; i.e. nearly one-half of the medical practitioners in the country, can supply. It appears that something like 60 per cent. of the insured patients receive medical treatment during a year, which implies that one-fifth of the population of the country is seen by an insurance doctor at least once in the course of each year.

A record is expected to be kept of each patient, and the annual expenditure of some eight millions of public money

in the provision of medical treatment "requires accounting for in some permanent though simple form" (Ministry of Health, Chief Medical Officer's Annual Report, 1921, p. 43). Friendly Societies or branches of these are seldom confined to one industry, and apart from this members not infrequently change occupation. Unless an almost impracticable amount of bureaucratic supervision is maintained, statistical returns of sickness are almost certain to be classified occupationally according to the insured person's occupation at entry, while his illness will be entered in accordance with the doctor's preliminary diagnosis! As regards duration of sickness two attacks which happen to be separated by less than twelve months constitute one attack for purposes of benefit. It remains to be seen whether the unwieldy mass of medical material of very variable value under the National Insurance Act can be utilized in present circumstances (see also p. 149).

To make such material useful, its severe limitations must be borne in mind. Like all vital statistics, sickness returns must be stated in age-groups and separately for the two sexes, and the population among whom the sickness occurred must similarly be divided. If confined to one locality, sickness statistics fulfilling the above conditions are likely to be feeble because of smallness of numbers. If random samples of larger groups are taken, there is some risk that the samples may not be truly random. A still more serious difficulty is that each case is apt to be classified according to the first and tentative diagnosis; and we may therefore agree with Sir A. Watson (discussion on Mr. Rusher's paper, quoted p. 149) that this is "not the proper material on which to build a huge statistical superstructure."

In America a number of interesting attempts at sickness registration have been made.<sup>1</sup> At the 1880 and 1890 censuses sickness and death data were collected by the enumerators. From these elaborate tables were compiled. A similar procedure was urged when preparations were being made for the 1861 census in England and Wales, and Miss Florence Nightingale supported the proposal, expressing the doubtful opinion that "where there is error, the error is uniform . . .

<sup>1</sup> See "Some Essentials of Sickness Statistics," by Edw. W. Kopf (*Proceedings of the Casualty, Actuarial and Statistical Society of America*, 1917).

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and corrects itself." At the American census of 1910 statistics of sickness were abandoned.

That a *census of sickness* is practicable has been demonstrated by Drs. L. K. Frankel and L. I. Dublin, of the Metropolitan Life Insurance Company, New York. Through their numerous local agents they have successfully organized

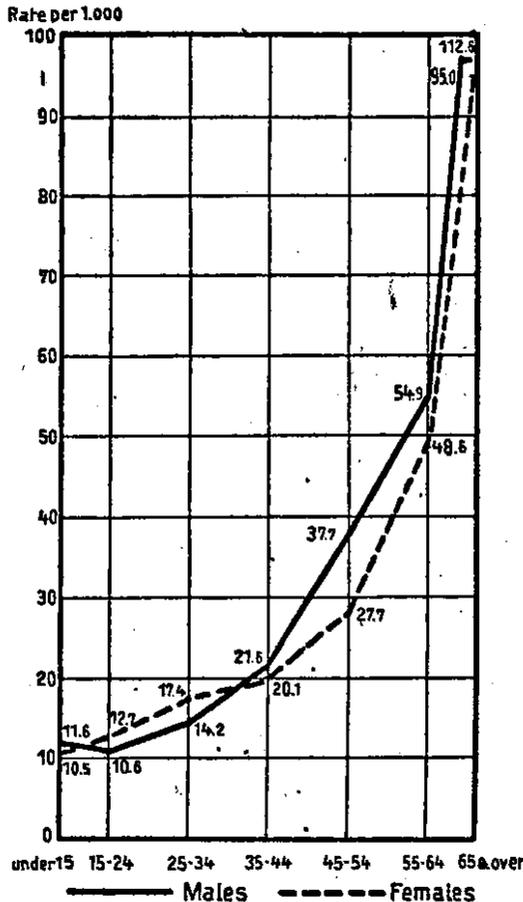


FIG. 14.—Number of Cases of Sickness in a Sample of the Population of Boston during the Week of July 17, 1916, per 1,000 Living at the Ages Specified.

seven sickness surveys in representative American communities. The reports on two of these, for Rochester in New York State, and for North Carolina, have been published in the reports of the United States Public Health Service. The survey of Boston, Massachusetts, may be taken as an example of the

method of sampling adopted. Over 300 men were employed in the survey, which took place in two weeks in July 1916, 20,497 families living in all parts of the city, comprising 97,259 persons, being canvassed, or 13 per cent. of the estimated population of the greater city. The sickness-rate, 2 per cent., was fairly constant in the several districts. Ninety-two per cent. of the persons sick were disabled for work. The proportion of the total sick receiving hospital treatment was 17.7 per cent. as against 2.4 per cent. in North Carolina and 10.7 per cent. in Rochester. The number of males and females sick at each age period are shown in Fig. 14. The consistent increase of sickness-rates with age is good evidence of the substantial character of the material. It is not necessary to discuss the kinds of illness discovered, which are set out in tables. Up to the date of the inquiry over one-quarter had been ill less than a month and nearly half less than six months. Of the total cases 73 per cent. had medical attendance, as compared with 61 per cent. in Rochester and 62 per cent. in North Carolina, nearly two-thirds being under the care of private physicians.

To secure the success of such a local census of sickness, a thorough publicity campaign is required, and the co-operation of local officials is important.

**The Framingham Experiment.**—The Metropolitan Life Insurance Company gave \$100,000 for a community health and tuberculosis demonstration to be conducted by the National Tuberculosis Association of America, under the supervision of a special national committee. Framingham, in Massachusetts, a town with a population of 17,000, of whom 20 per cent. were foreign born, was selected for this experiment, and the work was begun in April 1917 by a sickness census. Fourteen agents and 20 nurses were employed to obtain the house-to-house information asked for on a special census form, and at the visit by these agents a free and thorough medical examination by special physicians at the Community Health Station was offered.

Of the 1,455 families, comprising 6,582 people, enumerated at the census, 649 were later examined medically, entirely or in part. At the census 6.2 per cent. of the persons enumerated were reported as sick, which is nearly three times as high as the number reported in the census inquiries named

in the preceding paragraphs. Probably the intensive publicity campaign and a more liberal interpretation of sickness account for the difference.

At the census 38 cases were recorded as being tuberculous or possibly so ; and it is convenient to give here the statistical findings as to tuberculosis during the subsequent three years' working of the scheme, which comprised a most thorough medical and hygienic programme. Nearly 1 per cent. of the persons examined as the result of "medical examination drives," offering free medical examiners to all comers, were found to be suffering from active tuberculosis, and over 1 per cent. more were arrested cases. If this be assumed to hold good for the entire town, then there should be 9 or 10 active cases during the year to 1 registered death. It may be, however, that some degree of selection was at work, persons doubtful of their health being most likely to seek examination. The demonstration showed that 2 hospital beds were required for each death from tuberculosis. The tuberculosis death-rate in Framingham was 93 per 100,000 in 1917, 79 in 1918, and 76 in the first five months of 1919. The period is too short to draw valid conclusions as to the effect of the complete and continuous anti-tuberculosis campaign on the tuberculosis death-rate, and it is satisfactory that the experiment is to be continued for a further series of years, and probably repeated in other centres.

**Hospital Statistics.**—As an example of the use that can be made of hospital statistics, Dr. F. H. Hoffman's *Statistical Experience Data of the Johns Hopkins Hospital, 1892-1911*, should be consulted. It contains an historical study of some endeavours to utilize medical experience. It has been published as a Public Health Reprint, No. 42 (Government Printing Office, Washington, D.C.).

## CHAPTER XII

### THE COMPULSORY NOTIFICATION OF INFECTIOUS AND OF SOME OTHER DISEASES

IN Great Britain the reporting of births or deaths to the Registrar of Births and Deaths is known as *registration*; reporting of births or of cases of sickness to the medical officer of health—or, in the case of certain industrial diseases, to His Majesty's Inspector of Factories—is called *notification*. In the first case, a register is kept of each event recorded; in the second, this is done also, but it is not a legal duty, and the chief function of notification is fulfilled when appropriate inquiries concerning the case in question have been made and recorded.

The *notification of births* is discussed on page 76.

The *notification of each case of the chief infectious diseases* originated as indicated on page 125. The machinery for securing it, for those towns which had not already applied compulsory notification by local Acts, was provided by the Infectious Disease (Notification) Act 1889, which enabled any sanitary authority to make notification compulsory. In 1891 similar powers were applied in London, and in 1899 a general Act was passed enforcing the terms of the previous Act in every administrative area.

The exact form of compulsion is as follows:—

**Method of Notification.**—Where an inmate of any building used for human habitation within a district to which this Act extends is suffering from an infectious disease to which this Act applies, then, unless such building is a hospital in which persons suffering from an infectious disease are received, the following provisions shall have effect:—

(a) The head of the family to which the patient belongs, and in his default the nearest relatives of the patient in the building or in attendance on the patient, and in default of such relatives every person in charge of, or in attendance on,

the patient, and in default of any such person the occupier of the building, shall, as soon as he becomes aware that the patient is suffering from an infectious disease to which this Act applies, send notice thereof to the medical officer of health of the district.

(b) Every medical practitioner attending on, or called in to visit the patient, shall forthwith, on becoming aware that the patient is suffering from an infectious disease to which this Act applies, send to the medical officer of health for the district a certificate stating the name of the patient, the situation of the building, and the infectious disease from which, in the opinion of such medical practitioner, the patient is suffering.

Every person not complying with the above requirements is liable, on conviction, to a fine not exceeding 40s.; provided that if a person is required as above to notify only in default of some other person, he shall not be liable to any fine if he satisfies the Court that he had reasonable cause to suppose that the notice had been duly given.

A fee is payable to the medical practitioner for every case thus notified. The form of certificate on which notifications are made is shown on the opposite page.

For cases occurring in London, the doctor is required to state if the patient is an inmate of a hospital, the place from which and the date on which he was brought to hospital; he is also required to state whether the case occurred in his private practice or not.

The form of certificate gives a list of diseases which at present are compulsorily notifiable.

In most other countries notification is required without payment of a fee.

**History of Notification in U.S.A.**—Much information is given in Dr. Trask's brochure on Vital Statistics (Government Printing Office, Washington, 1914). The State Board of Health of Massachusetts in 1874 inaugurated a plan for the voluntary weekly notification of prevalent diseases, and over 100 physicians responded. Dr. Draper, who was in charge of the bureau collecting this information, said: "Sanitarians . . . know how much greater would be their power to protect the public health if data of the local development and progress of disease were promptly afforded to

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them. . . . In a still broader sense they see the great advantage which would result from the opportunity to study the rise and fall of epidemics, and the development of diseases whose cause lies in local and preventable conditions." In

**SCHEDULE A.**

No.

(NON-METROPOLITAN.)

**NOTIFICATION OF INFECTIOUS DISEASE.**

To the Medical Officer of Health for the.....of.....

I hereby Certify and Declare that, in my opinion

<sup>1</sup>.....  
 an inmate of <sup>2</sup>.....  
 is suffering from <sup>3</sup>.....  
 Age of Patient..... Sex.....  
 Date of onset of the disease..... 19....

The following ADDITIONAL PARTICULARS to be given IN THE CASE OF—

**TUBERCULOSIS :—**

Localization of the disease <sup>4</sup>.....  
 Occupation.....  
 Usual place of residence.....  
 (if other than above).....

**OPHTHALMIA NEONATORUM :—**

Date of Birth..... 19....  
 Name and Address of }  
 parent or other per- }  
 son (if any) having }  
 charge of child. }.....

**MEASLES OR GERMAN MEASLES :—**

Date of first appearance of rash..... 19.....  
 Signed.....  
 Medical Practitioner.

Address.....

Dated this.....day of..... 19.....

<sup>1</sup> Name in full of person suffering from disease.

<sup>2</sup> Number or name of the house, and name of the street or road, and parish or place, where person is resident. In the case of a ship, boat, tent, van, shed, or other similar structure, the name or description of the dwelling and the name of the place where it is situate should be given. The particulars given should be sufficient to enable the address to be promptly found.

<sup>3</sup> Name of disease.

<sup>4</sup> Here state organ or part affected.

1876 a similar system of obtaining postal-card information from physicians in the State of Michigan was organized by Dr. Henry B. Baker, who for many years did admirable pioneer work; and in 1883 Michigan made it obligatory on

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householders, etc., to notify to the health officer infectious diseases dangerous to the public health. In 1884 a similar law was passed in Massachusetts. This required physicians as well as householders to notify.

Each of the 49 States makes its own laws, and there is therefore some divergence in requirements; but as a rule the attending physician is required to notify to the local health officer who transmits the information to the State Health Department. Dr. Trask gives (1914) the following list of notifiable diseases and the number of States in which each is notifiable:—

Actinomycosis .. .. .	6	Rabies .. .. .	10
Anthrax .. .. .	15	Relapsing fever .. .. .	4
Barber's itch .. .. .	1	Rocky Mountain spotted fever	3
Berberi .. .. .	3	Scabies .. .. .	1
Cancer .. .. .	3	Scarlet fever .. .. .	45
Cerebrospinal meningitis ..	29	Septic sore throat .. .. .	1
Chagres fever .. .. .	1	Smallpox .. .. .	49
Chicken-pox .. .. .	21	Syphilis .. .. .	6
Cholera (Asiatic) .. .. .	41	Tetanus .. .. .	8
Colibacillosis .. .. .	1	Tetanus infantum .. .. .	1
Dengue .. .. .	8	Trachoma .. .. .	11
Diphtheria .. .. .	46	Trichinosis .. .. .	6
Dysentery .. .. .	3	Tuberculosis:	
Echinococcus disease .. .. .	1	All forms .. .. .	29
Epidemic dysentery .. .. .	6	Communicable forms .. .. .	1
Amœbic dysentery .. .. .	2	Laryngeal .. .. .	6
Erysipelas .. .. .	6	Pulmonary .. .. .	10
Favus .. .. .	2	Typhoid fever .. .. .	35
Filariasis .. .. .	1	Typhus fever .. .. .	31
Follicular conjunctivitis ..	1	Whooping cough .. .. .	27
German measles .. .. .	8	Yellow fever .. .. .	35
Glanders .. .. .	13	Veneral diseases .. .. .	2
Gonococcus infection .. .. .	5	Mental deficiency (including	
Hookworm disease .. .. .	7	epilepsy) .. .. .	1
Impetigo contagiosa .. .. .	1	Occupational diseases:	
Leprosy .. .. .	23	Arsenic poisoning .. .. .	12
Malaria .. .. .	9	Brass poisoning .. .. .	5
Malta fever .. .. .	1	Carbon monoxide poisoning	1
Measles .. .. .	31	Lead poisoning .. .. .	14
Mumps .. .. .	7	Mercury poisoning .. .. .	12
Ophthalmia neonatorum ..	14	Natural gas poisoning .. .. .	1
Paragonimiasis (lung fluke		Phosphorus poisoning .. .. .	12
disease) .. .. .	2	Wood alcohol poisoning ..	5
Paratyphoid fever .. .. .	3	Naphtha poisoning .. .. .	1
Pellagra .. .. .	8	Bisulphide of carbon poison-	
Plague .. .. .	28	ing .. .. .	1
Pneumonia .. .. .	11	Dinitrobenzine poisoning ..	1
Poliomyelitis .. .. .	26	Caisson disease (compressed	
Puerperal fever .. .. .	4	air illness) .. .. .	12

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The conditions under which these and sometimes other diseases are notifiable in the various States are set out in Reprint No. 510 from the Public Health Reports (Washington, 1919).

At a conference between State and Territorial Health Authorities and the United States Public Health Service held in June 1916, a "Model State Law for Morbidity Reports" was adopted, comprising the following summarized conditions:—

1. The following diseases and disabilities to be made notifiable:—

### GROUP I.—INFECTIOUS DISEASES.

<p>Actinomycosis. Anthrax. Chicken-pox. Cholera, Asiatic (also cholera nostras when Asiatic cholera is present or its importation threatened). Continued fever lasting seven days. Dengue. Diphtheria. Dysentery :     (a) Amœbic.     (b) Bacillary. Favus. German measles. Glanders. Hookworm disease. Leprosy. Malaria. Measles. Meningitis :     (a) Epidemic cerebrospinal.     (b) Tuberculous. Mumps.</p>	<p>Ophthalmia neonatorum (conjunctivitis of new-born infants). Paragonimiasis (endemic hæmoptysis). Paratyphoid fever. Plague Pneumonia (acute). Poliomyelitis (acute infectious). Rabies. Rocky Mountain spotted (or tick) fever. Scarlet fever. Septic sore throat. Smallpox. Tetanus. Trachoma. Trichinosis. Tuberculosis (all forms, the organ or part affected in each case to be specified). Typhoid fever. Typhus fever. Whooping cough. Yellow fever.</p>
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### GROUP II.—OCCUPATIONAL DISEASES AND INJURIES.

<p>Arsenic poisoning. Brass poisoning. Carbon monoxide poisoning. Lead poisoning. Mercury poisoning. Natural gas poisoning. Phosphorus poisoning. Wood alcohol poisoning. Naphtha poisoning.</p>	<p>Bisulphide of carbon poisoning. Dinitrobenzine poisoning. Caisson disease (compressed-air illness). Any other disease or disability contracted as a result of the nature of the person's employment.</p>
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### GROUP III.—VENEREAL DISEASES.

Gonococcus infection.

| Syphilis.

### GROUP IV.—DISEASES OF UNKNOWN ORIGIN.

Pellagra.

| Cancer.

2. Each physician who treats or examines any person afflicted with or suspected to be suffering from any one of the notifiable diseases shall immediately report such case of notifiable disease in writing to the local health authority having jurisdiction. Said report shall be forwarded either by mail or by special messenger and shall give the following information :—

- (1) The date when the report is made.
- (2) The name of the disease or suspected disease.
- (3) The name, age, sex, colour, occupation, address, and school attended or place of employment of patient.
- (4) Number of adults and of children in the household.
- (5) Source or probable source of infection or the origin or probable origin of the disease.
- (6) Name and address of the reporting physician.

Further conditions as to promptitude of notification, etc., are imposed for smallpox, diphtheria, cholera, yellow fever, etc.; and it is required, in the case of diphtheria, typhoid fever, scarlet fever, or septic sore throat that the physician shall state whether the patient or any member of his household is engaged in the handling of milk.

3. If there is no physician in attendance, the reporting of swollen eyes or an unnatural discharge within two weeks of birth is required from the midwife or attendant.

4. Teachers of day or Sunday schools are required to notify suspected cases of notifiable diseases.

**Veneraeal Diseases.**—In a large proportion of the States venereal diseases have been made notifiable, an experiment which is still on its trial. In England there is no notification of venereal diseases, except ophthalmia of the new-born, which is chiefly gonorrhoeal in origin. A large proportion of the total cases of venereal diseases, however, are treated at public clinics, and in respect of these some of the practical

advantages of notification are secured. It is likely that in present circumstances compulsory notification would lead to much concealment of cases, and thus defeat the object aimed at.

**Notification of Tuberculosis.**—This in many areas is much delayed, and a considerable number of cases fail to be notified. The explanation of this belongs largely to the sphere of public health administration.

**Notification of Sickness in the Great Industries.**—The chief weakness in the sickness statistics of Friendly Societies, so far as they are available, is that they give little or no information as to—

(1) The amount of sickness in defined industries, or, what is even more important, as to—

(2) The amount of sickness in particular branches of great industries.

Friendly Societies and branches of Friendly Societies are rarely confined to an industry. Changes in occupation cause a further difficulty. The occupation of each person under the National Insurance Act must be stated by him at entry; but motives of administrative economy have prevented a continuous record of occupation. It seems almost impracticable to evolve satisfactory statistics of sickness, and especially of causes of sickness, under the National Insurance Act with present centralized conditions. No such statistics would possess much value unless they clearly differentiated and stated sickness in terms of the population at risk in different age-groups. Certain diseases are made notifiable by Section 73 of the Factory and Workshop Act, 1901, superseding an earlier Act. The duty to notify devolves on the medical practitioner attending the patient as soon as he believes that the patient is suffering from a notifiable disease which has been contracted in any workshop or factory. The notification is to be sent to the Chief Inspector of Factories, Home Office, London. The occupier of every factory or workshop is required at intervals of from one to three years, as prescribed, to send particulars of the age, sex and occupation of all persons in his employment. This makes it practicable to obtain exact statistics of the incidence of notifiable diseases. The chief diseases thus rendered notifiable are :—

Lead poisoning,  
Phosphorus poisoning,  
Arsenic poisoning,  
Mercury poisoning,  
Anthrax,  
Toxic jaundice,  
Epitheliomatous ulceration,  
Chrome ulceration,

} contracted in any  
factory or workshop.

“Toxic jaundice” is defined as jaundice due to tetrachlorethane or nitro or amido-derivatives of benzene or other poisonous substances. “Epitheliomatous ulceration” is such ulceration due to tar, pitch, bitumen, mineral oil or paraffin, or any compound, product or residue of any of these substances.

“Chrome ulceration” is such ulceration due to chromic acid or bichromate of potassium, sodium or ammonium, or any preparation of these substances.

The industrial diseases notifiable in parts of the United States are enumerated on page 136.

**Objects of Notification.**—1. Action for preventing the spread of an infectious disease, for ascertaining its source, and so far as practicable for inhibiting the action of the infecting cause, depends largely on complete and prompt knowledge of each case of the disease. This rule applies whether the source of infection is human, e.g. an undetected case of the same disease, or whether it is water or milk infected by discharges from an infectious disease, or whether some other source of infection is involved.

The notification itself has a limited statistical value. Its importance depends on the extent to which administrative control of the notified disease can be and is exercised. This applies equally whether smallpox or tuberculosis is concerned, though the work involved in the latter case has a wider social range than in the former.

2. In tracing the source of an epidemic disease, it is important to have all the links of evidence. The absence of information as to a proportion of the cases may lead to failure in the investigation.

3. Much value attaches to the educational influence upon parents, householders, teachers, etc., and the still greater educational effect upon the members of local authorities, of the inspections resulting from notification. The constant

reiteration of the lessons taught by notifications has gradually and increasingly stimulated local authorities in the discharge of their duties.

4. Even if compulsory notification of infectious diseases had not prevented radiation of disease from a single focus of infection, and had not led to the discovery of a single evil condition competent to produce further disease, the continued operation of the Act would be desirable from a wider standpoint. A mass of information as to the seasonal, annual, epidemic, and cyclical prevalence of the chief infectious diseases is being accumulated such as has never previously been possessed by epidemiologists. As the first condition of success in the prevention of disease is knowledge of its natural history—its epidemicity, its relation to age and sex, to social and industrial conditions, to the complex meteorological conditions embodied in the words “season and climate”—such an accumulation of information may be expected to bear practical fruit. Medical officers of health are ceasing to be empiricists, concerned only with the enforcement of general cleanliness, and of measures of isolation and disinfection, when cases of infectious disease arise. They are concerned not solely with individual cases of disease, but also with the conditions producing and controlling entire epidemics. It is in this branch of their work that knowledge is as yet imperfect, and our hope of arriving at a less empirical conception of the causation of each infectious disease, and through that of its prevention, depends largely on the accumulation of accurate and complete information as to each epidemic and inter-epidemic period, and on the collateral study of the personal and environmental conditions associated with these periods.

**Effect of Notification of Infectious Diseases on Their Prevalence.**—Attempts have frequently been made to assess the value of notification as a sanitary instrument. Evidently it can have no value *per se*, unless by its means laws of epidemic prevalence are discovered, thus increasing means for control. Its direct utility depends on the extent to which the circumstances of every notified case are investigated, control over it exercised, and the notified case made the centre from which the search for overlooked or “missed” cases of the same disease may be begun. Even then there

is always risk of overlooked cases, though this does not justify neglect of such action as is practicable.

It is doubtful whether the conditions admit of appeal to figures in comparing areas with and without compulsory notification of a particular disease.

It is hardly possible that the periods and places compared should fulfil an indispensable condition when comparisons are instituted, viz. that *other things shall be equal*. Notification is but a means to an end. In some towns the information furnished by it has been made the basis of active and persistent preventive work, while in others this has not been so. The question is mixed up also with that of hospital accommodation and isolation. There may be no immediate good results from notification if the patients notified cannot be properly isolated.

Furthermore, after such a disease as measles or scarlet fever has gone unchecked through a town it exhausts the supply of persons prone to these diseases; and apart altogether from any administrative control some years may elapse before susceptible persons have accumulated. In addition, there are cyclical influences, the nature of which is imperfectly known, but which have important bearings on the prevalence of a given disease. So that neither, on the one hand, the comparative absence of a given infectious disease since notification came into force, nor, on the other hand, its increased prevalence, necessarily proves the utility or inutility of notification.

In attempting comparisons of death-rates from a particular infectious disease between periods before and after compulsory notification was enforced, the following precautions must be particularly regarded:—

(1) Avoid average statements for groups of years. In treating of epidemic diseases no method is so likely to conceal the truth as this. In connection with smallpox statistics it has led to numerous errors. In other infectious diseases it is frequently quite practicable to show an increase or a decrease of prevalence or mortality by adjusting the groups of years. The proper method is to compare year by year, if practicable in a long series, and the data necessary for this can be best displayed by making a curve of the annual death-rates for the period under comparison.

(2) It must be noted that the death-rate from a disease may decline to a much greater extent than its prevalence. This is especially true of scarlet fever, to a less extent of diphtheria.

(3) For whooping cough and measles, diseases chiefly fatal in childhood, death-rates should always be stated in terms of the population at the ages at risk. The need for age-analysis runs through all vital statistics. In Table 12 of the Registrar-General's Annual Report each year (p. 35 of the 1920 Report) the death-rates for a long series of years from measles, scarlet fever, diphtheria, and whooping cough are given per million persons living at all ages and per million living at ages under 15 years. For whooping cough and measles a statement of death-rate in terms of the population aged 0-5 might be preferable (p. 388). Similarly the death-rate from diarrhoea for children under 2 years old is stated per 1,000 births; and on page xxxviii of the same report (1920) will be found the death-rate under 1 from diarrhoeal diseases per 1,000 births for a series of years.<sup>1</sup>

**Further Uses of Notification.**—Knowledge of the prevalence of a communicable disease in any community is of more than local importance. In certain instances it has even international value, and this is particularly so for cholera, plague, yellow fever, smallpox, and typhus fever. By the terms of an international sanitary convention each Government conforming to the international regulations undertakes to inform other countries of any case of the three first above named diseases occurring within its area. This is the foundation of international regulations for controlling these diseases.

The British Government, the Federal Government of the United States and other Governments circulate to health officers within their area weekly and other periodical statements of cases of these diseases, and sometimes of other diseases, like smallpox and typhus, occurring in foreign countries, timely intimation of which is desirable.

In a given country it is important that the health officer of any district within it should know what diseases prevail in other parts of the country, and especially within the same county. A partial arrangement to this effect was organized

<sup>1</sup> In the Registrar-General's Statistical Review for the year 1921 (New Annual Series, No. 1, Part I) most of the above data are given in Table 6.

by Dr. John Tatham in 1888, by which a weekly statement of the number of cases of each notifiable disease in 33 towns was distributed to the health officers of each contributing town. In 1889 the task of tabulation and distribution of these weekly statistics was undertaken by the Local Government Board of England and Wales, and from the beginning of 1911 this return embraced the whole of the country. An order of the Local Government Board in 1910 made it the duty of the medical officer of health of every administrative district in England and Wales—(1) To notify immediately to the Board any case of plague, cholera, or smallpox, or any serious outbreak of epidemic disease in the district; and (2) to send to the Board each Monday a statement of the number of cases of each infectious disease notified to him during the week ended on the preceding Saturday night. Every medical officer of health received towards the end of the following week a printed statement of the number of infectious cases under each disease for the entire country. The figures are summarized and published in the quarterly returns of the Registrar-General, and each year from 1911 onwards the notifications of infectious disease and attack rates during the year have been published for every sanitary district, in a report entitled "Incidence of Notifiable Diseases in Each Sanitary District in England and Wales during the Year 19—." The three most recent of these have been issued by the Ministry of Health, in succession to the Local Government Board; the corresponding report for 1921 has been embodied in the Annual Report of the Registrar-General. In the first report, that for 1911, is a historical statement by myself of the progress of this work, and of its possibilities of usefulness. Their current value is great, their possibilities of usefulness for epidemiological investigations still greater.

A similar interchange of information is arranged in the United States. Thus "Public Health Reports" issued weekly by the United States Public Health Service contain information of the current prevalence of disease, at home and abroad. The same reports give from time to time tables of the prevalence of notifiable diseases in various areas. Thus No. 23, Vol. 37, for June 9, 1922, gives the case-rate, death-rate and fatality per 100 cases, in all cities of over 100,000 population, of a large number of infectious diseases, and

the report for July 14, 1922, gives the same information for cities of 10,000 to 100,000. The median case-rate is given for each disease as well as the rate for the current year. These weekly reports, like the weekly returns of the Registrar-General of England and Wales, in which a similar system is adopted, have a high value in public health administration.

**The Scientific Uses of the Notification of Disease.—**

The value of registration and notification of disease has already been emphasized. In the elucidation of the influence of age and sex, of urban and rural life, of locality, of occupation, etc., on the incidence of disease, there are vast possibilities of fruitful research based on the knowledge of both infectious and non-infectious disease.

The one defect of the annual report on the "Incidence of Notifiable Diseases" is that owing to the law for extra-metropolitan areas not having required the age of the patient to be stated prior to 1918, no tabulation of these cases according to age and sex has hitherto been made. For London this is not so, and special mention should be made of the statistics of infectious diseases in the Annual Reports of the County Medical Officer to the London County Council, and the statistical reports of the Metropolitan Asylums Board.

The late Dr. A. Ransome, F.R.S., in 1870 (*British Medical Journal*, 1870, vol. ii. p. 297) drew attention to the importance of "medical statistics, from which conclusions might in future be drawn respecting such subjects as the causes of disease, the laws of epidemics, the relations of atmospheric changes to various disorders, the influence of times of plenty or scarcity of food, and many other questions of interest to medical science." Our present ignorance as to the causes of epidemicity of various diseases, notwithstanding the work of Ransome, Brownlee, Greenwood, and others, may mean that statistical investigations have not been adequately pursued or have had to deal with inadequate data, or more probably that statistical investigations must be supplemented by collateral lines of research. Some of the earlier work of Dr. Henry Baker, e.g. as to the relation between temperature and pneumonia in Michigan, is admirable, in view of his imperfect data.

**Summary Statistics of Infectious Diseases.—**In supple-

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ment of the chapter on Registration of Sickness, some statistics of general sickness are given in Chapter XIII. Many similar statistics as to notifiable diseases will be found in the chapter dealing with the vital statistics of each of these diseases, and only a few illustrations of such statistics need be given here.

In the following table are stated some average sickness and death-rates for England and Wales in 1921, and for a number of cities with a population over 100,000 in the United States whose statistics are summarized in "Public Health Reports," United States, for June 9, 1922.

NUMBER OF CASES OF AND OF DEATHS FROM EACH DISEASE PER  
1,000 OF POPULATION IN 1921.

	Case Rates.		Death Rates.	
	England and Wales.	Aggregate of American Cities.	England and Wales.	Aggregate of American Cities.
Diphtheria .. ..	1.76	2.91 (68)	0.13	0.18 (68)
Measles .. ..	—	2.53 (68)	0.06	0.03 (68)
Scarlet fever .. ..	3.64	2.28 (68)	0.03	0.06 (68)
Smallpox .. ..	0.01	0.65 (56)	0.00	0.01 (56)
Typhoid fever .. ..	0.10	0.26 (67)	0.02	0.04 (67)
Tuberculosis (all forms)	1.99	—	1.13	1.04 (66)

The figures in brackets state the number of cities on whose experience the average rates are based.

It is not suggested that the English and American rates are strictly comparable. In the American report it is pointed out that gradual improvement, unequal in different cities, is occurring in the reporting of cases of infectious disease.

From the English report we learn that the smallpox sickness rate for England and Wales as a whole has varied between 1911 and 1920 but little, never exceeding 0.01 per 1,000; that the scarlet fever rate has varied from 4.47 to 1.44, the diphtheria rate from 1.24 to 1.86, and the entire fever rate (chiefly enteric) from 0.38 (in 1911) to 0.08 in 1920.

The notification figures for tuberculosis for England and Wales are interesting:—

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Year.	Primary Notifications of Tuberculosis and Deaths from Tuberculosis per 1,000 of population.			
	Pulmonary.		Non-pulmonary.	
	Case-rate.	Death-rate.	Case-rate.	Death-rate.
1915	1.94	1.15	0.63	0.38
1916	1.98	1.18	0.66	0.38
1917	2.04	1.26	0.62	0.40
1918	2.14	1.35	0.57	0.38
1919	1.66	0.98	0.45	0.28
1920	1.54	0.87	0.41	0.26
1921	1.49	0.88	0.40	0.24

The figures suggest incomplete notification, perhaps to an increasing extent.

There is no corresponding notification of venereal diseases, but the following table, taken like the above from the Third Annual Report of the Minister of Health, shows the numbers coming to the knowledge of the medical officers of treatment centres, and therefore to some extent under supervision and control :—

	Year 1920.					Year 1921.				
	Syphils.	Gonor- rhoea.	Soft Chancres.	Other Diseases.	Total.	Syphils.	Gonor- rhoea.	Soft Chancres.	Other Diseases.	Total.
(1) Number dealt with first time ..	2,918	346	2,257	599	6,120	2,431	278	1,924	540	5,173
(2) Number who ceased to attend:										
(a) Before completion ..	1,183	121	814	59	2,177	655	48	606	—	1,309
(b) After one or more courses, but before completion ..	127	14	111	5	257	460	12	102	—	594
(c) After completion but before final tests ..	—	—	—	—	—	—	—	—	—	—
(3) Number discharged after completion of treatment ..	240	123	599	406	1,368	155	130	430	329	1,044
(4) Number at end of year under observation ..	2,670	57	1,314	43	4,084	3,297	103	1,817	137	5,354

## CHAPTER XIII

### STATISTICS OF GENERAL SICKNESS AND OF ACCIDENTS

THE most complete statistics of a selected body of men, kept under strict observation, are supplied in the Army and Navy records. The first Annual Statistical Report on the Health of the British Army appeared in 1861, its author being Dr. Thos. Graham Balfour, F.R.S., and subsequent yearly reports form a valuable body of evidence of sickness and its causes among men, the majority necessarily unmarried, and therefore specially liable to suffer from venereal diseases.

The following table gives comparative data for the Army in the United Kingdom and at the same time indicates the measures of sickness employed :—

**ARMY IN GREAT BRITAIN AND IRELAND.**  
*Ratios per 1,000 of Strength.*

	1889-98.	1899-1908.	1909-13.	1914. <sup>1</sup>
Admissions .. .. .	712.5	560.1	354.9	403.0
Deaths .. .. .	4.3	4.4	2.6	2.8
Invalids finally discharged ..	17.0	27.4	10.0	9.0
Number constantly sick ..	41.1	31.8	20.2	21.2

<sup>1</sup> To July 31st.

The distribution of sickness according to cause is given in the following table :—

**MILITARY INEFFICIENCY FROM SICKNESS (1913).**

*Average Strength, 104,890.*

	{	Infectious Diseases .. .. .	90
		Venereal Diseases .. .. .	483
		Septic Diseases .. .. .	160
		Parasitic Diseases .. .. .	48
		Tuberculosis .. .. .	30
Average number constantly ill from	}	Rheumatic Fever .. .. .	48
		Nervous and Mental Diseases .. .. .	43
		Respiratory Diseases, including Pneumonia .. .. .	110
		Sore Throat and Tonsillitis .. .. .	92
		Digestive Diseases .. .. .	170
		Injuries .. .. .	310

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From the Statistical Report on the Health of the Navy for the year 1914 the following table relating to the Home Fleet is taken :—

HOME FLEET.	
<i>Average Strength, 88,240.</i>	
Average number constantly sick daily .. ..	1590·7
<hr/>	
Influenza .. .. .	19·6
Pneumonia .. .. .	21·9
Tuberculosis .. .. .	34·3
Chancroid .. .. .	45·2
Syphilis .. .. .	129·5
Gonorrhœa .. .. .	140·0
Rheumatic Fever .. .. .	31·0
Other Infectious Diseases .. .. .	28·2
Parasitic Diseases .. .. .	28·8
Mental and Nervous Diseases .. .. .	51·7
Eye Diseases .. .. .	20·1
Circulatory Diseases .. .. .	31·9
Respiratory Diseases .. .. .	96·9
Digestive Diseases .. .. .	194·9
Connective Tissue and Skin Diseases .. .. .	141·0
Injuries .. .. .	405·6
All other causes .. .. .	170·1
<hr/>	
	1590·7
Average annual rates per 1,000 of strength of cases of—	
Illness .. .. .	540·3
Invalided .. .. .	11·7
Dead .. .. .	44·7
Sick daily .. .. .	18·0

Apart from the statistics of Poor Law sickness, the largest body of evidence as to general sickness, in the sense of disabling sickness, is supplied from the records of Friendly Societies in this country. Reference may usefully be made to the following volumes and special papers :—

1. *Sickness and Mortality Experience of the Independent Order of Oddfellows, Manchester Unity, during the Years 1893–97*, by A. W. Watson, F.I.A.

2. *The Methods of Analysing and Presenting the Mortality, Sickness and Experience of Friendly Societies, with Examples, etc.*, by A. W. Watson (1900).

3. *Notes and Diagrams on the Sickness and Mortality Experience of the Manchester Unity*, by W. G. Appleyard (1906).

4. *Messenger Prize Essay on Friendly Societies*, by G. F. Hardy, F.I.A.

5. "The Statistics of Industrial Morbidity in Great Britain," by E. A. Rusher, F.I.A. (*Journal of the Royal Statistical Society*, December 20, 1921).

Only a few facts culled from these and other sources can be given here. Statistics of sickness are of value as deter-

mining financial claims on Friendly Societies; they throw considerable light on the public health, and they can be utilized to ascertain whether occupations are healthy or not. The pitfalls of such statistics are many for the uninitiated.

Benefits under most schemes and under the National Insurance Act are only for those "incapable of work."

It is stated in an official memorandum (Memo.  $\frac{280A}{I.C.}$ ) that an insured person "has been regarded as 'incapable of work,' when in such a condition, through some specific disease or bodily or mental disablement, that an attempt to work would be seriously prejudicial to his health." The entire memorandum shows how elastic must be the definition of incapacity, and goes far to explain the increasing amount of sickness at each age-period shown in the experience of the Manchester Unity of Oddfellows in successive historical periods (Fig. 15).

The *rate of sickness* per member per annum is the ratio between the number of weeks of sickness in the total experience and the "number exposed to risk." This number is the number of insured persons of given age or age-group, or in other words the number of years of life passed through at any particular age or group of ages.

The idea that the amount of tabulated sickness and the death-rate are closely correlated is negatived by Fig. 15; and there is little support for the statement as applicable to present conditions that two persons are constantly sick for each person that dies.

The migratory character of labour makes it difficult to arrive at any sound conclusion as to relative sickness in different industrial areas. It would appear, however, from various experiences that occupation is much more important than locality, and that, of all factors, age has the greatest influence upon the rate of sickness. This is shown in Fig. 15; also in Fig. 14 on p. 130.

From the public health viewpoint, the most interesting feature of the sickness statistics of the Manchester Unity, which are historically the most complete, is the increasing rate of sickness coincident with decreasing rate of mortality.

It is significant that in centralized Friendly Societies, like the Hearts of Oak Benefit Society, the rate of sickness is far in excess of that of the Foresters and Oddfellows who

have local branches. Without attributing this excess entirely or chiefly to fraud and malingering, there can be no hesitation in regarding the excess sickness both in centralized societies and in the more recent experience of the Independent Order of Oddfellows as partly due to diminished supervision

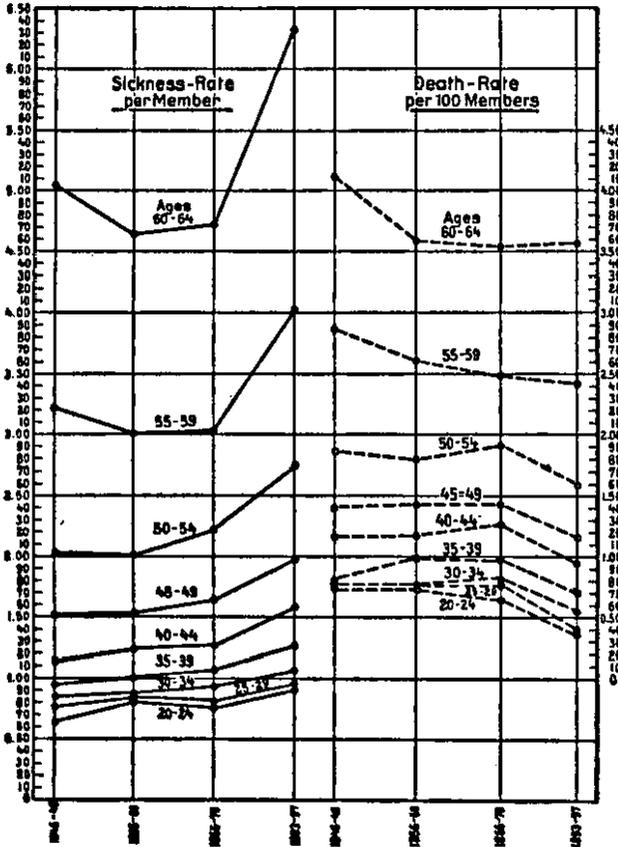


FIG. 15.—Experience of the Independent Order of Oddfellows, Manchester Unity, in respect of Sickness and Mortality at Four Successive Periods, 1848-49, 1856-60, 1866-70, and 1893-97, and at Various Age-groups, 20-24 to 60-64. (The marginal scales show sickness rates per member per annum, and death-rates per 100 members per annum.)

and to a slackened regard for the corporate society. This is associated with the life in large communities which has progressively displaced the life of smaller communities in which character and public opinion are more potent. It is subject to debate whether two further considerations do not enter

considerably into the result: (a) the greater appreciation of the desirability of treatment for minor complaints; and (b) some would say, survival of a larger number of weakly adults than in the days before sanitation and curative medicine were generally active. This last cause in my opinion is erroneously adduced, for the same causes may reasonably be expected to have led in at least a corresponding degree to a curtailment of disabling sickness and to a diminution of its occurrence.

The reports of the Chief Medical Officer of the Ministry of Health for 1920 and 1921 give certain statistics of the national insurance scheme from which the following particulars are taken: On the average, during the 8 years 1913-21, 14,476,000 weeks' work were lost every year through sickness, or 278,000 years, or in other words the equivalent of the annual work of 278,000 persons. There needs to be added to this the cost and trouble of attending these sick persons, and many other collateral expenses.

These figures must be regarded as a minimum estimate of illness, based on actual payments. The facts that benefits are reduced or disappear when contributions are in arrears, that there is no payment during the first three days of illness, and that there is no payment in workmen's compensation cases, illustrate this point.

In January 1922 the records of 226 panel practices distributed in 116 towns were examined. From the lists of these practitioners, comprising over 400,000 insured persons, from 100 to 200 record cards were selected in uniform alphabetical order. Altogether 30,069 cards were selected as a random sample, the number of cases of illnesses on these cards being 36,325. The chief causes of the sickness thus recorded are set out in the table on the opposite page taken from the 1921 report.

The noteworthy point in the table is that serious diseases like tuberculosis are represented on only a small scale. For tuberculosis this is in part explicable by the special sanatorium benefit; but there must be much failure to secure the early recognition of this disabling disease of the working years of life. Sir George Newman remarks: "The symptoms for which insured persons seek the advice of their doctors are consistent with the existence of only minor maladies,

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but in the aggregate they give rise to an enormous mass of suffering, incapacity and enforced idleness."

As related to Friendly Society experience, reference may be made here to Dr. Louis Dublin's valuable work on

**INSURED PERSONS IN REPRESENTATIVE CITIES—PROPORTION OF CERTAIN DISEASES TO TOTAL CASES, 1916.**

Disease.	Total.		Male.		Female.	
	No.	Per 1,000 of Total.	No.	Per 1,000 of Total.	No.	Per 1,000 of Total.
1. Influenza ..	3,097	85.3	2,004	90.2	1,093	77.5
2. Tuberculosis, all forms ..	505	13.9	320	14.4	185	13.1
3. Organic heart disease ..	520	14.3	355	16.0	165	11.7
4. Anæmia ..	1,157	31.9	74	3.3	1,083	76.8
5. Bronchitis, bronchial and nasal catarrh, cold, etc. ..	7,739	213.0	4,988	224.4	2,751	195.2
6. Pneumonia and other diseases of the respiratory system ..	537	14.8	395	17.8	142	10.1
7. Diseases of digestive system ..	4,766	131.2	2,797	125.8	1,969	139.6
8. Diseases of genito-urinary system ..	912	25.1	339	15.3	573	40.6
9. Diseases of nervous system and special senses ..	1,775	48.9	1,088	49.0	687	48.7
10. Skin diseases ..	1,741	47.9	1,039	46.7	702	49.8
11. Injuries and accidents ..	2,871	79.0	2,358	106.1	513	36.4
12. Abscess, boils, and other septic conditions ..	2,503	68.9	1,647	74.1	856	60.7
13. Lumbago, rheumatism, etc. ..	3,181	87.6	2,201	99.0	980	69.5
14. Debility, neuralgia and headache ..	1,999	55.0	855	38.5	1,144	81.1
15. Malignant disease ..	68	1.8	45	2.0	21	1.5
16. Other diseases ..	2,956	81.4	1,720	77.4	1,236	87.7
<b>Total ..</b>	<b>36,325</b>	<b>1000.0</b>	<b>22,225</b>	<b>1000.0</b>	<b>14,100</b>	<b>1000.0</b>

*Mortality Statistics of Insured Wage Earners and Their Families (New York, 1919), which gives an important review of the mortality experience of 10 million policy holders in the Metropolitan Insurance Company in the 6 years 1911-16.*

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**Industrial Sickness from Notification Returns.**—Dr. T. M. Legge, Chief Medical Inspector of the Home Office, has published statistics in the *Journal of Industrial Hygiene* (April and May, 1920), which may be referred to for details. The following attack-rates are taken from the Home Office Report for 1913 :—

LEAD POISONING IN EARTHENWARE AND CHINA WORKS.  
Attack-rate per 1,000 Employed.<sup>1</sup>

	1899-1902.	1903-06.	1907-10.	1911.	1912.	1913.
Males .. ..	19	9	10	10	9	8
Females .. ..	37	25	19	20	17	10
Based on the following number of cases in men and women ..	(160)	(98)	(89)	(92)	(80)	—

<sup>1</sup> Calculated on returns of employment for nearest year.

The total deaths from lead poisoning, as returned in the Registrar-General's reports, were as follows :—

AVERAGE ANNUAL DEATHS FROM LEAD POISONING REGISTERED IN ENGLAND AND WALES.

5 Years, 1906-10.	4 Years, 1911-14.	4 Years, 1915-18.	1919.	1920.
90	94	52	48	61

The attack-rate of lead poisoning in 1920 per 1,000 employed in various industrial processes, in which this disease is notifiable, was as follows : workers in white lead 26, electric accumulators 27, tinning of metals 20, paints and colours 16, file-cutting 2, printing 0.4.

**Workmen's Compensation Act.**—Under this Act the workmen can obtain compensation for injury from accident and from a certain number of diseases when due to the workmen's occupation. Under the Statutory Order, 1918, No. 287, the provisions of the Workmen's Compensation Act, 1906, are made to apply with certain reservations to arsenic and lead poisoning, to poisoning by benzene and its derivatives,

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to tar cancer, scrotal epithelioma, cataract in glassworkers, miner's nystagmus, glanders, writer's cramp and a few other conditions.

The statistics published in the Home Office official report (Cd. 1545) relate to seven groups of industries,<sup>1</sup> comprising 8,348,150 workpeople.

The total number of compensation cases in 1920 was 385,517, of which 3,531 were fatal; and the amount paid in compensation was close on 6 millions sterling. The average payment in case of death was £214, for disablement £13 14s. To the above expenditure must be added a large proportion for costs of insurance, etc. These additions are estimated to increase the total charge for compensation in the seven great industries to at least 8½ millions sterling. The charge per person employed varied in 1920 from 37s. 3d. in mines to 9s. 3d. in factories. For mines this worked out at 2.44d. per ton of coal raised. Of the cases terminated in 1920, in 9 per cent. the compensation payment had lasted less than two weeks, 2-3 weeks 30.9 per cent., 3-4 weeks 18.3 per cent., 4 weeks and less than 13, 35.6 per cent. Cases settled by the payment of a lump sum are not included in these percentages, which are therefore an understatement. Since the war, the amount paid in compensation has greatly increased, while the amount of litigation has greatly diminished. For details as to the varieties of accidents and disease, the official report should be consulted.

<sup>1</sup> Shipping, factories, docks, mines, quarries, constructional work, railways.

## CHAPTER XIV

### THE REGISTRATION OF DEATHS

THE Act requiring death certification implies a dual duty: registration (*a*) of the act of dying, and (*b*) of the cause of death. The history of complete death registration in England dates from the Act of 1836.

Under Sections 10 and 11 of the Births and Deaths Registration Act, 1874, personal information of every death has to be given to the registrar of the district within five days of its occurrence by the nearest relatives of the deceased present at the death or in attendance during the last illness; or failing these, by every other relative of the deceased dwelling or being in the same district as the deceased; or such person present at the death; or the occupier of the house, or each inmate of the house, or the person causing the body of the deceased to be buried.

If the deceased did not die in a house, a similar chain of responsibility is enacted.

Every medical practitioner attending the deceased in his last illness is required to furnish a certificate "stating the cause of death to the best of his knowledge and belief." A fine of 40s. may be inflicted for failure to give this certificate. The certificate is to be given to the "qualified informant," i.e. the person whose duty it is to give information of the death and convey this certificate to the registrar, subject to a penalty of 40s. (see pp. 158 and 159.)

The Registrar of Births and Deaths in Great Britain is an official of the Poor Law authorities, by whom he is appointed with the assent of the Registrar-General. He is controlled entirely by the Registrar-General in the discharge of his duties; and the registration service is, in substance, centralized and without local control, except in the initial appointment. This is admirable from the point of view of

uniformity and completeness of service. It is the duty of the local registrar to supply information respecting deaths, including copies of certificates of causes of death, to the medical officer of health on payment of a small fee.

**Uncertified Deaths.**—The registrar may register a death—

(a) On the statement of a "qualified informant" attending personally for the purpose, and producing a medical certificate of the cause of death, when the deceased has been attended in the last illness by a registered medical practitioner. When there has been no such medical attendance, the registrar must accept the "qualified informant's" statement as to the cause of death.

(b) On the certificate of the finding of a coroner's jury, where an inquest has been held.

The absence of a medical certificate of cause of death has involved since March 1914 a report to the coroner by the registrar. The registrar must also report the death to the coroner "where it appears that the death was caused directly or indirectly by violence, or was attended by suspicious circumstances, and whenever the death is stated to have been sudden, or the cause of death is stated to be "unknown." This applies to all cases, whether certified by a registered practitioner or not. In other cases the registrar may accept the statement of the informant as to the cause of the death, and the information thus accepted may include a certificate from an unregistered practitioner.

The registrar must report to the coroner the death of every infant which dies in a house registered under the Infant Life Protection Act, 1872. It is the duty of the local authority to furnish soon after January 1st in each year a complete list of all such registered houses, and to notify from time to time any alteration therein. If the local authority omits to furnish these lists, it is the registrar's duty to apply for them.

A table on page xovi of the Annual Report of the Registrar-General of England and Wales, 1920, shows that in 1878, out of every 100 deaths, 90·18 were certified by registered medical practitioners, as compared with 92·14 in 1920. The proportion of inquest cases in the same interval increased from 5·00 to 6·65 per cent., and of uncertified deaths decreased from 4·85 to 1·21 per cent. Only about 55 per cent. of

*[continued on page 160.]*

Form of Medical Certificate.—The form of certificate of death required to be furnished in this country is as follows:—

Not to be used by any other than a Registered Medical Practitioner.

BIRTHS AND DEATHS REGISTRATION ACT, 1874.

**MEDICAL CERTIFICATE OF THE CAUSE OF DEATH.**

To be given by the Medical Attendant to some Person qualified to be an Informant for the registration of the Death (*see over*).

No. of corresponding Entry in Register Book of Deaths to be inserted here by the Registrar.

I HEREBY CERTIFY that I attended \_\_\_\_\_ during h. \_\_\_\_\_ last illness; that such Person's age was stated to be \_\_\_\_\_; that I last saw h. \_\_\_\_\_ alive on the \_\_\_\_\_ day of \_\_\_\_\_ 191\_\_\_\_; that he Died\* \_\_\_\_\_ on the \_\_\_\_\_ day of \_\_\_\_\_ 191\_\_\_\_, at \_\_\_\_\_ and that to the best of my knowledge and belief the cause of h. \_\_\_\_\_ death was as hereunder written.

\* Should the Medical Attendant not feel justified in taking upon himself the responsibility of certifying the *fact* of Death, he may here insert the words "*as I am informed.*"

† *i.e.*, the disease which initiated the train of events leading to death, and not a mere secondary, contributory, or immediate cause, or a terminal condition or mode of death.

As to death from violence *see par. (e), p. li. [p. xxxix of this Manual].*

‡ A terminal condition or mode of death should not be entered as a secondary (or contributory) cause.

Cause of Death.	Duration of Disease from onset.			
	Years.	Calendar Months.	Days.	Hours.
† Primary _____				
‡ Secondary _____ (Contributory)				

[The Informant should read the Instructions on the back of this Form.]

Witness my hand, this \_\_\_\_\_ day of \_\_\_\_\_ 191\_\_\_\_

Signature \_\_\_\_\_

Qualifications as registered by Medical Council \_\_\_\_\_

Residence \_\_\_\_\_

N.B.—The Person to whom this Certificate is given by the Registered Medical Practitioner is REQUIRED TO DELIVER IT TO THE REGISTRAR OF BIRTHS AND DEATHS, and is liable to a penalty of forty shillings for failure to do so.

\*. \* The Registrar-General cautions all persons against accepting or using this Certificate for any purpose whatever except that of delivering it to the Registrar.

# THE REGISTRATION OF DEATHS

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The corresponding standard American form is as follows:—

## United States Standard Certificate of Death.

**1 PLACE OF DEATH.**

DEPARTMENT OF COMMERCE  
BUREAU OF THE CENSUS

County.....

STANDARD CERTIFICATE OF  
DEATH

Township.....

State of.....

or

Village.....

Registered No.....

or

City.....(No.....St.....Ward)

(If death occurred in a hospital or institution give its NAME instead of street and number.)

**2 FULL NAME.....**

**PERSONAL AND STATISTICAL PARTICULARS**

**MEDICAL CERTIFICATE OF DEATH.**

**3 SEX**..... **4 COLOR OF RACE**..... **5 SINGLE MARRIED WIDOWED OR DIVORCED**.....  
(Write the word)

**16 DATE OF DEATH**  
....., 191...  
(Month) (Day) (Year)

**6 DATE OF BIRTH**  
....., 191...  
(Month) (Day) (Year)

**17 I HEREBY CERTIFY, That I attended deceased from....., 191..., to....., 191..., that I last saw him alive on....., 191..., and that death occurred, on the date stated above, at.....m. The CAUSE OF DEATH\* was as follows:**

**7 AGE**  
.....yrs.....mos.....ds. **If Less than 1 day,.....hrs. or.....min.?**

.....(Duration).....yrs.....mos.....ds.  
**Contributory**.....  
(secondary)  
.....(Duration).....yrs.....mos.....ds.  
(Signed)....., M.D.  
....., 191... (Address).....

**8 OCCUPATION**  
(a) Trade, profession or particular kind of work.....  
(b) General nature of industry, business, or establishment in which employed (or employer).....

**9 BIRTHPLACE**  
(State or country)

**10 NAME OF FATHER**

\* State the Disease Causing Death, or, in deaths from Violent Causes, state (1) Means of Injury; and (2) whether Accidental, Suicidal, or Homicidal.

**11 BIRTHPLACE OF FATHER**  
(State or country)

**12 MAIDEN NAME OF MOTHER**

**18 LENGTH OF RESIDENCE (For Hospitals, Institutions, Transients, or Recent Residence).**

**13 BIRTHPLACE OF MOTHER**  
(State or country)

At place of death.....yrs.....mos.....ds.  
In the State.....yrs.....mon.....ds.  
Where was disease contracted, if not at place of death?.....  
Former or usual residence.....

**14 THE ABOVE IS TRUE TO THE BEST OF MY KNOWLEDGE**  
(Informant).....  
(Address).....

**19 PLACE OF BURIAL OR REMOVAL**..... **DATE OF BURIAL**  
....., 191...

**15**  
Filed..... 191...  
REGISTRAR.

**20 UNDERTAKER**..... **ADDRESS**.....

MARGIN RESERVED FOR BINDING.  
 WRITE PLAINLY, WITH UNFADING INK--THIS IS A PERMANENT RECORD.  
 Every item of information should be carefully supplied. AGE should be stated EXACTLY. PHYSICIANS should state CAUSE OF DEATH in plain terms, so that it may be properly classified. Exact statement of OCCUPATION is very important. See instructions on back of Certificate.

8-200 C  
 U.S. No. 98

the deaths upon which inquests were held in 1920 were of persons who were returned as having died violent deaths.

The proportion of medically uncertified to total deaths at ages under 1 was 2.1 per cent.; at higher ages it remained under 1 per cent. until the age of 45-55, reaching 1.4 per cent. at ages 65-75. The proportion was, as might be expected, much greater in rural districts than in towns. It was highest in the counties of Durham, 3.12 per cent., and Shropshire 2.75 per cent.; lowest in North London, 0.03 per cent., and Middlesex 0.13 per cent. To five causes 63 per cent. of the total uncertified deaths were attributed, viz. old age, heart failure, heart disease, convulsions and premature birth.

**Death Registration in U.S.A.**—The model law for the registration of births and deaths provides that no body shall be interred or otherwise disposed of or removed or temporarily held pending further disposition "more than seventy-two hours after death unless a permit for burial, removal, or other disposition thereof shall have been properly issued by the local registrar of the registration district in which the death occurred or the body was found. And no such burial or removal permit shall be issued by any registrar until, wherever practicable, a complete and satisfactory certificate of death has been filed with him. . . ." This insures the making of a death certificate and its registration in each instance of death unless the body is surreptitiously and illegally disposed of. In the rural districts of some localities bodies are frequently interred in private burial grounds and on farms in some chosen spot on the premises. Under these conditions bodies would occasionally be buried without registration, due to ignorance of the law. To meet the needs in such case the model law suggests a clause requiring every person or firm selling a casket or coffin (at retail) to keep a record showing the name and address of the purchaser, the name of the deceased, and date and place of death, and on the first of each month to report to the State Registrar the sales for the preceding month; also to inclose in each casket sold a notice calling attention to the requirements of the law and a blank certificate of death. These provisions do not apply when the person selling the casket is the undertaker in charge of the burial.

The responsibility of seeing that a certificate of cause of death is properly made out and filed with the registrar rests primarily upon the undertaker, according to the provisions of the model law, which specifies as follows:—

**SECTION 9.**—That the undertaker, or person acting as undertaker, shall file the certificate of death with the local registrar of the district in which the death occurred and obtain a burial or removal permit prior to any disposition of the body. He shall obtain the required personal and statistical particulars from the person best qualified to supply

them, over the signature and address of his informant. He shall then present the certificate to the attending physician, if any, or to the health officer or coroner, as directed by the local registrar, for the medical certificate of the cause of death and other particulars necessary to complete the record, as specified in Sections 7 and 8. And he shall then state the facts required relative to the date and place of burial or removal, over his signature and with his address, and present the completed certificate to the local registrar in order to obtain a permit for burial, removal, or other disposition of the body. The undertaker shall deliver the burial permit to the person in charge of the place of burial, before interring or otherwise disposing of the body; or shall attach the removal permit to the box containing the corpse, when shipped by any transportation company; said permit to accompany the corpse to its destination, where, if within the State of —, it shall be delivered to the person in charge of the place of burial.

## CHAPTER XV

### DEATH CERTIFICATION

THE revelations of the early returns of the Registrar-General as to the appalling mortality, especially from fever and from diarrhœa, in most of the large towns of England and Wales were a main impetus to sanitary work, and it is scarcely an exaggeration to maintain that modern sanitary science owes its continuance and extension to the registration of deaths and of their causes, and to the localization of the main forces of disease thereby insured. By this means, combined with the census returns, it has been possible to submit to numerical analysis the facts relating to the laws of vitality, the influence of age and sex, of civilization, occupation, locality, season, and many other agencies; and our knowledge of all the facts bearing on health and disease has attained a precision never before known.

The annual and weekly statistical returns of the Registrar-General and of local medical officers of health have drawn forcible attention to the local incidence of deaths, and it has thus become impossible to maintain complete inertia in respect of preventable sickness. As Benjamin Ward Richardson, writing of Farr's reports, eloquently said: it is now no longer true that pestilence walketh in the dark. It is measured and registered, walketh at last in the open day.

The form of certificate of death which the medical attendant on any deceased person is required to give is printed on page 158. For comparison the corresponding American standard form of certificate is also given.

**Ambiguous Certificates.**—The accuracy of registration of causes of death depends on the accuracy of the death certificate of the medical attendant, an essential fact which emphasizes the importance of direct instruction of every medical student in the duty of certification. Death certification cannot be more accurate than medical knowledge,

and in a certain number of cases ambiguous certification is inevitable. The attempt to substitute for an ambiguous an unambiguous entry, which is not backed by corresponding medical knowledge, involves misleading pseudo-accuracy in statistics.

There are several reasons for ambiguous and indefinite certification of causes of death. (1) As indicated above, the medical attendant, even though possessed of average medical knowledge, is doubtful of the real nature of the deceased's illness, and is unable to obtain an autopsy to clear up the diagnosis (see illustration p. 169). In exceptional cases doubt may continue after the autopsy, either because the pathologist was not competent, or because of essential obscurity in the case. The certificate of death is required for burial and for insurance benefits; the results of pathological examination may not be available until later. Modern diagnosis is becoming more complex, and it is doubtful if this difficulty can be overcome in the absence of adequate local professional supervision of certification. (2) The medical attendant is unwilling under present conditions of certification to state the real cause of death. This is particularly so when alcoholism or venereal disease is concerned. It applies to a less degree in death from cancer or tubercle. In some cases insurance considerations militate against accurate certification. (3) The medical attendant, through carelessness or apathy or ignorance of methods of certification, has used indefinite terms which do not convey the information required for classification, and which fail to show as fully as should be the cause of death.

Confusion between these reasons for ambiguity has led to much undeserved abuse of official methods of tabulation and classification of deaths.

The main cause of imperfect certification of deaths is the third enumerated above. Happily, it is steadily decreasing, as is shown by the proportion of deaths which the Registrar-General is obliged to classify as from ill-defined and unspecified causes.

The greater number of these occur in infancy and old age, i.e. at ages when the first cause of indefiniteness enumerated above is most operative, and definiteness of certification would often be in excess of knowledge. According to the

international rules, "ill-defined diseases" occurring in infancy and old age are omitted from this heading, and the adoption of this rule in 1911 in the English national returns meant that in 1920 only 1,734 deaths came under this heading, as compared with 33,954 if the indefinite headings of old age and infancy had been included. Fifteen years earlier the number in the wider sense was 50,529. The decrease is due almost entirely to fall in the number of deaths ascribed to old age and to atrophy, debility and marasmus of infants.

**Inquiries Addressed to Practitioners.**—For many years the Registrar-General has sent letters of inquiry relating to selected indefinite or obscure certificates. In 1920, inquiries were sent from the General Register Office to medical practitioners and coroners as to 6,402 indefinitely certified deaths, and 5,452 replies were received. The main causes of error in certification are set out in the "Suggestions to Medical Practitioners respecting Certificates of Death," prepared by the General Register Office, which are sent out to practitioners with books of forms of certificates. The following illustrations are given in the Registrar-General's Annual Report for 1920, based on answers to inquiries made as above.

"Basic meningitis" is a term wrongly used, not only for a type of sporadic meningococcal infection, but also for tuberculous meningitis. "Cerebro-spinal meningitis" meant cerebro-spinal fever in 142 out of 175 instances in 1920, but in the remaining 33 it did not. Of 128 cases returned as "pemphigus" of infants, 54 became syphilis after inquiry. Of 48 cases returned as "croup," 10 became diphtheria, 8 laryngismus stridulus, and 25 laryngitis. Of 70 certified as general paralysis outside asylums, only 40 were general paralysis of the insane; of 127 returned as peritonitis, 14 were tuberculosis, 4 cancer, 14 gastric ulcer, 28 appendicitis, 12 puerperal fever, etc.

**Loss of Comparability due to Increasing Accuracy of Certification.**—Increasing definiteness of certification tends to diminish comparability of statistics in many directions. Thus many deaths formerly returned as Cerebral Hæmorrhage now appear as Arterio-sclerosis; and deaths formerly ascribed to Old Age appear under Circulatory Diseases, etc.

The difficulty as regards cerebral hæmorrhage is being met in the Registrar-General's reports for England by listing separately deaths ascribed to cerebral hæmorrhage caused by arterio-sclerosis.

The document named above gives a list of unauthorized and indefinite or otherwise undesirable terms occasionally used in death certification, and adds the following remarks :—

In cases where an indefinite term has to be employed because more definite information is lacking, it would be well to indicate this fact in the certificate. The word "idiopathic" will be understood as indicating that the probable cause of the condition stated is unknown, e.g. idiopathic atrophy, idiopathic convulsions, idiopathic peritonitis, etc.

By "primary cause of death" is meant (in the case of deaths from disease) the disease, present at the time of death,<sup>1</sup> which initiated the train of events leading thereto, and not a mere secondary, contributory, or immediate cause, or a terminal condition or mode of death.

A terminal condition or mode of death should not be entered as a secondary or contributory cause. In a very large proportion of instances the statement of the primary cause gives all the information required; in these cases nothing is gained by adding as a secondary cause such a condition as syncope, heart failure, coma, exhaustion, etc. Thus a certificate of pulmonary tuberculosis is not improved by addition of "exhaustion" as a secondary cause, though if a complication such as "pneumothorax" had supervened this should be noted as a contributory cause of death.

The following additional rules from the same source are of importance :—

(a) **Smallpox.**—In certifying a death from smallpox, the patient's condition with respect to vaccination should be carefully stated—say, in one or other of the following forms: (1) No evidence of vaccination. (2) Vaccinated in infancy only—number of scars. (3) Vaccinated only after infection by smallpox. (4) Stated to have been vaccinated, but no scars. (If the patient has been re-vaccinated, the date should be given when possible.)

(b) **Cancer.**—Attention is particularly directed to the request that the seat of primary occurrence should be returned in all cases where known.

(c) **Diarrhœa.**—When this is due to improper feeding, or to any kind of food infection, the fact should be mentioned in the certificate. The Royal College of Physicians having condemned the use of the terms "*gastro-enteritis*," "*muco-enteritis*," and "*gastric catarrh*," as alternatives for the authorized term "*infective enteritis*," it is hoped that the use of these italicized terms will be entirely discontinued.

(d) **Childbirth.**—Whenever parturition or miscarriage has been in

<sup>1</sup> Acute specific diseases, if of recent occurrence, are to be considered the primary cause of death, even though the actual disease, as tested by power of infection, be no longer present at the time of death, e.g. measles (primary) 5 weeks; broncho-pneumonitis (secondary) 10 days.

any way a contributory cause of death, the fact should be mentioned on the certificates. Always qualify all diseases resulting from child-birth or miscarriage as puerperal, e.g. puerperal septicæmia, puerperal peritonitis, etc.

(e) **Violence.**—The term violence is understood as including all deaths from unnatural causes (including anæsthetics and poisons of all forms), whether accidental, suicidal, or homicidal.

It is rarely the duty of medical practitioners to issue certificates in the case of deaths from recently sustained violence, but it must be borne in mind that if a coroner declines to hold an inquest upon such a death a medical practitioner who has attended the deceased is bound by Section 20 of the Births and Deaths Registration Act, 1874, to give a certificate of the cause of death. When certifying deaths from violence which have not already been reported to the coroner (e.g. from paraplegia due to violence sustained many years before death), medical practitioners should advise the friends of the deceased to inform that official forthwith.

The following suggestions as to the form of certification of violent deaths are extracted from the Registrar-General's Circular to His Majesty's Coroners (1911)—

“In every case of death by violence or by suspected violence, whether the death resulted from the violence itself or from a pathological state induced by it, the verdict should state the form and means of violence, its accidental, suicidal or homicidal nature, and the nature of the injury, e.g. fracture of skull (*nature of injury*) due to being *accidentally* run over (*form of violence*) by a motor car (*means of violence*).”

(f) **Operation.**—In all cases where an operation has been performed for the disease or injury causing death, the operation, as well as the disease or injury for which it was performed, and any secondary conditions contributory to death and resultant from the operation, should be mentioned on the certificate. The interval between operation and death should also be recorded.

**Confidential Certification of Causes of Death.**—The medical certificate in this country is required to be handed to the informant, usually the nearest relative of the deceased, whose duty it is to register the death. The family thus are advised of the cause of death, which usually would also have been discussed before the patient's death. There is thus apt to be hesitation to state any cause which would be regarded unfavourably by surviving relatives. This subject, among others, was investigated by a Committee of the House of Commons on Death Certification, 1893, who recommended *inter alia*—

(2) That in each sanitary district a registered medical practitioner should be appointed as public medical certifier of the cause of death in cases in which a certificate from a medical practitioner in attendance is not forthcoming.

(3) That a medical practitioner in attendance should be required, before giving a certificate of death, to personally inspect the body ; but if, on the ground of distance or for other sufficient reason, he is unable to make this inspection himself, he should obtain and attach to the certificate of the cause of death a certificate signed by two persons, neighbours of the deceased, verifying the fact of death.

(4) That medical practitioners should be required to send certificates of death to the registrar, instead of handing them to the representatives of the deceased.

The British Medical Association on various occasions have advocated the reform recommended in (4) above. This was endorsed by Dr. Stevenson, of the General Register Office, who in giving evidence before the Royal Commission on Venereal Diseases (Cd. 8189, p. 21), proposed that a doctor should hand to the relatives of a deceased person a certificate stating only the fact of death, and should be required to send by post to the registrar a second certificate, on which he would set out the cause of death ; this certificate to be confidential, access to it being only possible on the order of a Court of Justice. There would doubtless be opposition to this proposal from insurance and other societies, but it would appear to be practicable for them to obtain independently the information required for their work.

In France and Germany apparently, and in Switzerland certainly, as well as in some other countries, there is confidential certification of causes of death. Thus in Paris the certificate furnished by the medical practitioner is numbered and kept secret by the Registration Office. The Swiss system is described by the late Sir Victor Horsley (*British Medical Journal*, November 7, 1914) as follows :—

The practitioner is furnished by the civil authorities with a form the upper part of which is detachable, and contains only the name of the deceased and a series number. This part is torn off and placed in a distinctive envelope by the practitioner in attendance, and must be delivered to the local registrar within forty-eight hours. The rest of the serially-numbered form contains spaces for the details of the cause of death, with a space wherein the practitioner can note the sanitary and social conditions of the dwelling of the deceased. This part is placed in a separate coloured envelope and sent with the other to the local registrar, who, however, forwards this second one unopened to the Central Health Statistical Bureau. The practitioner is remunerated for his certification.

It appears that the open form of certificate incorporated in a register accessible to the public is the special system

of the British Empire and the United States. Dr. Dunlop, the Scottish Registrar-General, in his evidence before the above-named Commission, opposed the confidential certification of cause of death, relying on the rapidly improving accuracy of registration. The present Scottish method differs from the English in that the registrar, when notified by the relatives of a death, sends to the medical attendant a form to be filled up, with a stamped envelope for its return. This certificate is open to access on payment of a fee, but the doctor is not called on to hand it in the first instance to the relatives.

It must remain doubtful to what extent the application of the Scottish, or still better of the Swiss system, would increase the accuracy of death certification. For such conditions as alcoholism and syphilis it would help greatly; for most other diseases the effect would be less. The more serious causes of defective certification of cause of death are lack of medical knowledge, especially in regard to infantile deaths and deaths in old age, and carelessness or ignorance of the scientific basis of death certification.

**Official Nomenclatures.**—The Registrar-General's "Suggestions" to medical practitioners as to the certification of deaths recommend the use of those terms only which are recognized in the Nomenclature of the Royal College of Physicians of London. This Nomenclature must not be confused with the "International List of Causes of Death," as now adopted for use in the official reports. The two types of publication deal with entirely different problems.

The "Nomenclature" furnishes medical practitioners about to certify a death with a list of acceptable forms of return *for the individual death with which they are concerned*. The "Manual of the International List of Causes of Death" is addressed to those, whether medical officers of health or official State statisticians, who are *concerned with the assignment to one or other of 206 headings* the many thousands of different forms of certificate which may be received by them.

In the United States the *Standard Nomenclature of Diseases and Pathological Conditions, Injuries and Poisonings for the United States*, First Edition, Washington, 1920, corresponds to the Nomenclature of the Royal College of Physicians. It has been prepared in the Bureau of the

Census under the direct supervision of Dr. W. H. Davis and Mr. R. C. Lappin, who state that this Nomenclature is an attempted consolidation of eight nomenclatures, including that of the Royal College of Physicians, London.

They incidentally make useful remarks on the inadvisability of deleting all functional names, e.g. anæmia, from the Nomenclature, because often "these symptoms give the only picture of the disease that is obtainable." A clean line between symptoms and diseases sometimes cannot be drawn; thus splenic anæmia may be a manifestation of syphilis, but should not be recorded under syphilis, unless the physician is confident. (On this see also p. 163.)

In this Nomenclature terms are cross-referenced, so no index is needed. The *Manual of the International Causes of Death*, 1912 (price 1s.), published by the General Register Office, London, fulfils both objects named above, for it gives the International List of Causes of Death, with sub-headings, guidance in classification to statisticians, and guidance in certification to medical practitioners. The very complete index, if utilized, removes doubt in any difficult case of certification or allocation. For a more recent edition of this List see page 173.

**Rules for Selection of Cause of Death.**—The general adoption of the International List (on this see p. 177) does not ensure, by itself, more than illusory comparability between local and national statistics, or between the statistics of different countries. This can only be secured by universal intelligent adoption by official statisticians of identical rules for allotment of causes of death to their appropriate heading.

A chief source of difficulty is that the medical certificate frequently gives more than one cause of death. On page xxxii *et seq.* of the *Manual* are given the rules used in the General Register Office, and on page xxxvi those of the International Commission in 1903. The two differ from each other in certain particulars. The rules of the International Commission have not been universally accepted, and they are not free from objection. For this reason English workers should preferably continue to use the English rules, thus preserving continuity with the past. For the definite headings for single diseases, the divergence in detailed rules for most diseases is not great. The rules as set

out in Appendix F have long been in use in the Registrar-General's office. They deal with principles of classification, and give specific instances of difficulty. The terms "primary" and "secondary" in the death certificate are indicative of the relative importance of the causes certified (see form of certificate, p. 158). They are intended to be used rather in a causal than in a chronological sense, though frequently the two will coincide. In Rule 10 of the English Office a chronic is preferred to an acute disease, while the corresponding French rule prefers an acute to a chronic disease. It would doubtless help in securing international uniformity in selecting the cause of death if the same form of certificate came into use in each country. In Continental countries merely "cause of death" is asked for. American and English certificates are now somewhat similar in the information required.

**Limitation to Disease "Present at the Time of Death."**

—This limitation, with the proviso stated in the footnote on page 165 (*Manual*, p. xxxviii) is only given in the English rules, though the international rules almost imply the same condition.

It is based on practical considerations. To act otherwise would involve complex considerations of causation. The further one goes back in the history of a patient, the more involved becomes the nature of causation. Thus every physician would agree in certifying a death from valvular disease of the heart; but there would be disagreement as to whether it was caused by the rheumatic fever from which the deceased suffered 30 years ago, or the syphilis which he acquired 10 or 15 years ago (see also p. 486).

**Accuracy of Statistics of Causes of Death.**—American experience is similar to that of England on this point. The *Physicians' Pocket Reference to the International List of Causes of Death* is sent on request to every physician in the United States, but the task of including nearly 900,000 deaths within the 189 (now 206) titles of the International List, especially when many physicians fail to use this guide, is great. The extent to which medical diagnoses may err is illustrated by the following extracts from figures relating to 3,000 autopsies in hospital practice in Boston, Mass., compiled by Dr. R. C. Cabot. The correct diagnosis per

100 cases assigned during life to each disease were as follows : diabetes mellitus, 95 ; typhoid fever, 92 ; aortic regurgitation, 84 ; cancer of colon, 74 ; lobar pneumonia, 74 ; chronic nephritis, 74 ; cerebral tumour, 73 ; gastric ulcer, 72 ; acute nephritis, 16 ; broncho-pneumonia, 33 ; acute endocarditis, 39 ; miliary tuberculosis, 52 ; active phthisis, 59. The results for phthisis are curious, and do not fit in with general experience. For both acute infectious diseases and tuberculosis, death certification may usually be accepted as not very inaccurate ; a possible exception is measles, deaths from which are sometimes returned as broncho-pneumonia, the primary disease being omitted from the certificate. On the other hand, Bright's disease, apoplexy, and certain cardiac affections are liable to be erroneously stated.

As in England, circular letters have been sent, together with copies of the *Physicians' Pocket Reference*, etc., to physicians in various parts of the United States requesting more precise statements of causes of death in cases reported as due to "meningitis," "paralysis," "convulsions," "pneumonia," and "peritonitis."

A paper by L. I. Dublin and E. W. Kopf (*Quarterly Publication of the American Statistical Association*, June, 1916) gives valuable figures of special action to the same end taken by the Metropolitan Life Insurance Company, New York. After acting first on a smaller scale, at last some 8·5 per cent. of the certificates of deaths received in the office were made the subject of inquiry from the certifying physicians. The following selection is taken from the printed table of results :—

PROPORTION OF DEATHS BEFORE INQUIRY (= 100) TO NUMBER AFTER INQUIRY.

Simple peritonitis .. ..	60	Cerebral hæmorrhage and apoplexy .. ..	106
Paralysis without specified cause .. ..	63	Influenza .. ..	109
Simple meningitis .. ..	68	Tuberculous meningitis .. ..	114
Locomotor ataxia .. ..	78	Alcoholism (acute or chronic)	121
General paralysis of the insane	80	Traumatism by fall .. ..	124
Acute nephritis .. ..	81	Syphilis .. ..	178
Cancer of unspecified site .. ..	90	Gonococcal infection .. ..	230
Lung tuberculosis .. ..	100	Cerebro-spinal fever .. ..	388
Appendicitis .. ..	104		

The figures opposite each disease represent the extent of presumably increased accuracy of certification produced by

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the inquiries. Although the answers to inquiries were in most instances probably not based on the results of autopsies, they give useful indications of relative degrees of accuracy in certification. The changes under alcoholism, syphilis, and gonorrhœa are significant.

A further remark is desirable on the additions made to syphilis in this investigation. Of 1,031 additions to the original, 1,322 entries under this heading, 148 were from *locomotor ataxia*, 49 were from *general paralysis of the insane*, and 104 from a large number of conditions, spinal lesions predominating. The advisability of transfer of deaths from locomotor ataxia and general paralysis of the insane to syphilis in classification is doubtful. The presence of syphilis was implied in the certificates as returned, and by their concealment under the general heading of syphilis much is lost (p. 485).

## CHAPTER XVI

### THE TABULATION AND CLASSIFICATION OF CAUSES OF DEATH

THE *Manual of the International List of Causes of Death*, 1912 (price 1s.), issued by the General Register Office, London, contains an admirable study of this subject, which is freely used in this chapter. A new edition of this will be shortly issued (1920 revision, see Appendix).

Some scheme is necessary in tabulating the causes of death for statistical presentation. The two chief sources of such statistics in this country are the reports of the Registrar-General and of local medical officers of health. A mere alphabetical list of the number of deaths under each heading would be too unwieldy for practical use, and deaths thus arranged would not show any natural relations of one disease with another.

Natural relations might be maintained by enumerating single diseases according to their anatomical site, or in accordance with their supposed causation. In tabulating English national statistics Farr recognized from the beginning the difficulties of classification according to cause, and adopted officially a regional arrangement according to anatomical sites involved. Such an arrangement is more stable than a classification by causation, which changes with increasing pathological knowledge; and it is in fact the only possible classification for practical purposes. There are, however, some diseases which do not lend themselves to this method of classification, viz. (1) infective diseases, due to infection *ab extra*, which may attack various parts of the body; (2) other general diseases, which may be the result of infection hitherto unrecognized, or of some dietetic error, or be of unknown source, e.g. cancer, rickets, etc. The main groups of the international classification are given below:—

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- I. Epidemic, Endemic and Infectious Diseases (1-41)
- II. General Diseases not included above (42-69).
- III. Diseases of the Nervous System and Sense Organs (70-86).
- IV. Diseases of the Circulating System (87-96).
- V. Diseases of the Respiratory System (97-107).
- VI. Diseases of the Digestive System (108-127).
- VII. Non-Venereal Diseases of the Genito-Urinary System and its Annexa (128-142).
- VIII. The Puerperal State (143-150).
- IX. Diseases of the Skin and Cellular Tissue (151-154).
- X. Diseases of the Bones and Organs of Locomotion (155-158).
- XI. Malformations (159).
- XII. Diseases of Early Infancy (160-163).
- XIII. Old Age (164).
- XIV. External Causes (165-203).
- XV. Ill-defined Diseases (204-206).

Those groups of causes of death are given for convenience. They do not constitute a natural system of classification. A high proportion of the diseases comprised in Groups II-XIII and in Group XV are really infective in character, and should logically come into Group I. The practical limitations of such transfer are considered below. Owing to changes of fashion in certification or advance of medical knowledge, it is somewhat dangerous to draw inferences from changes in the historical incidence, say of circulatory diseases or diseases of the nervous system, and still more so to compare one community with another in these respects. The use sometimes made of comparisons based on grouped classes of diseases is scarcely more scientific than Mark Twain's Christian Science method of division of the body into "Heart, Liver, Lights, Bones," etc. The groups in the official tables of causes of death should be regarded as a necessity for compact tabular statement, but their *use for comparative purposes should, as a rule, be eschewed.* (But see also p. 183.)

**Pathological v. Anatomical Classification of Causes of Death.**—Accurate knowledge of the pathology of each disease is indispensable for scientific certification of deaths; and there have been occasional struggles among nosologists

as to the relative merits of causal and anatomical grouping of results. The causal grouping cannot be consistently adopted, because the medical profession would not at present certify in accordance with it ; and because, if they attempted to do so, the certificates, written on this basis, would possess less value than at present, owing to inherent pathological doubts in a large proportion of deaths, and to changing views in pathology.

The anatomical classification of disease for statistical purposes evidently has its limitations, and in some instances it is difficult to decide on which side is the balance of practical advantage. Thus in the recent International Classification the heading gonococcal infection appears to imply that the rare deaths from systemic gonococcal infection, resulting in endocarditis, would require to be entered as gonococcal infection, while a similar rule would not apply to pneumococcal endocarditis. Stricture of the urethra due to gonorrhœa many years previously would, on the other hand, be classified under urethral diseases, in accordance with the rule that the cause selected for tabulation must be present at the time of death.

**Tuberculosis and Syphilis.**—On the other hand, tuberculosis is a well recognized infectious disease, and is rightly returned as such, whatever part of the body is affected. To place tuberculosis under the anatomical part of the body involved would in practice lead to confusion which is avoided by the present practice.

A similar remark applies, though less completely, for syphilis. For most parts of the body the specific or syphilitic disease should be classed under syphilis, if desired with anatomical sub-headings. There is great practical convenience in retaining separate headings for general paralysis of the insane, locomotor ataxy, and aneurism, which might be concealed if classed with syphilis. Their syphilitic character is adequately implied in separate classification.

Further grouped headings are considered on pages 180 to 186. From the above remarks and from what follows it is clear that grouped headings can only give approximate indications, and their conglomerate character should minimize their use for statistical purposes. But there may arise also—

**Fallacies of Statistics for Separate Diseases or Conditions.**—Of these a common but decreasing entry is “Old

Age," in necessary accordance with the medical practitioner's certificate. In 1901 this was the assigned cause of death of 101 deaths per 100,000 of the population of England and Wales, and of 96 in the year 1909, and of 67 in 1920. When such deaths are stated, as they should be, in terms of the population living at ages over 70, it is found still that the proportion has decreased. When "old age" is given in the death certificate along with the proximate cause of death, e.g. bronchitis or cardiac disease, the death is entered under the latter heading. The decrease under the heading "old age" has corresponded generally to the increase of the death-rate ascribed to diseases of the heart and blood-vessels.

The special cases of syphilis and gonorrhœa are discussed on page 175.

#### Illustrations of Difficulty in Allotment:—

1. A somnambulist while asleep falls and dies from a fractured skull.

2. A drunken man dies as the result of a fall from a plank.

In both these cases the death is classified as Accidental, under an appropriate sub-heading as to the nature of the accident. A secondary classification (p. 186) is desirable; and for alcoholic deaths is supplied in a special table of the Registrar-General's Annual Reports, and in the Reports of the American Bureau.

3. A chronic alcoholic drayman falls from his van and dies from erysipelas. The death is returned as Erysipelas (Rule 4 (e) on p. 607).

4. A man aged forty-five dies of cerebral hæmorrhage, stated to be probably due to syphilis. This would be classed with Syphilis.

5. An epileptic falling into the fire during a fit dies of his burns.

The special rule 4 (d) (p. 607) allots this death to epilepsy. On the other hand, there being no special rule to meet the case, the death of a patient with heart disease who faints in his bath and is drowned is classified under Accidental Drowning.

Many other instances arise in which allotment to a single heading is difficult, and may be arbitrary. Thus a death may occur from pelvic cellulitis or abscess, following parturition six months earlier; this raises the doubtful point as to the interval after confinement which should be allowed within which such a death should be returned as "puerperal septicæmia."

The following not uncommon certificates are especially difficult, and the difficulty could only be met completely by classification of secondary causes:—

Diabetes and Phthisis,  
Measles and Tuberculosis,  
Scarlet Fever and Diphtheria,  
Rheumatic Fever and Infective Endocarditis,  
Cerebral Hæmorrhage and Arterio-Sclerosis.

In the first of these, under the Registrar-General's rules, the death would be classified as Phthisis, in the fourth as the disease first named, while arterio-sclerosis would be preferred to cerebral hæmorrhage. In the third certificate the disease of longest duration, or the disease first mentioned, would be preferred.

**The International List of Causes of Death.**—In the Appendix is given the revised international list as agreed upon by an International Commission sitting in Paris, October, 1920. This represents the final stage of agreement for the tabulation of causes of deaths, to which the majority of civilized countries now conform. It provides a common standard for the compilation of mortality statistics, and so far as headings are concerned makes international comparisons for individual diseases practicable. The movement in this direction began in 1853 at the First International Statistical Congress at Brussels, when Drs. W. Farr and D'Espine were authorized to report on the subject. The list of diseases recommended by them was adopted by the Congress of 1855, and has since been revised several times. At the 1893 meeting of the International Statistical Institute, the successor of the Statistical Congress, this list was adopted with some modifications, and provision was made for decennial revision by an International Commission. The history of the movement is inseparably associated with the name of the late Dr. Jacques Bertillon, for many years chief statistician of the city of Paris, in whose honour it is commonly known as the Bertillon classification. The system was adopted in England in 1911, subject to certain modifications to ensure continuity with records for earlier years. For this purpose, of the 189 titles which it comprised (increased to 206 in the list on page 612), 65 were subdivided into 188 subdivisions. The recent revision will enable a great reduction to be made in the number of these subdivisions.

**The Shortened International List and Local Statistics.**—For many years it has been the duty of the medical officer of health of the 1,798 sanitary districts in England and Wales to prepare an annual report embodying the chief vital statistics of his district. Recently an instruction of the Ministry of Health recommends the publication of detailed statistics only once in five years. From 1911 onwards the Registrar-

General arranged a complete system of relegation of deaths to the district in which the deceased had resided, on a uniform system for the whole country. (For definition of transferable death, see page 195.) The short list recommended for the use of local sanitary reports was made comparable with the international short list of causes of death. (For particulars see page lviii of the Annual Report of the Medical Officer to the Local Government Board, 1910-11, and page lvi of the Report for 1911-12).

On pages xxiii-xxv of the *Manual* the means of comparing English and foreign returns on the shortened list are considered. The short list now in use is shown on page 179.

**Machinery of Central and Local Co-operation.**—Early in March of each year the Registrar-General supplies to each county medical officer of health for transmission to the several district medical officers of health in his county—(1) a statement showing the population, births by sex and legitimacy, deaths by sex from the diseases in the Short List of Causes of Death used in his Annual Reports, and total deaths of infants under 1 year of age by sex and legitimacy; and (2) a summary of the vital statistics for England and Wales and groups of towns for the year. Duplicates of the above are also sent to each county medical officer of health for his own use.

In April, each county medical officer of health receives a statement of deaths from the causes in the "Short List" by sex and age for the aggregate of urban and the aggregate of rural districts in his county.

The Registrar-General is prepared, when desired, to forward to the medical officer of health of each metropolitan or county borough about the middle of February a table of the Short List of Causes of Death by sex and age for his area.

The use of these centrally supplied tables obviates much laborious and irksome work on the part of the local medical officer of health. It furthermore ensures accurate local vital statistics. This is all to the good; and the risk that the local health officer may be tempted to avoid the important duty of studying week by week the death returns in his area will not be realized if he is intelligent and conscientious.

The annual statistics thus tabulated relate to the births and deaths registered during the calendar year, and are

corrected for inward and outward transfer (see pp. 80 and 195). They differ, therefore, from uncorrected figures compiled locally.

SHORT LIST OF CAUSES OF DEATH.

No.	Disease.
1.	Enteric Fever.
2.	Smallpox.
3.	Measles.
4.	Scarlet Fever.
5.	Whooping Cough.
6.	Diphtheria.
7.	Influenza.
8.	Encephalitis Lethargica.
9.	Meningococcal Meningitis.
10.	Tuberculosis of Respiratory System.
11.	Other Tuberculous Diseases.
12.	Cancer, Malignant Disease.
13.	Rheumatic Fever.
14.	Diabetes.
15.	Cerebral Hæmorrhage, etc.
16.	Heart Disease.
17.	Arterio-sclerosis.
18.	Bronchitis.
19.	Pneumonia (all forms).
20.	Other Diseases of Respiratory Organs.
21.	Ulcer of Stomach or Duodenum.
22.	Diarrhœa and Enteritis (under two years).
23.	Appendicitis and Typhlitis.
24.	Cirrhosis of Liver.
25.	Acute and Chronic Nephritis.
26.	Puerperal Sepsis.
27.	Other Accidents and Diseases of Pregnancy and Parturition.
28.	Congenital Debility and Malformation, Premature Birth.
29.	Suicide.
30.	Other Deaths from Violence.
31.	Other Defined Diseases.
32.	Causes ill-defined or unknown.

This list conforms to the rule previously enunciated. Few group items are included, and those left are to be regarded as a convenient aggregation of residual less important diseases, though special circumstances might arise necessitating careful investigation of any one disease in this conglomeration.

**Fallacies of Statistics for Groups of Diseases.**—The errors implied in historical or international comparisons of death-rates from groups of diseases may be gathered from the following illustrations :—

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## ENGLAND AND WALES.

### *Death-rate per Million Persons Living from Some Groups of Diseases.*

	1906.	1920.
Diseases of the nervous system <sup>1</sup> ..	1,032	574
Diseases of the bloodvessels <sup>2</sup> ..	874	1,097
Diseases of the liver and gall bladder .	175	87

<sup>1</sup> Excluding cerebral hemorrhage, apoplexy, hemiplegia.

<sup>2</sup> Including cerebral hemorrhage, apoplexy, hemiplegia.

Reference to the detailed International List of Causes of Death shows the complexity of diseases included in these groups. The first, for instance, embraces meningitis and chorea, as well as syphilitic diseases; the second arterio-

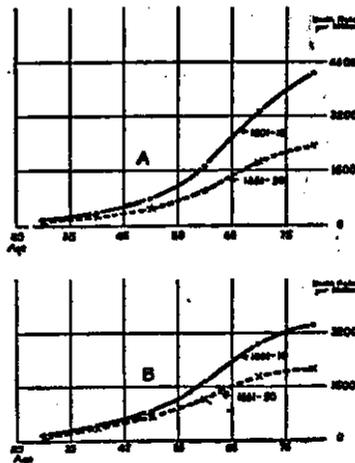


FIG. 16.—England and Wales:—Death-rate per Million Males at Each Age-Period over 25 in 1881-90 and 1901-10.

A, Valvular diseases of the heart, endocarditis and angina pectoris.

B, Acute and chronic nephritis, Bright's disease.

sclerosis and phlebitis, as well as aneurism and some other diseases; while the third includes alcoholic cirrhosis of the liver and other conditions. The utmost caution is needed in comparisons based on deaths under the above headings, whether the whole of each group or selected members of it are used.

Heart diseases and diseases of the respiratory system require separate discussion.

**Cardiac Diseases.**—Organic heart disease forms one of

the chief causes of death. But the same lesion may have, in different cases, differing origin; and attempts to classify the members of this group according to causation, although desirable, necessarily increase confusion unless the frequent occurrence of transference between members of the group and between these and causes of death previously included in other groups is remembered. In Fig. 16 a comparison of the age distribution of death-rates from valvular cardiac diseases at ages over 25 in two decennia is shown. The death-rate from these diseases has greatly increased at the higher ages; but this figure should be compared with

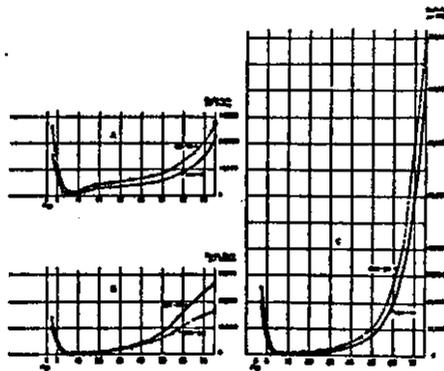


FIG. 17.—England and Wales: Death-rate per Million Males at Different Age-Periods in 1881-90 and 1901-10.

- A, Group of diseases with decreasing death-rate.<sup>1</sup>
- B, Group of diseases with increasing death-rate.<sup>1</sup>
- C, All other causes of death.

<sup>1</sup> CAUSES OF DEATH.

Group A, *Decreasing* from 1881-90 to 1901-10.

- Smallpox
- Measles
- Scarlet fever
- Whooping cough
- Croup
- Enteric fever
- Syphilis
- Tuberculosis
- Rheumatic fever and rheumatism of the heart
- Meningitis
- Epilepsy
- Laryngitis
- Bronchitis
- Pleurisy
- Violence

Group B, *Increasing* from 1881-90 to 1901-10.

- Influenza
- Diphtheria
- Diarrhoeal diseases
- Pneumonia
- Cancer
- Diabetes mellitus
- Valvular diseases of heart, endocarditis
- Nephritis and Bright's disease
- Suicide

Fig. 17, before it is concluded that any real increase in the death-rate from cardiac disease has occurred. In A is shown the combined death-rate from all the diseases in group A<sup>1</sup> according to age in two decennia at intervals of 20 years, in B the corresponding facts for group B and in C for all other causes of death is shown.

A comparison of A, B, and C, confirmed by the table on page 180, shows a decline in the aggregate of all causes of death. Evidently, then, there are three possibilities: (1) increased mortality from cardiac diseases in middle and advanced life has been more than counterbalanced by decreased mortality from other diseases; or (2) there has been merely transference of entries owing to gradually increasing accuracy of certification of deaths; or (3) these two factors are represented in the results to an uncertain extent.

In the International Classification (p. 615) subdivisions of cardiac diseases are given, and in the Registrar-General's Annual Review, 1921, the classification is as follows:—

## 87. Pericarditis.

## 88. Acute Endocarditis and Myocarditis.

- (1) Infective endocarditis.
- (2) Other acute endocarditis.
- (3) Acute myocarditis.

## 89. Angina Pectoris.

## 90. Other Diseases of the Heart.

- (1) Aortic valve disease.
- (2) Mitral valve disease.
- (3) Aortic and mitral valve disease.
- (4) Other or unspecified valve disease.

A pathological classification of the above conditions would imply an exact knowledge of the causation of each case. A large share, probably the great part of the total, besides the deaths definitely returned as "infective or ulcerative endocarditis," is caused by infection by special micro-organisms, of which the commonest are the rheumatic, the syphilitic and the pneumococcic, though the meningococcus, the diphtheria bacillus, and various septic organisms are responsible for many cases of endocarditis. To attempt such a subdivision of deaths is hopeless, and this is an instance in which the whole group is more instructive than

<sup>1</sup> See footnote on preceding page.

subdivisions of it. But the whole group cannot be trusted numerically, especially for comparative purposes; and if any use is made of it, the fact that it is a conglomerate and not a unit needs to be borne constantly in mind.

**Respiratory Diseases.**—Similar considerations apply to respiratory as well as to circulatory diseases. Grouped returns are open to criticism, but the individual items of

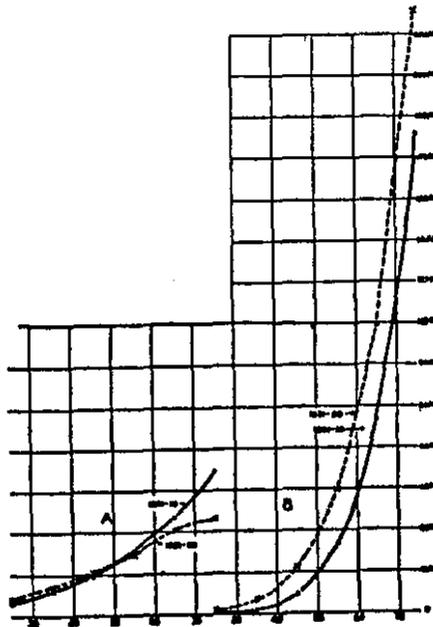


FIG. 18.—England and Wales: Death-rate per Million Males at Each Age-Period in 1881-90 and 1901-10 from—

A, Pneumonia.

B, Bronchitis.

each group vary according to fashions in certification and advance in knowledge. For pneumonia and bronchitis there is the special difficulty that in the earlier period the primary influenza or measles which preceded the pneumonia or bronchitis in all probability was oftener omitted from the certificate of death than in the later period. In the above curves the death-rates from pneumonia and bronchitis in England and Wales among males at various ages over 25 for the two periods 1881-90 and 1901-10 are compared.

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Internationally the difficulty is greater still.

RESPIRATORY DISEASES.

	Proportion of Total Deaths from Respiratory Diseases, 1913.		Death-rates per 100,000, 1906-10.	
	France.	England.	England and Wales.	Registration Area, U.S.
Pneumonia .. ..	32	24	123	144
Bronchitis .. ..	29	47	110	26
All other respiratory diseases ..	39	29	20	18
	100	100	253	188

The total respiratory death-rates in France and England in 1913 (not given in the above table) were similar, but the deaths were very differently distributed, as shown by the figures of proportionate mortality given above. The contrast given in the same table between death-rates in England and in the United States shows a great unexplained excess of mortality from bronchitis in England. In the following diagrams, for which I am indebted to Mr. T. J. Duffield of Harvard University, an interesting comparison of the death-rate from tuberculosis and from bronchitis in three countries is made. Judging from this diagram it would appear improbable that the higher death-rate from bronchitis in England is due to transfer from tuberculosis, though this possibility is not entirely excluded. The second diagram shows the relative death-rate from bronchitis in each of the three countries; the enormously excessive death-rate from this disease in England at ages 65 and over, and the smaller excess of the death-rate from this disease in Australia as compared with the United States at the same age-period are displayed; and the third diagram, showing the smaller death-rate from tuberculosis at ages over 45, lends colour to the possibility that at these ages there may be still some, though a diminishing, confusion of tuberculosis with bronchitis. There is much difference of opinion as to the frequency of senile tuberculosis. Owing to emphysema the results of physical examination may be dubious, and reliance must be placed on the discovery of tubercle bacilli in the sputum. In the United States the certification of chronic

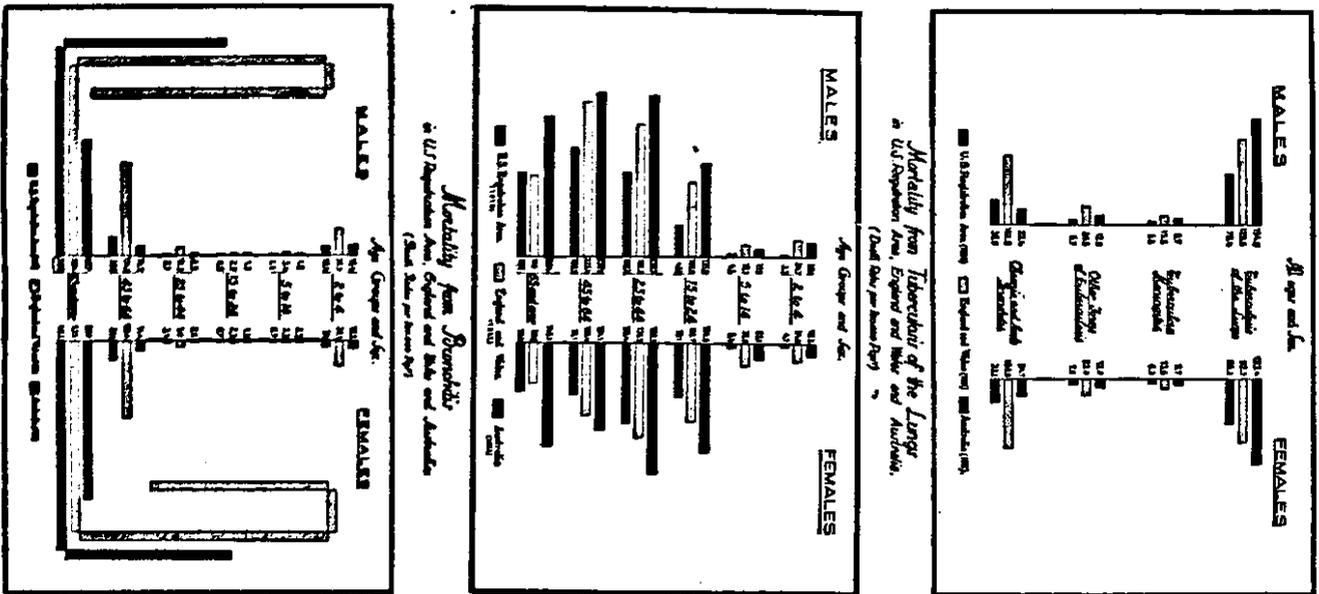


FIG. 19.

- A, Death-rates from Tuberculosis and Bronchitis in Three Countries, according to Sex.
- B, Death-rates from Pulmonary Tuberculosis in Three Countries, according to Age and Sex.
- C, Death-rates from Bronchitis in Three Countries, according to Age and Sex.

bronchitis is discouraged: thus in New York medical certificates stating chronic bronchitis as the cause of death are sent back for revision. These facts introduce doubt into the comparisons shown in the diagrams.

The preceding facts support the conclusion that a historical comparison of all respiratory diseases (excluding tuberculosis) together, or of bronchitis and all forms of pneumonia together, is more likely to be trustworthy than a comparison of each respiratory disease separately.

**Double Classification.**—Evidently, whatever rule be consistently applied in classifying (i.e. allotting) deaths according to cause, if two conditions are named on the certificate, there is some loss of knowledge. For instance, if a patient with cancer dies under an anæsthetic administered for its removal, it is important to tabulate the death both to cancer and to the anæsthetic. So also when a patient dies from pneumonia after accidental immersion, or from tetanus after a railway injury. This can only be done by subsidiary tables. For many years such subsidiary tables have been published in the Registrar-General's reports for mortality in connection with childbearing, and for deaths in which alcohol, anæsthetics, tumours, etc., were concerned. Such dual classification is especially valuable when dealing with statistics of alcoholism and some other conditions.

In the Registrar-General's Annual Report for 1911 was begun the tabulation of a number of causes of death in which secondary are stated in conjunction with the primary cause of death, each separate combination of causes being tabulated separately. Thus in the 1912 report is given a valuable statement in two tables of the different combinations of certificates all coming under the heading Syphilis. It was proposed to complete the treatment of all diseases by this method in about ten years, but unfortunately the war intervened. It will doubtless be continued, in view of its high medical value.

By such tables can be seen how many cases of broncho-pneumonia are concealed behind the main entry of whooping cough or measles; in how many deaths from tuberculosis diabetes was associated with the fatal result; what association in the opinion of the certifying physician there was between cerebral hæmorrhage and arterio-sclerosis, and so on.

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For the United States Death Registration Area a similar classification of *Contributory Causes of Death in relation to Primary Causes of Death* has been made since 1917 in the Federal Mortality Statistics. In that year 35 per cent. of the total deaths having a double assignment of causes of deaths were thus tabulated, and it is pointed out in the Annual Report for 1918 that "an occasional tabulation of this kind is essential to paint properly the mortality picture of the various causes of death." In 1917 alcoholism was credited in the regular tables with only 3,907 deaths, but the contributory table shows that 5,363 other death certificates had alcoholism given in them. Bright's disease, again, was credited with 74,369 deaths, but this was given as a contributory cause in 23,180 further deaths. In measles we learn that of 10,442 deaths, more than half had pneumonia as a contributory cause; and in scarlet fever in 507 out of 3,124 total deaths nephritis is also given on the certificates. Other instances are given in "Mortality Statistics" for 1918, exemplifying the value of these supplementary tables.

These American returns give only one secondary cause of death in each case, and the following illustration shows the difficulties in comparing international statistics. In "Mortality Statistics" for 1918, out of a total of 62,417 deaths from cerebral hæmorrhage, 14,842 were complicated by arterial disease, but there were only 24 from arterial disease complicated by cerebral hæmorrhage. In England, as stated on page 180, cerebral hæmorrhage is treated as secondary to and therefore a complication of arterial disease. That this implies incompleteness of classification of contributory causes, or that the practice in certification is very different in the two countries, is further suggested in the following table, giving the number of deaths from three diseases, which are closely inter-related through the occurrence of cerebral hæmorrhage:—

	1920. No. of Deaths from			Proportion from Each Cause to 100 Deaths from		
	Diseases of Arteries.	Cerebral Hæmorrhage.	Bright's Disease.	All Three Diseases.		
United States ..	(1) 19,977	(2) 70,780	(3) 72,488	(1) 12·2	(2) 43·4	(3) 44·4
England and Wales	11,626	23,107	10,691	25·6	50·9	23·5

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Arterio-sclerosis is not provided with a separate column in the American statistics; in England it appears to be superseding cerebral hæmorrhage as a cause of death. Renal disease is a common cause of cerebral hæmorrhage; and the fact that deaths under this heading are 7 times, while deaths under cerebral hæmorrhage are only  $2\frac{1}{2}$  times, as many in the United States as in England, points to considerable incomparability in the data.

## CHAPTER XVII

### DEATH-RATES

THE circumstances under which life ends are of primary importance to the hygienist and the social investigator. Assuming that accurate and complete population and mortality returns are available, deaths need to be considered in relation to age and sex, the place of death, the race, social conditions, occupation, marital condition of the deceased, and according to the certified cause of death. The items thus enumerated do not exhaust the possible categories. It will be seen that death-rates may be classified as general or specific, the first relating to all causes of death and to the general population, the second to special causes of death, or to deaths in special groups of the population. Whether general or specific death-rates are under consideration, two rules must always be followed:—

1st. The population used must be precisely that which produced the deaths contained in the death-rate; and conversely the deaths must comprise all the deaths occurring in this population and no others.

2nd. The preceding rule, which is the rule as to population "exposed to risk," should apply with equal rigidity to special death-rates for different ages, for the two sexes, for occupational groups, and for special causes of death.

These rules carry with them the execution of the method adopted in Great Britain since 1910 of transferring the records of deaths which occur elsewhere than in the administrative area in which is the home of the patient (p. 195). They embody the only sound principle of giving, so far as is practicable, "all the deaths occurring in the population" of a district, which may be more or less than all that occur in the district. They avoid, furthermore, the impossible task of attempting to allocate deaths to the place where presumably the fatal disease was contracted.

**General Death-rates.**—A general death-rate is the number of deaths occurring among a given number, say 1,000, of the population, *during a unit of time*, which, unless otherwise stated, is always taken to be a year.

**Estimation of Death-rate.**—The death-rate may be reckoned—(1) in proportion to every thousand of the mean population; or (2) the proportion of deaths, taken as unity, to the whole population may be stated. Thus, a death-rate per 1,000 of 19·3 is equivalent to 1 in 51. This second method has only historical interest.

In problems of life contingencies it is assumed that the deaths in each year of age are uniformly distributed. This assumption introduces an error which, except in the first two years of life, is very small. For the first two years, the recorded deaths are given by months in the Registrar-General's reports. The ratio between deaths and population is known as the *death-rate* or *rate of mortality*, having been so-called by Farr. By actuaries, however, it is known as the *central death-rate*, the name *rate of mortality* being reserved for the probability of dying in one year, *qx*.

**Death-rates for Short Periods.**—An annual death-rate per 1,000 implies the number of deaths that occur among 1,000 persons during a complete year. Death-rates for shorter periods are calculated on the assumption that the deaths would have continued in the same proportion during the remainder of the year. By this means the weekly-annual death-rates are placed on the same basis as the annual death-rates, and the figures are on a scale with which all are familiar. It is evident that the shorter the period to which a death-rate refers the greater the liability to error, owing to accidental causes of variation. The death-rate for a short period expresses a fact, the errors only arising when we draw too wide inferences from it. Large fluctuations from accidental causes occur, especially in connection with small populations. A temporarily high death-rate may, for instance, mean that, owing to the prevalence of inclement weather, a considerable number of unstable and fragile lives have their deaths slightly hastened.

For a week might be obtained, if there were 52 weeks in a year, by multiplying the deaths per year by 52, and then proceeding

as for an annual death-rate. But the correct number of days in a natural year being 365·24226, the correct number of weeks is 52·17747. Thus, if the population of a town is 143,956, its weekly population is

$$\frac{143,956}{52 \cdot 17747} = 2,758,$$

which is assumed to remain constant for the year for which the calculation is required. If there are 35 deaths in one week, the annual death-rate for the week in question

$$= \frac{35 \times 1,000}{2,758} = 12 \cdot 69$$

The alternative method of multiplying the deaths of each week by 52·17747 would require an additional arithmetical calculation each week.

Death-rates for *each quarter* refer to the 13 weeks most nearly corresponding with the natural quarter; and the quarterly population is obtained by multiplying by 13 the population of one week.

The death-rate for the entire year is sometimes made to relate to 52 (or 53) weeks, and sometimes to the 365 (or 366) days of the calendar year. The latter plan should be followed.

The death-rate, expressing the proportion borne by deaths from all causes to each thousand of the population, is known as the **crude death-rate**. The fallacies detracting from its use for comparative purposes must always be borne in mind. These relate chiefly to unusual distribution of persons of different ages and of the two sexes. The crude death-rate must be regarded as a first test of the vitality of a population. When used as a test of the salubrity of a small district, especially when an exceptionally low death-rate is concerned, it is to be regarded with suspicion. Some source of fallacy almost certainly lurks in the returns. The population in question may contain a large excess of women and very few children under 5, and adequate correction for "external deaths" (see p. 195) may not have been made. The crude death-rate for one year in an area with a small population may be compared with the death-rate in the same

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area in other years, within the same decade, but not legitimately with the death-rate of other areas. Even for larger towns marked differences in the distribution of population according to age and sex exist, and standardized death-rates (p. 224) are to be used in preference. Thus the factor of correction (p. 223), 1911 census, for Bath was 0·8648 and for Burnley 1·1051, and the crude death-rates of these two towns in 1912 were 12·9 and 15·0, the standardized death-rates being 11·2 and 16·6.

**Corrections for Residence.**—The chief difficulty in securing accurate local death-rates arises from the steadily increasing resort of patients to public institutions, such as hospitals, asylums, nursing homes, which are often situate outside the area in which the patient previously resided. For many years correction to a certain extent has been made in English statistics for such deaths.

The previous residence of persons dying in institutions is in each instance inserted in the weekly death-returns received by the medical officer of health from the local registrar of births and deaths in order to afford to the medical officer of health the means for obtaining the information necessary to correct the death statistics of his district. Until recently, however, in many small urban and rural districts this correction has been avoided, and erroneous because defective death-rates have been published. Evidently without further machinery the medical officer of health is enabled to exclude his "outward transfers," but not to include his "inward transfers."

A useful example of the theoretical corrections needed is furnished by the following case reproduced from the first edition of this book:—

The Wandsworth sub-district of the Borough of Wandsworth, London, had within its borders the County Lunatic Asylum, the Hospital for Incurables, St. Peter's Hospital, Wandsworth Prison, and the Royal Patriotic Asylum for Girls; and it sent its sick poor to the Wandsworth and Clapham Workhouse Infirmary, which was outside its borders, while some of its inhabitants died in the large metropolitan hospitals.

Total deaths in Wandsworth in 1885 were .. ..	628
Of these there occurred in its internal institutions ..	132

In addition there occurred in the Union Infirmary and other out-lying institutions 78 deaths.

The mean population of Wandsworth in 1885 was 31,497.

(1) The death-rate, uncorrected for deaths in internal institutions, and not including deaths in outlying institutions, was—

$$\frac{628 \times 1,000}{31,487} = 19.83 \text{ per thousand.}$$

(2) In order to ascertain the death-rate corrected for internal institutions without including the deaths in outlying institutions, we must ascertain the *population of its institutions* as well as their *deaths*. By the census of 1881 this was 1,482, which may be taken as nearly correct for 1885.

$$\text{Corrected population} = 31,497 - 1,482 = 30,015.$$

$$\text{Corrected deaths} = 628 - 132 = 496.$$

$$\text{Death-rate} = \frac{496 \times 1,000}{30,015} = 16.52.$$

(3) The death-rate, excluding the population and deaths of internal institutions, and including the deaths (but not the population, because this is unknown) of Wandsworth parishioners in outlying institutions.

$$\text{Population} = 30,015.$$

$$\text{Deaths} = 496 + 78 = 574.$$

$$\text{Death-rate} = \frac{574 \times 1,000}{30,015} = 19.12.$$

The last death-rate more nearly than any other represented the true mortality of the Wandsworth sub-district. For it excluded the population and deaths in its numerous internal institutions (to which Wandsworth contributed only an inappreciable quota) and it allowed for the deaths of Wandsworth parishioners in external institutions. The only fallacy was that no allowance was made in the population for those inhabitants of Wandsworth who were in the outlying institutions without their illness proving fatal. This number must, however, have been comparatively small, and could not very materially affect the result.

The need for such corrections as the above is urgent when it is desired to compare the effect of some branch of public health administration on the death-rate. Thus in one large city the good influence of a special type of work against tuberculosis was said to be demonstrated by the steadily declining death-rate from phthisis. On investigation it was found that a large proportion of the deaths from phthisis occurred in the city infirmary which was without the city boundaries, and that these deaths had not been included in the official statistics. When the necessary correction was made, city A had no greater decrease of death-rate from tuberculosis than city B, in which the same kind of anti-tuberculosis work had not been attempted. Even in the 29 boroughs into which London is administratively divided serious errors have arisen in the past by neglect to correct for

institutional deaths. The large general hospitals are nearly all grouped within the inner circle of London in a few boroughs ; so likewise are the large maternity and children's hospitals and various special hospitals. On the other hand, many institutions for metropolitan patients are in the country. This is especially true for lunatic asylums, convalescent institutions, asylums for the feeble-minded, and tuberculosis sanatoria. Inward and outward correction for all these deaths is needed to secure accurate and comparable results. In some instances the transference appears almost absurd, e.g. when the death of a patient dying after 20 years' residence in an external lunatic asylum is allotted to his former home ; but it works impartially, and to make an exception on account of prolonged residence in an external institution would lead to anomalous results.

The case of maternity institutions presents special difficulties, the rule of the Registrar-General being that—

the deaths of infants born and dying within a year of birth, at any temporary address (institution or private house) to which the mother went for her confinement, and deaths of infants in institutions to which they were transferred for treatment from the place of birth, are transferable to the district of fixed or usual residence of the mother.

Prior to the beginning of 1911 a gradually increasing effort had been made to refer deaths in institutions to the place of residence of the deceased ; but no attempt had been made either at the central clearing house (the General Register Office) in London or by local medical officers of health to correct for deaths other than those occurring in public institutions. The general result had been that death-rates calculated locally were generally understated by exclusion of the deaths of non-residents without corresponding inclusion of the deaths of residents occurring outside the district. Even in London, where systematic distribution of institutional deaths had been arranged, the deaths of non-Londoners were excluded, but those of Londoners occurring outside greater London were not included.

Many deaths, other than institutional, occur without the district of residence of the deceased, e.g. in a city street, in a railway accident, etc. In 1911, after careful consultation between the General Register Office and the Local Government Board, it was decided to attempt the formidable task of

relegating all transferable deaths, whether in an institution or not, in accordance with a uniform system.

**Transferable Deaths.**—A transferable death was defined as the death of a person who, having a fixed or usual residence in England and Wales, dies in a district other than that in which he resided. The deaths of persons without a fixed or usual residence, e.g. casuals, with rare exceptions, are not transferable. The adoption of the system of transference has been made possible by the Registrar-General—in whose office a copy of every death certificate is received—supplying every medical officer of health directly, or, outside county boroughs, through the county medical officer of health, with slips containing the particulars of deaths of residents not registered in the district. The rules for action in doubtful cases are set out in the following official note:—

(1) **Institutions.**—Persons dying in institutions for the sick or infirm, such as hospitals, institutions for the insane or mentally deficient, workhouses, and nursing homes, must be regarded as residents of the district in which they had a fixed or usual residence at the time of admission. If the person dying in an institution had no fixed residence at the time of admission, the death is not transferable. If the patient had been directly transferred from one such institution to another, the death is transferable to the district of residence at the time of admission to the first Institution.

- (a) **Almshouses, Convents, Industrial Schools, Institutions for the Blind, Poor Law Residential Schools, and other similar residential institutions** are not regarded as institutions for the sick or infirm, and should therefore be taken as the permanent addresses of the inmates.
- (b) **Homes for Incurables** are considered to be institutions for the treatment of the sick. Deaths occurring in them are treated as transferable.
- (c) **Poor Law Institutions** belonging exclusively to a single administrative area are regarded as part of that area for the purposes of death distribution, even although the institution may be situated outside the area it serves, as in such cases previous residence in the area in question can be inferred. Where, however, a Poor Law institution serves more than one administrative area, the area of previous residence cannot be inferred from the fact of residence in the institution, and consequently such deaths are treated as non-transferable in the absence of information as to the administrative area concerned. Every effort is made in such cases to ascertain the administrative area of previous residence from the authorities concerned, but when, for instance, the only information as to previous residence of an asylum inmate is that he was admitted from the workhouse of a union comprising several admini-

strative areas, the death cannot be transferred, for it is impossible to say to which particular area it belongs.

(d) **Prisons.**—Deaths in ordinary prisons are treated as transferable, but not deaths in Borstal institutions or in *convict* prisons, with the exception of the criminal lunatic asylums, which it has been decided to treat, not as convict prisons, but as lunatic asylums.

(e) **Residential Staff.**—The institution where resident is regarded as the usual residence.

(2) **Common Lodging Houses.**—In the absence of evidence of a more permanent residence being maintained elsewhere, a common lodging house will be regarded as the fixed or usual residence, whatever the length of stay.

(3) **Domestic Servants.**—Regarded as resident in employer's house, where residence is fixed for term of employment.

(The parents' home is regarded as the usual residence of unmarried domestic servants out of employment, in the absence of definite evidence of residence elsewhere.)

(4) **Hotels, Boarding Houses, etc.**—Deaths of persons in hotels, boarding establishments, apartments, etc., where they were temporarily resident without maintaining more permanent homes elsewhere, cannot be regarded as transferable.

(5) **Nurse Children** are regarded as resident where they are put out to nurse. Their deaths, therefore, are not transferable to the district of residence of parent.

(6) **Husband and Wife Living Apart.**—The death of a wife separated from her husband is not regarded as transferable to the husband's area of residence.

(7) **Seamen and Canal Boatmen.**—Unless there is evidence of a definite shore residence, these cases are treated as non-transferable.

(8) **Army and Navy.**—Deaths of members of His Majesty's Forces or of those of other nations are not now included in the statistics of any local area.

(9) **Infants.**—The deaths of infants born and dying within a year of birth, at any temporary address (institution or private house) to which the mother went for her confinement, and deaths of infants in institutions to which they were transferred for treatment from the place of birth, are transferable to the district of fixed or usual residence of the mother.

(10) **Deaths from Violence** are to be referred (a) to the district of residence, under the general rule; (b) if this district is unknown, or the deceased had no fixed abode, to the district where the accident occurred, if known; (c) failing this, to the district where death occurred, if known; and (d) failing this, to the district where the body was found.

There has thus been secured a really national rule of practice in the compilation of death returns, locally by each medical officer of health, and centrally by the Registrar-General. The importance of this reform is increased by the fact that from 1911 onwards the old system of publishing in

the Registrar-General's returns vital statistics for registration or Poor Law areas has been abandoned, administrative areas for public health purposes being substituted.

**Administrative Areas.**—In 1911 there were 14,614 civil parishes and 3,296 municipal wards in England and Wales. These are the minimum official subdivisions of Local Government areas. These parishes and wards are comprised in:—

1. Local Government areas,
2. Judicial areas,
3. Registration and Poor Law areas,
4. Ecclesiastical areas,
5. Parliamentary areas,

differing from each other in area and population, and with much overlapping of boundaries. Prior to 1911, the Registrar-General's vital statistics related to 3 above, which numbered 635, with 2,009 registration sub-districts. From 1911 onwards they relate to Local Government areas, which in 1911 numbered 1,747, and in 1921 had increased to 1,798.

A, County Boroughs	..	75		
B, Administrative Counties	..	62,	subdivided into—	
1. Urban Districts	1,090	{	(a) Metropolitan Boroughs	28
including			(b) Municipal Boroughs	.. 250
			(c) Other Urban Districts	.. 812
2. Rural Districts	..	657		

**Official Statistics.**—These statistics, so far as they relate to births, to infant mortality, and to total deaths, formerly from 29 now from 32 causes of death (p. 179), are published for every sanitary area in the Registrar-General's Annual Report, and can be compared with the corresponding items in the Annual Report of the local medical officer of health. The efficiency of the medical officer of health depends in no small measure on his weekly study of the vital statistics of his area, and on his annual stock-taking of the same statistics; and the arrangement for economizing his labour set out on page 178 needs to be safeguarded by this important consideration.

It will be seen that by the above means a corrected statement of all the deaths properly belonging to a given area can be obtained. It is impracticable, as already stated (p. 29), to obtain a corresponding corrected population for every area; but the possible error resulting from this is seldom large, and is usually insignificant.

Attempts at correction of deaths by *reference to district of origin* of disease are bound to end in failure. It is only practicable to correct for residence. Thus a man may lunch

in one area, dine in a second area, and reach home after a long motor ride, developing two days later a fatal attack of pneumonia or cerebro-spinal fever. The only plan equally applicable to all cases is to debit the death to the place of residence of the deceased.

**Deaths of Non-residents in the United States.**—In the United States the transference of “transferable” deaths, as defined on page 195, is hampered by the fact that each of the 48 States has an independent registration system. Reference to Table I, B, on page 96 *et seq.* of the Mortality Statistics, 1918, Bureau of the Census, shows that correction for non-residents sometimes makes large changes in local death-rates. Thus in Shreveport, Louisiana, the local death-rate would be increased by corrections 12 per cent., in Cambridge, Massachusetts, by 4 per cent., in Sacramento County, California, by 30 per cent. In health resorts for tuberculosis a large minus correction is often required. The rules for correction for non-residents are not identical with the English rules, and do not conform in all respects to the lines of action recommended above. They are as follows:—

Residence has been determined in each case exactly as it was done by the census enumerators in taking the population census in 1910.

Briefly stated, the principal points are as follows:—

Residence refers to “usual place of abode.” As a rule the “usual place of abode” is the place where a person regularly sleeps.

Non-residents therefore include—

Persons visiting a town.

Transient boarders or lodgers who have some other usual or permanent place of abode.

Students and children living or boarding in towns in order to attend some school or college, but not regarding the place as their home.

Servants or other persons working in town, but not sleeping there.

Decisions for special cases:—

(a) Civilian employees of the United States are treated as resident at the place where they regularly sleep. For example, employees in the Government offices in Washington who regularly sleep in Washington are treated as resident at Washington, even though they may have “legal residence” elsewhere.

(b) Any person who was formerly a resident of the town, but has since become an inmate of an *out-of-town* asylum, almshouse, home for the aged, reformatory or prison, is treated as resident at the town in which the asylum or prison is located.

(c) Persons having an unknown residence should be treated exactly as those having no permanent home or usual place of abode, and should be counted as residents of the place in which they die.

(d) Inmates of medical or surgical hospitals are usually there only for temporary treatment, and are therefore treated as resident at their home towns.

These differences in practice in the interpretation of "transferable" deaths need to be borne in mind in instituting international comparisons of local statistics.

**Effect of Migration on Death-rate.**—Evidently the death-rate in a given town or county or in an entire country may be changed by migration, when this changes the average age and sex constitution and the healthiness of the population. The mortality of most large and growing towns would stand higher than it does but for the large number of young and healthy immigrants from rural districts.

In watering-places and residential towns similarly the crude death-rate would be lowered greatly because of the large proportion of domestic servants, were this not more than neutralized by the influence of elderly people retiring to these towns. Thus in 1911 Bournemouth had a multiplying factor of correction (see p. 223) of 0.9142, Brighton of 0.9092, Hastings of 0.8410, etc.

It is unnecessary to assume that the migratory part of a population has had a full year's experience in the new residence, for migration presumably is a continuing process, and helps to determine the census population on which standardized death-rates (p. 221) are calculated, the outgoing balancing roughly the incoming residents of short duration.

The relative insalubrity of urban life fails in part to show itself in urban death-rates, owing to dilution of the effects of this insalubrity by importation of rural lives of higher value.

Some partial concealment of effects of local causes of insalubrity and mortality by migration occurs when occupational mortality and mortality from special causes is under consideration. A coal-miner may suffer as the result of his occupation, become unfit for it, and migrate to another area, dying there from disease engendered in his former occupation some years previously. The case of tuberculosis is particularly difficult. A person may die from this disease acquired two or three or even twenty years earlier from a consumptive relative. On the other hand, the infection of

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tuberculosis may remain latent unless provoked into activity by unsatisfactory recent conditions of life. These difficulties are not capable of complete statistical correction; but in drawing inferences to remember the existence of such possibilities is valuable in promoting caution and avoidance of dogmatism.

## CHAPTER XVIII

### MALE AND FEMALE MORTALITY AT DIFFERENT AGES, AND IN RELATION TO MARITAL CONDITION

THE crude death-rate at all ages is only a preliminary test in comparing the vitality of two communities, because the death-rate varies greatly at different ages and for persons of the two sexes. Corrections must therefore be made either by—(1) giving the death-rate separately for each successive period of life, or (2) calculating the standardized death-rate for the whole of life by the method to be described in the next chapter.

To obtain separate death-rates for different age-periods in the two sexes, we need to know—(1) The male and female population at these age-periods; (2) the male and female deaths at these age-periods.

The age-groups adopted by the Registrar-General for the vital statistics of England and Wales as a whole are :—

Under 1 month .. ..	25-
1-3 months .. ..	30-
3-6 months .. ..	35-
6-12 months .. ..	40-
Total under 1 year .. ..	45-
1- .. ..	50-
2- .. ..	55-
3- .. ..	60-
4- .. ..	65-
Total under 5 years .. ..	70-
5- .. ..	75-
10- .. ..	80-
15- .. ..	85 and upwards
20- .. ..	

In other tables the Registrar-General gives a statement of—

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- (1) Standardized Death-rate for All Ages.
- (2) Deaths of Infants under 1 Year per 1,000 Births.
- (3) Death-rate per 1,000 Living at Each Age-period.

0-	..	..	..	..	35-
5-	..	..	..	..	45-
10-	..	..	..	..	55-
15-	..	..	..	..	65-
20-	..	..	..	..	75-
25-	..	..	..	..	85 and upwards

The deaths at age-period 5-, commonly stated 5-10, mean the deaths at ages over 5 *and under* 10. In reading the tables of rates throughout this volume, and in most English official reports, the "dash" between the age-figures should be read as if it meant *and under*. In the American mortality statistics the age-groups are quinquennial, as above, in statistics of deaths from all causes, and decennial in statistics of causes of death, after the tenth year of life. The age-periods chosen are 10-19, 20-29, etc. Here 10-19 is equivalent to 10-20 in the English tabulation, and so on, a point to be remembered. In the English Census Report for 1921 this method of statement, e.g. 0-4, 5-9, etc., is adopted, with the definite indication that the figures refer to *age last birthday*. Retention of the older method appears to be preferable. The exact age 5 is the experience of a single day, so that any person not yet 5 years old is always between 0 and 5, and so for the ages between 20 and 25, etc.

To estimate the population in a given area at each age-period, the following method may be adopted. The total population male and female at the last census being known, the corresponding population for, say, 1923 is estimated by the modified method employed by the Registrar-General (p. 46). The population at the last census at each age-period is also known; and the corresponding numbers for 1923 are ascertained on the assumption that the population at the age-periods 0-5 . . . 55-65, etc., is the same fraction of the total population in 1923 that the population of these age-periods was of the total population in the census year 1921. This assumption may be only approximately correct, but no better method appears to be available.

**Errors in Method of Statement of Mortality.**—*Two erroneous methods* of estimating the rate of mortality at different ages require to be noted. The first of these is to calculate the proportion of deaths to total deaths, and

the second to calculate the proportion of deaths at various age-groups to the population at all ages. The fallacy involved in the first method arises from the fact that either a diminution in the total deaths or an increase in the deaths at any age-group would increase the proportional deaths at the age-group under consideration, though its interpretation in the two cases would be essentially different. Or if a reduction in both the total deaths and the deaths at a given age-group occurred, this last reduction might be entirely hidden by the statement of the result as a proportion between the two.

The second method is equally fallacious, inasmuch as apart from any conditions adverse to health, the number of deaths at various age-groups, and therefore the proportion of these to the entire population, will vary with the number living at the same age-groups.

For *small populations* a too minute division of age-groups is inadvisable. Given homogeneous data, deductions from a small number of individual facts are seldom so trustworthy as when the basis on which an inference is founded is wider and thus accidental causes of variation are to a large extent eliminated.

The *infant mortality*, i.e. of children less than one year old, is stated per 1,000 births in the same year. Chapter XXIX, deals with this important death-rate, including the occasional fallacy arising when the births vary greatly from year to year.

For the *United States* death registration area the report of the Census Bureau (1918) emphasizes the fact that—

comparison of the crude death-rates of different countries or of different places in a single country for a single year may serve as a starting-point for the investigation of conditions, but conclusions from such a comparison must be guarded, unless such factors as the age and sex distribution of the places compared are known and taken into account.

Unless birth returns are complete, death-rates for the first two years of life cannot be given with accuracy. The birth registration area of the United States is smaller than the death registration area, and census figures of population at these ages in all countries are far from reliable.

**Death-rates at Different Ages and in the Two Sexes.**  
—Table 3 of the Annual Review of the Registrar-General for 1921 gives a valuable table showing for every year since

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1881 and for groups of years since the beginning of civil registration the death-rates of males and of females for 12 age-groups. From advance sheets of the United States "Mortality Statistics" for 1921 the following American statistics are obtained, comparing for each sex American with English experience for the years 1911-15 and 1920 respectively:—

### ENGLAND AND WALES AND U.S.A.

*Death-rates per 1,000 Living at Each Age-period.*

Age.	Males.				Females.			
	1911-15.		1920.		1911-15.		1920.	
	Eng. and Wales.	U.S. Reg. Area.	Eng. and Wales.	U.S.	Eng. and Wales.	U.S.	Eng. and Wales.	U.S.
0-	40·6	37·8	35·7	32·0	33·8	31·2	28·5	26·0
5-	3·4	3·3	3·2	3·4	3·3	2·9	3·1	3·0
10-	2·0	2·2	1·9	2·4	2·1	2·0	2·0	2·1
15-	3·1	3·7	?	3·9	2·7	3·2	2·7	3·7
20-	3·9	5·3	?	5·0	3·1	4·5	3·9	5·3
25-	5·0	6·5	?	6·2	4·0	5·6	3·9	6·7
35-	8·3	10·1	?	8·3	6·6	7·9	5·4	7·6
45-	15·1	15·9	13·3	13·1	11·7	12·6	9·5	12·1
55-	30·8	30·1	25·2	26·7	23·6	24·9	19·4	24·2
65-	65·9	61·7	56·1	58·6	52·6	54·5	45·3	55·0
75-	143·5		130·5		123·5		112·4	
85 and upwards	279·5	} 144·6	235·4	} 145·0	253·0	} 136·4	246·1	} 138·4

There are interesting differences in the experience of the two countries. Comparing the experience of the two countries in 1911-15, the male death-rate at ages under 5 is much lower in the United States; while from ages 15 onwards to 55 that of the United States is higher than that of England. For the female death-rate the excess in the United States after the age of 5 persists until the age of 75.

The death-rate in each country is highest at the two extremes of life; but the very high death-rate at ages 0-5 has greater importance than the death-rate at ages 65 and over, for two reasons: (1) the child population is much larger than the population surviving to ages over 65, and (2) the possibilities of utility of each person have not been reached in childhood, while at ages over 65 they are approaching their end.

The preceding table shows clearly that the age-distribution of the population which would be most favourable to a low crude total death-rate for all ages is one which contains an unusually large proportion of persons aged 5 to 45, and relatively few infants or old people.

**Effect of Sex on Mortality.**—The same table shows that in England at all ages except 10–15, and at all ages in the States, the death-rate in the male is higher than in the female sex. The difference between the experience of the two sexes in 1911–15 is shown in the following table:—

PERCENTAGE EXTENT TO WHICH THE DEATH-RATE OF FEMALES DIFFERS FROM THAT OF MALES AT DIFFERENT AGE-PERIODS IN THE 5 YEARS 1911–15.

	0-	5-	10-	15-	20-	25-	35-	45-	55-	65-	75-	85 and upwards
England & Wales } -16	-3	+5	-13	-20	-20	-20	-22	-23	-20	-14	-10	
U.S. Reg. Area	-17	-12	-9	-13	-15	-14	-11	-21	-17	-12	-6	

With the exception noted above, males suffer from a higher death-rate than females at all ages. There is a great excess of male mortality in childhood, and from the age of 20 onwards at nearly all ages there is an even greater excess in England. This is much less marked in the States.

The standardized death-rate (see p. 219) of males regularly exceeds that of females. The excess was about 9 per cent. until about 1860, but in the 15 years ending with 1914 it averaged about 20 per cent. It increased to 30 per cent. in 1917, doubtless owing to the withdrawal of the best part of the male population from civilian statistics. In 1921 the excess had become 21 per cent. Distributed according to age, in 1921 male exceeded female rate of mortality at ages under 5 by 25 per cent.; at ages 5–10 by 3 per cent., at ages 15–45 by 39 per cent., at ages 45–55 by 39 per cent., at ages 55–65 by 30 per cent., at ages 65–75 by 21 per cent., and at ages 75–85 by 14 per cent. At ages 10–15 male mortality was 3 per cent. less, at ages 85 and over it was 5 per cent. less than that of females.

The exceptional experience of the period near puberty is illustrated in the following table, showing death-rates at various age-periods under 20 in successive groups of years. The figures in black type show where the female exceeds the male death-rate at the corresponding age-period.

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## ENGLAND AND WALES.

*Death-rates per 1,000 Living of Each Sex at Each Age-period.*

Period.	At Ages							
	0-5.		5-10.		10-15.		15-20.	
	M.	F.	M.	F.	M.	F.	M.	F.
1841-50	71.2	61.1	9.2	8.9	5.1	5.4	7.1	7.9
1851-60	72.4	62.7	8.5	8.4	4.9	5.1	6.7	7.4
1861-70	73.5	63.7	8.2	7.8	4.5	4.5	6.2	6.6
1871-80	68.4	58.3	6.7	6.2	3.7	3.7	5.3	5.5
1881-90	61.6	51.9	5.3	5.3	3.0	3.1	4.3	4.4
1891-1900	62.7	52.8	4.3	4.4	2.4	2.6	3.8	3.7
1901-10	50.0	41.9	3.5	3.6	2.1	2.2	3.1	2.9
1911-16	40.6	33.8	3.4	3.3	2.0	2.1	3.1	2.7
1916-20	34.1	28.2	3.6	3.6	2.4	2.5	?	3.6

The same table also indicates clearly the great decline in death-rate at each age-period in both sexes.

The historical course of infant mortality and of the death-rate for each of the first five years of life is seen in Figs. 44, 47, and 48.

The changes at ages over 20 can be seen in part in the tables on pages 204 and 208.

In order that it may be better appreciated how comparatively infrequent is death in old age the following table is given at this point:—

### UNITED STATES REGISTRATION AREA, 1920.

*Proportion of Deaths at All Ages (= 100) at Different Age-periods.*

Age.	Males.	Females.
First 5 years . . . . .	23.0	20.3
Twenty years, 5-25 . . . . .	10.2	11.1
Twenty years, 25-45 . . . . .	16.8	18.2
Twenty years, 45-65 . . . . .	22.4	20.1
Ages 65 and upwards . . . . .	27.6	30.3
		100.0

Thus in actual experience only 27.6 per cent. of the male and 30.3 per cent. of the female live over 65.

Sex Mortality in Infancy.—The difference in the female lives is shown markedly in the first of the live-birth,

through every week of the first month, and in each trimester of the first year of extra-uterine life; and it is shown in American and in English experience alike. That greater facility of birth of females owing to a smaller cranium is not the sole cause is evidenced by the persistence of the phenomenon of superior vitality at higher ages.

DEATH-RATE AT EACH PERIOD OF INFANCY PER 1,000 BIRTHS.

	England and Wales, 1920.		United States, Birth Registration Area, 1920.	
	Males.	Females.	Males.	Females.
Under one day .. .. .	11.5	9.1	16.7	12.7
1 day and under 1 week ..	13.2	9.9	16.4	12.4
2nd week .. .. .	5.9	4.8	6.0	4.8
3rd week .. .. .	5.2	3.9	4.1	3.4
4th week .. .. .	3.8	2.8	3.5	2.7
Total under 1 month .	39.7	30.4	46.7	36.1
1 to 3 months .. .. .	18.3	13.0	14.5	11.3
3 to 6 months .. .. .	14.0	10.9	14.5	11.7
6 to 9 months .. .. .	10.2	8.4	10.7	9.2
9 to 12 months .. .. .	7.8	6.6	8.8	7.8
	90.0	69.3	95.1	76.1

It is pointed out in the Registrar-General's Annual Report for 1921 that the excess in mortality of male infants has slowly increased. Prior to 1900 the male infant mortality usually exceeded the female about 21-22 per cent.; during the present century the difference has become greater with the increasing decline in total infant mortality.

In the same report attention is drawn to the bearing of these changes on the proportion between avoidable and inevitable infant mortality. As the death-rate falls, the share of the latter group must increase; and the fact that in recent years improvements in environment have been accompanied by a smaller decline in male than in female mortality suggests that a higher proportion of male than of female mortality is unavoidable. This is confirmed by the greater male excess in the earlier months of infancy. In foreign countries similar statistics are seen. Thus comparing experience in years of maximum and of minimum infant mortality, the male excess of infant mortality in Belgium was 18 per cent. (max.) and

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ENGLAND AND WALES.

*Death-rates per 1,000 Living of Each Sex at Each Age-period.*

Period.	At Ages							
	0-5.		5-10.		10-15.		15-20.	
	M.	F.	M.	F.	M.	F.	M.	F.
1841-50	71.2	61.1	9.2	8.9	5.1	5.4	7.1	7.9
1851-60	72.4	62.7	8.5	8.4	4.9	5.1	6.7	7.4
1861-70	73.5	63.7	8.2	7.8	4.5	4.5	6.2	6.6
1871-80	68.4	58.3	6.7	6.2	3.7	3.7	5.3	5.5
1881-90	61.6	51.9	5.3	5.3	3.0	3.1	4.3	4.4
1891-1900	62.7	52.8	4.3	4.4	2.4	2.6	3.8	3.7
1901-10	50.0	41.9	3.5	3.6	2.1	2.2	3.1	2.9
1911-15	40.6	33.8	3.4	3.3	2.0	2.1	3.1	2.7
1916-20	34.1	28.2	3.6	3.6	2.4	2.5	?	3.6

The same table also indicates clearly the great decline in death-rate at each age-period in both sexes.

The historical course of infant mortality and of the death-rate for each of the first five years of life is seen in Figs. 44, 47, and 48.

The changes at ages over 20 can be seen in part in the tables on pages 204 and 208.

In order that it may be better appreciated how comparatively infrequent is death in old age the following table is given at this point:—

### UNITED STATES REGISTRATION AREA, 1920.

*Proportion of Deaths at All Ages (= 100) at Different Age-periods.*

Age.	Males.	Females.
First 5 years .. .. .	23.0	20.3
Twenty years, 5-25 .. .	10.2	11.1
Twenty years, 25-45 .. .	16.8	18.2
Twenty years, 45-65 .. .	22.4	20.1
Ages 65 and upwards .. .	27.6	30.3
	100.0	100.0

Thus in actual experience only 27.6 per cent. of the male and 30.3 per cent. of the female deaths occur at ages over 65.

**Sex Mortality in Infancy.**—The superiority of female lives is shown markedly in the first day after live-birth,

through every week of the first month, and in each trimester of the first year of extra-uterine life; and it is shown in American and in English experience alike. That greater facility of birth of females owing to a smaller cranium is not the sole cause is evidenced by the persistence of the phenomenon of superior vitality at higher ages.

DEATH-RATE AT EACH PERIOD OF INFANCY PER 1,000 BIRTHS.

	England and Wales, 1920.		United States, Birth Registration Area, 1920.	
	Males.	Females.	Males.	Females.
Under one day .. .. .	11.5	9.1	16.7	12.7
1 day and under 1 week ..	13.2	9.9	16.4	12.4
2nd week .. .. .	5.9	4.8	6.0	4.8
3rd week .. .. .	5.2	3.9	4.1	3.4
4th week .. .. .	3.8	2.8	3.5	2.7
<b>Total under 1 month .</b>	<b>39.7</b>	<b>30.4</b>	<b>46.7</b>	<b>36.1</b>
1 to 3 months .. .. .	18.3	13.0	14.5	11.3
3 to 6 months .. .. .	14.0	10.9	14.5	11.7
6 to 9 months .. .. .	10.2	8.4	10.7	9.2
9 to 12 months .. .. .	7.8	6.6	8.8	7.8
	<b>90.0</b>	<b>69.3</b>	<b>95.1</b>	<b>76.1</b>

It is pointed out in the Registrar-General's Annual Report for 1921 that the excess in mortality of male infants has slowly increased. Prior to 1900 the male infant mortality usually exceeded the female about 21-22 per cent.; during the present century the difference has become greater with the increasing decline in total infant mortality.

In the same report attention is drawn to the bearing of these changes on the proportion between avoidable and inevitable infant mortality. As the death-rate falls, the share of the latter group must increase; and the fact that in recent years improvements in environment have been accompanied by a smaller decline in male than in female mortality suggests that a higher proportion of male than of female mortality is unavoidable. This is confirmed by the greater male excess in the earlier months of infancy. In foreign countries similar statistics are seen. Thus comparing experience in years of maximum and of minimum infant mortality, the male excess of infant mortality in Belgium was 18 per cent. (max.) and

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23 per cent. (min.), of France 20 and 22 per cent. respectively, of Prussia 17 and 19 per cent., and so on.

**Increases and Decreases of Death-rates at Different Age-periods.**—In the following table<sup>1</sup> is shown the historical trend of the death-rates of England and Wales in five successive decennial periods, the increase or decrease of the death-rate for various age-groups being stated as a percentage of the death-rate for the preceding period :—

*Increase or Decrease per Cent. of the Death-rate for Each Sex and Age-group Compared with the Death-rate for the Same Group in the Immediately Preceding Decennium.*

		England and Wales.			
		1871-80 compared with 1861-70.	1881-90 compared with 1871-80.	1891-1900 compared with 1881-90.	1901-10 compared with 1891-1900.
<b>Males</b>					
under 5	..	- 6.9	-10.0	+ 1.8	-20.2
5-	..	-18.1	-20.3	-19.4	-18.7
10-	..	-17.3	-20.4	-17.1	-16.1
15-	..	-15.1	-17.8	-12.2	-18.5
20-	..	-13.1	-22.1	-11.7	-17.4
25-	..	- 6.0	-16.9	-13.0	-17.6
35-	..	+ 2.3	-10.2	- 7.2	-20.4
45-	..	+ 4.2	- 3.5	- 2.2	-14.4
55-	..	+ 5.2	- 0.5	+ 0.7	- 9.0
65-	..	+ 3.9	+ 1.1	- 0.1	- 7.9
75 and over		+ 2.3	- 3.9	- 1.6	- 4.8
<b>Females</b>					
under 5	..	- 8.4	-11.0	+ 1.6	-20.7
5-	..	-20.1	-15.6	-16.9	-17.3
10-	..	-17.5	-16.4	-17.5	-15.6
15-	..	-17.9	-18.9	-17.1	-21.1
20-	..	-14.6	-18.7	-19.5	-21.6
25-	..	-11.4	-14.4	-17.5	-22.0
35-	..	- 3.6	- 9.0	- 9.4	-21.5
45-	..	- 0.2	- 3.3	- 2.4	-15.1
55-	..	+ 2.7	- 0.7	- 0.1	-12.6
65-	..	+ 3.2	- 1.0	+ 0.5	-11.2
75 and over		+ 0.8	- 5.2	- 1.1	- 7.0

In the following table is given a comparison of the percentage change in male and female death-rates at each age-period, comparing 1910 with 1900, and 1920 with 1910 in

<sup>1</sup> From Table XI on page xxvii of Supplement to Seventy-Fifth Annual Report of the Registrar-General of England and Wales, Part III.

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the death registration States of the United States.<sup>1</sup> Comparisons for other years and more detailed comparison for various parts of the United States can be made by utilizing the data given in the volume on the United States Life-Tables.<sup>2</sup>

**U.S.A.—REGISTRATION STATES OF 1900.**

*Increase or Decrease per Cent. of the Death-rate for Each Sex and Age-group Compared with the Death-rate for the Same Group 10 Years Earlier.*

Age-periods.	Males.		Females.	
	1910 compared with 1900.	1920 compared with 1910.	1910 compared with 1900.	1920 compared with 1910.
0-5 .. .. .	-16	-29	-16	-32
5- .. .. .	-21	- 8	-24	-14
10- .. .. .	-14	- 4	-22	-12
15- .. .. .	-20	0	-27	+ 6
20- .. .. .	-21	- 9	-25	+ 6
25- .. .. .	-28	-11	-23	+ 6
35- .. .. .	- 2	-21	-14	- 9
45- .. .. .	+ 3	-19	- 8	- 6
55- .. .. .	+ 7	-13	0	- 6
65- .. .. .	+ 6	- 6	+ 4	- 1
75 and over .. ..	+ 3	- 3	+ 2	- 2

Experience in England, when 1871-80 is contrasted with 1861-70, shows an increased death-rate at all ages over 35 for males, and at ages over 55 for females. When 1881-90 is contrasted with 1871-80, there is no evidence of increased death-rate at any age except in men aged 65-75; and the experience of the 20 years 1891 to 1910 shows a declining death-rate in both sexes at all ages, with the exception of a slight increase at ages 55-65 in males and at ages 65-75 in females in 1891-1900, owing probably to the influenza pandemic of 1889-93. There has been steady advance in the age to which increasingly favourable death-rates extend.

The experience of the United States as shown above indicates some increase of death-rates for males at ages 45 and upwards between 1900 and 1910, without any corresponding female experience, except at ages over 65. Comparing 1920 with 1910, the female death-rate shows some increase

<sup>1</sup> The percentage changes in death-rates have been calculated from tables supplied in advance of publication by Dr. William C. Davis of the Washington Bureau.

<sup>2</sup> United States Life Tables (Washington, 1921).

between 15 and 35. The experience of Massachusetts can be compared in the American Life Tables for 1890, 1900-2 and 1910. The male death-rate for ages over 65 increased in each of the later periods in males, when compared with 10 years earlier; and this held good for the female death-rates for age-periods over 55. The American experience is much more affected by immigration of foreign populations than that of England; but looking at the facts broadly it would appear that so far as concerns changes in the age-distribution of death-rates the registration area stands historically in the same position as England in 1871-80.

Writing in 1893, I commented on the earlier conditions in England as follows:—

Although in England, owing to the large number of lives saved during the early years of life, the number surviving to the higher ages has increased, thus securing a great gain to the community, this is not incompatible with a stationary or even diminished prospect of life for each individual over a certain age. In England the death-rate for males was higher in 1871-80 for *all age-groups above the 25-35 period*, and for females was higher in 1871-80 for all age-groups above the *35-45 period* than in preceding decennial periods.

After discussing the influence of increased wages and improved nutrition in more than counterbalancing the tendency of city life to cause a heavier mortality, stress was laid at the same time on the following factor, which must, I believe, be given a large share of the credit for the reduced death-rate which has now been realized at older as well as at younger ages.

Another consideration requires to be borne in mind. We are at present in a transition period. The Public Health Acts of 1871 and 1875 heralded immense improvements in sanitation, the fruits of which have not yet been fully reaped. There has been, more especially since 1875, steady and increasing improvements in the conditions under which people live. Men now 40 years of age were born in the pre-sanitary period, and the first 20 years of their life were spent under more unhygienic conditions than those now holding good. This fact would go far towards explaining a stationary death-rate at the higher ages. It does not, however, explain an increased death-rate at those ages.

The explanation of this increased death-rate at the higher ages will probably be evident when at the end of another 20 or 30 years the improved conditions of life have endured sufficiently long to enable their full force and value to be determined. We must be content in the meantime to have stated the more important factors which appear to be at work, leaving the complete solution of the problem to a time when the statistical experience of our country is more mature.

At the end of the time mentioned in the last sentence, it is noteworthy that at every age, even beyond 75 years of age, the number dying for a given number at risk has decreased; and the improved conditions of modern life, sanitary, social, and economic, have resulted in England in a lowered death-rate at every recorded age-period. The exceptions to this statement due to the abnormal events of 1914-18 do not invalidate the conclusion as to the trend of events. This subject is further discussed in Chapter XXII, by means of life-table expectations of life and of a statement of the number of survivors at given ages out of a given number at birth.

**International Comparisons of Death-rates According to Age.**—The Registrar-General's Annual Report for 1909 (p. cxviii) gave an interesting study of male and female death-rates in 11 age-groups from which the following particulars are taken. From this study it appears that from ages 10 to 35 the English mortality experience was very favourable, and from 35 to 75 was almost equally unfavourable, especially in the male sex. The following table illustrates the last-named point:—

DEATH-RATES OF MALES PER 1,000 LIVING AT EACH AGE-GROUP.

Country.	Date of Experience.	0-5.	35-45.	45-55.	65-85.
New Zealand .. ..	1900-02	25.0	6.9	11.9	22.0
Queensland .. ..	1900-02	31.8	10.8	16.5	22.0
Denmark .. ..	1900-02	42.1	8.1	13.5	24.7
Sweden .. ..	1899-1901	40.3	8.3	12.4	22.0
Italy .. ..	1900-02	76.9	8.4	13.6	27.0
Netherlands .. ..	1898-1900	55.4	7.6	12.9	25.4
Belgium .. ..	1899-1901	59.4	9.1	16.4	30.1
Switzerland .. ..	1899-1901	50.6	10.4	18.8	34.3
England and Wales ..	1900-02	58.3	10.9	18.7	34.8
France .. ..	1900-02	51.7	11.6	17.5	31.5
Germany .. ..	1901	80.3	10.1	17.7	32.5

This comparison, as remarked by Dr. Stevenson in the above report, indicates that "much of the mortality amongst our middle-aged and elderly men must be preventable, though not prevented." The publications of the International Statistical Institute make comparisons possible on similar lines for more recent years.

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It will be noted that there is no consistent connection between child mortality and mortality at higher ages (see p. 358).

In the Annual Report of the Registrar-General for 1910 (pp. xci and xcii) are given tables comparing the male and female death-rate from all causes in 20 countries in age-groups. The relative position of England and Wales in relation to these 19 other countries is shown below:—

	All Ages.	Under 5	5-	10-	15-	20-	25-	35-	45-	55-	65-	75-
Males ..	12	11	13	16	18	19	14	6	4	3	6	12
Females	14	11	14	18	18	19	19	11	6	8	11	11

Thus the figure 12 relating to males at all ages indicates that 11 of 20 countries had a higher and 8 had a lower standardized death-rate at all ages than England and similarly in other cases.

“The high mortality of men between 35 and 75 and of women between 45 and 65 in this country as compared with others is remarkable, and is in sharp contrast to its favourable position in regard to mortality of young persons.”

Death-rate per 1,000 at Age <sup>1</sup>	Australia.	England.	Germany.	Norway.	Italy.	United States.
0-1 .. ..	95.10	144.34	202.34	81.45	167.71	127.38.
5 .. ..	2.81	5.42	5.28	4.38	7.68	5.24
10 .. ..	1.79	1.82	2.44	2.98	2.26	2.61
15 .. ..	2.55	2.61	2.77	4.08	4.12	3.19
20 .. ..	3.70	3.78	5.04	9.07	6.19	5.46
25 .. ..	4.48	4.54	5.13	8.78	6.85	6.22
30 .. ..	5.19	5.66	5.56	7.57	6.67	7.31
35 .. ..	6.33	7.32	6.97	7.35	7.06	9.14
40 .. ..	8.16	9.31	9.22	7.78	8.48	10.40
45 .. ..	10.83	12.23	12.44	8.92	10.31	13.10
50 .. ..	13.95	16.57	16.93	11.11	13.45	15.28
55 .. ..	18.16	23.08	23.57	14.16	17.73	21.38
60 .. ..	25.84	32.62	32.60	19.14	26.62	29.90
65 .. ..	38.59	45.57	47.06	28.80	39.83	42.92
70 .. ..	61.62	67.08	69.36	42.76	64.49	59.90
75 .. ..	96.10	100.62	106.40	66.91	102.62	90.15

<sup>1</sup> NOTE.—The death-rates are for the stated year of life, not the average death-rates for quinquennial periods.

In the above table are shown the male death-rates per 1,000 living at 5 yearly intervals of age based on the experi-

ence of 1901-10. The table is derived from a table giving the death-rate for each year of life in 14 countries, on page 204 of *United States Life-Tables* (published 1921). Of these countries Australia has the most favourable experience, Norway coming next. Germany's experience is the worst, that of Italy coming next. The anomalies of distribution of favourable or unfavourable death-rates at different ages can be seen in the table.

**Marital Conditions and Mortality.**—The question of effect of sex on mortality is closely related to that of the influence of the inter-relation of the sexes in matrimony, a subject which has long interested social statisticians, who have not been restrained from its statistical study by the perennial joke that married is not more prolonged than celibate life, but only appears so!

As Farr said<sup>1</sup> in 1858: "The family is the social unit; and it is founded in its perfect state by marriage. The influence of this form of existence is therefore one of the fundamental problems of social science." Quoting some French statistics relating to the year 1851, he concludes that "the single individual is more likely to be wrecked on his voyage than the lives joined together in matrimony." A more recent discussion of the subject is contained in a paper by M. Lucien March,<sup>2</sup> from which the table on page 214 is abstracted.

One could have wished that the age-groups in the above table had been less wide, as this opens up the possibility of error. The table as it stands shows at all ages a much lower death-rate among married than among single or widowed men; among married women the death-rate is somewhat higher at ages 20-40 than among single or widowed women, but at ages 40-60 and over 60 the superiority of married women is very evident. At these higher ages the dangers of childbirth are nearly or entirely absent, and married women at these ages on an average are better protected and less impoverished than unmarried. The superiority of married men at all ages may be variously interpreted. Numerous factors are at work, some connected with, others independent

<sup>1</sup> *Vital Statistics: A Memorial Volume of Selections, etc., of Writings William Farr*, p. 438 (1885).

<sup>2</sup> "Some Researches Concerning the Factors of Mortality," by L. March (*Journal of the Royal Statistical Society*, March, 1912).

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of, matrimony itself. Comparative freedom in marital life from the terrible risks of syphilis must be given weight. A moral self-selection is connected with this fact. As a rule a married man is in a more secure social position than an unmarried, and correspondingly has a better economic and sanitary environment. Probably still more influential is the fact that married men are selected, the less fit or the actually unhealthy being less likely to marry than healthy men. The statistics of relative mortality of married and unmarried are therefore of dubious value as showing the influence of married life *per se* on vitality. They are the product of

AVERAGE ANNUAL DEATH-RATE PER 10,000 LIVING IN EACH AGE-GROUP DURING THE PERIOD 1886-95 IN FRANCE, PRUSSIA, AND SWEDEN.

	Males, aged			Females, aged		
	20-40.	40-60.	60 and over.	20-40.	40-60.	60 and over.
France :						
Married .. ..	77	153	583	80	121	456
Single .. ..	103	246	794	78	166	730
Widowed or divorced	211	293	1,148	145	198	930
Prussia :						
Married .. ..	71	175	582	79	128	497
Single .. ..	84	231	806	59	179	729
Widowed or divorced	201	346	1,091	101	172	805
Sweden :						
Married .. ..	53	114	453	66	96	364
Single .. ..	83	204	690	61	120	528
Widowed or divorced	104	190	856	98	132	698

this influence, intertwined with the influence of selection in matrimony, of comfortable social conditions, and other factors.

For England and Wales a more detailed statement is practicable for women (Registrar-General's Annual Report, 1912), based on the census data for 1911 and the deaths of unmarried, married and widowed women in the three years 1910-12.

The figures given in that report show an excess of mortality of married over that of single women up to the age of 43, which, as stated in the report, "is the more remarkable in view of the number of women debarred from marriage by ill-health." This excess is chiefly attributable to the risks of maternity. From 40-60 there is practical equality of

mortality in married and in single women. Widows in the aggregate have a much higher death-rate at all ages than either single or married women. Corresponding figures for widowers are unobtainable; it is probable that all that is connoted by the term "social misery" is more instrumental in causing an excessive death-rate among widows than among widowers.

## CHAPTER XIX

### STANDARDIZED DEATH-RATES

THE extent to which the number living at different ages and the proportion between the two sexes may vary will be further illustrated, as a thorough comprehension of the significance of these variations is indispensable in the study of vital statistics. The figures on pages 59 and 60 give some international comparisons. These deal with large masses of population, in which local variations are averaged out. The following examples illustrate variations in England and Wales, and incidentally demonstrate the insufficiency of crude death-rates at all ages jointly as a measure of relative vitality of these communities.

Reference has already been made (p. 58) to the valuable study of types of population in the General Census Report, England and Wales, 1911 (Cd. 8491). In this report six groups of population were differentiated according to the distribution of each population in respect of age and sex. In Group I the populations showed excess of both males and females during childhood and deficiency at nearly all adult ages. This group consisted of ports and manufacturing towns. Group II resembled the first group, except that the proportions of males remained above the average for the whole country till about age 45. This type is determined by relatively high birth- and death-rates, absence of attraction for female labour, and the continued immigration of young men, as in mining and certain industrial districts. Group III showed excess of both males and females throughout the working period of life, and deficiency in childhood and old age, as in Blackpool, four central London areas, and in textile towns. Group IV was distinguished by excess over the general average during the first three, succeeded by deficiencies in the fourth and fifth quinquennia of life; there followed a second period of excess between 25 and

45, and then a second period of deficiency for the rest of life. The districts included in this group belonged to what are described in the census report as the "workman's dormitory" type. The age distribution of Group V, consisting chiefly of residential districts, was most distinctive in the female sex, the proportion being uniformly below the mean during the three first quinquennia of life and above it afterwards, almost exactly the converse of the conditions in the two first groups. Group VI was the largest group of all.

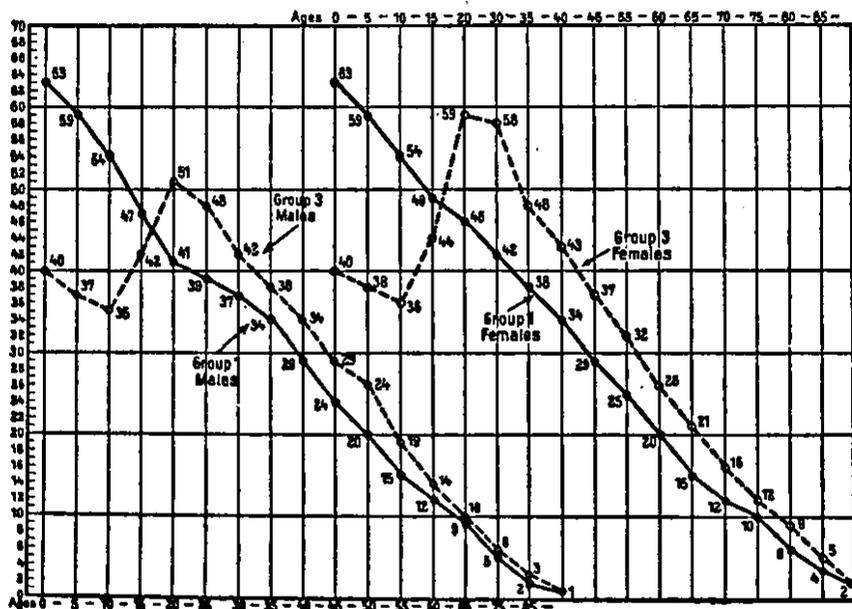


FIG. 20.—Number in 1,000 Males and 1,000 Females at all ages, of Males [●—●—●] and of Females [○ - - - ○ - - - ○] at Each Quinquennial Period of Life in 1911.

The diagram, derived from the Registrar-General's table, for Group I relates to the following districts: Bethnal Green, Poplar, Shoreditch, Edmonton, West Ham, Walsall, West Bromwich, Stoke-on-Trent, Sunderland, South Shields, Tynemouth, and West Hartlepool.

The diagram, derived from the Registrar-General's table, for Group III comprises Bradford, Dewsbury, Halifax, Huddersfield, Rochdale, Bury, Blackburn, Oldham, and Burnley.

In it the proportional numbers were generally below the mean for the whole country up to about 40-50 years of age, and afterwards in an increasing excess. The areas included in this group were of predominantly rural type.

In the diagram above the males in Group 1 and 3 and

the females in these two groups are contrasted; and from what has already been written it will be evident that a lower crude death-rate at all ages, in the aggregate, for both males and females will hold good for Group 3 than for Group 1, assuming that in the compared groups the death-rates at each age-period 0-5, 5-10 . . . 75-85, etc., are equal in all the groups.

A further illustration of the need for corrections for age-distribution of population may be quoted from Dr. Ransome, as given in an earlier edition of this book, although it is now too extreme to be matched in current experience. This illustration does not show correction for sex, but only for age:—

Suppose two towns, *A* and *B*, each with a mean population of 1,000, and exactly alike in their sanitary conditions. *A* has 150 children under 5; *B* has only 100 under 5, which in each town die at the rate of 10 per cent. per annum, while persons over 5 die at the rate of 10 per mille. Reckoning up the total mortality per 1,000 at all ages, we find that—

In *A*, out of 150 children, 15 die.

In *A*, out of 850 over 5, 8.5 die; the total death-rate being 23.5 per 1,000 of the entire population.

In *B*, out of 100 children, 10 die.

In *B*, out of 900 over 5, 9 die; the total death-rate being 19.0 per 1,000.

Thus there is a difference of 4.5 per 1,000 in the two death-rates, due simply to differences in the age composition of the two populations, and apart altogether from their state of health.

In the paper from which this illustration is taken Dr. Ransome further points out that a death-rate of 10 or even 12 per 1,000, which not infrequently is recorded in certain favoured districts, cannot be regarded as a true measure of longevity of its inhabitants. It has been stated that a death-rate of 10 per 1,000 means either that every child born attains the age of 100 before he dies, or else that the average age at death is 100; and that if some die in infancy, others must have lived much more than 100 years. Similarly, a death-rate of 12 per 1,000 means an average age at death of over 80. This would be true in a life-table population, i.e. one in which the births equal the deaths, and no disturbing

migration occurs. In a population in which births exceed deaths (the usual type), and in which migration disturbs ratios between ages and sexes, a crude death-rate of 10 per 1,000 would not carry the above consequence. To attain a continuous death-rate of 10 per 1,000 of population, two conditions are generally required: (1) A favourable age and sex distribution of population, and (2) an exceptionally healthy population after allowance has been made for the first factor.

**Standardized Death-rates.**—Standardized death-rates can be obtained by two methods, direct and indirect, as described in the Annual Report of the Registrar-General, England, 1911. In both the crude death-rates of various districts are modified to show what they would have been had the local populations been constituted as to age and sex like the total population of England and Wales in 1901. The direct method gives slightly more accurate results, but it is laborious in application and demands knowledge of the mortality of the local population in question at the several age and sex groups; the indirect method ordinarily gives substantially accurate results, and can be applied, with relatively little trouble, once the necessary factor has been calculated, to any area of which the age-distribution was recorded at the census.

**Direct Method of Standardization.**—In this method a million persons, grouped as to age and sex like the population of England and Wales in 1901, is taken. The death-rates for each sex at each of 11 age-periods in the area *A*, whose standardized death-rate is required, being known, these local death-rates are applied to the number living at each of these age-periods in a million of the population of England and Wales, 1901, constituted as to age and sex distribution like the population of the whole country, and the aggregate deaths in this million thus calculated give the deaths in a standard million. (See page 228 for a fully worked example.) This death-rate was formerly known as the corrected death-rate, but the alternative name standardized death-rate was proposed by Dr. Cressy L. Wilbur, formerly of the Washington Census Bureau. "Corrections" are made for non-resident deaths as well as for age and sex, and the substituted name for the latter correction has therefore been adopted in this country.

The standardized death-rate obtained by this method, as stated in the Registrar-General's Report for 1911, "accurately summarizes the tendency to death of each sex and age group of the population concerned, and is of course strictly comparable with similarly prepared statements relating to any other populations, however differently constituted." As has been stated in the following happy illustration: Looking upon mortality as a tax, the standardized death-rate measures the tax, and the crude death-rate the yield.

**Standard Population.**—In this country the population of England and Wales in 1901 has continued to be used as a standard, in order to avoid the great practical inconvenience of a 10-yearly change in the basis of comparison, and the corresponding need for re-calculating to the new standard the death-rates of former decades, in order to retain comparability of data.

The continued use of the 1901 population as a standard, although most desirable from the standpoint of continuity of comparisons, involves the fact that standardized rates based on it run low, the constitution of the population of England and Wales in 1901 favouring a low aggregate mortality. Such rates can only be compared among themselves, and are too low for comparison with rates for other countries, which have not been reduced to the same standard, and even then may not be altogether free from occasional distortion.

In the American Mortality Statistics of 1911, Dr. Wilbur adopted the standard of the 1901 population of England and Wales, and thus the possibility of accurate comparison between the vital statistics of two kindred nations was established.

The International Statistical Institute formerly recommended that the population of Sweden in 1890 divided, without distinction of sex, into the five age-groups 0-1, 1-20, 20-40, 40-60, and over 60, should be made the basis of comparison; but this would give much less accurate results than the 11 age-groups and sex-classification of the English method. This plan has been abandoned more recently in favour of a composite European population in 11 age-groups (*Annuaire International de Statistique, II, Mouvement de la Population, Europe, 1917, p. viii*) based on the census

populations in or about 1900 of a large group of European populations. The following table compares the two standard populations for persons. It will be noted that the English standard has a younger population than that of the other standard.

STANDARD MILLION (PERSONS).

	England, 1901.	International Statistical Institute.
0-5 ..	114,262	119,900
5- ..	107,209	} 206,900
10- ..	102,735	
15- ..	99,798	} 183,200
20- ..	95,946	
25- ..	161,579	147,900
35- ..	122,849	120,500
45- ..	89,222	93,900
55- ..	69,741	70,800
65- ..	33,080	40,500
75- ..	13,581	16,400
	1,000,000	1,000,000

**The Choice of Standard.**—This is important for two reasons: (1) The distribution of the population—for instance, if it contains an unusually large proportion at ages of low or high death-rate—may be such as to secure a lower or higher standardized death-rate at all ages than would occur in another population differently constituted. A comparison of the population of France with the younger average population of England would illustrate this point. If the standard chosen favours a low standardized death-rate, as is the case with the standard population of England and Wales in 1901, standardized death-rates thus obtained, while generally comparable with each other, will be unduly low for comparison with most crude death-rates or with rates standardized on a less favourable basis. Moreover (2) rates based on a standard population which comprises a high proportion of persons at any age (or sex) will be influenced to an undue extent by the mortality of that group. Thus the standard population, England and Wales, 1901, contained a high proportion of persons aged 20-25, at which age English death-rates are

exceptionally low, as compared with death-rates in other countries for the same age-period (see Table LXXI in the Annual Report of the Registrar-General, 1910). Consequently the standardized rate over-emphasizes this low mortality, and the English rate is understated—probably not to a material extent—as compared with that of other countries. If the French population were taken as a standard, undue weight would be given to the mortality of the aged, and the standardized death-rate of the English rural population would be prejudiced, because the rural death-rate in old age is nearer the average death-rate of the aged in the whole country than the rural death-rate at earlier adult ages, which is very low.

More important than the actual standard is the method to be prescribed for its application. Of the two methods enumerated below the first is wrong, the second right. (a) The male mortality may be standardized by a male standard, female mortality by a female standard, and total mortality by a standard of persons. This apparently is the proposal of the International Statistical Institute. (b) The standard of persons is used for both males and females, and by this means fair and unbiased comparisons can be made between the mortality of the two sexes, they being both referred to the same standard (see Annual Report of the Registrar-General, 1913, p. xx). But for standardizing the death-rate for persons a standard is used which distinguishes sex, thus allowing for sex differences in the populations compared. The international standard fails to do this. It gives the same result whether a high local death-rate at ages 45–65, for instance, is due to high mortality or to a high proportion of males in the population. Furthermore, it gives incomparable results for males, females, and persons because the standard used varies in each case.

**Indirect Method of Standardization.**—By the use of this method, knowledge and use of the district death-rates at each age is not required, and much labour is thereby saved. The factor of correction (standardizing factor), once ascertained, can be employed, with approximate accuracy during an entire decennial period, provided that no great change occurs in the character of the population.

In this method an *index death-rate* is first calculated for

the district. This, up to 1914, has been obtained by applying the *standard* death-rate, i.e. the death-rate at each age for each sex in England and Wales for 1901-10 to the local population.

Thus *index death-rate*

$$= \frac{\text{sum of} \left( \begin{array}{l} \text{populations of district} \\ \text{in each sex and} \\ \text{age-group} \end{array} \times \begin{array}{l} \text{standard death-rates} \\ \text{for each sex and} \\ \text{age-group} \end{array} \right)}{\text{total population of district.}}$$

The term "index death-rate" has been used officially to show that it is merely a measure of the extent to which the age and sex constitution of the population is favourable or unfavourable as compared with the population of England and Wales, 1901. The index death-rate has nothing to do with the mortality recorded in the area dealt with, but is only an index of the peculiarity of the local population for which allowance is made in the standardized death-rate.

The *standardizing factor*

$$= \frac{\text{Index death-rate of standard (England and Wales, 1901)}^1}{\text{index death-rate of district.}}$$

This factor measures the extent to which the crude death-rate of the district is influenced by variations in its age and sex distribution from the corresponding distribution of the standard population; and when this factor is multiplied into the crude death-rate of the district, its *standardized death-rate* is given. A detailed example of the working of this indirect method is given on page 228.

In the Registrar-General's Reports for 1911-14 are given the standardizing factors for every administrative area in England and Wales. After that date they became inapplicable, owing to changes in age and sex distribution of population caused by the war. The same reason will make it difficult, if not impossible, to give death-rates for males at ages 15-45 for the period 1911-20. The following examples

<sup>1</sup> I.e., the death-rates for sex and age-groups applied to the population of England and Wales, 1901.

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relating to the year 1911 show that standardized sometimes differ markedly from crude death-rates:—

	Standardizing Factor.	Death-rate 1911.	Standardized Death-rate.
<i>County Boroughs—</i>			
Hastings .. .. .	0·8410	14·1	11·9
Brighton .. .. .	0·9092	14·2	12·9
Wigan .. .. .	1·1149	18·5	20·6
Burnley .. .. .	1·1051	18·1	20·0
Birmingham .. .. .	1·0373	16·7	17·3
Manchester .. .. .	1·0799	17·1	18·5
<i>Administrative Counties—</i>			
Surrey .. .. .	0·9763	10·8	10·5
Glamorganshire .. .. .	1·0659	14·3	15·2
Oxfordshire .. .. .	0·8400	13·0	10·9
<i>Rural Districts—</i>			
Braintree .. .. .	0·7900	13·5	10·7
Watford .. .. .	1·0454	8·9	9·3
<i>Urban Districts—</i>			
Wokingham .. .. .	0·7651	16·7	12·8
Eton .. .. .	1·3431	9·1	12·2
Portland .. .. .	1·3272	8·5	11·3

The instances of Eton and Portland are interesting as showing the influence of a large public school and a large prison respectively, necessitating a large correction in the crude death-rates.

In a table given on page xxxvi of the Annual Report of the Registrar-General, 1912, the following comparison is given, showing that the differences in the results obtained by application of the direct and the indirect methods are not as a rule of much importance. The table also shows rates calculated on the standard recommended by the International Statistical Institute.

	England and Wales.	London.	County Boroughs.	Other Urban Districts.	Rural Districts.	
Crude death-rate per Million of population, 1912 ..	13,290	13,832	14,712	12,523	12,340	
Standardized Rates {	A, By direct method .. (England and Wales Standard, 1901)	12,914	13,782	15,164	12,392	10,506
	B, By indirect method . (England and Wales Standard, 1901)	13,011	13,832	15,102	12,444	10,936
	C, By direct method .. (International Standard, 1890)	15,879	16,451	17,900	15,085	13,400

It will be noted that the International standard death-rates are much higher than those calculated on the basis of the population of England and Wales, 1901. It has already been emphasized that unless death-rates are standardized to the same basis, they are incomparable.

In the following table the differences between comparisons of such death-rates calculated by the different methods are seen by comparing London with rural districts, the death-rate of London by each method being given as 100 :—

	Crude Death-rate.	Death-rate by Method.		
		A.	B.	C.
London .. .. .	100	100	100	100
Rural Districts .. .. .	89.4	76.2	79.3	81.3

In rural districts there is a very high proportion of persons over 75 which is duly allowed for, both by the direct and by the indirect method ; but in the rural districts the death-rate at ages 75 and upwards is higher relatively to that at other ages than in England and Wales as a whole, and the disadvantage accruing to them from their large proportion of aged persons is increased on this account. The indirect method makes no allowance for this increase, and so under-corrects the total death-rate of the rural districts for their high proportion of aged persons. The direct method, on the other hand, as it takes no account of the proportion of population at this or any other age, avoids this difficulty. In most instances the differences between the results of the two methods are almost negligible.

An illustration of standardization of death-rates for a single disease is given on page 335.

The factors calculated as above can only be applied for the standardization of the general death-rate, and must not be used for the death-rate from individual diseases, which would require to have their own appropriate factors calculated in each instance.

**Criticism of Standardized Death-rates.**—Professor W. F. Willcox, in the paper quoted on page 490, has described the insistence on standardized death-rates in comparing cancer death-rates as a veritable bed of Procrustes ; for

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its acceptancé excludes "at one stroke probably all other cancer statistics" than those in Messrs. King and Newsholme's paper (p. 489). If standardization is necessary, the significant material, he adds, is still so meagre as to make an extensive study of cancer even now quite out of the question. The English experience is scarcely meagre, though standardized figures for other countries are so. Thus in the English Registrar-General's Annual Report for 1917 are given data for England and Wales enabling standardized comparisons to be made between 1868, 1888, and 1917. It is unfortunate that nearly all other available statistics do not enable death-rates to be compared in which the influence of varying age and sex distribution of population on cancer mortality has been eliminated; but the sparsity of such material does not justify comparisons based on unstandardized death-rates if standardization is necessary. The necessity for some measure of standardization is illustrated in Professor Willcox's paper by the following data:—

ENGLAND AND WALES.  
*Cancer Death-rates per Million of Population.*

Crude.		Percentage Increase.	Standardized.		Percentage Increase.
1901.	1911.		1901.	1911.	
843	993	17·8	843	915	8·7

In this table the standardized death-rate for 1911 was obtained by applying the cancer death-rates at each age-period in 1911 to the male and the female population of England in 1901, the statistics of which year are taken as a standard, and therefore the crude equals the standardized death-rate for all ages in the aggregate. Evidently, when more than half of the increase in the crude cancer death-rate is due to the decennial change in the sex and age composition of the population, standardization of crude rates is necessary, before they are used for comparative purposes.

A further example from King and Newsholme's original paper (quoted on p. 489) shows the influence of age distribution on cancer mortality, the standard in this instance being that of the English Life-Table No. 3 (Persons).

## STANDARDIZED DEATH-RATES

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### COMPARISON OF STANDARDIZED AND UNSTANDARDIZED CANCER DEATH-RATES.

Period.	Not Standardized.		Standardized.	
	England.	Ireland.	England.	Ireland.
1860-66.. .. .	498	553	625	614
1867-73.. .. .	597	627	747	661
1874-80.. .. .	719	680	911	699
1881-87.. .. .	902	807	1,152	824
1888-90.. .. .	1,091	894	1,393	912

In the first two periods, it will be observed, Ireland had a slightly higher crude death-rate from cancer than England, in the three next periods it was lower. The standardized death-rates (which supply correction for the fact that Ireland had a larger proportion of its population at cancer ages) show Ireland with a lower death-rate than England in each period. In the period 1888-90 Ireland's crude death-rate is 17.9, and its standardized death-rate 34.3 per cent. lower than that of England.

But Professor Willcox concludes that "standardized death-rates are likely to be misleading rather than helpful for dealing with this problem, because the amount and rate of increase shown in them depend largely upon the standard which is used." The possibility that standardized death-rates may exaggerate differences between A and B, if either A or B has a very unusual age or sex distribution of its population or its death-rate at different age-periods, has already been pointed out, but the exaggerations thus produced are almost always small as compared with those of crude death-rates; and Professor Willcox's criticism arises largely from comparisons of standardized death-rates obtained by the use of a life-table population, which comes within this exceptional category. Such exceptional populations may give standardized rates which exaggerate differences; though in the instance of Frankfort, given in Professor Willcox's paper (p. 490) the effect is a difference between 57 and 53 per cent. increase only according to the two standards contrasted.

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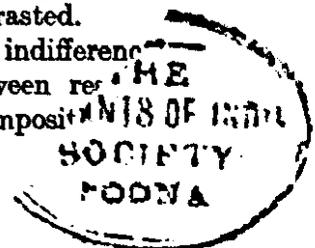
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## ILLUSTRATION OF METHODS OF STANDARDIZING DEATH-RATES.

### A. DIRECT METHOD.

(In this example quinquennial age-periods are taken; more usually after age 25 decennial death-rates are employed.)

*Aggregate of County Boroughs: Standardized Death-rates per Million Living in the Year 1913.*

(For standard million population see Census of England and Wales, 1911, vol. vii, p. 426.)

Age Groups.	Standardization of "Persons" Rate.						Standardization of "Sex" Rates.					
	Males.			Females.			Standard Million Population (Persons), 1901.	Males.		Females.		
	Standard Million Population, 1901.	Recorded Death-rates per Million. <sup>1</sup>	Deaths in Standard Million Population.	Standard Million Population, 1901.	Recorded Death-rates per Million. <sup>1</sup>	Deaths in Standard Million Population.		Recorded Death-rates per Million. <sup>1</sup>	Deaths in Standard Million Population.	Recorded Death-rates per Million. <sup>1</sup>	Deaths in Standard Million Population.	
0- .. ..	57,039	47,676	2,719	57,223	39,887	2,282	114,262	47,676	5,448	39,887	4,558	
5- .. ..	53,462	3,575	191	53,747	3,626	195	107,209	3,575	383	3,626	389	
10- .. ..	51,370	2,036	105	51,365	2,194	113	102,735	2,036	209	2,194	225	
15- .. ..	49,420	2,988	148	50,376	2,666	134	99,796	2,988	298	2,666	266	
20- .. ..	45,273	3,829	173	50,673	3,272	166	95,946	3,829	367	3,272	314	
25- .. ..	40,835	4,458	182	45,998	3,814	175	86,833	4,458	387	3,814	331	
30- .. ..	35,590	5,954	212	39,156	4,624	181	74,746	5,954	445	4,624	346	
35- .. ..	31,803	8,221	261	34,153	6,561	224	65,956	8,221	542	6,561	433	
40- .. ..	27,591	11,185	309	29,302	8,599	252	56,893	11,185	636	8,599	489	
45- .. ..	23,364	15,259	357	25,001	11,373	284	48,365	15,259	738	11,373	550	
50- .. ..	19,560	21,490	420	21,297	15,813	337	40,857	21,490	878	15,813	646	
55- .. ..	15,295	30,399	465	17,064	22,458	363	32,359	30,399	984	22,458	727	
60- .. ..	12,618	44,938	567	14,764	32,423	479	27,382	44,938	1,230	32,423	888	
65- .. ..	8,682	60,779	528	10,676	44,585	476	19,358	60,779	1,177	44,585	863	
70- .. ..	6,009	98,509	592	7,713	75,312	581	13,722	98,509	1,352	75,312	1,033	
75- .. ..	3,477	142,303	495	4,654	112,926	526	8,131	142,303	1,157	112,926	918	
80- .. ..	1,603	194,465	312	2,356	162,852	384	3,959	194,465	770	162,852	645	
85 and upwards ..	552	281,549	155	939	242,502	228	1,491	281,549	420	242,502	362	
All ages ..	483,543		8,191	516,457		7,400	1,000,000		17,421		13,983	

$$\text{Death-rate (Persons)} = \frac{8,191 + 7,400}{483,543 + 516,457} = \frac{15,591}{1,000,000}$$

or 15,591 per million.

$$\text{Death-rate (Males)} = \frac{17,421}{1,000,000} \text{ or } 17,421 \text{ per million.}$$

$$\text{Death-rate (Females)} = \frac{13,983}{1,000,000} \text{ or } 13,983 \text{ per million.}$$

## STANDARDIZED DEATH-RATES

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actual populations are relatively small, and the general case for the necessity for standardization and the avoidance of crude death-rates remains.

### ILLUSTRATION OF METHODS OF STANDARDIZING DEATH-RATES.

#### B. INDIRECT METHOD.

*Aggregate of County Boroughs : Standardized Death-rate (Persons)  
per Million Living in the Year 1913.*

Age Groups.	Males.			Females.		
	Mean Death-rates in England and Wales, 1901-10 per 1,000 Living.	Enumerated Population of County Boroughs, 1911.	Deaths in County Borough Population at England and Wales Rates.	Mean Death-rates in England and Wales, 1901-10, per 1,000 Living.	Enumerated Population of County Boroughs, 1911.	Deaths in County Borough Population at England and Wales Rates.
0- ..	50.03	624,850	31261.2	41.87	620,153	25965.8
5- ..	3.50	585,204	2048.2	3.61	589,798	2129.2
10- ..	2.05	549,212	1125.9	2.17	559,567	1214.3
15- ..	3.09	512,471	1583.5	2.89	555,667	1605.9
20- ..	4.18	472,297	1974.2	3.50	555,171	1943.1
25- ..	5.57	918,347	5115.2	4.74	1,027,536	4870.5
35- ..	9.15	749,969	6862.2	7.53	807,699	6082.0
45- ..	16.22	525,862	8529.5	12.51	577,090	7219.4
55- ..	31.81	324,439	10320.4	24.85	368,681	9161.7
65- ..	64.85	163,307	10590.5	53.93	217,016	11703.7
75- ..	152.45	46,621	7107.4	136.20	78,317	10666.8
All ages		5,472,579	86518.2		5,956,695	82562.4

*County Boroughs : Index Death-rate (1911)*

$$= \frac{86518.2 + 82562.4}{5,472,579 + 5,956,695} = \frac{169080.6}{11,429,274} = 14.794 \text{ per 1,000.}$$

England and Wales : Index Death-rate (1911) (similarly calculated) = 15.190.

$$\text{County Boroughs : Standardizing factor} = \frac{15.190}{14.794} = 1.0268.$$

Standardized Death-rate per million (1913) = 15,113 (crude rate) × 1.0268 = 15,518.

## CHAPTER XX

### LIFE-TABLES, HISTORY AND DESCRIPTION

IN previous chapters the measurement of the incidence of mortality has been considered in so far as—(1) crude or general death-rates, (2) death-rates for each sex at different age-groups, and (3) standardized or corrected general death-rates enable this to be done.

For all the practical purposes of a medical officer of health or a social investigator these methods give all that any method of statement of total deaths can supply. Subject to accuracy and completeness of figures of deaths and population, no further measure of mortality from all causes is needed; though, in order to arrive at a satisfactory knowledge of the causes which have produced a high or a low rate of mortality, the inquiry must be pursued, until the incidence of each of the chief causes of death has been studied.

But for actuarial and insurance work, further and more minute investigation by means of life-tables is needed, enabling a statement for any given age of the prospects of survival to be given either for a limited number of years or for the rest of life; and such a statement gives the health officer an opportunity of emphasizing by an additional and impressive statement the importance of preventive medicine.

Death-rates for groups of persons, like the expectations of life derived from a life-table, when employed to forecast future death-rates and life-expectations are based on human experience; human life, although very uncertain for the individual, being measurable with a striking approximation to accuracy in the mass for large groups of individuals.

Life-tables represent "a generation of individuals passing through time," the data on which they are founded being the number and ages of the living and the number and ages of the dying. Dr. Farr called the life-table a *biometer*, and spoke of it as of equal importance, in all inquiries con-

nected with human life or sanitary improvements, with the barometer or thermometer and similar instruments employed in physical research. It is the keystone or pivot on which life assurance hinges, converting it from a mere lottery into an accurate science.

Addison, in his *Vision of Mirza*, possibly writing with Halley's graduated life-table before him, gave the following allegory, which illustrates the contents of this and the next chapter :—

The bridge thou seest, said he, is *Human Life*; consider it attentively. Upon a more leisurely survey of it, I found that it consisted of *threescore and ten entire arches*, with several broken arches, which, added to those that were entire, made up the number *about an hundred*. As I was counting the arches, the Genius told me that this bridge consisted at first of a *thousand arches*; but that a great flood swept away the rest, and left the bridge in the ruinous condition I now beheld it. But tell me further, said he, what thou discoverest on it. I see multitudes of people passing over it, said I, and a black cloud hanging on each end of it. As I looked more attentively, I saw several of the passengers dropping through the bridge into the great tide that flowed underneath it: and upon further examination perceived that there were innumerable trap-doors that lay concealed in the bridge which the passengers no sooner trod upon, but they fell through them into the tide, and immediately disappeared. These hidden pit-falls were set very thick at the entrance of the bridge, so that throngs of people no sooner break through the cloud, but many of them fell into them. They grew *thinner towards the middle*, but multiplied and laid closer together towards the end of the arches that were entire. There were, indeed, some persons, but their number was very small, that continued a kind of hobbling march of the broken arches, but fell through one after another, being quite tired and spent with so long a walk.

**History of Life-Tables.**—Captain Graunt (1620–74) laid the foundations of “Political Arithmetic” in England by his study of the London Bills of Mortality or burial registers. He constructed a table showing the ages and causes of death in the city from 1628–37. He was in close relationship with Sir William Petty (1623–87), who initiated the above name for the new science; but Petty himself dealt more with the collection of non-statistical facts, some of his conclusions being based on very insufficient data. The first actual life-table was constructed by Edmund Halley (1656–1742). It was based on the death-registers of Breslau, in Germany, for the five years 1687–91. Males and females

were not distinguished in it, and, like the Northampton table, it was based on deaths alone, *not on a comparison of the deaths and living at each age*, which alone can give accurate results. Thus this life-table gave only the  $d_x$  column of a life-table, i.e. the number dying at any age  $x$ ; and it was assumed, as a working hypothesis, that this column gave the number dying at each successive year of age out of a number born equal to the sum of the deaths at all ages. This supposition is only true if three conditions are fulfilled, viz., that (1) Throughout the experience the same number of births occur, year by year; (2) the vitality according to age, or, stated otherwise, the death-rate according to age, in the population in question remains unaltered throughout the experience; and (3) no disturbing emigration or immigration occurs.

De Moivre's hypothesis was suggested by Halley's Breslau Tables. He concluded that the hypothesis that out of 86 persons born one dies every year till all are extinct would very nearly represent the mortality of the greater part of life, and that in the calculation of annuities its errors would nearly compensate one another. Tables formed on this hypothesis, as well as on the Northampton Table to be next considered, overstated the mortality of young adults. The consequence is, that in life assurances calculated on the results of De Moivre's and Price's Tables, the young were made to pay for the old, and injustice was done to those who insured comparatively early in life.

The first life-table used for the purpose of determining the rate of premium to be paid for life assurance was Price's Northampton Table, published in 1783, which was used by the Equitable Office on its establishment in 1762. Like Halley's Table, owing to the want of proper materials, the Northampton Table was not constructed by a comparison of the deaths and the living at each age, but from the deaths alone, which is only justifiable with an undisturbed stationary population. It was based on the death returns for the parish of All Saints, Northampton, for 46 years, 1735-80. Dr. Price was under the misapprehension that the population of this parish was stationary, judging by the number of infantile baptisms. But at the time the data for this table were recorded, there were a large number of Baptists in Northampton, who repudiated infantile baptism. The consequence of this oversight was that Dr. Price assumed the mean duration of life to be 24 years, when it was really about 30 years. Unfortunately, his table was made the basis for the Government annuity schemes; and the same error which gave the insurance offices one-third too high premiums induced the Government to grant annuities by one-third too large for the price charged, resulting in a loss to the public funds of about 2 millions sterling before the error was corrected.

Dr. Price also constructed a correct life-table from the population

and deaths in Sweden, "which was the first national life-table ever made, and redounds much more to his fame than the Northampton Table" (Farr).

The Carlisle Table was constructed in 1815 by Mr. Milne, from the observations of Dr. Heysham, upon the mortality of two parishes in that town in the years 1779-89, and two enumerations of their population in 1779 and 1787. It represented a great advance in life-table technique, being based on the experience of the lives "exposed to risk of death." At the time it was constructed it showed results too favourable for the whole country; but owing to the decrease of mortality which followed, it became more accurate. De Morgan gives the following expression, based on the Carlisle Table, as representing more nearly the mortality from the age of 15 to that of 65 than does De Moivre's hypothesis. Of every 100 persons aged 15, one dies every year till the age of 65. Or if we take the mean after-lifetime, according to the Carlisle Table, between the ages of 10 and 60, for rough purposes it may be said: Of persons aged 10 years, the mean after-lifetime is 49 years, with a diminution of 7 years for every 10 years elapsed; thus, of persons aged 20 years, the mean after-lifetime is  $49 - 7 = 42$  years; at 30 years of age, 35 years, and so on. The mean after-lifetime, according to different life-tables, is shown in figures 23 and 24.

The Carlisle Table, although based on scanty and uncertain data, has been largely employed in insurance work until recent years. Many individual insurance offices have investigated their mortality experience, alone or in combination with other offices. The experience of insured persons is that of persons who usually have been carefully examined in respect of health, only persons being insured at ordinary rates in whom no disease is detected and who are not unacceptable because of an unhealthy occupation or residence in unhealthy climates. The Equitable Insurance Society framed tables based on its experience of 5,000 lives from 1762 to 1829, and Government tables gave the experience of 22,000 Government annuitants.

In 1843 was published the *Seventeen Offices' Experience*, and later the *Twenty Offices' Experience*. The last named was published in 1869, and included the Healthy Males ( $H^M$ ) table. This table, compiled by the Institute of Actuaries, soon became the standard table, and remained so until the issue of the *British Offices' Tables*, based on data relating to the period from 1863 to 1893, which were supplied by sixty British offices. The work of compilation was carried out by the Institute of Actuaries and the Faculty of Actuaries jointly. The  $O^M$  table of this work for male lives has taken

the place of the H<sup>M</sup> table. In 1912 the Government Annuitants' tables were published.

The national experience of England and Wales has been made the subject of a series of life-tables prepared in the General Register Office.

**English Life-Table, No. 1.**—Dr. Farr constructed his No. 1 Table, based on the census returns of 1841 and the deaths of the same year (Registrar-General's Fifth Report). Thinking, however, that the records of *one year's deaths* might be open to challenge owing to the short time embraced in them, he constructed the **English Life-Table, No. 2**. This is founded on the census enumerations of 1831 and 1841, and the deaths of 7 years, viz. those in 1841 and the 3 previous and 3 subsequent years.

The difference between the data in these two English life-tables is slight.

**The English Life-Table, No. 3**, constructed by Dr. Farr, was based on the census enumerations of 1841 and 1851, and upon the 6,470,720 deaths registered in the 17 years 1838–54.

For a detailed description of the methods of construction of this table, the reader is referred to "The English Life-Table" by Dr. W. Farr: Longman & Co., 1864.

The near agreement between the results obtained by these three English life-tables is very remarkable, and shows that, notwithstanding annual fluctuations, there was a fairly stationary mortality during 1838–54, which, we may add, continued up to the year 1871. The latter fact led Dr. Farr to abandon his intention of constructing a fourth English Life-Table down to 1872.

**The Healthy Districts Life-Table** was constructed by Dr. Farr on the basis of the mortality during the five years 1849–53 in 63 selected English districts, which showed, during the decennium 1841–50, a mean annual death-rate not exceeding 17 per 1,000 persons living. As pointed out by Dr. Farr, it expresses "very accurately the actual duration of life among the clergy and other classes of the community living under favourable circumstances." It represented also a standard of healthiness already attained, and was therefore useful for purposes of comparison. This table is printed in the Thirty-Third Annual Report of the Registrar-General.

The English Life-Table by Dr. Ogle, published in the Supplement to the Thirty-Fifth Annual Report of the Registrar-General, deals with the national experience in the decennium 1871-80, and those by Dr. Tatham with the corresponding experience of 1881-90 and 1891-1900.

The New Healthy Districts Life-Table, by Dr. Tatham, gave a valuable index of sanitary and social progress. Thus, whereas in 1849-53, the period dealt with by Dr. Farr's Healthy Districts Life-Table, "less than 6 per cent. of the total population lived in districts the crude death-rates in which were below 17.5 per 1,000; in 1881-90, on the other hand, no less than 25 per cent. of the population lived in districts the crude death-rates in which fell below 17.5 per 1,000, and 4½ per cent. in districts the crude death-rates in which did not reach 15.0 per 1,000." When differences of age and sex constitution were allowed for by obtaining death-rates in a standard population, it was found that about one-sixth of the entire population, or 4,606,503 persons, had death-rates below 15 per 1,000 in 1881-90. This new healthy districts table was therefore calculated on 46 million years of life, a basis more than nine times as great as that of the older table. In the corresponding Healthy Districts Life Table for 1891-1900 it was found practicable to utilize the experience of an aggregate population of 4,447,485 in 260 districts whose death-rates did not exceed 14 per 1,000.

As to comparability of methods in constructing the above life-tables see page 252.

For the decennium 1901-10 much more abundant information has been supplied. The making of national life-tables for this period was entrusted to Mr. George King, F.I.A., F.F.A., whose report should be on the shelf of every student of vital statistics.<sup>1</sup> In this report he describes the method of construction of full and abridged life-tables, and the following life-tables are given:—

(1) Life-tables for England and Wales for males and females, respectively, based on the experience of the 10 years 1901-10 (No. 7), and corresponding to the English Life-Table No. 6 for the decennium 1891-1900.

(2) Life-tables for England and Wales, for males and

<sup>1</sup> Supplement to the Seventy-Fifth Annual Report of the Registrar-General, Part I, Life-Tables (Cd. 7512).

females, based on the Census of 1911 and the deaths of the 3 years 1910-12 (No. 8).

(3) Life-tables for females only, according to marital condition, single, married, or widowed, based on the Census of 1911 and the deaths in 1910-12.

(4) Sectional life-tables, for males and females respectively, for—

- (a) The administrative county of London.
- (b) The aggregate of county boroughs.
- (c) " " urban districts.
- (d) " " rural districts.

These are based on the deaths in 1911 and 1912, and on the estimated population in the middle of each of these years.

Subsequently Part II of the same supplement, dealing with life-tables (Cd. 1010) was issued, containing a series of abbreviated life-tables prepared by Dr. E. C. Snow.

*United States Life-Tables*, 1890, 1901, 1910, and 1901-10, have been published by the Government Printing Office, Washington (1921), giving an explanatory text, mathematical theory, computations, graphs, and original statistics. The text of this report forms a textbook of points relating to life-tables. The methods employed in constructing the life-tables for persons, males and females, for white persons and negroes, for foreign born and native born, for rural and urban sections, and for selected registration states, appear to be the same as have been used in the construction of the *English Life-Tables* for 1901-10 and 1910-12. The report embodies also a useful comparison of survivorship, death-rates, and expectation of life at each age for 12 countries, in most instances for the period 1901-10.

There have been published also life-tables dealing with the experience of New Zealand and Australia, as well as for a number of foreign countries. Given the inexorable conditions that (1) in each of the countries under comparison the population and deaths are accurately known by enumeration and by registration, and that (2) the life-tables are constructed by identical or strictly comparable methods—failing which serious errors may arise—the hope expressed by Farr in his Fifth Annual Report of the possibilities arising

from life-tables for various countries may hereafter be realized, as expressed in the following eloquent words :—

A comparison of the duration of successive generations (in various countries) would throw much light on the physical condition of the respective populations, and suggest . . . many ways of diminishing the sufferings and ameliorating the health and condition of the people. . . . By these comparisons a noble national emulation might be excited ; and rival nations would read of sickness diminished, deformity banished, life saved—of victories over death and the grave—with as much enthusiasm as of victories over each other's armies in the field ; and the triumph of one would not be the humiliation of the other, for in this contention none could lose territory, or honour, or blood, but all would gain strength.

The question as to whether life-tables enable the important comparisons, the need for and value of which is vividly stated above, to be made more usefully and more succinctly than by death-rates may be regarded as debatable.

**Description of a Life-Table.**—In previous editions of this work the method of constructing life-tables was described in much detail. This appears to be unnecessary in the present edition for two reasons. First, the utility of life-tables for public health purposes is only limited (see p. 261). Secondly, methods of constructing life-tables are explained in Mr. George King's report to the Registrar-General (Cd. 7516), where both a detailed and a short method are described, which give accurate results conforming closely to the original facts. For students in the United States very full instructions for the construction of a life-table are given in *United States Life-Tables 1890 to 1910*, Washington (1921).

These reports are easily accessible, and in view of the growth of this volume in other directions, it has been decided to give here only a short description of a life-table and of the deductions to be drawn from it.

In the construction of a life-table two parallel items of information are needed: (1) The number exposed to risk of death, and (2) the deaths occurring in this number. Each item must be tabulated separately for each year of life. The ratio of (2) to (1) gives the yearly rate of mortality for the year in question ; and obviously if one assumed that a given number born, say 100,000, or the survivors of these from earlier ages, were exposed to the yearly rate of mortality of the community under examination at every age, a third column could be constructed showing the number who would

survive to each successive birthday, until the whole number started with have died. The difference between every two successive numbers in this third column shows the number of deaths in each year of age, and thus a fourth column is obtained. The third column is known as the  $l_x$  and the fourth as the  $d_x$  column.

Except in insurance practice, life-tables are not based on the experience of persons traced through life, in that case through their insured lives. For instance, it is required to make a life-table for the years 1920-21-22 for England and Wales or some local community. The number of deaths for males and females in each age-group are ascertained. The male and female population for the same period in each age-group is estimated from the census returns. From these groups the annual number living and the number dying in each year of age are ascertained by an analytic or graphic method of interpolation. *It is then assumed that the rate of mortality for any age of life, ascertained from these two series, will be applicable to other persons out of a given number started with at birth, as they successively attain the age in question.* The life-table constructed from these data becomes a record of recent experience, as well as a means of forecasting the future; whereas if it were based on the actual watching of 100,000 persons from birth to death, the experience would be obsolete before it was complete.

The probability of living one year is obtained by the formula

$$p_x = \frac{2 - m_x}{2 + m_x}$$

where  $m$  is the rate of mortality per unit at the age  $x$ .

Thus in the English Life-Table No. 8 (Males) the probability of a male at birth living one year

$$= \frac{2 - 0.12044}{2 + 0.12044} = 0.87956.$$

Having ascertained  $p_x$ , the number living at each age ( $l_x$ ) is obtained by multiplying the number living at the immediately preceding year by  $p_x$ , and the mean between  $l_x$  and  $l_{x+1}$  gives the  $L_x$ , i.e. the number living in the middle

of each year. A complete column at all ages of  $L_x$  being obtained, the aggregate number of years which a person at age  $x$  will live, if his experience is that of the average, is the sum of all the numbers in the  $L_x$  column from that age until all the lives became extinct. In this way the  $Q_x$  column is formed, and the average expectation of life for any person at age  $x = \frac{Q_x}{l_x}$ .

A description of the graphic method of obtaining the population and deaths for each single year of life from data giving this information for age-groups will be found in the *Journal of Hygiene*, vol. iii, p. 297, 1903, by Newsholme and Stevenson, and of the analytical method in the English and the American official reports on life-tables.

#### Short Methods for the Construction of a Life-Table.

—The long methods of constructing a life-table are laborious, and for most medical purposes the results obtainable from a life-table scarcely justify the trouble incurred in its construction.

Several shorter methods which give approximately accurate results are available. One described by the late Dr. T. E. Hayward was included in the last edition of this book, and a description of it will be found in the *Journal of the Royal Statistical Society*, vol. lxii, part iii, 1899.

Mr. George King embodied in his Government Report on Life-Tables (Cd. 7512) the description of a short method of constructing abridged life-tables, which gives accurate results. It does not deal with the ages of infancy and early childhood.

Dr. J. Brownlee has shown (*Journal of Hygiene*, vol. xiii, No. 2, 1913) that the expectation of life by formulæ devised by him may be obtained approximately from the standardized death-rate.

Dr. E. C. Snow (Part II, Supplement to the Seventy-Fifth Annual Report of the Registrar-General) has prepared a number of abbreviated life-tables for various divisions of England and Wales, based on the mortality in the years 1911–12. This method, it is claimed, enables a life-table to be constructed in a few hours, provided the ordinary death-rates in various age-groups of the population concerned are available.

The student, therefore, need have no difficulty in constructing a life-table by an abbreviated method, should he

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desire to do so. It remains to be discussed whether much is gained by doing this, beyond the mastery of the details of probabilities of life at different ages, which is secured by detailed study of the statistics of population and mortality, necessitated in the construction of a life-table. This point is discussed at the end of the next chapter.

## CHAPTER XXI

### METHODS OF CALCULATING THE DURATION OF LIFE

THE preceding chapters have prepared the way for a consideration of trustworthy summarized statements of duration of life.

The duration of life is the problem with which vital statistics are largely occupied, while preventive medicine is largely concerned with endeavours towards the attainment of Isaiah's ideal (chap. lxxv. 20): "There shall be no more thence an infant of days, nor an old man that hath not filled his days: for the child shall die an hundred years old." Although nothing is more uncertain than the duration of life, when the maxim is applied to the individual, there are, as Babbage has put it, "few things less subject to fluctuation than the duration of life in a multitude of individuals." It is on this principle that annuities and life assurance can be made the subject of definite and exact calculations, the final results being found to vary within but narrow limits.

An exact statement of the average duration of human life from birth or from any subsequent age can only be given by means of the life-table method; but several other tests have been employed, viz. :—

- (1) The mean age at death;
- (2) The probable duration of life;
- (3) The mean duration of life;
- (4) The expectation of life, or mean after-lifetime;
- (5) The number living out of which one dies annually.

In a life-table, i.e. a stationary population, when all the lives are included in the calculation, the mean age at death, the expectation of life, and the number out of which one dies annually, are numerically identical. The comprehension

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desire to do so. It remains to be discussed whether much is gained by doing this, beyond the mastery of the details of probabilities of life at different ages, which is secured by detailed study of the statistics of population and mortality, necessitated in the construction of a life-table. This point is discussed at the end of the next chapter.

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In a life-table, i.e. a stationary population, when all the lives are included in the calculation, the mean age at death, the expectation of life, and the number out of which one dies annually, are numerically identical. The comprehension

of this point will elucidate the relationship between the five above means of testing the duration of life.

In the construction of the life-table we have seen (p. 239) that when the sum of the numbers living at all the ages higher than a given age  $x$  is taken, *each life is counted once for every complete year it survives after the age  $x$* . The sum total represents the total number of complete years of life lived by the persons who enter upon the year of life  $x$ . If this sum be divided by the number who, according to the life-table, enter upon this year of life, the quotient will be the individual expectation of life at the age  $x$ , so far as complete years of life are concerned. (If we add to this amount half a year as representing the average duration of existence, during the  $x^{\text{th}}$  year of life for those who die during that year, we obtain the complete expectation of life.) But the above sum (of the numbers living at all the ages above  $x$ ) is also the number constantly living above the age  $x$ . Thus in the Brighton Life-Table, out of 51,195 male children at birth, 69 were left at the age of 95 years, and the sum of the number living at all higher ages was  $44 + 29 + 17 + 10 + 6 + 4 + 3 + 2 + 1 = 116$  years. But  $\frac{116}{69} = 1.68 =$  the individual curtate expectation at the age of 95. The number 116 also represents the sum of the number of males constantly living in Brighton at ages above 95 out of 51,195 male children born, who have been traced through life in accordance with the mortality experience in 1881-90. In other words, it represents the entire population aged over 95. Inasmuch as these all die at this or some subsequent age, if we divide the entire population 116 by the number 69 who are living at the age 95, we obtain the number out of which one dies annually, which in a life-table population is identical with the expectation of life.

In the preceding illustration it has been shown that the number out of which one dies annually and the expectation of life are identical for the age 95. It can similarly be shown that they are identical at birth or at any subsequent age.

At birth the mean age at death in a life-table population is also identical with the mean expectation of life, as may be ascertained by the somewhat laborious method of finding the sum obtained by adding together the total ages of the

dying in each year of life, and dividing this sum by the total number of deaths.

Thus *in a stationary or life-table population* the following represent identical quantities :—

$$\begin{aligned} &\text{Mean age at death of persons at all ages} \\ &= \frac{\text{Sum of ages at death}}{\text{total No. of deaths}} \\ &= \frac{\text{number of population}}{\text{No. of deaths in one year}} \\ &= \left. \begin{array}{l} \text{Mean duration of life} \\ \text{or, Mean expectation of life} \\ \text{or, Mean after-lifetime} \end{array} \right\} \text{at birth.} \end{aligned}$$

Mean Age at Death =  $\frac{\text{sum of ages at death}}{\text{number of deaths}}$ . Thus, if

5 persons die at the ages 10, 20, 30, 40, 50, their mean age at death =  $\frac{10 + 20 + 30 + 40 + 50}{5} = 30$  years; and

if a second group of 5 die at the age of 25, 30, 45, 50, 70 respectively, their mean age at death will be  $\frac{25 + 30 + 45 + 50 + 70}{5} = 44$  years. Assuming that these

two groups of persons were exposed during life to similar influences, the question arises, Would the mean age at death of the two groups form a safe standard of comparison between them? It should be noted, to begin with, that the number of persons in the instances quoted is very small, and cannot therefore form a trustworthy basis for comparison. But even if each group embraced a large number of persons, erroneous conclusions would certainly be drawn, as the age-constitution of the two groups is so different. In a life-table population, the mean age at death is, as already seen, the same as the expectation of life at birth. But in a population like that of England and Wales, where the births constantly exceed the deaths, and the population is an increasing one, the mean age at death is necessarily lowered by the large proportion of deaths of young children. On the other hand, when a high birth-rate continues for a series of years, there being added every year to the population more persons than are taken from it by death and migration, there results an excessive proportion of persons between the ages of 5

and 55, during which period of life the death-rate is below the average death-rate for all ages.

It follows that in contrasting different communities the mean age at death is a most fallacious test, owing to variations in birth-rate and in migration of population.

In the comparison of different *classes of society*, and those engaged in different *occupations*, serious errors have arisen by the use of this test to determine their relative vitality. It would be absurd, for instance, to draw any inferences from a comparison of the mean ages at death of bishops and curates, as men do not usually become bishops till they have passed the middle period of life. Similarly in comparing the gentry with tradesmen. Many gentry are retired tradesmen, and their mean age at death is therefore higher than that of tradesmen. A Socialist leader in 1890 stated that the mean age at death of workmen was 29-30 years, of the well-to-do classes 55-60 years. This statement does not shed any light on the relative vitality of the two classes under comparison. It simply shows that the Trade Union Societies, from which the above figures were derived, consisted largely of young men, whose age at death, if they died at all, must necessarily be lower than that of the well-to-do classes, consisting as they do in a large measure of persons retired from active work.

The acceptance of the mean age at death as a test of the duration of life is a fragment of the error involved in the construction of a life-table from the deaths alone, as in Dr. Price's Northampton Table (see p. 232).

**Effect of Birth-rate upon the Mean Age at Death.—** We have already seen that in a stationary population unaffected by migration, in which the births equal the number of deaths, the expectation of life at birth is identical with the mean age at death, and with the number of the population out of which one death annually occurs. Inasmuch as the births and deaths are equal in number, the mean age at death is also equal to the number out of which one annual birth occurs. In a non-stationary population the state of matters is altogether different.

The late Sir B. W. Richardson claimed for the inhabitants of his "Hygeiopolis" that their death-rate would be reduced to five per 1,000. It was soon afterwards asserted

in *The Times* that this would imply a mean duration of life (using the term in the sense of mean age at death) of 200 years, and that *a fortiori* Sir B. W. Richardson's anticipations were absurd. It is only, however, where the population is stationary that the mean age at death, with a death-rate of 5 per 1,000, would be 200 years; and in a population with a high birth-rate the above anticipation was not so absurd as it appeared.

Dr. Rumsey urged that returns should be made of the mean age of the living =  $\frac{\text{sum of ages of population at census}}{\text{number of population}}$  as a

corrective of the fallacies connected with the mean age at death. He adds it is now "clear that the average duration of the lives of those who *die* in any place or country does not imply the average age of those who *live* there, any more than it means their average 'expectation of life.'" He gives the following example, taken from the experience of the metropolis a quarter of a century before the date of his remarks: "Paradoxical as it may seem to the uninitiated, 1 out of 41 may die annually, the mean age at death may be 29, the mean age of the living may be 26, and the mean expectation of life may be 37; in the same population at the same time." (*Essays on Some Fallacies of Statistics*, 1875, p. 211.) Sir E. Chadwick found that in fairly healthy districts the mean age of the living was to the mean age at death as about 3 to 4, while in insanitary districts with shifting and increasing populations the line of vitality was higher than that of mortality. But this is due to the fact that insanitary conditions increase mortality, especially among young children, and, in addition, there are always crowds of young and healthy persons ready to immigrate from country to town, thus lowering the mean age of the town populations, among whom insanitary conditions are especially rife. On the whole, therefore, the mean age of the living as a test of the duration of life is as untrustworthy as is the mean age of the dying.

The Probable Duration of Life (also called equation of life, or *vie probable*) is a term used to signify the age at which any number of children born into the world will be reduced to one-half, so that there are equal chances of their dying before and after that age. The name is unfortunate, as

every possible duration of life has a probability which may be determined, and is therefore mathematically a "probable lifetime." Using the term in its limited sense, the English experience in 1838-54 gave a probable lifetime for males at birth of 44-45 years; according to the experience of 1881-90 it was 51-52 years, and according to the experience of 1901-10 it was 58-59 years.

**De Moivre's Hypothesis.**—This assumed that the decrements of population are in arithmetical progression, and that of every 86 persons born, 1 would die uniformly every year until all were extinct. Such an assumption was convenient in the calculation of annuity tables, before accurate life-tables were constructed. According to this hypothesis there is no such function as the probable duration of life, the probability of death in any year being as great as in any other. It confessedly errs greatly at the beginning and end of life, and is only a very rough approximation to the truth for the middle period of life.

**The Expectation of Life** (synonyms: mean after-lifetime, mean duration of life, *vie moyenne*) is found, as already described (p. 239), from a life-table. A life-table shows how many of a given number, started with at a given age, live through each subsequent year of life, and what is the sum of the number of years they live. The expectation of life is obtained by dividing the sum of these years by the number living at the year of age from which the expectation of life is desired.

It should be observed that the expectation of life is the *average* number of years which persons of a given age, taken one with another, live, assuming that they die according to a given table of the probabilities of life. The term "expectation of life" does not imply that an individual may reasonably expect to live a given number of years. The excess of those who die late is distributed among those who die early, "those who live longer enjoying as much more in proportion to their number as those who fall short enjoy less of life." Thus the expectation of life is not the most probable lifetime of any given individual.

Many attempts have been made in the absence of a life-table to ascertain the expectation, but none of them give trustworthy results.

The formula of Willich gives approximate results for ages between 25 and 75.

It is as follows :—

If  $x$  = expectation of life, and  $a$  = present age, then

$$x = \frac{2}{3}(80 - a).$$

Thus at the age of 45 years the expectation of life according to this formula =  $\frac{2}{3}(80 - 45) = 23.3$  years. According to the English Life-Table (No. 8) it varies from 23.3 for men to 25.5 for women.

**Probabilities of Life.**—It is sometimes desirable to ascertain not only the probable duration of life, but also the probability of dying within a given period.

In mathematical language, the words *chance* and *probability* are used as synonymous; but in common language the first word is used when the expectation that an event will happen is small, and the second when it is large.

If the number of possible events =  $a + b$ , of which  $a$  are favourable and  $b$  unfavourable, and if  $p$  = the probability of a favourable event happening, and  $q$  = the probability of an unfavourable event happening, then, on the supposition that one of these events happens,  $p = \frac{a}{a + b}$ ;  $q = \frac{b}{a + b}$ ; where  $p + q = 1$ , or certainty.

Thus, if we wish to find the probability of a man aged 30 living till he is 50, and also the probability that he will die before that age, we consult the life-table for males. If the number living (out of a million males born) at 30 is 669,279, and at 50 is 517,639, the probability of a man aged 30 living to 50 =  $\frac{517,639}{669,279}$ .

And as  $669,279 - 517,639 = 151,640$  = the number dying during the period; therefore  $\frac{151,640}{669,279}$ , or  $1 - \frac{517,639}{669,279}$  = probability of dying between 30 and 50.

If there be several independent events, the probabilities of the happening of which are respectively  $p_1, p_2, p_3$ , etc., then the probability that all the events will happen is  $p_1 \times p_2 \times p_3 \times$  etc.; that all will fail  $(1 - p_1)(1 - p_2)$

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$(1 - p_3)$  etc.; that at least one event will happen,  $1 - (1 - p_1)(1 - p_2)(1 - p_3)$  etc.; and that exactly one will happen and all the rest fail,  $p_1(1 - p_2)(1 - p_3)$  etc.  $+ p_2(1 - p_1)(1 - p_3)$  etc.  $+ p_3(1 - p_1)(1 - p_2)$  etc.  $+ \text{etc.}$

Thus, if  $p = \frac{a}{a+b}$  and  $p_1 = \frac{c}{c+d}$ , then the probability that both will happen is  $\frac{a}{a+b} \times \frac{c}{c+d}$ , and the probability that neither will happen is this amount subtracted from unity.

Thus, the probability that a married couple—the husband's age being 40, and that of the wife 35—will both live 15 years, is obtained as follows:—

If by the life-table out of 1,000,000 of each sex at birth, there are—

Of males at 40 years old, 604,923; at 55 years old, 462,981.

Of females at 35 years old, 638,912; at 50 years old, 516,375.

The probability of both these persons surviving 15 years from their present age =  $\frac{462,981}{604,923} \times \frac{516,375}{638,912}$ , which product gives the required result.

## CHAPTER XXII

### PROBABILITIES OF LIFE IN THE TWO SEXES, AT DIFFERENT AGES AND IN DIFFERENT COMMUNITIES

A LIFE-TABLE makes it practicable to study the life-history of the persons who in the table are traced through life. In life-tables constructed from the experience of insurance societies, the same persons are traced throughout the whole of their insured lives. National life-tables or local life-tables, dealing with the experience of the entire population in a given country or area, do not trace the same persons throughout life, but assume that a given number of persons are subjected throughout the whole of their lives to the death-rates of a given group of years.

For such a study the life-table supplies three chief numerical results:—

- (a) The probability at each exact age of living one year ( $p_x$ ) in the two sexes separately.
- (b) The number of survivors out of 100,000 children born of each sex, at the end of each succeeding year of life, until the whole number become extinct by death.
- (c) The expectation of life, or mean after-lifetime, of males and females at the end of each year of life.

The first of these merely gives us the same information as  $m_x$ , the central death-rate or rate of mortality for each year of life,  $m_x$  and  $p_x$  being connected in the manner shown in the formula on page 238. For ordinary purposes the death-rates 0-5, 5-10 . . . . 20-25, 25-35, 35-45, etc., give us all that is required of current information respecting a community, and enable adequate comparison to be made with past experience.

The two additional tests supply composite information respecting the average past and the average future expected

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experience of a section of a given community, which is supplied only by a life-table in this composite manner.

By means of these tests it is practicable to compare these experiences for the two sexes, for different communities and at different periods.

**Comparison of the Two Sexes.**—The English experience of 1901–10, as shown in Mr. King's life-table, is given in part in the following table:—

ENGLISH LIFE-TABLE, No. 7 (EXPERIENCE OF 1901–10).

Age.	No. of Survivors at Different Ages.		Expectation of Life in Years.	
	Males.	Females.	Males.	Females.
0- .. ..	100,000	100,000	48·53	52·38
1- .. ..	85,566	88,257	55·68	58·31
5- .. ..	79,398	82,178	55·90	58·53
10- .. ..	78,083	80,756	51·81	54·53
15- .. ..	77,297	79,898	47·31	50·08
20- .. ..	76,113	78,756	43·01	45·77
25- .. ..	74,546	77,391	38·86	41·54
30- .. ..	72,741	75,779	34·76	37·36
35- .. ..	70,472	73,769	30·79	33·31
45- .. ..	64,230	68,359	23·27	25·53
55- .. ..	54,435	60,179	16·48	18·27
65- .. ..	39,278	46,716	10·80	11·99
75- .. ..	19,754	26,418	6·41	7·10
85- .. ..	4,349	7,094	3·53	3·94
95- .. ..	149	393	2·07	2·32
105 .. ..	2	20	0·78	1·20

The survivorships shown in this table confirm the death-rates given in Chapter X, the superiority of the aggregate female over the aggregate male vitality being visible throughout life, both as regards survivorship to any given age, and expectation of life from that age onwards. At birth a female infant, on the basis of the experience of 1901–10, had an expectation of 3·75 more years of life than a male infant; at the age of 20 the female expectation was 2·76 years greater than the male; at 30 it was 2·60 years greater; at 45 it was 2·26 greater; and at 75 it was still 0·69 years greater for females than for males. The student will find further comparisons of male and female survivorships and life expectations in the official volume containing Mr. King's life-tables.

**Life-table Comparison of Married and Unmarried.**—The official English tables based on the experience of mortality in 1910-12 enable the vital experience of women to be stated in accordance with marital condition. In the following table, in which the age 25 is taken as the starting-point, some of the results of this examination are shown :—

LIFE-TABLE FOR ENGLAND AND WALES, FEMALES (EXPERIENCE OF 1910-12).

*Number of Survivors at Different Ages.*

Age.	Spinsters.	Wives.	Widows.
25- .. ..	10,000	10,000	10,000
30- .. ..	9,833	9,806	9,739
35- .. ..	9,623	9,584	9,442
40- .. ..	9,372	9,308	9,092
45- .. ..	9,053	8,971	8,674
50- .. ..	8,625	8,570	8,134
55- .. ..	8,088	8,047	7,489
65- .. ..	6,520	6,472	5,739
75- .. ..	4,021	3,961	3,234
85 .. ..	1,188	1,180	863

At each age widows survive in fewer numbers than either spinsters or wives ; but the difference between wives and spinsters is almost insignificant. (See also p. 213.) Such differences as are visible are probably explicable rather by the less favourable average social circumstances of widows than by any essential relationship between marriage and long life.

**Historical Changes in Survivorship and Life Expectation.**—From the facts and arguments included in preceding chapters we can start with the following general statements : First, when it is desired to ascertain at what ages in either sex a change in vitality has occurred, death-rates for each age-group must be compared, as in the table on page 204. No life-table elements—except  $p_x$  and  $m_x$  for each year of life, which for ordinary public health purposes give a confusing minuteness of detail—can in practice replace these age-distributed death-rates. Secondly, when it is desired to summarize for any age the total past experience at lower ages ( $l_x$ ), or the total future expectation of life for any age ( $e_x^\circ$ ), the life-table is needed. Such information, however, fails to reveal the age at which any variation from the ordinary

occurs, and therefore tells less than the death-rates at successive age-groups.

In the following paragraphs comparisons are made chiefly of survivorships after the age 25. This has important bearing on the question as to whether the great saving of life during the last fifty years, which has been most marked in childhood, has been associated with improvement in adult life.<sup>1</sup> The subject is more fully discussed elsewhere.<sup>2</sup>

In the tables on page 253 the facts are shown for males.

As shown in Table A, in each successive English life-table the number of survivors to the age 25, out of equal numbers born, has continuously increased with lapse of time. The subsequent course of events for adult life can more accurately be followed in Table B. It will be seen that with the exception of ages 60 and upwards in the decennium 1881-90, the number of survivors out of every 1,000 reaching the age of 25 years has steadily increased with lapse of time until after the Psalmist's term of life is passed. Similarly, out of every 1,000 reaching 40 years of age (Table C), with the exception of ages 55 and upwards in 1881-90, improvement is shown at all ages over 40. These tables give no evidence of national deterioration at higher ages. They show, on the contrary, increased longevity in each succeeding period. This is further illustrated in Fig. 21.

In the last table are embodied data from Dr. S. W. Abbott's life-table based on the experience of Massachusetts in 1893-7, which are probably comparable with corresponding data from the United States Census Bureau's Report for 1909-11.

When the whole of life is taken into account, the results in Massachusetts show improved prospects of life in every age-period, so in the main do the figures for equal numbers starting at age 25; but for equal numbers starting at age 40 there is no evidence of improvement after the age of 65.

The series of life-tables issued by the Bureau of the Census, based on the deaths in the three years 1909-11 and the population of 1910, give valuable material for comparison

<sup>1</sup> Mr. George King has pointed out that in the English Life-Table for 1838-54, that for higher ages, and especially for ages over 60, the death-rate was under-estimated, and that therefore the improvement in recent years is much greater than appears.

<sup>2</sup> See my "Harvey Lecture, January 29, 1921, on "National Changes in Health and Longevity," published in the *Quarterly Publication of the American Statistical Association*, June, 1921.

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A. NUMBER OF MALE SURVIVORS AT HIGHER AGES OUT OF 1,000 BORN.

Experience of	England and Wales.				Massachusetts, U.S.A.	
	1838-54.	1881-90.	1901-10.	1910-12.	1898-97.	1909-11.
No. at birth ..	1,000	1,000	1,000	1,000	1,000	1,000
No. at age						
25 .. ..	624	694	745	779	680	760
30 .. ..	595	669	727	762	651	739
35 .. ..	564	640	705	742	620	713
40 .. ..	532	605	677	717	588	683
45 .. ..	496	564	642	685	554	646
50 .. ..	456	518	599	643	515	604
55 .. ..	400	463	544	590	468	551
60 .. ..	356	398	476	521	411	482
65 .. ..	295	322	393	435	344	395
70 .. ..	223	239	299	334	267	296
75 .. ..	148	154	198	224	185	197

B. NUMBER OF SURVIVORS AT HIGHER AGES OUT OF 1,000 AT AGE 25.

No. at age	England and Wales.				Massachusetts, U.S.A.	
	1,000	1,000	1,000	1,000	1,000	1,000
25 .. ..	1,000	1,000	1,000	1,000	1,000	1,000
30 .. ..	954	964	976	978	958	972
35 .. ..	904	922	946	952	912	938
40 .. ..	852	872	909	920	865	899
45 .. ..	794	813	862	879	815	850
50 .. ..	731	746	804	826	758	795
55 .. ..	655	667	730	758	688	725
60 .. ..	570	574	639	669	604	634
65 .. ..	473	464	528	558	506	520
70 .. ..	357	344	401	429	393	389
75 .. ..	237	222	266	288	272	259

C. NUMBER OF SURVIVORS AT HIGHER AGES OUT OF 1,000 AT AGE 40.

No. at age	England and Wales.				Massachusetts, U.S.A.	
	1,000	1,000	1,000	1,000	1,000	1,000
40 .. ..	1,000	1,000	1,000	1,000	1,000	1,000
45 .. ..	932	932	948	956	942	946
50 .. ..	857	856	885	897	876	884
55 .. ..	769	765	804	823	796	807
60 .. ..	669	658	703	727	699	706
65 .. ..	556	532	580	606	585	578
70 .. ..	420	396	442	466	454	433
75 .. ..	278	255	291	312	315	288

NOTE.—Heavy type is for ages at which survivorship has deteriorated.

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with the data of England and Wales. Dr. William H. Davis, the chief statistician for vital statistics of the Census Bureau, informs me that the national English and the American life-tables are comparable with respect to methods of construction. In the tables on page 255 are compared the number of survivors out of 1,000 males at birth, at age 25, and at age 40, and in each successive 5 additional years of age. The columns for different sections of the population

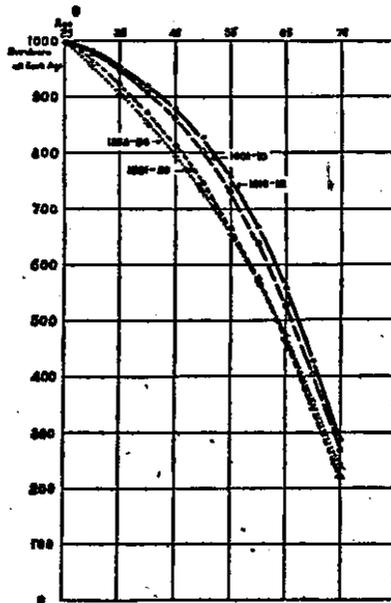


FIG. 21.—Life-Table Experience, England and Wales, for Four Periods. Number of Male Survivors at Each Subsequent Age out of 1,000 at Age 25, in 1838-54, 1881-90, 1901-10, and 1910-12.

of the United States are arranged in order of the number of survivors to the highest age, beginning with the experience of greatest vitality.

It will be noted that the aggregate white males in the rural parts and in the whole of the registration area, and the population of the States of Indiana and Michigan, showed the largest number of survivors to age 25, Michigan coming next.<sup>1</sup>

In Fig. 22 the relative experience of males in rural parts and in cities and of Massachusetts as a whole is shown.

<sup>1</sup> Separate life-tables have been published for Indiana, Massachusetts, Michigan, New Jersey, and New York.

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UNITED STATES LIFE-TABLES, 1909-11, FOR MALES.

*A. Number of Survivors at Higher Ages Out of 1,000 Born.*

	Total White Males (Rural parts). <sup>1</sup>	Native- born White Males. <sup>1</sup>	Total White Males. <sup>1</sup>	White Males in Cities. <sup>1</sup>	Indi- ana.	Michi- gan.	New Jersey.	New York.	Massa- chusetts.
No. at birth	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
No. at age									
25 ..	806	768	770	751	804	791	764	756	760
30 ..	785	744	748	728	782	771	741	731	739
35 ..	763	716	721	698	757	749	712	701	713
40 ..	738	683	688	662	732	725	677	662	683
45 ..	710	648	651	619	702	698	637	619	646
50 ..	677	608	607	569	667	663	591	569	604
55 ..	637	561	556	510	628	621	537	511	551
60 ..	581	501	490	435	570	565	466	440	482
65 ..	506	426	409	347	498	489	381	358	395
70 ..	409	337	315	253	404	393	288	269	296
75 ..	294	237	216	162	290	279	194	180	197

*B. Number of Survivors at Higher Ages Out of 1,000 at Age 25.*

No. at age	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
25 ..	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
30 ..	974	969	971	969	973	975	970	967	972
35 ..	946	932	936	929	942	947	932	927	938
40 ..	916	889	894	882	911	917	886	876	899
45 ..	881	844	846	824	873	882	834	819	850
50 ..	840	792	788	758	830	838	774	753	795
55 ..	790	731	722	679	781	785	703	676	725
60 ..	721	652	636	579	709	714	610	582	634
65 ..	628	555	531	462	619	618	499	474	520
70 ..	507	439	409	337	503	497	377	356	389
75 ..	365	308	280	216	361	353	254	238	259

*C. Number of Survivors at Higher Ages Out of 1,000 at Age 40.*

No. at age	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
40 ..	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
45 ..	962	949	946	935	959	963	941	934	946
50 ..	917	890	882	860	911	915	873	859	884
55 ..	863	821	808	770	858	857	793	772	807
60 ..	787	734	712	657	779	779	688	664	706
65 ..	686	624	595	524	680	675	563	540	578
70 ..	554	493	458	382	552	543	426	406	433
75 ..	398	347	314	245	396	385	287	272	288

<sup>1</sup> In the original registration States.

The picture is not materially changed when the survivorship of 1,000 men starting at age 40 in each of these States is contrasted. The populations living preponderantly in cities evidently occupy an inferior position. That the conditions of city life explain, largely at least, the marked differences of vitality in the different States is suggested by the partial coincidence between degree of urbanization and paucity of survivors. At the Census of 1910, 92.9 per cent. of the population in Massachusetts was urban (i.e. lived in districts with a population exceeding 2,500); 78.9 per

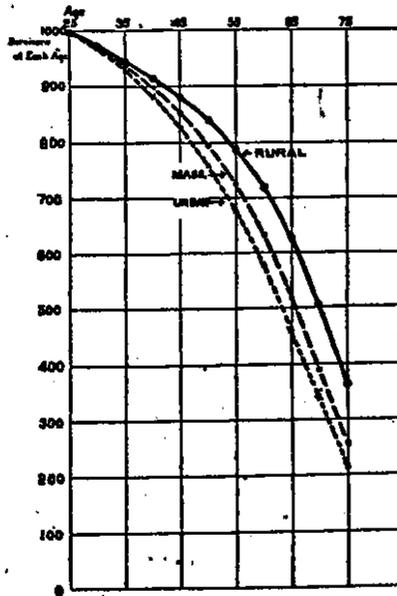


FIG. 22.—Life-Table Experience of the United States (1909-11). Number of Male Survivors at Each Subsequent Age out of 1,000 at Age 25 in the Aggregate Urban and Rural White Populations of the Original Registration States and in Massachusetts.

cent. in New York and 75.2 per cent. in New Jersey, as against 47.2 per cent. in Michigan and 42.5 per cent. in Indiana. The proportion of foreign-born population in 1910 was about 32 per cent. in Massachusetts and New York State; 29.5 per cent. in New Jersey; 22.1 per cent. in Michigan; and 9.2 per cent. in Indiana. It may be added that for every 100 foreign-born persons in Massachusetts the highest proportion is Irish (21.2 per cent.); in New York the greatest number are Russians (20.5 per cent.), followed by Italians (17.5 per cent.) and Germans (16.0 per cent.).

If the experiences from age 25 onward be compared, rural males, the males of Michigan and of Indiana have approximately an equal number of survivors to the age 70, while Massachusetts, New Jersey, and the State of New York have relatively few.

**Changes in Expectation of Life.**—The table on page 253 shows that in England and Wales the probability of survival has increased at all ages right up to advanced years. This continuance of higher survivorship means that from any age onwards the future expectation of life has also increased. As the original tables are readily available, it is scarcely necessary to quote them.

**Urban and Rural Life-Table Experience.**—For many years past the Registrar-General has published tables showing year by year the death-rates, according to sex and age, in London and in the aggregate great towns (county boroughs), in the aggregate smaller towns (urban districts), and in all rural districts in the aggregate. Mr. King's contribution on life-tables (Cd. 7512) shows for each of these combinations expectations of life and survivorships at various ages in both sexes. From this report the following table has been extracted:—

LIFE-TABLES FOR THE THREE YEARS, 1910-12.

Number of Survivors Out of 1,000 at Age of 12.

Age.	Males.				Females.			
	County of London.	Aggregate of County Boroughs.	Aggregate of Urban Districts.	Aggregate of Rural Districts.	County of London.	Aggregate of County Boroughs.	Aggregate of Urban Districts.	Aggregate of Rural Districts.
12 ..	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
15 ..	993	993	994	995	994	993	994	994
20 ..	980	977	979	982	982	978	981	981
25 ..	963	959	962	965	970	962	966	965
30 ..	942	935	942	947	954	943	949	947
35 ..	913	906	920	925	934	921	929	926
40 ..	875	869	891	901	906	890	905	903
45 ..	825	822	856	870	869	853	875	877
55 ..	685	685	744	783	763	746	784	801
65 ..	480	475	532	625	598	569	623	663
75 ..	233	213	277	360	351	306	362	416
85 ..	48	40	61	87	97	73	99	125

The table starts at the age of 12, and therefore ignores

differences of experience in the earlier years of life. Children start fair at the age of 12 in the tables, and this fact is relevant to the discussion on pages 212 and 358. For instance, the children in county boroughs have been subjected prior to this age to more serious dangers to life than children in rural districts. Had this resulted on a large scale in selective influence on survivors, the expectation of life (as can be tested by reference to the original report) should be higher at older ages than in rural districts, unless this influence is veiled by the continuance of adverse influences or by migration of population. No such influence is seen. Thus the male expectation of life at age 25 in county boroughs was 37·80 years, and in rural districts 42·84 years. Evidently environmental influences, with some possible influence of migration in addition, are predominant in the circumstances of civilized life in a large community.

**Comparing Males and Females.**—In London female survivors out of a given number starting at age 12 are more numerous than male survivors before the age of 25 is reached, and the preponderance increases with age. A similar course of events occurs in the great towns. In the smaller urban districts, and still more in rural districts, the excess survival of females is much less marked, and does not appear so early in life.

**Comparing Different Areas for Males.**—But little difference is seen before the age of 35, though county boroughs have the least favourable experience. At higher ages urban and rural districts show a relatively favourable record.

**Comparing Different Areas for Females.**—It is evident that as contrasted with London and urban districts the superiority of country over town is very slight until the age of 55 is reached, but in county boroughs the difference appears earlier and is greater.

How far the above results may be affected by migration of a kind which cannot be corrected by the official method of relegation of deaths (p. 195) is difficult to determine.

**International Comparisons.**—As supplementing the comparisons between the United States Death Registration Area and England and Wales, the following curves of life-table experience show for the period 1901–10 for a number of countries the number of survivors at each age out of

100,000 at birth, for males and females separately. The curves are copied from the United States Life-Tables by permission of the Federal Census Bureau.

A summarized statement of the expectation of life at

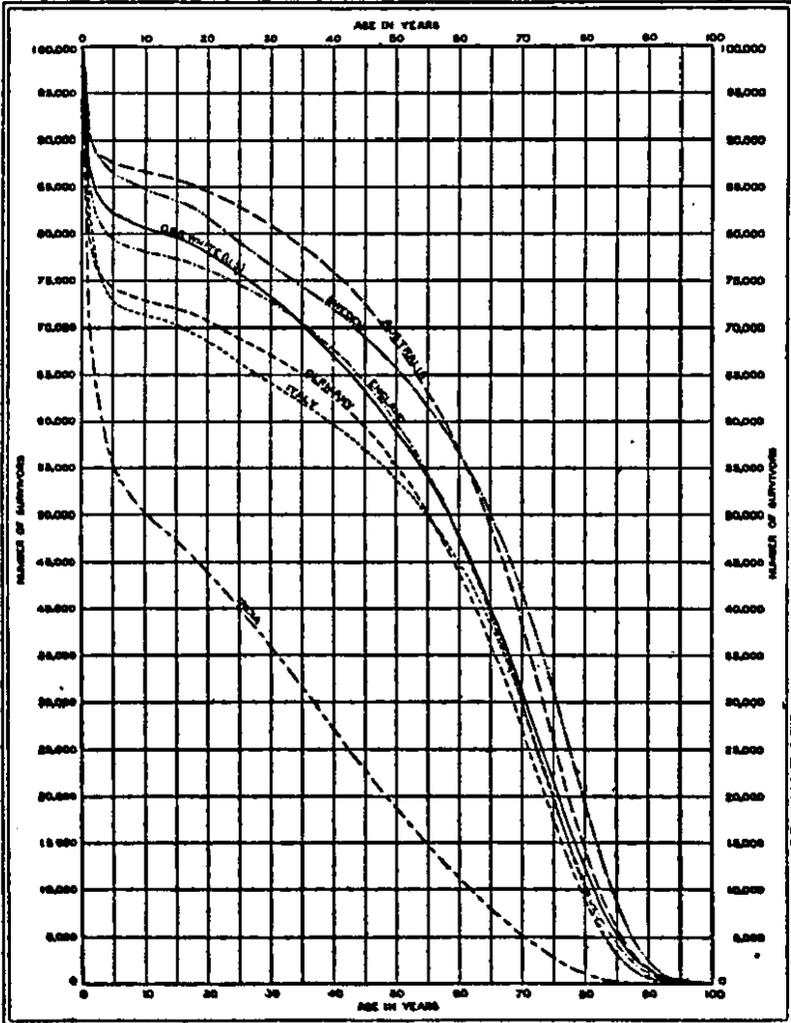


FIG. 23.—Number of Male Survivors at different Ages out of 100,000 Born Alive in the Countries named, 1901-10.

various ages and for different historical periods in many European countries is given on pp. 180-182 of *Annuaire Internationale de Statistique, II, Mouvement de la Population (Europe)*.

The Place of Life-Tables in Statistical Investigations.  
 —As already indicated, the chief practical use of a life-table is to facilitate life insurance work, the calculation of annuity values, etc.

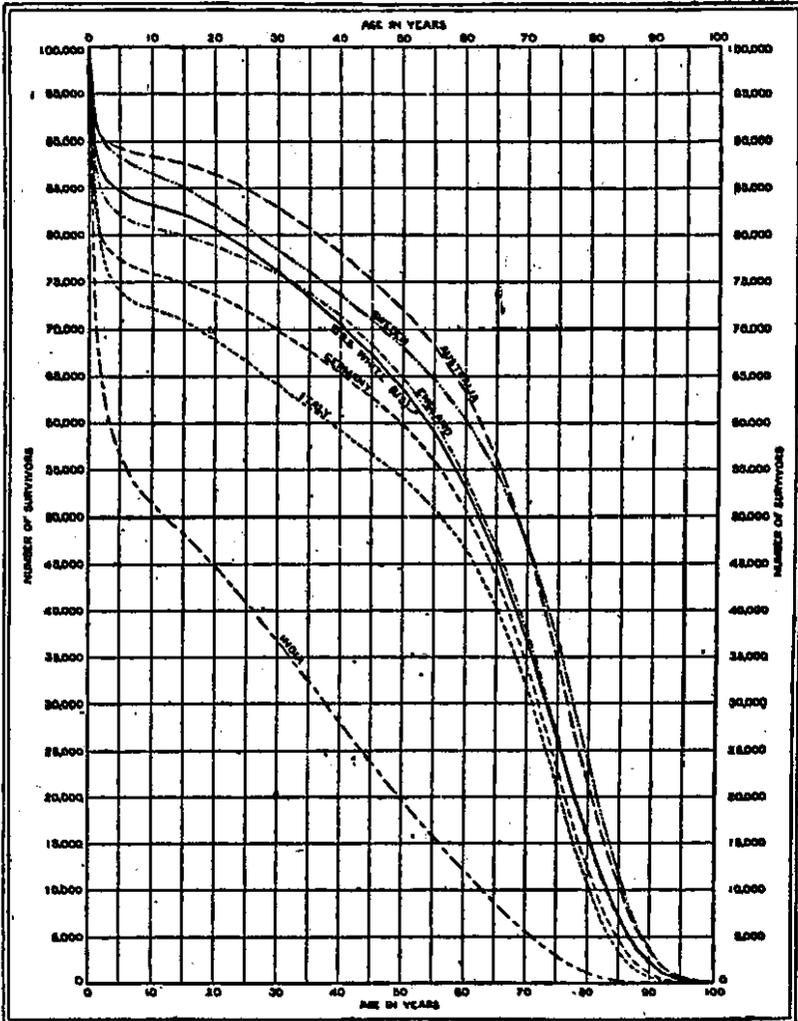


FIG. 24.—Number of Female Survivors at different Ages out of 100,000 Born Alive in the Countries named, 1901-10.

Does it supply any useful indications in public health and similar inquiries beyond what is supplied by death-rates (male and female) per 1,000 living in each age-group, and  $l_x$  standardized death-rates?

In a recent discussion at the Royal Statistical Society (*Journal*, Vol. 85, Part IV, 1922), introduced by Dr. Greenwood, the relative merits of standardized and life-table death-rates were debated. Dr. Brownlee held that the experience of life-table populations is the proper subject of comparison, standardized death-rates being misleading; but this view did not find favour, and it may be regarded as axiomatic that the experience of persons living at given ages, should be compared with that of others living at the same ages, and that we should only accept death-rates for all ages as final tests when they have been standardized, i.e. when constant weights have been attached to each of the death-rates under comparison for varying age or sex distribution of population. The standardized death-rate thus provides a summary of the death-rates for age-groups. A life-table death-rate does not.

The life-table gives a concise and almost dramatic method of stating survivorships up to any given age and prospective duration of life from that age onwards. Such a summarized statement is valuable, but it does not obviate the need for investigation into special death-rates according to age and sex. These death-rates are the fundamentally important items.

Comparative mortality figures are substantially standardized death-rates, and the possibility of unequal age distribution of persons industrially employed not infrequently arises in connection with these (p. 313).

## CHAPTER XXIII

### SOME FACTORS INFLUENCING THE DEATH-RATE

IN previous editions of this work a special chapter has been devoted to the "influence of climatic and social conditions on mortality." One of these conditions, that of marriage, has already been discussed (p. 213). Other factors that may be mentioned in this connection are climate, season, cyclical changes, race, poverty and wealth, sanitation, urban and rural life, density of population, occupation. Nearly every one of these important problems, however, is complex, and cannot be profitably discussed in detail, unless specific as well as general death-rates are displayed; and many of the problems involved are discussed from various angles in other chapters of this work. Here it is proposed to state briefly statistics bearing on the influence of race, climate, and season on mortality, giving some illustrations of influence of these factors on specific death-rates.

The American vital statistics given in the annual "Mortality Statistics" for the United States include death-rates in different countries. The influence of race is discussed in a number of papers by Dr. L. Dublin; and a comparison of the vitality of white and coloured populations is contained in Dr. Hoffman's treatise on *Race Traits and Tendencies of the American Negro* (1896, Publications of the American Economic Association).

**Race and Tuberculosis.**—A considerable body of evidence exists showing that the gradual tuberculization by minimal doses of tubercle bacilli is a condition of subsequent relative immunity to tuberculosis. This evidence is summarized in Dr. G. E. Bushnell's *Epidemiology of Tuberculosis* (1920), and Professor Lyle Cummins has contributed evidence to a similar effect in the *International Journal of Public Health*.

The infantile and early adult peaks of tuberculosis mortality (p. 446) are explicable on this hypothesis, and

the hypothesis goes far to explain the very marked differences in racial mortality from tuberculosis. Whether, apart from differences in degree of exposure to infection during early life, racial differences in immunity to tuberculosis exist, may be regarded as still doubtful.

The following table comparing death-rates from various diseases in white and coloured persons has been taken from Dr. L. I. Dublin's work on *Mortality Statistics of Insured Wage Earners and Their Families*, 1919. It is concerned with the experience of nearly 28 million male policy-holders in the industrial department of the Metropolitan Life Insurance Company, of whom nearly 7 millions are coloured. All these are industrial workers, and there would appear to be a possibility of distinguishing racial characters, though it is probable that in other conditions, besides race, the two groups differ greatly.

RELATIVE DEATH-RATES, 1911-16, OF COLOURED MALES, THE DEATH-RATE IN WHITE MALES AT EACH AGE BEING STATED AS 100.

Age-Period.	Relative Mortality of Coloured Males from		
	All Causes.	Tuberculosis.	Cancer.
1-5 .. .. .	172	796	70
6-10 .. .. .	149	1,030	67
11-15 .. .. .	200	1,127	20
16-20 .. .. .	248	431	79
21-25 .. .. .	202	235	28
26-35 .. .. .	154	145	85
36-45 .. .. .	121	103	78
46-55 .. .. .	117	99	58
56-65 .. .. .	117	118	51
66-75 .. .. .	106	124	37
76 and over .. .. .	95	163	47

It is not unlikely that the death-rate from tuberculosis in negroes is somewhat overstated, but the difference in death-rate from this disease, even if large allowance be made for overstatement, is appalling, especially in childhood and youth. The same cause—lack of accurate medical certification—which may explain some of the apparent excess of “consumption,” is also responsible in part for the lower death-rate from cancer in the coloured population.

So far as concerns total mortality, the following life-table figures, based on the United States experience in the

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Registration States, 1909-11, show the difference between whites and negroes in respect of survivorship :—

*Assuming a Stationary Male Population unaffected by Emigration and Immigration, and that the Death-rates at Each Age-period holding good in the 3 Years 1909-11 continued, then the Survivors out of 1,000 Born at the following Ages would be—*

	White Population.	Black Population.
Birth .. ..	1,000	1,000
5 .. .. .	827	686
10 .. .. .	812	664
15 .. .. .	803	645
25 .. .. .	767	577
35 .. .. .	716	499
45 .. .. .	645	406
55 .. .. .	550	298
65 .. .. .	403	178
75 .. .. .	212	75

Jews are credited with exceptional longevity, with a very low death-rate from tuberculosis, and with a high death-rate from cancer and from diabetes. Their experience has been collected in an article on "The Longevity and Mortality of Jews," by Dr. F. L. Hoffman, 1903. Comparisons between Jews and Christians are disturbed by many cross-currents; the change of religious belief is one, but the most serious is the difficulty of securing groups for comparison, which in respects other than religion are similar. Jews, as Dr. Hoffman points out, are rather a people than a race, having two main branches, the Spanish Jews and the northern type to which German, Polish, and Russian Jews belong. Available statistics relate chiefly to the last-named group. Körösi collected separate statistics for the Jews in Budapest, who formed one-fifth of its total population, and the death-rates show a superiority of Jews over Catholics and Protestants in every age-period. The following extracts from a table quoted by Hoffman from Körösi may be given (see table at top of p. 265).

The table does not include diabetes; but it is stated that the death-rate among Jews from this disease is double that for non-Jews both in Budapest and in Amsterdam. Cancer also appears to be excessive in Jews; but Hoffman gives Rotterdam death-rates for cancer of the uterus of 8.2 for Jews,

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BUDAPEST, 1886-90.

*Death-rates per 100,000 of Population.*

	Jews,	Catholics,	Lutherans.
Consumption .. .. .	287	723	708
Pneumonia .. .. .	186	406	349
Diarrhœal diseases .. .. .	154	429	344

23·8 for Protestants, and 22·8 for Roman Catholics. A certain element of doubt attaches to all these figures, but there is less ambiguity for—

**Infant Mortality Rates for Jews.**—Dr. W. H. Guilfooy, Registrar of the City of New York, in a special report on “The Influence of Nationality upon the Mortality of a Community” (No. 18, November, 1917), has given striking and anomalous statistics of infant mortality in New York according to the nationality of the mother. From this report the following table is extracted :—

INFANT MORTALITY ACCORDING TO NATIVITIES OF BOTH PARENTS.

New York City, 1915.				Birth Registration Area, U.S., 1920.
Nativity of Both Parents.	No. of Deaths under 1 Year.	Death-rate per 1,000 Births.	Death-rate per 1,000 Births.	
Austria-Hungary .. .. .	942	79·8	112·9 <sup>1</sup>	93·7 <sup>1</sup>
Russia—Poland .. .. .	1,903	77·9	71·8	?
Scotland .. .. .	16	79·2	75·8	90·7
England .. .. .	67	137·9	94·1	81·3
Ireland .. .. .	600	119·3	66·4 <sup>2</sup>	75·8
Italy .. .. .	3,068	103·2		
Germany .. .. .	220	115·6		
Sweden .. .. .	36	65·5		
United States .. .. .	3,935	106·3		

<sup>1</sup> Austria, Poland, Hungary.

<sup>2</sup> Denmark, Norway, and Sweden.

The results are somewhat startling. Under the conditions of life in New York City the infants of English parents in 1915 had a higher infant mortality than those of any other country. Obviously further investigation is desirable, especially as to the environment and social status of the compared groups, and as to the possibility of differences in completeness of

registration of deaths during the first three days after live-birth. The Austro-Hungarians and Polish Russians in the experience are chiefly Jews; and it is likely that maternal nursing in them has been almost universal. Dr. Guilfooy states that "the avoidance of motherhood by German and American mothers by interference with the course of nature is the most prolific cause of the high mortality among these infants." The table cannot be said to give trustworthy evidence of the influence of nationality *per se* on infant mortality.

In the last column above are given infant mortality rates in the United States Birth Registration Area in 1920 according to country of birth of the mother, which should be compared with one another and with the corresponding rates in 1915 for New York City.

**Cyclical Influences** alter the total death-rate by causing a large excess of one or more epidemic diseases. It has been usually assumed that these cycles are related to the accumulation during epidemic intervals of persons unprotected by previous attack. Even in measles this explanation is not adequate, and in such diseases as smallpox, influenza, rheumatic fever, diphtheria, and scarlet fever, other unknown or little understood factors must be invoked to explain their cyclical changes in prevalence and sometimes also in fatality (case mortality). See also pages 400, 408, 438.

**Climate.**—The influence of climate can only be separated with difficulty from that of other conditions of environment. No useful comparison bearing on this point can be made between the general death-rate of communities possessing fairly good vital statistics, but living in different climates. The divisions of Australia, of New Zealand, of British South Africa, and of Canada, all furnish instances of remarkably low death-rates associated sometimes with sub-tropical summers and extremely cold winters. Where a country is notoriously unhealthy, this is usually due in large measure to the endemicity of malaria or of other insect-borne diseases, often along with parasitic diseases, e.g. anchylostomiasis; and these causes of mortality can be removed.

Climate has a marked influence on the prevalence of particular diseases, as of the diseases just named and of yellow fever, in each of which a high temperature is needed for

effective multiplication of the vectors of infection. Diphtheria and scarlet fever prevail little in tropical countries, and may be absent. Rheumatic fever varies greatly in prevalence in different countries.

Pneumonia is a more fatal and presumably a more prevalent disease in America than in England; and in the United States Registration Area in 1920 the death-rate per 100,000 from this disease varied from 182 in Pennsylvania and 178 in Delaware, to 80 in Florida and 103 in Virginia. The death-rate from this disease in Maryland was 253 for the coloured and 133 for the white population, which accords with the general racial rule.

Season.—Much more is known of the influence of season than of climate on the death-rate. The best plan of showing seasonal mortality is to give proportional figures, the absolute figures for any one season or month in a given year being compared with corresponding figures in another year, irrespective of the populations producing the deaths. A convenient plan of stating monthly deaths is to assume a standard month of 31 days, call the deaths in this period = 100, and state other months in proportion to this. Thus, if the average deaths in 31 days during a year is 4,169, and 4,161 occurred in January, this number = 99.8. If 3,714 occurred in February, then this equals in a month of 31 days  $\frac{3,714 \times 31}{28} = 4,112$ , and its ratio = 98.6. The

general death-rate in England and Wales is almost uniformly highest in the first quarter of the year, usually next highest in its fourth quarter, the position of the third quarter in relation to the second being determined largely by the summer temperature and corresponding variation in the diarrhoeal death-rate.

The seasonal incidence of mortality from all causes in London, over a long series of years, is shown in Fig. 25.

The continuous and dotted lines indicate the constancy of the summer and winter rises of mortality, when plotted for the average of many years; and the upper diagram similarly shows the relation of these two peaks to high summer temperature and low winter temperature.

The course of seasonal mortality can be seen by plotting out from the weekly returns of deaths issued for London

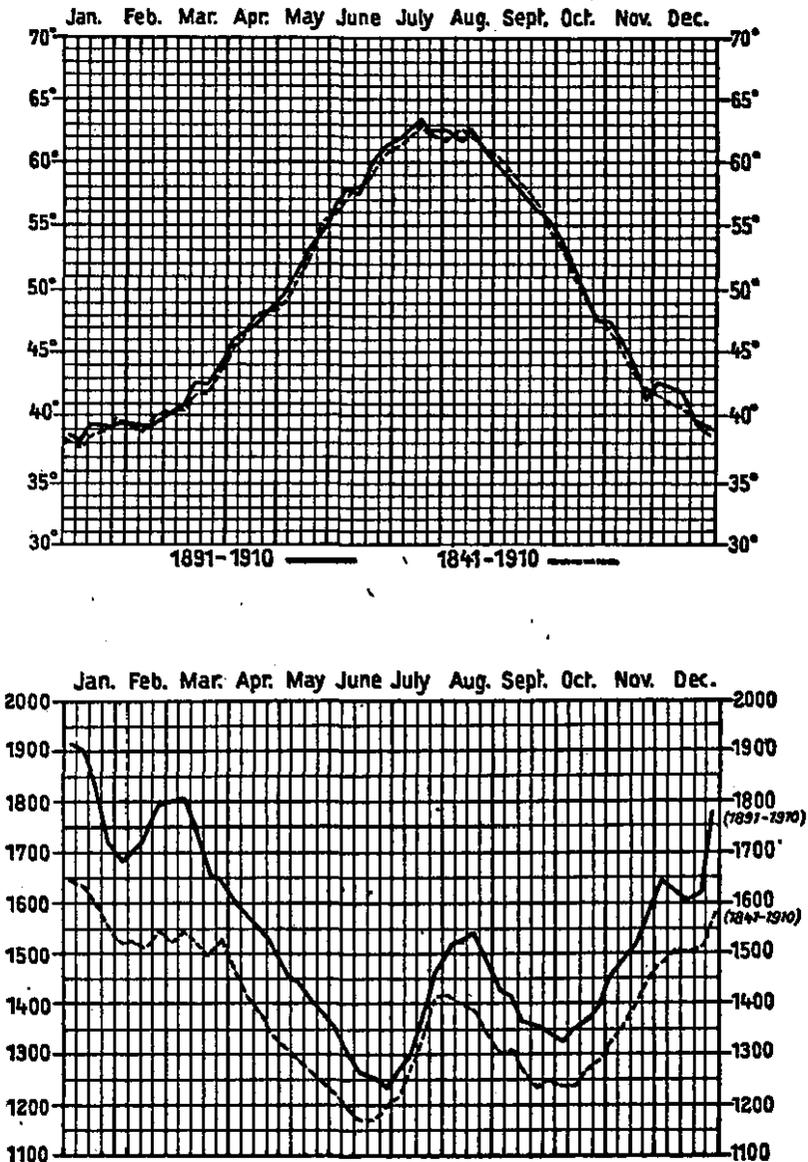


FIG. 25.

*Upper Diagram.* London: Average Weekly Temperature (Fahrenheit) at the Royal Observatory, Greenwich, in the 20 Years 1891-1910 and in the 70 Years 1841-1910.

*Lower Diagram.* London: Average Weekly Deaths from all Causes in the 20 Years 1891-1910 and in the 70 Years 1841-1910.

or some other large town, the weekly total deaths and the deaths at ages over 60 and under 1 year respectively.

Mild winters and cool summers both lower the death-rate, the former especially of the old, the latter of the young, and especially of the infantile population. A cold, wet summer is always accompanied by a low death-rate. The two chief groups of diseases producing changes in the seasonal

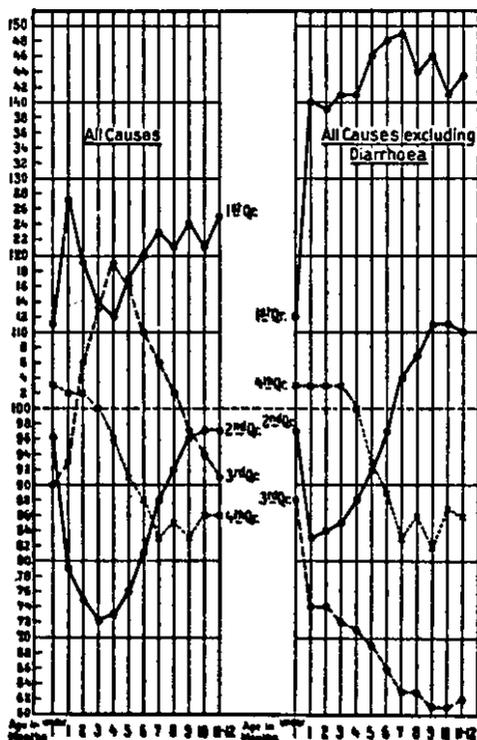
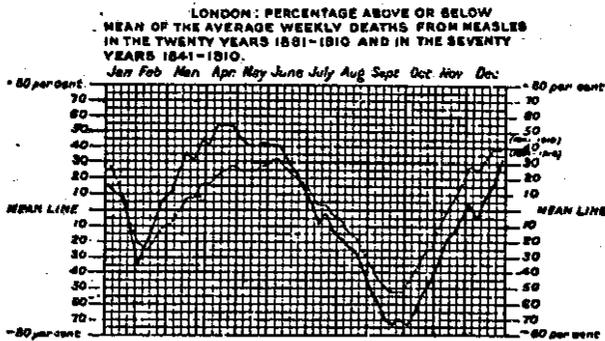


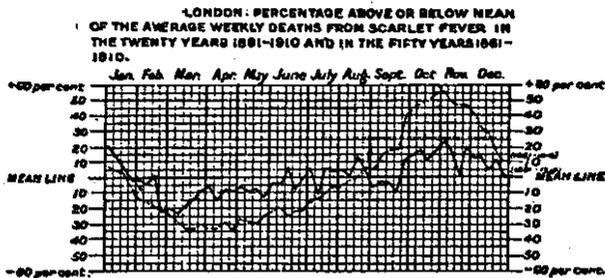
FIG. 26.—Seasonal Distribution of Infant Mortality per 1,000 Corresponding Births, 1911-20 (Quarterly Rates per Cent. of Yearly Rate).

incidence of sickness are diarrhoeal diseases and diseases of the respiratory organs.

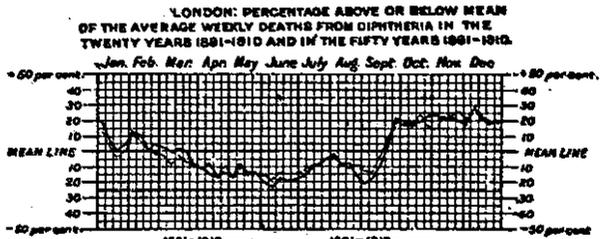
**Season and Infant Mortality.**—The Annual Report of the Registrar-General, 1920, gives an interesting study of this subject. Owing to the extreme variations of the birth-rate during the Great War (p. 339), it was necessary to adopt a special method for relating the deaths of infants occurring in each portion of the first year of life during each quarter to the births of the quarterly periods in which the infants concerned may have been born. For details of the process



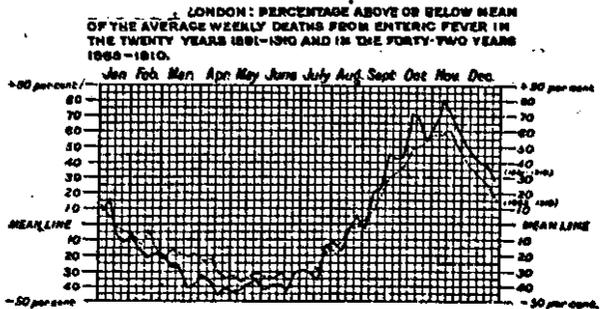
THE MEAN LINE REPRESENTS AN AVERAGE WEEKLY NUMBER OF 44 DEATHS IN 1891-1910 AND OF 36 DEATHS IN 1841-1910.



THE MEAN LINE REPRESENTS AN AVERAGE WEEKLY NUMBER OF 12.4 DEATHS IN 1891-1910 AND OF 31.3 DEATHS IN 1861-1910.



THE MEAN LINE REPRESENTS AN AVERAGE WEEKLY NUMBER OF 28.3 DEATHS IN 1891-1910 AND OF 18.2 DEATHS IN 1861-1910.



THE MEAN LINE REPRESENTS AN AVERAGE WEEKLY NUMBER OF 8 DEATHS IN 1891-1910 AND OF 12.5 DEATHS IN 1868-1910.

FIG. 27.—Seasonal Incidence of Mortality from Measles, Scarlet Fever, Diphtheria, and Enteric Fever in London.

applied see the above-named report. The results for seasonal mortality during 1911-20 are shown in Fig. 26.

In the first quarter of the year the highest death-rate is in the second month after birth, in the second quarter in the tenth and twelfth months, in the third quarter in the

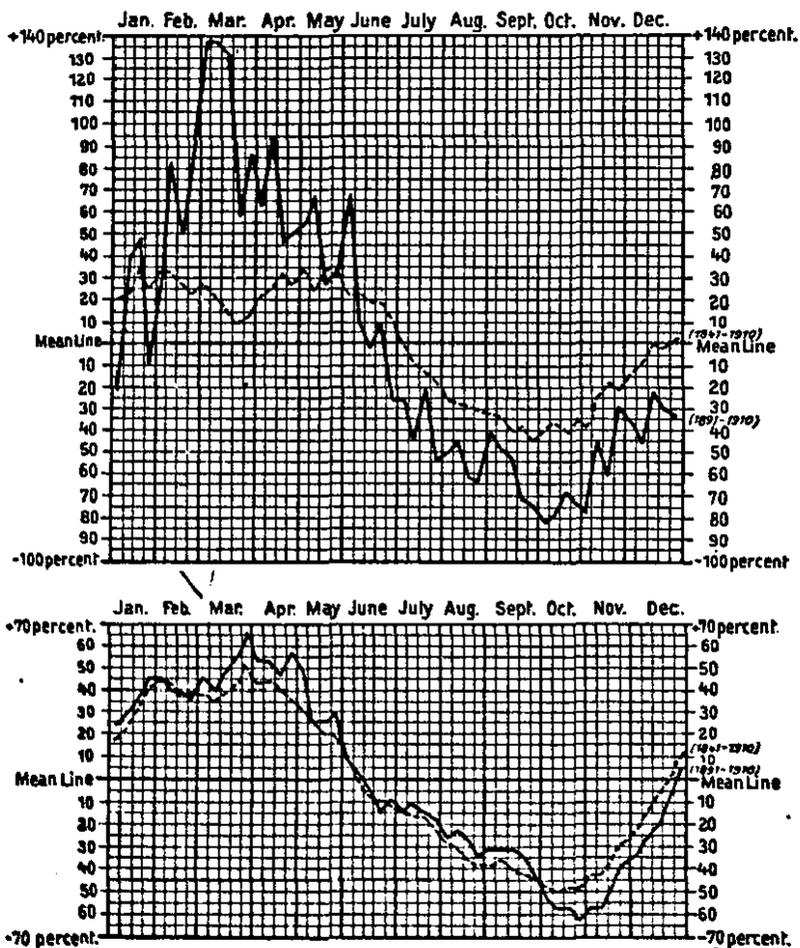


FIG. 28.—Seasonal Incidence of Mortality from Smallpox (upper curves) and Whooping-Cough (lower curves).

fifth month, and in the fourth quarter in the first three months after birth. The result of excluding diarrhoea is shown in the right half of the diagram. The more detailed table in the official report shows well-marked correspondence between temperature and mortality as early as the first week after birth, a point of much importance in preventive medicine.

**Season and Infectious Diseases.**—The diagrams on pages 270 and 271, copied by permission of the Registrar-General from the Annual Summary for 1910, give the seasonal incidence of death from the more common infectious diseases in London. It must be remembered that the curves give composite pictures of the experience of a long series of years, and that in a given year the course of events may not coincide with the smoothed curve. Thus a mild outbreak of scarlet fever, diphtheria, or enteric fever in an "off-season" would spoil the "normal" curve, though such outbreaks most commonly occur in the season of maximum incidence of the disease in question. A curve of seasonal incidence helps in forecasting events. Thus in England we can be fairly certain that the stress on fever hospital accommodation for scarlet fever and diphtheria will diminish from January until the following August, and that the maximum number of cases of enteric fever will occur in the late autumn. Similarly, if a few cases of smallpox occur in May, and adequate measures to prevent infection spreading have not been taken, it is much less likely that a considerable epidemic will occur than if this failure had occurred between December and February. For measles a double maximum is observed in April-May and in December, which does not mean that in a given locality two outbreaks will occur during a single year.

Influenza is interesting as regards seasonal incidence. The following points summarized from a contribution on "Epidemic Catarrhs and Influenza," by me (*Lancet*, November 23, 1918), give the week of maximum number of deaths from influenza in London in a number of outbreaks:—

1890, maximum, 3rd week of the year.  
 1891, maximum, 20th week of the year.  
 1892, maximum, 3rd week of the year.  
 1895, maximum, 10th week of the year.  
 1900, maximum, 2nd week of the year.  
 1908, maximum, 9th week of the year.  
 1909, maximum, 12th week of the year.

In 1918 pandemic influenza began as a summer epidemic not previously experienced. The weekly deaths from influenza from the twenty-fifth to the thirty-first week inclusive were

28th  
week  
10, 67, 218, 287, 192, 86, 38.

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A second wave occurred later in the year, the number of weekly deaths from influenza in the forty-first and following weeks being

44th  
week  
80, 330, 1,256, 2,458, 2,433, 1,065, 1,178, 942, 660, 322.

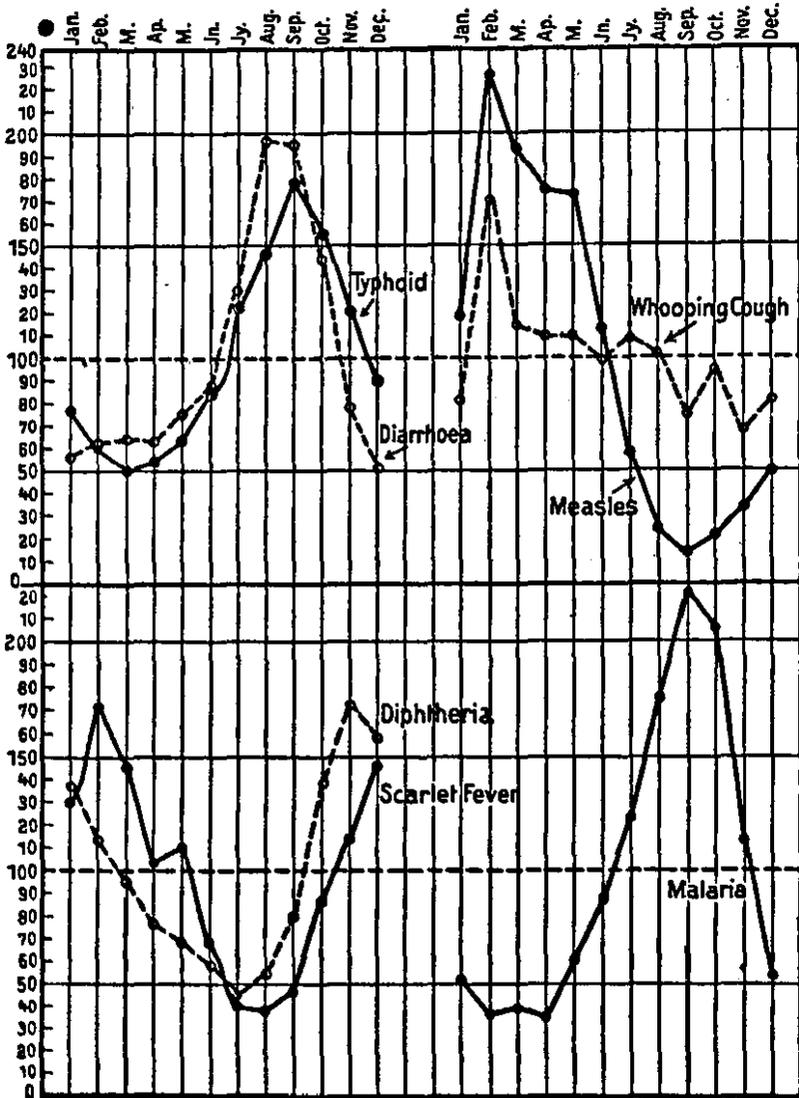


FIG. 29.—Seasonal Incidence of Infectious Diseases in the United States Registration Area in 1920.

The two peaks were separated by 16 weeks, the next nearest approach to so short an interval in the metropolis

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being 35 weeks between the epidemic peaks of 1891 and 1892.

The curves in Fig. 29 show the seasonal incidence of the common infectious diseases for the United States death-registration areas as a whole in the year 1920. All the items are reduced to the same scale, the average monthly number of cases for each disease being taken as 100. It must be remembered that the experience of only a single year is given in the curves, and that other years may show variations from this; furthermore, that the curve represents the composite experience for a wide continent. The significance of this last fact can be tested by ascertaining the maximum period under each disease in different States and cities. The following examples of this may be cited. In 1920 in Mississippi the maximum incidence of typhoid fever was in July and in California in August, in the town of Providence, N.J. (average of 1856-1915), it was in November. The maximum incidence of measles occurred consistently in the first three months of the year. In Kentucky the maximum for whooping cough occurred in October, in Mississippi in July. Scarlet fever culminated in February in New York and Massachusetts, in October in Kentucky, and in December in Pennsylvania. Diphtheria reached its maximum in months varying from November to February; while the maximum diarrhoeal death-rate was in June in Mississippi, in August and September elsewhere. A more complete study of seasonal incidence of the various infectious diseases in various parts of America, carried over a series of years, would have much epidemiological interest.

## CHAPTER XXIV

### DENSITY OF POPULATION AND MORTALITY

ONE of the greatest influences militating against health in the last century has been the increasing gravitation of population into crowded cities. By the year 1851 about half the population of England and Wales had become aggregated in towns, and in 1921 only 20·7 per cent. of the population was left in rural districts (p. 39). The maleficent influence of town life, especially in its earlier unregulated stages, is due to many factors. Streets have taken the place of green fields; rows of unsatisfactory dwellings have replaced country cottages; there is dust and belching smoke and noise instead of sunshine and country air and quiet; bustle and turmoil instead of life in close touch with mother-earth; a preponderance of indoor in lieu of outdoor occupations and these changes have been associated with an almost unlimited inter-communication of human beings, and a corresponding increase in opportunities for the transmission of infection. Prior to the industrial revolution locomotion was slow and tedious, and correspondingly disease travelled by slow and deliberate stages. Now infections from all over the world may be sampled in any town in the course of a few weeks. Difficulties of water supply and of removal of excremental filth have made towns the destroyers of mankind, though man has triumphed in these particulars. Higher rents and less ground space imply that each family on an average lives in fewer and more crowded rooms than in rural districts.<sup>1</sup> At the census of 1911 in England and Wales over eight times as large a proportion of the urban as of the rural population lived in one-roomed tenements, and nearly twice as large a proportion lived in two-roomed tenements; while the proportion of one-roomed tenements in towns which were overcrowded, in the sense of having more than two persons

<sup>1</sup> For a fuller discussion of this subject, see the author's *Public Health and Insurance: American Addresses*. 1920 (Johns Hopkins Press).

to a room, was seven times as great in towns, and of two-roomed tenements was twice as great as in rural districts. It is not surprising, therefore, that nearly always the rural is lower than the urban death-rate, when large aggregates of population are considered. An apparent exception to this rule is shown in Fig. 30.

In the year 1910 the death-rate in the city of New York and in rural New York State had become practically identical, the city death-rate previously having been higher, to a diminishing extent, than the rural rate. In 1915 the rural

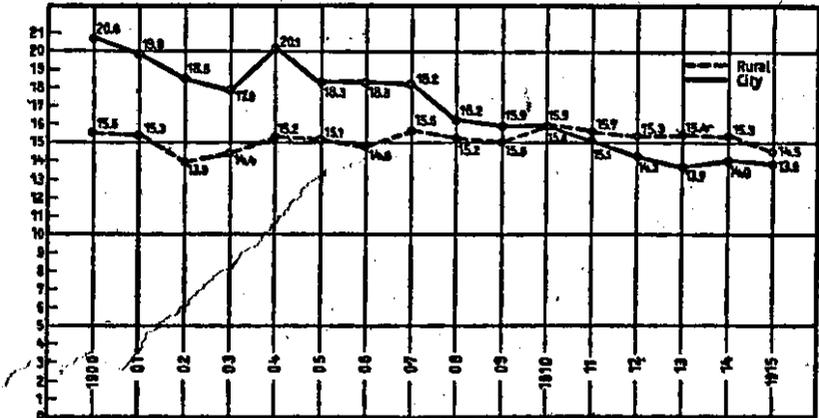


FIG. 30.—Crude Death-rates in New York City, ●—●—●, compared with those in Rural New York State, ○—○—○ (Villages below 8,000 Population classed as Rural.)<sup>1</sup>

rate was 14.5, the city rate 13.9. "The change," it is stated in the book from which the diagram is copied, "is due almost wholly to the efficient health work in cities." This conclusion would be confirmed, (a) if the death and population returns of the two compared areas were fairly comparable in accuracy throughout the period, including an equal inward and outward correction for non-residential deaths, p. 198), (b) if no marked change due to immigration or differences in birth-rates, in the age-distribution of the two populations, had occurred, and (c) if either the age and sex distribution of the two populations was identical or the requisite correction had been applied by means of census data (p. 228). A more satisfactory comparison would have

<sup>1</sup> This diagram is copied from *The Health Officer* by Drs. F. Overton and W. J. Denno (Philadelphia, 1919).

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been between the death-rates at various age-groups in the two communities for corresponding years, say for 1900-09 and for 1910-15. Had the suggested corrections been made, it is doubtful if the rural would be higher than the city death-rate at any age. The presumption in favour of this conclusion is confirmed by English experience, in which the contrast in efficiency of rural and urban sanitation is perhaps not so marked as in the United States. (For further particulars as

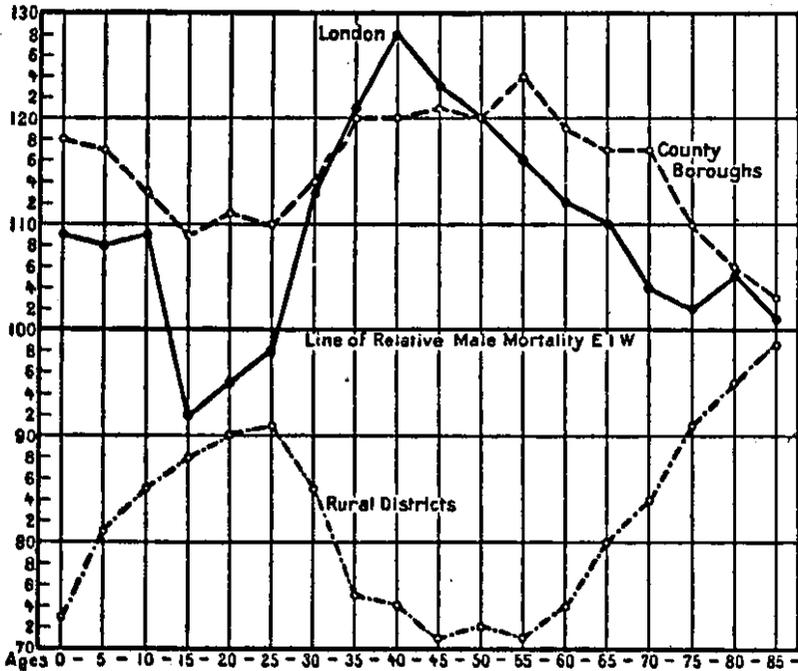


FIG. 31.—Mortality of Males at Each Age-group per Cent. of Male Mortality at the Same Ages in England and Wales, 1911. London, ●—●—●; Aggregate of County Boroughs, ○...○...○; Aggregate of Rural Districts, ○—○—○.

NOTE.—In this diagram the rate of male mortality at each age-period in England and Wales is stated as 100.

to Mortality in Town and Country see pages xlix–lii of the Annual Report of the Registrar-General, England and Wales, 1911.)

In this diagram the death-rate of the whole country at each quinquennial age-period is taken as 100, and the corresponding proportional mortalities for London, county boroughs (i.e. largest towns), and for rural districts are

calculated. It will be seen that the curve of relative mortality in rural districts keeps below the curves for county boroughs and for London, and below that for the average of the whole country at each successive age-period; while the curve for London crosses the county borough curve at ages 35-50. It will be noted also that urban conditions are most unfavourable to life in early childhood and in the middle ages, and more so in the aggregate county boroughs than in London, which in some respects is a province rather than a city. London, however, has a special unfavourable mortality at ages 35-50. The approximation of the three curves in early adult life may not, but probably does not, accurately represent the facts. Corresponding curves for females show even closer approximation at these ages; and it appears probable that the chief explanation of this anomaly is that the most robust adolescents and young adults find their way into the cities, and that those failing in health return to their country homes, and die after an interval when arrangements for "correction" are impracticable (p. 195). This probably is particularly true for phthisis. The curves illustrate the composite result of a number of forces. The better medical, and especially the better hospital, service obtainable by town-dwellers—the difference between town and country is diminishing in these respects with modern ease of locomotion—is more than counterbalanced by the less favourable housing conditions, by the evils of indoor industry, and by the social—especially the alcoholic and venereal—risks of town life.

**Sex Differences in Effect of Urban Conditions.**—The following figure taken from data in the official report already quoted should be studied in association with the facts given on page 205.

It will be seen that in each class of area the ratio of male to female death-rate is lowest in later childhood and highest in adult and later adult life, decreasing in extreme age. The excess of male over female mortality, whether stated proportionally as in Fig. 32, or as death-rates, is least in rural districts and greatest in London. In London, even at ages 5-15, the death-rate of males is higher than that of females, although, taking the country as a whole, female and male death-rates are about equal at ages 5-10, and the

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death-rate at 10-15 is higher in females. Urban conditions of life evidently are much more unfavourable for males than for females, and this excess is in close relation to the risks for males of extra-domestic conditions in towns, socially and industrially.

The English Registrar-General's reports for many years contained studies of the influence of density of population

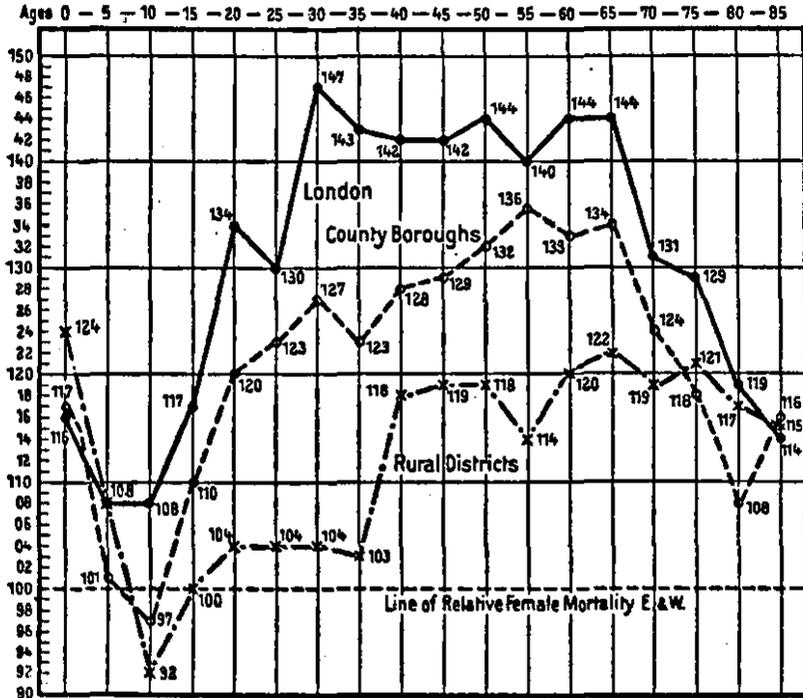


FIG. 32.—England and Wales, 1911: Ratio per Cent. of Total Mortality of Males in Each Age-group to that of Females in the Same Age-group in the Same Areas. ●—●—●, London; ○—○—○, County Boroughs, x.—x.—x, Rural Districts.

NOTE.—In this diagram the rate of female mortality in each age-period is stated as 100.

upon mortality, the earliest appearing in William Farr's contribution to the Fifth Annual Report, 1843.

**Method of Calculating Degree of Aggregation of Population.**—Two methods are commonly adopted: (1) The number of persons living to each square mile of area is stated. (2) The average number of acres occupied by each person in the population is stated.

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The following table gives an example of both these methods :—

ENGLAND AND WALES.  
*Density and Mortality.*

	1851-60.	1861-70.	1871-80.	1881-90.	1891-1900.	1901-10.
Death-rate per 1,000 <sup>1</sup> .. ..	22.2	22.5	21.4	19.1	18.2	15.4
Persons to a square mile .. ..	325	365	416	470	525	586
Acres to a person (mean density) .	1.96	1.74	1.53	1.35	1.22	1.09

<sup>1</sup> These are crude rates. The corresponding standardized rates (Decennial Supplement, Part III, 1901-10, p. xxiv) are: 21.2, 21.3, 20.3, 18.6, 18.1, 15.2.

If Area = A, and population = P,

then  $\frac{P}{A} = D =$  mean population on each unit of area,

while  $\frac{A}{P} =$  the mean area to each person.

The unit of space in the first method is taken to be a square mile; in the second an acre.

Apparent densities of population do not always correspond with real densities, because the population in one of the towns to be compared may be lodged on only a portion of its area, the remaining area being occupied by a lake, common, park, etc.

**Relation between Density and Mortality.**—Dr. Farr found that the mortality increases with the density of the population, but not in direct proportion to these densities, but as their sixth root.

Thus, if  $d$  and  $d' =$  density of population in two places, and  $m$  and  $m' =$  mortality of population in two places,

then 
$$\frac{m'}{m} = \sqrt[6]{\frac{d'}{d}}$$

and 
$$m' : m :: \sqrt[6]{d'} : \sqrt[6]{d}$$

In his report for 1843 Dr. Farr gives as examples seven groups of districts the death-rate of which, calculated from

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their densities, approximated very closely to the observed death-rates. Thus:—

*Death-rates—*

*Calculated:* 18.90—19.16—20.87—25.92—28.08—37.70—38.74.

*Observed:* 16.75—19.16—21.88—24.90—28.08—32.49—38.62.

The formula was subsequently modified by Dr. Farr (Supplement to Thirty-Fifth Annual Report, p. clviii), 0.11998 being substituted for  $\frac{1}{8}$  in the above formula, i.e. the death-rate varies approximately as the eighth root of the density of the respective populations; or, more exactly—

$$m' = m \left( \frac{d'}{d} \right)^{0.11998}$$

Thus, in 1861–70, in the 345 districts which had a mortality of 19.2, the density was 186 persons to a square mile; in the 9 districts with a density of 4,499, what was the mortality? It was—

$$(186)^{0.12} : (4499)^{0.12} :: 19.2 : x, \text{ that is } x = 28.1,$$

This formula only gives slightly different results from the preceding one. So closely was the ratio found to be followed in places whose sewage and water supply and other sanitary conditions were fairly the same, and which apparently differed only in density of population, that Dr. Farr suggested that in any sanitary inquiry the influence of density should first be discovered by means of the above formula, and that the effect of other influences above or below this should then be investigated. As he remarked, “the formula thus eliminates the element of density from the analysis of the causes of insalubrity.”

This thesis under present changed conditions cannot be maintained. Although cleanliness of air, water, and soil are more difficult to secure, although infectious diseases, and especially tuberculosis and syphilis, are more fatal, and although poverty, vice, and intemperance are usually more widespread, accidents more common, and indoor occupations more general, in town than in country, the evils just enumerated are in large measure preventible, and do not imply a law of nature necessitating a higher death-rate in town than in country. The conditions which appear to be universally unfavourable in towns are excessive noise and

vibration, the deficiency of sunshine, and the excess of smoke and dust. Even in respect of these there is much that is remediable.

That Farr himself regarded the relationship expressed by his formula as not inevitable may be gathered from a study of his reports, although at one time he expressed the above quoted opinion. He quotes Dr. Price's statement as to great cities being called the graves of mankind, and endorses the principle enunciated by him that "the mortality of towns has a tendency to increase at the same time as they extend." In his early report of 1843 he states, "it is proved beyond doubt that, if the population be the same in other respects, an increase of density implies an increase of mortality, and that the ratio of increase in the mortality is as certain roots of the density." But in his first report he says: "The mortality of cities in England and Wales is high, but it can be immeasurably reduced . . . the unhealthy tendency (of density) can be counteracted by artificial agencies."<sup>1</sup> And he reverts to the same note in his Twenty-Fifth Annual Report, stating, "the mere proximity of the dwellings of the people does not necessarily involve a high rate of mortality."

In a recent report<sup>2</sup> Dr. Brownlee has reopened the subject. He points out that Farr employed crude death-rates, and that these gave a fairly good fit in the use of the formula, but that when standardized death-rates were employed, "the law obviously did not hold." Inasmuch as standardization merely removes arithmetical causes of variation of death-rates, due to incomparable proportions of persons living at different ages (p. 219), this non-fit throws doubt on the "law," and confirms some of Farr's statements quoted above. But Dr. Brownlee adopts the alternative of rejecting standardized death-rates in favour of life-table death-rates. A life-table death-rate as defined by Dr. Brownlee signifies "the ratio of the number of deaths of persons above any defined age to the number living above that age in a stationary population." Dr. Brownlee regards the life-table death-rate as the criterion of ultimate impor-

<sup>1</sup> Quoted from the Memorial Volume of Farr's *Vital Statistics*, p. 168.

<sup>2</sup> *The Use of Death-rates as a Measure of Hygienic Conditions*, by Dr. John Brownlee (Medical Research Council, 1922).

tance, and considers that had the construction of a life-table been easy, no one would have used a standardized death-rate, which is thus a *pis aller* (see also p. 260).

The use of life-table death-rates implies the preference of crude to standardized death-rates (see p. 219); for such death-rates are not corrected for any weighting caused by an excess as compared with other populations of persons at ages at which relatively high or low death-rates prevail. Thus in the experience of a large city like Manchester, the life-table death-rate at ages 30 and over depends on the deaths at higher ages; but the weight of this experience in determining the total life-table death-rate at all ages from birth onwards is relatively small, because in the circumstances of such a city survivors reaching the age of 30 are comparatively few. On the other hand, comparison between the death-rates at a given age-period, e.g. 20-25, 25-35, in two communities gives an exact and unbiassed comparison of their vital experience at the given age-period; and standardized death-rates are in most instances (see p. 221) almost equally free from bias, as in them correction has been made merely for the artificial weighting caused by variations in age-distribution of population.

As bearing on the same point, reference may be made here to another portion of Dr. Brownlee's report. According to the National Life-Tables prepared by Mr. George King, based on death-rates for 1911-12, the rural male's expectation of life at the age of 15 is nearly  $2\frac{1}{2}$  years higher than that of the average inhabitant of county boroughs at the same age. At age 40 the corresponding expectations are 25·80 and 30·35 years; at 55 they are 15·48 and 18·63 years respectively, and so on. That is, life on the average is shorter in town than in country, which in Dr. Brownlee's statement means that "it has been rendered probable that the inhabitant of the country is at the ages 55-65 biologically about 6 to 7 years younger than the inhabitant of the town." The fact underlying this statement is undoubted; but from the standpoint of preventive medicine it is more important to know that, for instance, the standardized death-rate from valvular disease of the heart in county boroughs is higher than that in rural districts in the proportion of 85 to 62, than to be told that the amount of this disease in

town and country is about the same as judged by the life table death-rate.

Premature ageing of tissues may be regarded as an important factor in the earlier age at death in towns; but this does not make the statement helpful that "it is not a matter of more of the disease being present in a city, it is rather a matter of the disease developing at earlier ages." The life-table method of statement of relative mortalities may even tend to minimize the impetus to further inquiry into the reason why at each successive age-period, right up to the age of 70, the recorded death-rate is lower in rural than in urban districts.

It will be understood from the gist of the above comments that Dr. Brownlee's contention appears to partake somewhat of a *petitio principii*, and no conviction is carried by the statement that when life-table death-rates are used Farr's "law" holds good, the power of the density having remained unchanged during 40 years, only the constant multiplier having been affected by hygienic measures.

It is doubtful whether any advantage can arise from the continued use of Farr's formula, except as a reminder of the risks of density of population. Hygienists are concerned with the analysis of a complex cause of insalubrity, such as density of population, into its constituent elements, or as near an approach to this as is practicable. Some of the causes of excessive mortality in crowded populations have been enumerated, and it is clear that notwithstanding the tendency of density to cause a high death-rate, this tendency can in large measure be overcome. The declining death-rate in towns shows this. Its decline has been relatively greater than in rural districts during the last 20 years. The "law" therefore is in process of disappearing.

The following illustration is reproduced from an older edition of this work. It is realized that the case of these artizan block dwellings is somewhat artificial, even though corrections are made for hospital deaths and for variations in age and sex.

**A Further Test of Density of Population.**—In a paper on "The Vital Statistics of Peabody Buildings" (Royal Statistical Society, February, 1891), I showed the inapplicability of Farr's formula to block dwellings in which the

## DENSITY OF POPULATION AND MORTALITY 285

maximum density of population occurs, although these populations live under conditions of life which are otherwise not unhealthy. Thus during the year 1889 the number of persons to an acre in London was 58, in the Peabody Buildings 751. What according to Farr's formula ought to be the death-rate in the Peabody Buildings, that of London being 17.4 per 1,000 ?

$$m' = 17.4 \left( \frac{751}{58} \right)^{0.11998}$$

Consequently  $m' = 24.21$ .

But the actual death-rate of the Peabody Buildings was 16.49 per 1,000. Hence the actual death-rate was 7.72, or 31 per cent., lower than the death-rate, calculated on the assumption that mortality varies with density of population according to the above finally modified formula of Farr.

In the same paper I pointed out that an essential element in testing the true density of population is *a statement of the number of persons living in each occupied room*. It is probable that this test, combined with a determination of the population on a given area, would give the most trustworthy available estimate of density, and that the two together would give a fair guide to the probability of the incidence of the diseases connected with overcrowding, especially those the infection of which is received by the respiratory tract.

## CHAPTER XXV

### THE STATISTICS OF POVERTY AND OF HOSPITAL PROVISION

POVERTY is used in this chapter to denote a degree of privation which deprives one or more members of a given family of one or more necessaries for the maintenance or restoration of normal health and efficiency.

Thus defined it differs from poverty in the official sense, which has been defined by Niven as "that deficiency of means which is of sufficient force to cause appeal to the guardians of the poor for relief in money or for medical aid."

Official poverty, as tested by administrative statistics, may vary out of proportion to real changes in privation, or even in opposite directions, according to the method of administration of relief. This is illustrated in the Third Annual Report of the Ministry of Health, England and Wales, 1921-22, dealing with the year beginning April 1, 1921—a year of almost unexampled lack of employment, throwing great strain on the Poor Law local administration. The figures failed to show any constant relation between pauperism and unemployment indicating distress, as is illustrated by the following figures extracted from the report. The names in column A give the places in order of the *relative* amount of unemployment in each area; and column B gives the same towns or metropolitan boroughs in the order of variation from the average rate of pauperism. In each column the average is 100, based on the experience of 16 unions all having a very excessive poor-rate.

	A.	B.
Stockton ..	128·3	144·1
Walsall ..	112·9	126·0
Poplar ..	106·4	214·9
West Ham ..	105·7	134·3
Mile End	94·8	107·0
Whitechapel }		
Bermondsey ..	100·8	153·9

The table reveals, for instance, the difference of administrative expenditure between West Ham and Poplar on the one hand and Whitechapel and Mile End on the other..

The amount of poverty in England, as defined above, has been the subject of careful local investigations by Charles Booth, Seebohm Rowntree, and A. L. Bowley and others. The two first of these investigations, which took place in East London and York respectively, showed that 30–35 per cent. of the population in given areas in London, and of all the wage-earning families in York were in a condition of poverty. In the case of York two sections were distinguished, viz.—(1) *primary poverty*, that of families whose total earnings did not suffice to secure the minimum necessities for the

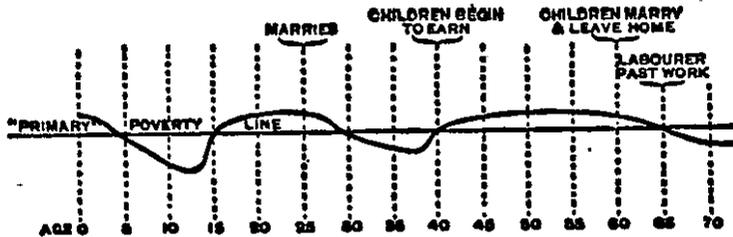


FIG. 33.—Cycles in Life of Unskilled Labourers (S. Rowntree).

maintenance of merely physical efficiency; and (2) *secondary poverty*, that of families whose earnings would have sufficed for this elementary need, had not some portion been absorbed by other expenditure. These investigations took place prior to the Great War, but the volumes giving particulars of the investigations still deserve study as illustrations of social investigation. The above diagram, taken from Rowntree's *Poverty: A Study of Town Life*, 1903, graphically illustrates the five alternating periods of want and comparative plenty which were to be seen in the life of many unskilled labourers, brought up as the children of unskilled labourers, probably underfed in childhood and until industrial work is begun. In early married life the labourer is relatively prosperous, and then goes below the poverty line until his children begin to earn. When his children leave home and he is past work he gradually again becomes unable to earn his living, the last phase being greatly relieved by an old age pension.

The methods of investigation of poverty on satisfactory

lines may be studied in *Livelihood and Poverty*, by Professor A. L. Bowley and A. R. Burnett-Hurst (1915).

This investigation illustrates the value of sampling conducted on right lines in social investigation. A random sample of 1 in 23 of the population in working-class houses of Northampton, 1 in 19 of that of Warrington, 1 in 21 of that of Reading, 1 in 17 of that of Stanley, and a similar sample of Bolton were made the subject of inquiry in the three years preceding the war, the result being that 6 per cent. of the population of Stanley, 8 per cent. that of Bolton and

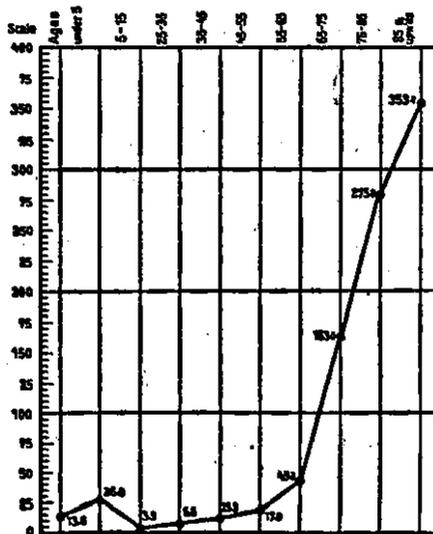


FIG. 34.—England and Wales: Census of Paupers, 1906, showing Age distribution per 1,000 of Population at Each Age-period (not including Lunatics in Institutions).

Northampton, 12 per cent. of Warrington, and 24 per cent. of that of Reading were below the "poverty line" as defined in the report, the standard in defining which was somewhat modified from the York standard; and from one-half to one-third of the families in some of these towns were living in poverty, because the wages of the head of the household were so low that he could not support a family of three children or even less.

**Pauperism—Official Poverty.**—The amount, as already stated, varies with the economic position of a community, but local variations may depend even more on the degree of rigidity or laxity of Poor Law administration. On March 26,

1921, in England and Wales 449,612 persons, or 1 in 84 of the estimated population, were in receipt of domiciliary relief, a proportion which had not been previously exceeded since the coal dispute of March 1912. Great changes have taken place in the proportion of paupers to population, of indoor to outdoor paupers, and of age-distribution of those receiving relief, as well as in the cost of Poor Law administration. Some of these changes are seen in the following table:—

ENGLAND AND WALES.

	Ratio per 1,000 of the Estimated Population.				Amount per Head of Population which would have been required if the actual Poor Law Expenditure had been raised by a Poll-tax.
	Indoor Paupers. <sup>1</sup>	Outdoor Paupers. <sup>1</sup>	Able-bodied Indoor Paupers. <sup>2</sup>	Able-bodied Outdoor Paupers.	
	(1)	(2)	(3)	(4)	(5)
1849	7.7	51.4	1.5	11.7	s. d. 6 8
1870	7.1	38.2	1.2	6.7	6 11
1880	7.1	23.2	0.9	3.7	6 4
1890	6.6	18.8	0.8	2.4	5 11
1900	6.6	15.8	1.1	1.9	7 3
1910	8.0	15.2	1.5	2.1	8 5
1911	7.9	14.2	1.5	2.0	8 5
1912	7.6	11.3	1.2	1.9	8 0

<sup>1</sup> Excluding lunatics in county and borough asylums and other registered institutions. "Outdoor" paupers receive relief at home, "indoor" in institutions.

<sup>2</sup> The numbers in this column are included in columns (1) and (2). "Able-bodied" includes those temporarily disabled.

There has been a marked decrease in able-bodied outdoor pauperism, and in domiciliary relief; the amount of indoor relief, representing largely residential accommodation for the aged and infirm, and still more hospital treatment for the sick, particularly the chronically sick, has remained almost stationary. Its character, however, has steadily changed, hospital increasing at the expense of "workhouse" accommodation.

Further light on destitution is thrown by a census of persons in receipt of parochial relief in England which was taken on March 31, 1906, for the purposes of the Royal Commission on the Poor Laws. The total number of paupers was 717,012 (not including lunatics in institutions or "casuals"), or 23.8 per 1,000 of population. Their age distribution was as shown in Fig. 34 (p. 288).

Destitution is seen to be largely a function of age, occurring chiefly at the ages of dependency. At the census named above persons over 60 years old formed 46·5 per cent., and persons under 16 years old 29·1 per cent. of the total number relieved.

From the same report is taken the following table, showing that short periods of receipt of relief preponderate :—

PROPORTION RECEIVING RELIEF.

	Per Cent.
Not exceeding four weeks .. .. .	34·5
4-13 weeks .. .. .	19·4
One quarter to less than one year ..	22·2
The whole year .. .. .	23·9
	100·0

**Poverty and Sickness.**—The chief medical interest of poverty lies in its close relation to sickness. Nothing is more certain than the statement that the removal of poverty would effect an enormous reduction of disease; we may subscribe also to Samuel Johnson's repeated declaration that the test of the civilization of a country is the state of its poor. Sir John Simon, in his Sixth Report to the Privy Council (1864), wrote: "The public health of a country means the health of its masses, and the masses will scarcely be healthy, unless, to their very base, they be at least moderately prosperous."

The Report of the Royal Commission on the Poor Laws (1909) found that in 128 Poor Law unions specially investigated by them about 30 per cent. of the total paupers were sick, most often from illness of a chronic nature. On page 289 of the report it is stated :—

"Sickness is therefore admittedly one of the chief causes of pauperism, and the more chronic its character and the longer its duration, the greater the likelihood of its producing dependence on the rates.

"We estimate that at least one-half of the total cost of pauperism is swallowed up in direct dealing with sickness. . . . It is probably little, if any, exaggeration to say that, to the extent to which we can eliminate or diminish sickness among the poor, we shall eliminate or diminish one-half the existing amount of pauperism."

The following additional facts are summarized from the

same report. Nearly one-half of the indoor poor (in institutions), and about one-fifth of the outdoor poor, were under medical treatment. The proportion under medical care rose to three-fifths for men under 50 years of age, and to two-thirds for such men relieved in institutions. Outside London less than one-half and in London over three-fourths of the destitute poor receiving medical treatment were being relieved in Poor Law institutions. Thus, except for the old and for young children, pauperism means the need for aided medical attendance and nursing. On November 4, 1911, a special return of paupers was obtained by the Local Government Board from all unions in England and Wales. The return excluded insane and casual paupers. It showed that 29.1 per cent. of the total in receipt of relief were under medical treatment. Of the total number being treated 15.5 per cent. were being treated in institutions. Three-fourths of the patients under treatment were chronic cases. Of the total institutional patients 8.8 per cent. were consumptives.

A most noteworthy change has gradually occurred in the Poor Law system of relief, it having become preponderantly a problem of aid in sickness and infirmity.

Hence the official figures of pauperism must now be regarded less as a test of the amount of destitution in the community than as an indication of the increasing willingness of the public to regard Poor Law hospitals in the same light as they regard voluntary hospitals, resort to which is legitimate in sickness, either gratuitously or on payment of a relatively small sum.

**Other Measures of Poverty.**—The amount of official pauperism having ceased to be an adequate measure of the destitution in a community, the question arises as to other possible tests. The number of domestic servants per 1,000 of population at the last census is perhaps the least unsatisfactory of these, though its value is decreasing in view of changes in domestic service. Number of rooms per dwelling and rentals are useful tests in intensive investigations, when it is proposed to contrast one part with another part of the same city. A knowledge of industrial conditions also helps, and sometimes it is possible to classify groups according to real wages.

The number of hospital beds provided for each com-  
ill

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"We estimate that at least one-half of the total cost of pauperism is swallowed up in direct dealing with sickness. . . . It is probably little, if any, exaggeration to say that, to the extent to which we can eliminate or diminish sickness among the poor, we shall eliminate or diminish one-half the existing amount of pauperism."

The following additional facts are summarized from the

same report. Nearly one-half of the indoor poor (in institutions), and about one-fifth of the outdoor poor, were under medical treatment. The proportion under medical care rose to three-fifths for men under 50 years of age, and to two-thirds for such men relieved in institutions. Outside London less than one-half and in London over three-fourths of the destitute poor receiving medical treatment were being relieved in Poor Law institutions. Thus, except for the old and for young children, pauperism means the need for aided medical attendance and nursing. On November 4, 1911, a special return of paupers was obtained by the Local Government Board from all unions in England and Wales. The return excluded insane and casual paupers. It showed that 29·1 per cent. of the total in receipt of relief were under medical treatment. Of the total number being treated 15·5 per cent. were being treated in institutions. Three-fourths of the patients under treatment were chronic cases. Of the total institutional patients 8·8 per cent. were consumptives.

A most noteworthy change has gradually occurred in the Poor Law system of relief, it having become preponderantly a problem of aid in sickness and infirmity.

Hence the official figures of pauperism must now be regarded less as a test of the amount of destitution in the community than as an indication of the increasing willingness of the public to regard Poor Law hospitals in the same light as they regard voluntary hospitals, resort to which is legitimate in sickness, either gratuitously or on payment of a relatively small sum.

**Other Measures of Poverty.**—The amount of official pauperism having ceased to be an adequate measure of the destitution in a community, the question arises as to other possible tests. The number of domestic servants per 1,000 of population at the last census is perhaps the least unsatisfactory of these, though its value is decreasing in view of changes in domestic service. Number of rooms per dwelling and rentals are useful tests in intensive investigations, when it is proposed to contrast one part with another part of the same city. A knowledge of industrial conditions also helps, and sometimes it is possible to classify groups according to real wages.

The number of hospital beds provided for each ce

munity is a very unsafe measure of poverty, as in poor communities the provision is much less adequate than where poverty is less marked; the hospitals, furthermore, are apt to be provided chiefly in large centres of population. Notwithstanding these points, the provision of hospital accommodation is statistically so closely related to poverty as to justify inclusion of facts concerning it in this chapter.

**Infant Mortality and Poverty.**—A striking illustration

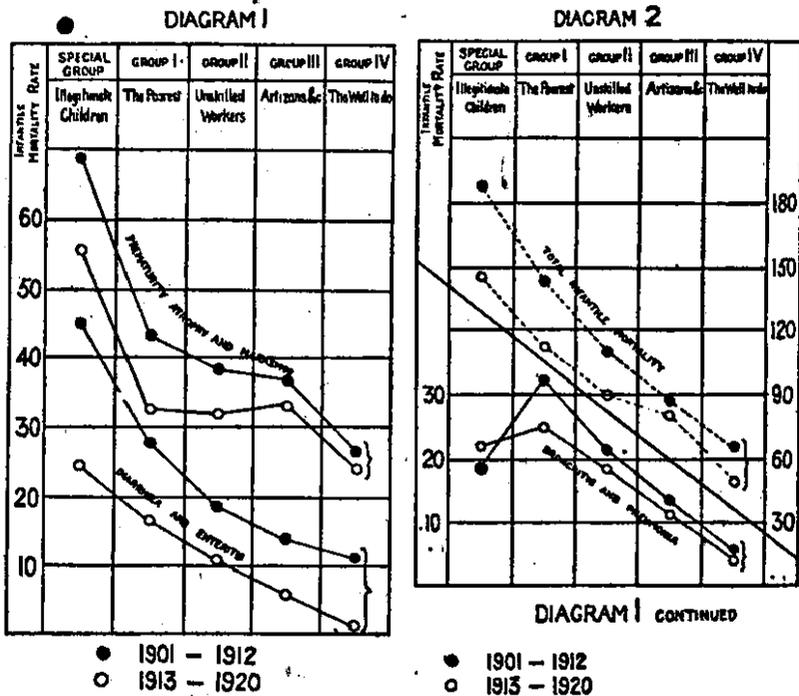


FIG. 35.

of the relation between wages and infant mortality is illustrated in Fig. 35, taken from Dr. Forbes's Annual Report, 1921, on the health of Brighton. The tables summarize the experience derived from 50,877 births and 5,256 deaths under one year in 1901-20 inclusive. These have been divided into two decennial periods and five social groups, so that the relative position in each group in the two periods and the contemporaneous relative position of each group can be seen at a glance.

In the upper part of diagram 2 total infant death-rates

are shown for each group in the two decennia. Although there has been improvement in each group, the curves remain high or low in accordance with social position. It will be seen that this is so also for the three chief causes of infant mortality shown in diagrams 1 and 2. A large part of this mortality is preventible in each of the groups.

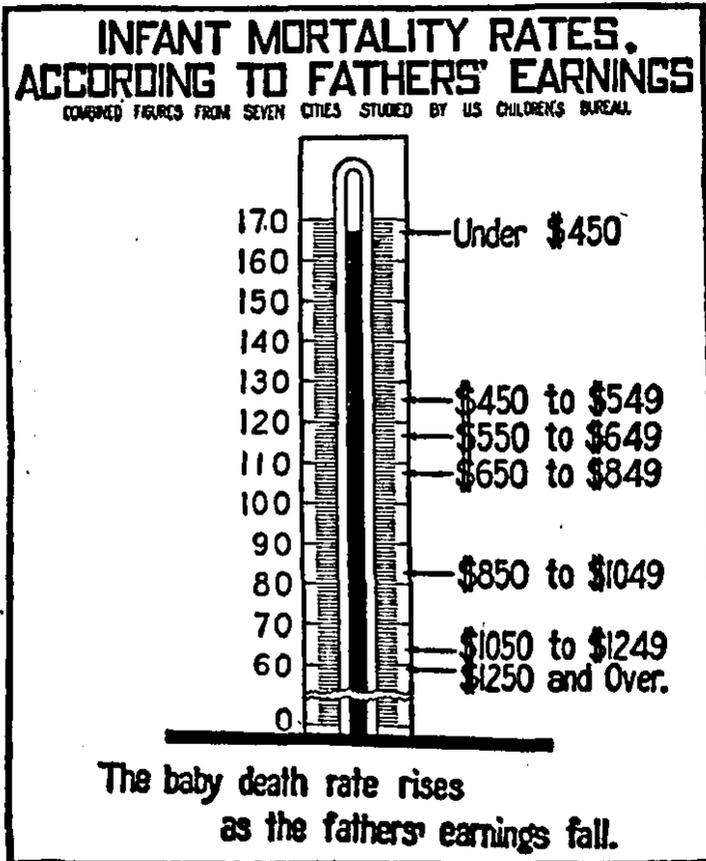


FIG. 36.

The same relationship is illustrated in Fig. 36, showing in investigations of the Federal Children's Bureau, United States, the inverse relation between wages and rate of infant mortality. The coexistence when investigations on a large scale are made is undoubted, though if individual instances in the various groups are examined numerous exceptions will be found. In fact the difference in infant mortality com-

monly displayed between rates of infant mortality in various social classes is not due solely to differences between poverty and ease of circumstances *per se*. If it were so, the infant death-rate in Ireland, and still more so in Norway, should be much higher than in England and Wales. It was 138 per 1,000 births in England and Wales in 1901-5, and 118 in 1907, as compared with 81 and 67 in Norway, and with 98 and 92 in Ireland. (On Ireland see also pp. 227 and 348). The difference in the main is due to certain removable evils, which are commonly associated with poverty, and from which the well-to-do in a large measure escape. Poverty is a complex condition, including a number of elements, and it is important to determine what elements of poverty are most potent in producing excessive infant mortality. Nor is the difference merely owing to the fact that greater care can be bestowed on small than on large families, though this is suggested by the fact that the average family is smaller among the well-to-do than among the poor. The populations of Norway and Ireland have larger families than the English population. In 1901 the standardized birth-rate of England and Wales was 28.4, of Norway 37.8, and of Ireland 36.1 per 1,000 of population (p. 102).

The association of poverty with excessive infant mortality is chiefly an urban phenomenon: Thus in the year 1920 the infant mortality in the county of Galway was 53, in Dublin it was 141, and in Belfast 132 per 1,000 births, although the average standard of life was probably lowest in Galway. Infant mortality is highest in the poorest wards in any given town and in the poorest parts of a given ward of a town. Poverty in one instance may be due to insufficient earnings of the parent, and then additional money or its equivalent is required. It may be caused by intemperance or gambling or improvidence, when other remedies are indicated.

The relative child mortality in various towns gives numerous illustrations of the fallacy of looking at poverty as a simple element. In the mining areas there is nearly always excessive child mortality, even when wages are good. Here bad housing, a low standard of cleanliness, and the existence of secondary causes of poverty, are responsible in many instances for the destruction of child life. Among these secondary causes of poverty, gambling, intemperance,

and improvidence occupy an important place. The moral and the physical causes of poverty act and interact.

When sickness and poverty concur, it is often difficult to disentangle cause and effect, and in the chain of causation, cause and effect may be interchangeable. Such a chain presents the hopeful characteristic that its fracture at any point may have effects along each link of the chain.

**Housing and Poverty.**—This subject is discussed also in Chapter XXVI. The statistical study of poverty is complicated by the inseparability of the associated problems of—(1) deficient nutrition and inadequate or unsuitable clothing, and (2) deficient housing, which accompany poverty. The only sound plan is to regard them as mutually inter-related, and to attack any of the phenomena involved in these three problems, in the justifiable belief that by so doing the vicious chain of circumstances can be broken. To assume, on the contrary, that in the main the poor are poor because they are inferior in moral, mental, or physical qualities, although this may be true in a proportion of cases, is to encourage inertia in regard to the large proportion, especially of the young, who, given more favourable conditions, will escape from the inferiority associated with poverty. The community as a whole has not hesitated to take this more favourable view; and so we have had enforcement to some extent of sanitary housing and of sanitary conditions of collective labour, restriction of the facilities for alcoholic indulgence, and even in a few sweated industries compulsory regulation of wages.

These general considerations have importance in considering the effect of bad housing in causing poverty by causing disease. The disease due to bad housing is very largely communicable disease, and especially tuberculosis; and, as seen in Chapter XXVI, the relation between amount of housing accommodation and amount of phthisis is not constant.

**Tuberculosis and Poverty.**—Dr. T. H. C. Stevenson, in a contribution on "The Incidence of Mortality upon the Rich and Poor Districts of Paris and London" (*Journal of the Royal Statistical Society*, January 1921) summarizes an article by Professor M. L. Hersch in the *Revue d'Économie politique* (Nos. 3 and 4, 1920) on Paris statistics. These show extremes

of tuberculosis death-rate of 1.08 and 6.36 in the richest and poorest parts of Paris, as compared with 0.81 and 2.47 in the richest and poorest parts of London in 1911-13. Tested by a special taxation test not comparable with any tax in London, it was found that the proportion of total deaths in Paris due to tubercle rises steeply with increasing poverty. For four groups it was 13.4, 20.6, 25.5, and 26.2. For four groups in London, arranged according to the proportion of domestic servants in each group, the corresponding proportions were 10.5, 10.8, 12.0, and 12.9. Now, the proportion of poverty in Paris as measured by the proportion of households escaping from payment of a particular tax was 45.9, 64.1, 79.0, and 89.6 per cent. in the four groups. If the ratio of poverty and of tubercle mortality for the whole of Paris be taken as 1, the rates for the four groups and the whole city are as follows:—

Proportional rates { Tubercle : 0.38, 0.68, 1.09, 1.49, 1.00.  
Poverty : 0.62, 0.86, 1.06, 1.21, 1.00.

The square roots of the tubercle rates are—

0.62, 0.82, 1.04, 1.22, 1.00,

a very close approximation to the poverty rates, and M. Hersch believes that this represents a natural law of the quantitative relation of poverty to tubercle mortality. It is only applicable to the particular standard of poverty used in this case, and it is still doubtful if it is applicable to other cities, even if the same standard were available.

Whatever measure be used in defining the relationship of poverty to tubercle, it still remains the duty of the public health administrator and social reformer to dissect out the constituent elements of the complex constituted by poverty, to attack these individually, and not to be content with relieving destitution.

**Institutional Mortality.**—In Chapter XI the importance of collecting hospital sickness statistics on a comparable basis has been mentioned. In Chapter XXXVIII the value of hospitals as furnishing an essential of modern life, *supplementary housing with skilled attendance during sickness*, has been emphasized.

It is not too much to say that the amount and quality of the general and special hospital provision of a community

is an accurate, and perhaps the most accurate, measure of its social and sanitary position among communities. This does not imply that the prevention of disease is not more important than its successful treatment. Pure water supplies and other means of preventing typhoid infection rank higher than hospital provision for individual cases of typhoid fever; but conversely unskilled nursing of a single case of typhoid fever at home may lead to a group of new cases or even to a wide outbreak of the same disease. In the prevention of chronic infective diseases, like tuberculosis and syphilis, treatment, which often must be institutional to be satisfactory, forms an indispensable element. In general medicine the range of necessary hospital treatment is rapidly increasing; and part of the lowered death-rate of recent decades must be attributed to the triumphs of modern surgery, especially in hospital practice.

The progress of hospital provision in England and Wales can be gathered from the Registrar-General's figures which are quoted on page 298. An analysis of the diseases and other conditions for which hospital treatment was sought will be found on pages 261-275 of the Registrar-General's Annual Report, 1920. Thus of 18,184 deaths of males from pulmonary tuberculosis in England and Wales in 1920, 6,583, or 36.2 per cent., occurred in public institutions, viz. 14.2 per cent. in Poor Law infirmaries, 4.0 per cent. in the hospitals of Public Health Authorities, and 18.0 per cent. in voluntary hospitals. More than half the deaths resulting from violence occurred in hospitals. The proportion to which hospital treatment was available—as measured by the proportion of total deaths occurring in hospitals—is shown for 1920 below:—

ENGLAND AND WALES.

*Proportion per Cent. of Total Deaths of Males and of Females occurring in 1920 in Public Institutions in—*

	London.	County Boroughs.	Other Urban Districts.	Rural Districts.	England and Wales.
Males .. ..	50.8	30.3	21.3	17.1	27.7
Females .. ..	45.2	24.9	17.7	13.9	22.9

In Fig. 37 is shown the steady increase of the three chief forms of hospital accommodation in England and Wales.

**Increasing Importance of Hospitals.**—A return prepared by the Local Government Board in 1915 gave the number of hospital beds in England and Wales (not including lunatic asylums, tuberculosis institutions, or convalescent or nursing homes) as 4·9 per 1,000 of the population. In this return

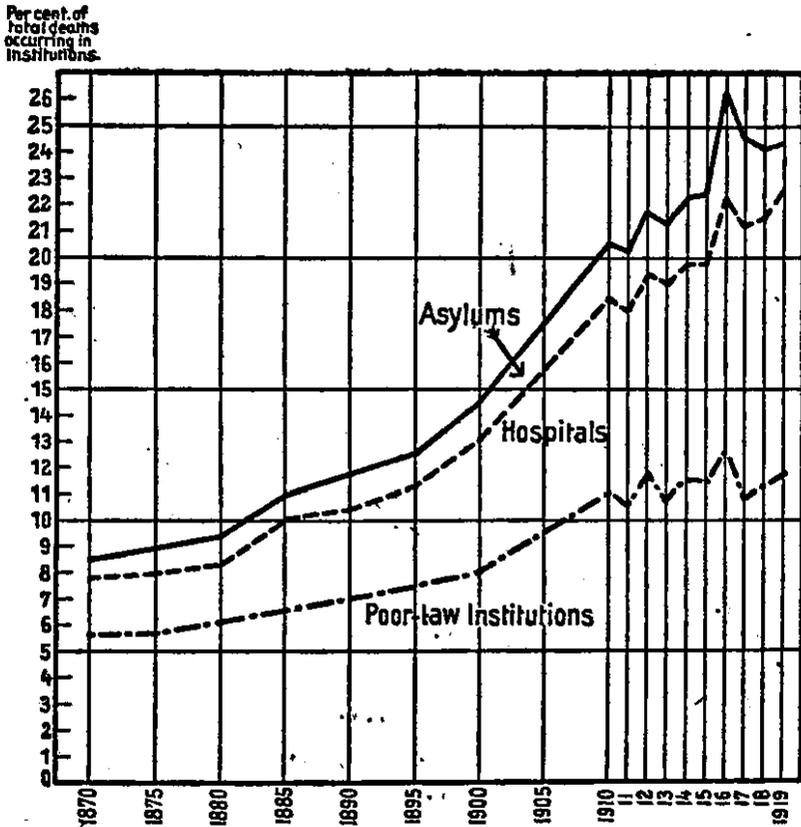


FIG. 37.—Showing the Proportion of Total Deaths in England and Wales in each Year 1870-1919 which occur in (a) Poor Law Institutions, (b) Hospitals, (c) Asylums.

NOTE.—The space between each of the curves gives the proportion in each class of institution. Thus in the year 1920 (not shown in the diagram) 24·4 per cent. of all deaths occurred in public institutions, viz. 10·7 per cent. of all deaths in hospitals, 2·0 per cent. in asylums for the insane, and 11·7 per cent. in Poor Law institutions.

2,664 institutions were included, having 178,525 beds. In the United States, according to the *Modern Hospital Year Book for 1919*, the number of hospital beds amounts to 6 per 1,000 of the population, or 3·4 per 1,000, excluding beds

for mental and nervous cases. The two sets of figures may not be comparable, and in both instances the distribution of hospital provision is unequal, large areas in each country being left unprovided with available hospital accommodation.

In a statistical study of institutional provision, as an index of fulfilment of social needs, it would be necessary to ascertain—(1) the locality of each hospital or allied institution and its relation to the population to be served by it; (2) the number and proportion of beds for acute and chronic cases, for surgical and medical cases, for young children, for tuberculosis, for venereal diseases, for lunatics and feeble-minded, and for other special diseases.

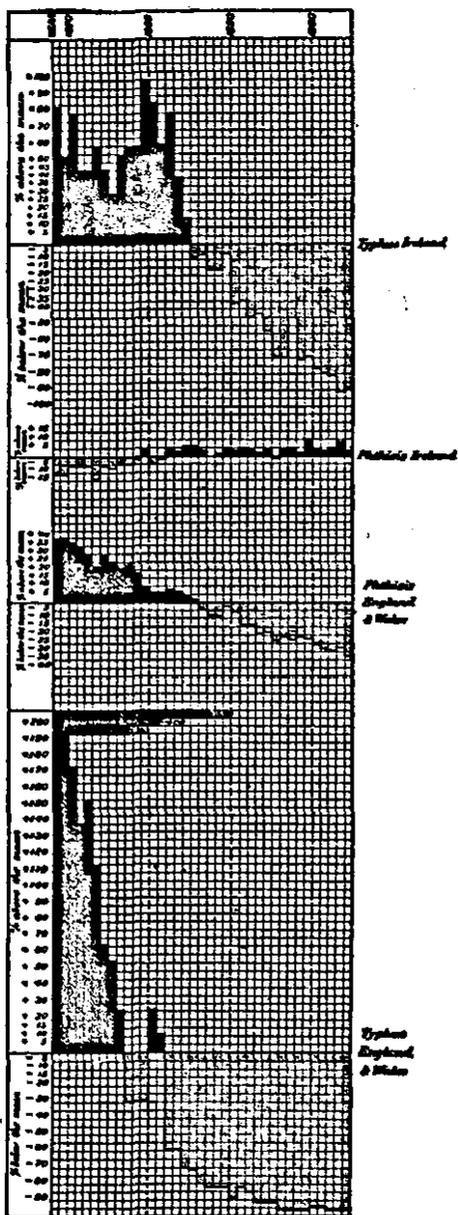
Some facts bearing on such an investigation are given in the Final Report of the Voluntary Hospitals Committee (Cd. 1335). They relate only to voluntary hospitals, which supply 12,997 beds in the metropolitan area and 31,265 in the rest of England and Wales. The distribution of these beds varies greatly in different counties. It averages 1.06 per 1,000 of the population, varying from 1.50 in Gloucester and Somerset to 0.52 in Monmouthshire. In addition there are some 92,000 beds in Poor Law institutions, and many in Public Health hospitals.

**Fever Hospital Statistics.**—The following method of tabulation of such statistics, which is in use for the Metropolitan Asylums Board statistics, is suggested for general use. The year exemplified is 1922.

	Diseases.			
Remaining on Dec. 31, 1921				
Admitted during 1922 ..				
Total under treatment during 1922 .. ..				
Discharged during 1922 (recovered) .. ..				
Died during 1922 .. ..				
Mortality per cent. ..				
Remaining on Dec. 31, 1922				

The mortality rates (fatalities) are calculated according to the Registrar-General's formula:—

$$\frac{\text{No. of deaths} \times 100}{\frac{1}{2} (\text{sum of admissions} + \text{discharges} + \text{deaths in year})}$$



Comparison of the Changes in the Death-rates from Typhus and Phthisis in Ireland and in England and Wales, as shown in each case by Percentage Distances from the Average Death-rate for the same period.

FIG. 33.

The history of typhus fever and of phthisis in Ireland illustrates strikingly the close relation between destitution

and disease. The course of these diseases also shows, when considered alongside of the history of Ireland, the close relation between immobilization of infection and reduction of disease. The details of this are given in a presidential address by me on "Poverty and Disease," October 1907 (*Proceedings of the Royal Society of Medicine*). The following remarks summarize the statistical argument: (1) The great epidemics of typhus have occurred in Ireland in famine years. In these years nutrition was decreased and vagrancy vastly increased. By vagrants infection was spread broadcast. (2) The introduction of local Poor Law relief helped to immobilize the infection of typhus and to diminish its amount. It may be argued that diminished overcrowding and improved well-being occurred contemporaneously with the increased immobilization of infection, and that they were the chief agents in reducing typhus. This can be tested by comparing the experience of Ireland as regards typhus and phthisis. Ireland, until recent years, has encouraged the domestic treatment of cases of phthisis, and its phthisis death-rate has increased. In a report from the Medical Department of the Local Government Board for Ireland (September 1908) on "Tuberculosis in Ireland," emphasis is laid on the dislike of the Irish for the only form of institutional treatment available, i.e. in the workhouse infirmaries, and on the enormous increase in out-door relief. It is added, "the whole evidence favours the theory of infection. An ill-nourished people, enfeebled by emigration and other causes, are subject to excessive infection owing to lack of means of segregation of patients." The difference in the course of events in England and Ireland is shown in Fig. 38 taken from the above-mentioned paper.

## CHAPTER XXVI

### HOUSING STATISTICS

THE housing data of the 1921 census for many parts of England (May 1923) are not yet published, and therefore one is obliged to fall back on the figures for 1911 (see General Report, Census, England and Wales, 1911, Cd. 8491).

A *family* in the census schedule is regarded as including boarders, visitors, servants, etc. In 1891 and 1901 the inquiry as to such families was confined to those occupying less than five rooms; in 1911 every occupier was required to state the number of rooms occupied by his family, and at this census a definition of room was added. The instruction to occupiers was to include as a *room* the kitchen, but not the scullery, landing, lobby, closet, bathroom, or warehouse, shop or office.

The *dwelling* or *tenement* was defined as a place in which any person entitled to receive a schedule usually lives. The total number of tenements, i.e. of private families enumerated in England and Wales in 1911, was 7,943,137, and they were distributed as to accommodation as follows:—

Of 100,000 tenements—

3,207	consisted of one room,
8,314	consisted of two rooms,
13,948	consisted of three rooms,
24,947	consisted of four rooms,
20,635	consisted of five rooms, and
28,949	consisted of more than five rooms.

---

100,000

The size of the families were distributed in the following proportion of 100,000 tenements:—

5,328	were occupied by families of one person,
16,161	were occupied by families of two persons,
19,282	were occupied by families of three persons,
18,122	were occupied by families of four persons,
14,424	were occupied by families of five persons,
10,364	were occupied by families of six persons,
16,319	were occupied by families of more than six persons.

---

100,000

The average number of occupants per room gradually diminished from 1·90 in the one-roomed tenements to 0·56 in the nine-roomed.

The housing of urban compares unfavourably with that of rural communities in England, as can be seen in detail on page 175 *et seq.* of the Census Report. Space has much greater value in town than in country, and small tenements are seen in higher proportion in towns. In the following table the proportion of different dwellings in England and Wales at the two censuses of 1901 and 1911 is shown:—

Rooms per Tenement.	Proportion per Cent. of Total Population Living in Each Class of Tenement.			Proportion per Cent. of Total Population with More than Two Occupants per Room.		
	1891.	1901.	1911.	1891.	1901.	1911.
<i>Aggregate of Urban Districts.</i>						
1	2·9	2·0	1·7	1·6	1·0	0·7
2	9·4	7·4	6·5	4·4	3·1	2·5
3	11·5	10·3	12·7	3·5	2·6	3·0
4	22·4	21·2	23·1	2·8	2·2	2·2
	46·2	40·9	44·0	12·3	8·9	8·4
<i>Aggregate of Rural Districts.</i>						
1	0·4	0·2	0·2	0·3	0·1	0·1
2	5·6	3·9	3·5	2·5	1·5	1·2
3	10·1	8·1	10·8	2·8	2·0	2·2
4	20·3	24·0	25·5	2·9	2·2	2·1
	42·4	36·2	40·0	8·5	5·8	5·6

The general trend of improvement in respect of rooms per family and overcrowding is seen in both urban and rural districts; but the figures as to number of occupants in overcrowded rooms show that, for every form of tenement, conditions are much worse in urban than in rural districts. It will be noted, furthermore, that in 1911, 7 times as large a proportion of the urban population lived in one-roomed and twice as many in two-roomed tenements as of the rural population.

In London the smaller tenements predominated, 541 out of every 1,000 tenements having less than 4 rooms, as compared with 255 for England and Wales as a whole, and this is not wholly due to the greater proportion of small families as shown by the number of occupants per room. At the

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1911 census it was found that while children under 10 years of age formed 20·7 per cent. of the population of all dwellings, they formed 38·2 per cent. of the population of tenements containing more than 2 occupants per room. The proportion of children was highest in the tenements of 2 rooms and gradually diminished as the size of the tenement increased.

The figures as to rooms do not take account of the sizes of rooms, and this partially, but not entirely, explains the remarkable differences in housing in various towns, and is a factor in the frequent lack of apparent relation between housing and disease.

Considerations of space do not admit of further extracts from the section of the General Census Report dealing with housing, but it should be carefully studied as a whole.

**Overcrowding in London.**—The London Census Report for 1921 (Part I, Tables) shows that as judged by the number of rooms occupied by families in 1911 and in 1921 the position is not markedly changed since 1911.

### LONDON.

*Percentage of Families Living in Various Units of Occupation.*

Year.	1 Room.	2 Rooms.	3 Rooms.	4 Rooms.	5 Rooms.	Over 5.
1911	13·5	19·2	21·4	16·1	9·2	20·6
1921	13·2	21·1	23·5	18·0	9·0	15·2

This table needs to be supplemented by a statement of the number living in each type of dwelling, a correction which is evidently needed in view of the fact that of the total families enumerated in London 11·6 per cent. consisted of one person, 20·7 per cent. of two, 20·4 per cent. of three, 16·4 per cent. of four, 11·6 per cent. of five, and 19·3 per cent. of more than five persons. The percentages in the above table cannot be compared with those in the table on page 303.

The data given in the Census Report for London in 1921 unfortunately are not easily comparable as regards overcrowding with those for 1911. The following table shows the more recent method of tabulation :—

## LONDON.

*Density of Occupation, 1921. Population at following densities of occupation (rooms per person) stated in proportion to the total population in private families (4,057,271).*

	Under 0·3.	0·3 and Under 0·5.	0·5 and Under 0·7.	0·7 and Under 1·0.
Percentage of population in private families .. ..	3·1	13·1	27·1	14·1

Between 1911 and 1921 the average size of family had dropped 9 per cent., from 4·15 to 3·79 persons, a somewhat similar drop having occurred in other parts of England. It is pointed out in the London census report that the ratio of rooms to persons requires to be supplemented by further data as to movements in the size and accommodation of family, which are the "unit of occupation," in order to judge of changes in the standard of housing. The following table extracted from this report (p. 9) brings out for smaller tenements the inferior housing of London as compared with that of other large towns and of England as a whole.

*Average Number of Rooms per Person in Each Size of Family.*

No. of Persons in Family.	London 1921.	London 1911.	County Boroughs (excl. London) 1911.	England and Wales 1911.
1 .. .. .	1·79	1·67	2·75	2·78
2 .. .. .	1·42	1·38	2·02	2·03
3 .. .. .	1·12	1·15	1·47	1·49
4 .. .. .	0·94	0·96	1·15	1·14
Average rooms per person in all families .. ..	0·91	0·88	1·02	105

In weighing the evidence as to the influence of housing on health, Robert L. Stevenson's words in *Prince Otto* might be taken as a motto:—

And though we should be grateful for good housing, there is, after all, no house like God's out-of-doors.

**Housing and Health.**—The relation between housing and health illustrates the intricacy of the connection between any two connected social events. Is the excessive death-rate and sickness rate in small tenements due to the drifting of the physically and mentally inferior section of the people into

these dwellings by a process of selection, or are the dwellings themselves responsible for the result? Doubtless the above and other factors are operating together, and skilled knowledge and much judgment are needed to disentangle the factors, which usually do not admit of more than elementary arithmetical statement.

Professor K. Pearson has no hesitation in ascribing chief importance to the physically and mentally unfit parents in the inferior homes, and as seen on page 546 finds little or no relation between home environment and such conditions as glandular enlargements, ear diseases, keenness of vision, etc. He says: "The Edinburgh statistics (p. 544) show that the effect of home influence is not one-tenth that of heredity," and adds a remark as to the "relative insignificance of nurture in influencing man's welfare." Medical officers of health have never accepted this view, and sometimes, perhaps, they may have magnified the influence of bad housing as a factor in causing ill-health. The following illustrations serve to bring out some of the chief statistical points.

The results of an early investigation were published by Dr. J. Burn Russell, in 1888, and are summarized in the table below, showing for Glasgow in 1885 the death-rates in various sizes of dwelling per 100,000 inhabitants:—

## GLASGOW.

	One and Two-room Houses.	Three and Four-room Houses.	Five Rooms and upwards.
Zymotic diseases .. .. .	478	246	114
Acute diseases of the lungs ((including consumption) .. .. .	985	639	328
Nervous diseases and diseases of nutri- tion in children .. .. .	480	235	91
Accidents and syphilis in children .. .. .	32	11	—
Miscellaneous unclassified diseases .. .. .	799	764	590
All causes .. .. .	2,774	1,945	1,123

The above results, which are based on unstandardized and grouped death-rates, show the close relation between these and size of dwelling. They are confirmed by more recent investigations by Dr. A. K. Chalmers for the same city.<sup>1</sup> He

<sup>1</sup> "The House as a Contributory Factor in the Death-rate" (*Proceedings of the Royal Society of Medicine*, 1913).

worked out standardized death-rates for different-sized tenements, in which correction was made for varying age and sex distribution, finding that the correction only altered materially the death-rates for one-apartment dwellings. The standardized total death-rates per 1,000 living were as follows :—

One-room dwellings	.. ..	20.1
Two-room dwellings	.. ..	16.8
Three-room dwellings	.. ..	12.6
Four rooms and upwards	.. ..	10.3

Special interest attaches to the death-rates in childhood.

		Number of Rooms.			
		1.	2.	3.	4 and over.
Death-rates per 1,000 living	{ Under 1	210	164	129	103
	{ 1-5 ..	41	30	18	10
Relative mortality	{ Under 1	100	78	61	49
	{ 1-5 ..	100	73	44	24

The Glasgow experience confirms the experience for England (p. 358) that a high death-rate in infancy is associated with a relatively high death-rate at ages 1-5.

In regard to (a) the chief infectious diseases of childhood and (b) pneumonia, the death-rates were 16 and 6 in one-roomed, 12 and 6 in two-roomed, only 7 and 2 in three-roomed, and 3 and 1 in four and more roomed dwellings. Here the influence of environment rather than any selective influence almost certainly preponderates. The same remark will apply to the death-rates from food infections and total diseases of respiratory organs, as shown below :—

Death-rate of Males under 1 per 1,000 caused by	Number of Rooms.			
	1.	2.	3.	4 and over.
Food infections, including diarrhoea and enteritis and other digestive disorders .. ..	32.8	25.8	14.9	16.8
Disorders of the respiratory organs .. ..	39.8	35.5	26.7	20.0

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In this instance it will be noted that groups of diseases are employed in statistical comparisons (see p. 179). The paucity of data almost necessitated this course, and in dealing with contemporaneous comparisons in the same city the likelihood of error is small.

The relation of housing to pulmonary tuberculosis is intimate, as Koch emphasized, laying special stress on bedroom accommodation. When the composite experience of a large number of towns is examined, however, no consistent relation is found between the number of one- and two-roomed tenements and of overcrowded tenements and the magnitude of the local phthisis death-rate. Thus in 1911 :—

	Belfast. <sup>1</sup>	Manchester.	Liverpool.	Birmingham.	London.	Edinburgh.	Dublin. <sup>1</sup>	Glasgow.
Proportion per cent. of total population living more than two in a room ..	5.5	7.0	9.5	9.8	16.8	31.1	37.9	53.6
Phthisis death-rate per 1,000 total population ..	2.52	1.56	1.60	1.14	1.35	0.96	2.80	1.47

<sup>1</sup> The figures for the two Irish cities relate only to tenements of less than 5 rooms.

Either the above test of overcrowding is unsatisfactory, or overcrowding has not such an important influence as is supposed, or its influence is counteracted—in a measure which varies in each city—by education in sanitary precautions, and by home or hospital segregation of the infectious sick, or its influence is concealed by other countervailing circumstances.

Further light is forthcoming from separate vital statistics for each kind of tenement. Fig. 39, taken from a paper by the late Dr. A. W. Williamson, Medical Officer of Health of Edinburgh, shows death-rates from phthisis in three Scottish cities, arranged according to the size of dwelling. In all these cities the phthisis death-rate is highest among the dwellers in the smallest tenements, and this experience may be regarded as general. It is unlikely that corrections for age and sex would have altered the relative positions of the different groups. Evidently then in Edinburgh there is a relation between the amount of overcrowding and the phthisis

death-rate (on this see also p. 456). This might be caused by combinations to a varying extent of the following factors :—

- (1) The selection which brings the weakest members of the community into the lowest stratum of society.
- (2) The drifting of persons already consumptive and unable to earn good wages into less satisfactory homes.
- (3) The deficient nutrition of occupants of such homes.
- (4) The general insanitation of these homes ; or
- (5) The greater exposure to intensified infection due to the intimate contiguities of a small dwelling.

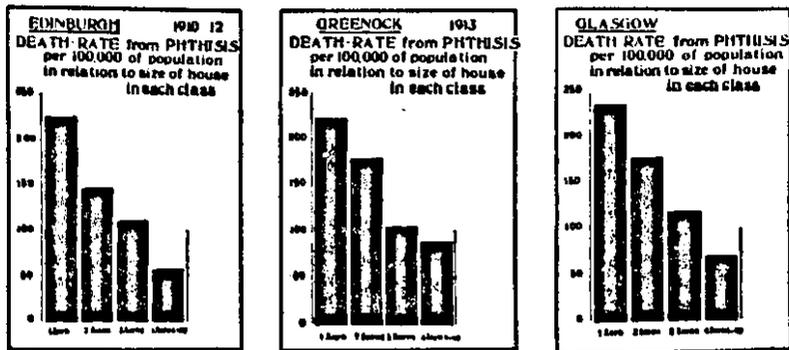


FIG. 39.—Phthisis Death-rates in Three Scottish Towns, according to Size of Dwelling.

The last-named item must play a large part in the general result ; and the discrepant results of overcrowding in different communities are best explained by the varying extent to which overcrowding is limited to the healthy, owing to the bed-ridden and specially dangerous consumptives having been hospitalized, and by the more cleanly habits of some sections of the population in circumstances of overcrowding.

A further illustration of the difficulty in establishing relation between housing and tuberculosis is given by Dr. C. V. Chapin in his valuable work on *The Sources and Modes of Infection*, 1910. It refers to the much quoted "Lung Blocks" in New York City, and his statistics are taken from the Report of the New York Department of Health for 1896. During 5 years, 42 per cent. of the deaths from tuberculosis in the city occurred in 5.25 per cent. of all the houses in the city.

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In Ward IV, 55·8 per cent. of the cases occurred in 10·5 per cent. of the houses in the ward.

In Ward VI, 44·7 per cent. of the cases occurred in 7·0 per cent. of the houses in the ward.

The figures have been quoted as supporting the view that tubercle bacilli become attached to the interior of the dwelling, apart from human carriers of infection, and that disinfection of premises is *a* if not *the* most important item in the prevention of tuberculosis. To show that the tuberculosis of a large proportion of the occupants of these blocks was caused by infection acquired in them would require an exhaustive inquiry into each case, especially as to the past history of prolonged exposure to infection; and in such an inquiry it would be necessary to attempt to differentiate between rooms supposed to be infectious *per se*, and the much more common and abundant source of infection furnished by open cases of tuberculosis in the same rooms.

## CHAPTER XXVII

### OCCUPATION IN RELATION TO SICKNESS AND MORTALITY

OF the many circumstances of man's environment which influence his health, housing and occupation are two of the most influential, and measurement of their effect is an important branch of vital statistics. The coincident operation of numerous factors on health, for some of which no measure may be available, renders statistical statement difficult, and figures need to be judged as more or less important, in proportion as they fit with inferences drawn from collateral branches of knowledge.

In order to measure the connection between occupation and health, as a fact—which may or may not be a *causal* relationship—the following statistical data are needed:—

1. A statement of the number engaged in the occupation in question, distributed according to age and sex, and if possible according to the duration of their engagement in this occupation.
2. A statement of the number of days of sickness, amounting to incapacity to work, of the persons engaged in the occupation, and the character of the sickness.
3. A statement of the number of deaths among the same persons similarly classified according to age and sex, and the cause of death in each case.

It is convenient to deal first with—

**Occupational Mortality.**—The census returns give the needed information as to occupation, and the instructions at the back of the census form (p. 607) indicate the chief methods of grouping occupations. The Register of Deaths similarly gives the occupation of the deceased, the information being furnished by the "informant," usually a relative of the deceased. It is a question whether the informa-

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tion thus obtained has the same degree of accuracy as the information filled in at the census by the head of the household.

**Methods of Statement.**—Among the various methods of comparison between occupations.

1. A comparison of mean ages at death has been employed. This is very misleading, as the mean ages at death obviously will depend on the mean age of the living.

2. A statement of the death-rate per 1,000 engaged in a given occupation may, like a crude death-rate for the general population, give fallacious indications. Thus in 1910-12 the crude death-rate of farmers aged 15-75 was 11.6, of coal-miners 9.3 per 1,000, but the death-rate at each age-period was much higher for coal-miners than for farmers.

AVERAGE ANNUAL DEATH-RATES, 1910-12, PER 1,000 LIVING AT EACH SUCCESSIVE AGE-PERIOD.

	Ages.							All Ages.
	15-.	20-.	25-.	35-.	45-.	55-.	65-.	15-75.
Farmers ..	0.5	1.5	3.1	4.6	8.6	20.0	51.3	11.6
Coal-miners ..	3.2	3.8	4.4	6.7	12.7	30.1	82.3	9.3

The reason for this apparently discrepant result is that farmers are older men on the average than coal-miners, and therefore, irrespective of occupational differences, experience a higher crude death-rate.

3. Given adequate data, the best method is shown in the above table, the death-rate of those engaged in one occupation and of a given age being compared with the death-rate of those engaged in a second occupation and of a corresponding age.

4. But this method may, when the numbers are limited, necessitate the calculation of death-rates for each age-period based on scanty facts, and variations from chance are likely to arise. This objection is minimized by the calculation of deaths in a standard population; and apart from this point, a standardized death-rate, while eliminating in large measure arithmetical causes of variation, gives a view

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of the whole of the facts in a single figure, and thus enables comparisons to be easily made.

The method employed in the Registrar-General's Report on Occupational Mortality is dual: (1) The death-rate at each age-period is given for males engaged in 132 occupational groups. (2) The number of deaths is given for each occupation in a standard population of 71,005 distributed as follows:—

25-35 years old	.. ..	26,259
35-45        "	.. ..	20,407
45-55       "	.. ..	14,748
55-65       "	.. ..	9,591
		71,005

The population, the number of deaths from all causes, and from any single cause of death in a given occupation being known for each age-period, the corresponding death-rates for this occupation are calculated. From these the number of deaths in each group of the standard population is ascertained. Among "All Males" in the official tables, the numbers are as follows:—

Ages.	Death-rate per 1,000 at Each Age-period.	Death in Standard Population from	
		All Causes.	Phthisis.
25-	4.80	126	44.7
35-	7.99	163	42.6
45-	14.65	216	33.8
55-	29.69	285	20.9
		790	142.0

The total deaths in the standard population are also known as the *Comparative Mortality Figure*. It is 790 for all causes for All Males and 142 for Phthisis. For clergymen the corresponding comparative mortality figures are 443 and 45, and these two sets of figures are exactly comparable. Possible weighting of results by this method owing to preponderant influence of excessive mortality at one age-group is mentioned on page 225. This source of possible error when the groups at each age-period are large is negligible.

**Proportionate Mortality.**—This term (see p. 202) may

be employed to denote the proportion of deaths from all causes or from any given cause, to total deaths from all causes, or to total deaths from the given cause at all ages, or a similar proportion for any age-period. In either case it implies a proportion between two variables A and B, which do not necessarily change in unison. Hence comparison of A : B in various groups may have a variable causation, and is to be deprecated. To ensure comparable items each of the terms A and B should be stated in its ratio to the population concerned in the experience. But sometimes the population of the group under investigation cannot be ascertained, and this is particularly apt to arise in investigations of small occupational and social groups, and the choice lies between abandoning the investigation and using an imperfect and sometimes fallacious measure.

Some early investigations by Dr. William Guy, one of the ablest of early English statisticians, illustrate the value which may attach to investigations with imperfect data, when judiciously employed.

In a paper entitled "A Contribution to a Knowledge of the Influence of Employments on Health" (*Journal of the Royal Statistical Society*, June, 1843), Dr. Guy, from a study of the hospital patients in King's College Hospital, showed that when the ratio of the cases of phthisis to other less severe affections entered on the hospital books was obtained, this ratio in indoor occupations showed that phthisis formed a larger proportion of the total cases in occupations requiring little exertion than in occupations requiring much exertion. Among letter-press printers 1 case in 5.12, and among tailors 1 in 2.94 was phthisis. The possible errors of such an inference were known to him, including probably the general objection stated above, as well as the fact that various occupations may be entered into at different ages. This he eliminated in some instances. His general remarks bear quotation even now, as indicating the importance of converging lines of evidence, no one of which is adequate or entirely satisfactory.

The ratios, he says,

are not employed as a certain test of the tendency of different occupations to promote Phthisis, but merely as a probability in conjunction with others derived from analogous sources.

He adds :—

The coincidence of the probabilities established by two classes of facts gives the strongest reason for believing that the conclusions which have been arrived at are in accordance with the true state of the case.

In a later paper (1843) he adds :—

These three concurrent probabilities must be admitted to have a force scarcely inferior to that of positive proof.

The degree of reliance which may be placed on proportionate mortalities has been investigated by Drs. M. Greenwood and A. E. Tebb (*Medical Research Council Special Reports*, No. 22, 1919), who found that the correlation at ages 35–45 between proportionate mortality from phthisis and the death-rate from phthisis in the Registrar-General's Occupational Groups, 1900–2, was,  $0.75 \pm 0.04$ . It is emphasized by them that these results hold good for averages with fair accuracy, although possibly much in excess or defect of the truth in individual observations.

The *International Journal of Public Health*, Vol. II, No. 6, 1921, contains an article signed F. Humbert, which comments on the occupational experience of the Prudential Insurance Company of America, 1907–12. The following table is extracted from this article :—

PERCENTAGE PROPORTION BETWEEN DEATHS FROM SPECIAL DISEASES AND TOTAL DEATHS FROM ALL CAUSES IN THE GIVEN AGE-PERIOD.

Ages at Death.	Phthisis.	Other Respiratory Diseases.	All Other Causes.	All Causes.
15–24—				
Bakers .. .. .	24.4	7.8	67.8	100.0
Draymen and teamsters	34.5	8.9	56.6	100.0
Printers .. .. .	47.0	8.6	44.4	100.0
File-makers .. .. .	50.0	10.0	40.0	100.0
25–44—				
Bakers .. .. .	35.0	14.1	50.9	100.0
Draymen and teamsters	40.5	10.7	48.8	100.0
Printers .. .. .	48.2	9.1	42.7	100.0
File-makers .. .. .	65.0	15.0	20.0	100.0

In the above article it is stated that “the relative danger of tuberculosis can only be determined for any given trade by expressing the tuberculosis death-rate therein as a percentage of the total death-rate,” and a further table is given,

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as below, from which it is argued that clergymen are not so exempt from tuberculosis as are coal-miners, and that innkeepers and agriculturists do not suffer very differently in respect of mortality from this disease.

### TUBERCULOSIS.

	Death-rate, 1910-12, per 1,000 Males Aged 15-65.	Deaths per Cent. of Total Mortality from all Causes.
Coal-miners ..	0.95	11.72
Clergymen ..	0.65	13.85
Innkeepers ..	2.10	16.47
Agriculturists ..	0.81	15.77

In these instances the statement of liability to death from tuberculosis given in the first table and in the second column of the second table is obviously misleading, as a measure of the liability to tuberculosis of special groups of the population (see also p. 202). Given equal numbers at equal ages in the above groups, the above figures show that the rate of mortality of coal-miners from tuberculosis is 18 per cent. higher and of innkeepers is 159 per cent. higher than that of agriculturists.

The following table, derived from data in the Registrar-General's Occupational Report, further illustrates the relative value of three methods of estimating occupational mortality:—

PHTHISIS: OCCUPATIONAL MORTALITY FIGURES, 1910-12.

	A.	B.	C.	A'.	B'.	C'.
	Death-rate. <sup>1</sup>	Proportionate Mortality. <sup>2</sup>	Deaths in Standard Population. <sup>3</sup>			
Agricultural labourers (Group 33) ..	0.99	15.1	71	100	100	100
Coal-miners (36) ..	1.04	10.5	76	106	70	108
Stone-getters (42c) ..	6.25	29.0	415	632	193	585
Barmen (125a) ..	5.84	25.3	434	590	168	612

<sup>1</sup> Per 1,000 living at ages 25-65.

<sup>2</sup> Per 100 deaths from all causes at ages 25-65.

<sup>3</sup> Comparative mortality figures as defined on page 313.

The figures in column C are approximately comparable, those in column A, being death-rates at all ages 25-65,

may be regarded as crude death-rates, while those in column C suffer from the drawbacks already indicated. In columns A', B', C' these rates are stated proportionally; and C' being accepted as the standard, it is clear that A' closely approaches the accuracy of C', while B' (proportionate mortality) is extremely wide of the mark.

6. Dr. Dunlop, in preparing the report on the Scottish Occupational Mortalities, has employed additional methods of statement, viz. :—

(1) Grouping of the occupations according to whether their death-rates, loaded with their probable errors, are greater or less than or are not decidedly different from those of all males.

(2) A comparison of the expectation of life during the working age-periods.

(3) A comparison of probabilities of reaching age 65.

The first of these methods makes allowance for probable error due to paucity of figures, but, as Dr. Dunlop remarks, it does not show finer distinctions. The death-rates are calculated for ages 25-45 and 45-65, within each of which somewhat wide variations of mortality might in some instances be caused by different age-distributions of compared groups. These death-rates are more trustworthy for large than for small groups.

A modification of Farr's short method of constructing life-tables is employed by Dr. Dunlop for the second test; and for the third test, if the number at age 25 be taken to be 100,000, the probability of surviving a 10-year age-period is calculated thus :—

$$\frac{\text{Population of period} - \frac{1}{2} \text{ deaths in period}}{\text{Population of period} + \frac{1}{2} \text{ deaths in period}}$$

the result being raised to the tenth power. The survivors at ages 35, 45, 55, and 65 were estimated by successively applying the rates of probability of surviving through each 10-yearly period.

One difficulty runs through all the methods enumerated above. They pay no regard to survivors over the age 65. They ignore the fact that the effect of a given occupation on mortality may be postponed. No ideal method is

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practicable; the facts collected by any of these methods may give indications, though some methods are more accurate than others. Furthermore, it will be remembered that the data, however obtained, represent the composite result of a number of factors of which industrial occupation is one.

A good illustration of this important point is furnished by the experience of hotel-keepers and of persons aged 25-65 in the other occupations enumerated in the following table:—

OCUPATIONAL EXPERIENCE, 1910-12.

	Expected Deaths from All Causes at Ages 25-65 per Cent. of Number if Experience had been Same as "All Males."	Number of Deaths in Standard Population (Comparative Mortality Figure) for		
		All Causes.	Phthisis.	Alcoholism and Cirrhoels of Liver.
	Per. Cent.			
Gardeners .. ..	58.1	457	76.	7
Agricultural labourers .. ..	59.0	470.	71	5
Clergy .. ..	59.7	443	45	4
Coal-miners .. ..	91.2	727	76	9
Butchers .. ..	110.5	885	127	48
Brewers .. ..	129.5	1,023	181	49
Waiters .. ..	133.8	1,050	281	35
Inn servants .. ..	157.2	1,173	294	51
Inn hotel-keepers .. ..	160.0	1,265	198	156
All males .. ..	100.0	790	142	17

In the first three occupations enumerated in the above table we may see the combined result of an open-air life and of relative freedom from alcoholism and from syphilis and other infections, including tuberculosis. The favourable experience of coal-miners in respect of phthisis may possibly be related in part to infrequent industrial exposure to infection. It has been suggested that coal dust, possibly by exciting phagocytosis, exercises a beneficent influence; and the contrast between phthisis in coal-workers and in silica workers is striking. An initial selection of stronger men for mining, and a weeding out of weaker men, plays its part in the result.

Does a similar but inverse process explain the excessive mortality among brewers, waiters, innkeepers and inn servants? It may enter into the result, but the baneful influence of alcoholic excess, and its special effect in lowering

resistance to phthisis and in supplying more frequent opportunities for massive and repeated infections in public-houses, etc., must bear a much larger part in making the preparation and sale of alcoholic drinks a specially dangerous industry.

**Sources of Error in Occupational Statistics.**—The pitfalls of occupational statistics are well known; but their value as an index of the vitality of men of various social position is undoubted, always remembering that the influence of the occupation is not alone concerned, but that the non-industrial circumstances, domestic and non-domestic, of the man's life play an important part in the statistical result.

1. *Vagueness of Definitions.*—The occasional vagueness of entry of occupation in census returns and still more in death registers has already been mentioned. Only well-defined occupations should be made the subject of statistical research.

The Registrar-General points out that the instructiveness of the occupational classification is somewhat impaired, because it is, "on the whole, rather of an industrial than of a strictly occupational nature, and thus obscures in many instances the full effect of dangerous processes or operations." Thus it does not differentiate in the pottery trade between workers in lead glaze and others, nor in the cutlery trade between grinders and others, and the result is to dilute the mischievousness of certain industrial processes, and to lead to some understatement of the facts. On the other hand, to attempt to separate these portions of industries would, in many instances, result in scanty figures, and the effect of transfers from one process to another could scarcely receive correction. The most fruitful plan from the point of view of investigation of occupational mortality is to retain occupational classification with an industrial framework.

2. *Changes of Occupation.*—The most serious difficulty, and one which appears insuperable, is the original selection involved in the choice of an occupation, supplemented by outward selection, especially from laborious work, when unfitness declares itself. Those who follow the several industries do not start on equal terms as regards healthiness. A weakling will not become a navvy, but a shopman or tailor by preference. The occupations demanding great muscular strength and activity, to some extent then, consist of picked men, stronger at the commencement, and main-

tained up to a certain standard by the fact that weaklings are drafted into lighter occupations.

Thus the death-rate of the more laborious occupations is lowered by such selection as compared with the death-rate (a) of those engaged in lighter occupations, or (b) of those who are returned as having no occupation, or (c) of those who have to betake themselves to odd jobs, as general labourers, messengers, costermongers and street-sellers.

3. Errors due to wrong methods of stating occupational mortality are described in previous paragraphs.

4. The main error in occupational statistics is in the inferences drawn from them, from disregard of the factors mentioned above.

The following statement from the official Report on Occupational Mortality, 1910-12,<sup>1</sup> emphasizes the main precaution which is required:—

It is not . . . by any means necessarily illogical or unscientific to classify by reference to occupation alone the mortality which is due to all forms of human environment, so long, of course, as it is fully recognized that the attribution of mortality to occupation can only be justified on the widest construction of the facts, and that the naked figures merely represent the mortality of the person following a given occupation.

The tables on page 321 are extracted from the Occupational Mortality Report of the Registrar-General issued in 1922. In the first table are displayed the comparative mortality figures of five social classes and of three special occupational groups. The increasing total mortality with lowering of social position illustrates the composite influence of poverty (p. 295), as do also the phthisis figures. That rural life may more than counteract the influence of social position is shown by the phthisis figures for agricultural labourers (71) and for upper and middle classes (121). The excess of cancer in unskilled workers is unexpected.

In the second table on page 321 is given a selection from the statistics of 132 occupations or occupational groups comprised in the Registrar-General's Occupational Report. Detailed comment is scarcely necessary, but the original report deserves study in detail.

<sup>1</sup> Supplement to the Seventy-Fifth Annual Report of the Registrar-General for England and Wales. Part IV. Mortality of Men in Certain Occupations in 1910-12.

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## DEATHS IN STANDARD POPULATION AT AGES 25-65 FROM

	All Causes.	Phthisis.	Alcoholism and Cirrhosis of Liver.	Bronchitis.	Pneumonia.	Cancer.	Suicide.
All occupied and retired males .. .. .	790	142	17	38	67	78	19
<b>Social Class—</b>							
I. Upper and middle classes ..	695	121	33	16	47	78	20
II. Intermediate ..	745	123	37	26	58	71	24
III. Skilled workmen ..	758	155	14	37	57	79	16
IV. Intermediate ..	735	131	13	38	62	76	18
V. Unskilled workers ..	1,121	215	20	71	115	102	22
VI. Textile workers ..	801	128	14	47	63	80	22
VII. Miners ..	741	87	0	50	65	61	11
VIII. Agricultural labourers ..	470	71	5	14	39	54	12

## DEATHS IN STANDARD POPULATION AT AGES 25-65 FROM

	All Causes.	Phthisis.	Alcoholism and Cirrhosis of Liver.	Bronchitis.	Pneumonia.	Cancer.	Suicide.	Accident.
<i>A. Professions.</i>								
Civil Service ..	585	96	17	15	36	61	14	22
Clergy, ministers ..	448	45	4	5	28	45	9	13
Barristers, solicitors ..	627	58	28	7	45	77	29	25
Medical practitioners ..	693	65	27	9	66	70	33	29
Schoolmasters, teachers ..	506	70	12	11	42	57	14	15
<i>B. Dusty Occupations.</i>								
Coal-miners ..	727	76	9	51	64	61	11	118
Iron-miners ..	652	73	5	37	76	56	15	93
Tin-miners ..	1,579	684	—	76	95	93	—	95
Lead-miners ..	1,185	335	—	50	49	82	—	96
Stone-getters:								
Masons ..	951	237	13	60	60	74	16	67
Tools, scissors, file, etc., makers ..	1,010	308	10	68	74	76	20	25
File-makers ..	1,529	434	15	88	127	78	28	28
Cutlery, scissors-makers ..	1,285	466	12	82	83	106	29	23
Tin plate goods makers ..	1,072	243	35	84	83	97	29	25
<i>C. Alcoholic Indulgence.</i>								
Clergy, ministers <sup>1</sup> ..	448	45	4	5	28	45	9	13
Commercial travellers ..	724	121	25	21	52	92	22	19
Coach, cab, omnibus service, etc. ..	921	176	23	54	73	97	26	48
Barge-men, lighter-men ..	1,103	142	22	67	105	88	6	103
Dock and wharf labourers ..	1,127	232	30	84	140	98	15	100
Messengers, porters, waiters (not railway) ..	1,137	252	24	66	107	118	20	47
Butchers ..	885	127	44	35	67	105	28	25
Maltsters ..	580	64	24	27	51	47	15	35
Brewers ..	1,023	181	49	45	95	125	22	30
Innkeepers ..	1,263	193	145	29	104	85	33	35
Inn, hotel, etc., servants ..	1,173	204	51	55	103	99	29	29
Bar-men ..	1,724	434	112	75	185	137	43	36
Chimney sweeps ..	1,015	202	50	66	92	107	23	47

<sup>1</sup> This column is given here as a control.

**Occupational Sickness.**—As stated on page 129, there is but little information as to the relation between the amount and character of sickness and the pursuit of a given industry. Most of the Industrial Insurance Societies are on a basis which includes many occupations, and separate experiences for occupations have not been adequately investigated. Sir A. Watson in his investigation (ref. p. 149) found that the sickness and mortality rates of Friendly Society experience were but little related to each other (p. 151), also that geography governed mortality more than occupation, while the reverse held good for sickness. The explanation depends largely on the nature of the occupations; some can be continued during minor illness, others cannot. Sickness as measured by Friendly Society statistics does not measure the sickness of occupations completely, what is measured being "not pathological sickness, but claims upon the funds for benefits in respect of incapacity for work" (Watson).

A paper by Mr. E. A. Rusher, F.I.A., on "The Statistics of Industrial Morbidity in Great Britain" (*Journal of the Royal Statistical Society*, vol. lxxxv, January 1922), gives a valuable summary of this subject, including the history of various attempts at compilation of experience. He concludes that (1) among the factors concerned, age has the greatest influence on rates of sickness, and next to this occupation. As suggested on page 320, occupation is an index, higher occupational mortality not being necessarily due to the occupation in question. (2) That occupation has more influence on health than either locality or density of population. It is, however, often not possible to dissociate the influence of density from that of occupation. One is obliged to confirm the conclusion stated by Sir A. Watson in the discussion on this paper, that inasmuch as sickness certificates often give symptoms, and the records retain this first and often tentative diagnosis, this is "not the proper material on which to build a huge statistical superstructure." This does not mean that information as to the total amount of recorded sickness, and comparison of this in different occupations, according to age, is without value. It will have greater value if it becomes practicable to divide the experience of a large industry into its constituent parts, showing the influence on sickness experience of the different parts and processes of the industry.

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**Industry in Females.**—But little information is available as to occupational sickness and mortality in females. In their case the effect of influences, other than occupational, is probably greater than for men.

**References.**—Fuller information on the subject of this chapter is contained in the occupational volume of the Registrar-General's Decennial Supplement; in Dr. J. C. Dunlop's contribution on "Occupation Mortalities" (*Transactions of the Faculty of Actuaries*, vol. v, 1911), in Dr. M. Greenwood's Milroy Lectures (*British Medical Journal*, 1922, vol. i, p. 667 *et seq.*), and in Collis and Greenwood's *Health of the Industrial Worker*, 1921. Special papers by Dr. F. L. Hoffman, of Newark, N.J., may be consulted with advantage, especially his study of "The Problem of Dust Phthisis in the Granite-Stone Industry" (*U.S. Bureau of Labour Statistics Bulletin*, No. 293, 1922).

## CHAPTER XXVIII

### STATISTICS OF ALCOHOLISM IN RELATION TO THE PUBLIC HEALTH

EXACT physiological experimentation has shown that ever small doses of alcohol have a deteriorating influence on muscular and mental work ; but for evidence as to the evil results of alcoholism we must in the main depend on statistics of destitution obtained by intensive investigation, and on statistics of crime and disease.

The national death-statistics give valuable information, though for obvious reasons the mischief resulting from alcoholism is gravely understated in them.

In the short list of diseases, alcoholism and cirrhosis of the liver are placed in juxtaposition,<sup>1</sup> the number of deaths from these two causes in England and Wales in 1920 being 216 and 1,763 respectively. In the corresponding long list of the International Classification, Alcoholism (Acute and Chronic) has 216 deaths debited to it, while Cirrhosis of the Liver is subdivided in the Registrar-General's Report into—

	Number of Deaths.	
	Males.	Females.
A, Cirrhosis of the liver, not returned alcoholic	1,069	529
B, Ditto, returned as alcoholic .. .. .	95	33
C, Diseases formerly classed as "other diseases of liver and gall bladder" .. .. .	16	21
	1,180	583

Prior to 1911, when the medical certificate of death gave some organic disease attributed to alcoholism, the entry was made by the Registrar-General under the heading Alcoholism. In accordance with the international rules the two are now

<sup>1</sup> In the short list on p. 179 and in the Annual Review of the Registrar-General, 1921, Alcoholism is omitted.

separated, and it thus arises that the 216 deaths attributed to alcoholism in 1920 would have been 577 according to the old rules. Table 9 in the Registrar-General's Report for 1920 gives the classification according to the old rules, and difficulty in continuity of comparisons is thus obviated.<sup>1</sup>

The above figures do not represent the entire mortality from alcohol, and, on the contrary, an uncertain proportion of cases of cirrhosis of the liver are non-alcoholic in origin.<sup>2</sup> Table lxvii in the Registrar-General's Report, 1920, gives

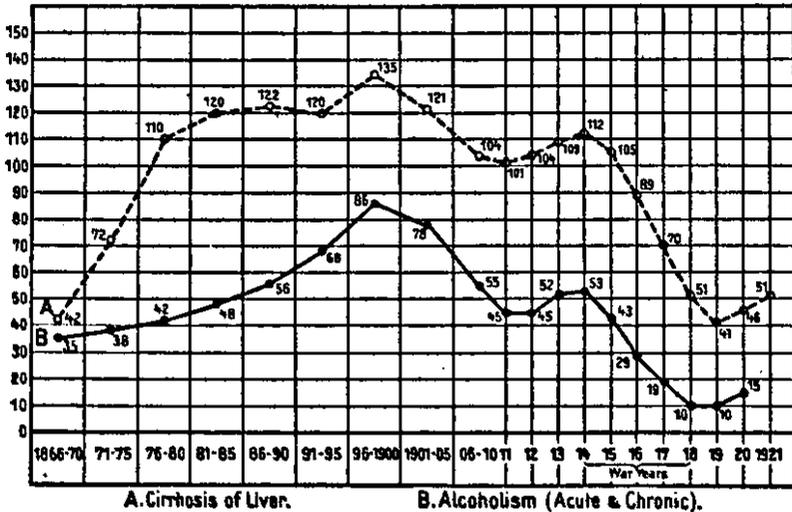


FIG. 40.—England and Wales: Average Annual Death-rates in Nine Quinquennial Periods 1866-70 to 1906-10, and for Single Years 1911-20 from A, Cirrhosis of Liver; B, Alcoholism (Acute and Chronic)—Old Classification.

a total of 719 deaths, or 142 in excess of the 577 referable to the old heading. In 130 instances of deaths from violence, 62 of heart disease, 34 of pneumonia, 14 each of bronchitis and neuritis, alcoholism also was mentioned.

The total thus obtained is relatively insignificant. Stated as rates per million of the population, the death-rates from alcoholism and cirrhosis of liver are shown in Fig. 40.

<sup>1</sup> The Registrar-General's Statistical Review of England and Wales for 1921 (New Annual Series, No. 1), Part I, gives the deaths from acute and chronic alcoholism according to the new classification for each year 1911 to 1921. In 1921 the number was 182.

<sup>2</sup> In 1920, 7.4 per cent., and in 1921, 8 per cent. of the total deaths from cirrhosis of liver in England and Wales were returned as alcoholic in origin; but these figures cannot be taken as representing more than a fraction of the total alcoholic cirrhosis.

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The upward trend of both curves till the end of the nineteenth century represents in part the final product of the increased drinking which in the past has been constantly associated with increase of national prosperity; in the main, probably it represents an increasing accuracy of certification of deaths. The downward curve from 1906-10 onwards, occurring in association with a continuance and increase of proportion of accurate certification, may be regarded as indicating a gradual improvement in the habits of the people. The remarkable drop in the war years is doubtless the result of restricted supply of liquor, its great cost, and restrictions in hours during which it was obtainable. The above rates apply to persons. The death-rate from cirrhosis of liver in males in 1920 was 66 and in females 30 per million living, the corresponding rates for alcoholism in the two sexes being 24 and 7. In the following table are shown for the years since 1913 the death-rates (according to the older classification) for each sex separately from the two chief registered conditions, which are due wholly or in part to alcoholic excess. The death-rates for males apply only to the civilian population.

DEATH-RATES PER MILLION LIVING.

Year .. ..	1914.	1915.	1916.	1917.	1918.	1919.	1920.	1921.
<b>Alcoholism, delirium tremens—</b>								
Male .. ..	64	53	40	26	17	17	24	—
Female .. ..	43	35	21	14	5	5	7	—
<b>Cirrhosis of liver—</b>								
Male .. ..	130	133	123	105	79	57	66	72
Female .. ..	96	81	62	44	32	27	30	33

Some doubt attaches to the male death-rates, owing to the large military population and the non-inclusion of their deaths in the statistics, but the similarity of trend in male and female death-rates is seen in Fig. 41.

The statement of consumption of proof spirits and standard barrels of beer retained for consumption in the United Kingdom in each year in this figure is taken from official returns. The amount of spirits in 1914 was 32 and of beer 34 million gallons. Each of these is stated as 100. One drawback to the statement of relative mortalities as in

Fig. 41 will be noted. It must not be inferred from the diagram that the female is as high as the male death-rate. The only legitimate comparison is of relative amounts in each curve in any given year in relation to the amount in the initial year.

The curves of death-rates from cirrhosis and alcoholism in males and still more in females show a remarkable declension following on the reduction in consumption of alcoholic drinks ; and as might have been expected, the mortality curve lags

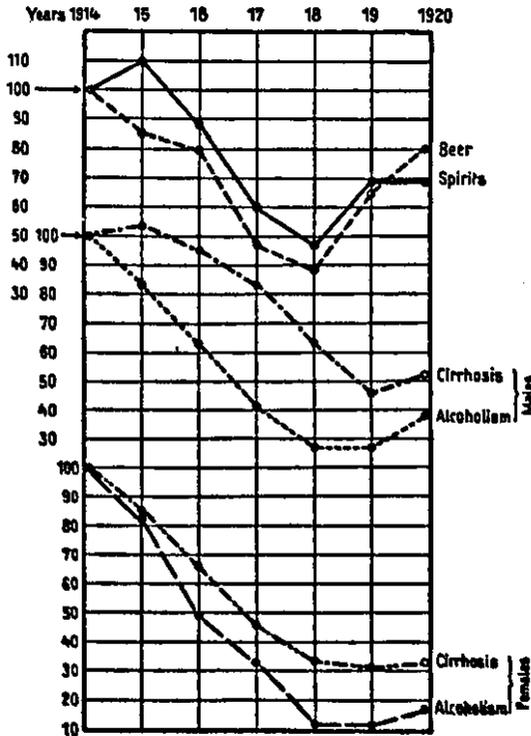


FIG. 41.—England and Wales: Relative Mortalities and Alcoholic Consumption of Beer and of Spirits in 1914 to 1920 (the amount under each heading in 1914=100).

behind the curve of consumption. The 1915 figures for male cirrhosis show no decline, unlike all the other mortality curves, and this may possibly be associated with the increased consumption of spirits in that year. There is little doubt that the next few years' returns under the heading both of mortality and consumption will confirm the results shown in

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the diagram in an inverse direction, in view of the diminished stringency of regulations for the sale of intoxicants. In order that this may be tested, the notes as to changes in classification in the Registrar-General's reports must be regarded.

With the death-rates in Fig. 40 may be compared the following American death-rates :

### U.S.A. DEATH REGISTRATION STATES.

#### *Death-rates per Million Persons.*

	Average 1901-05.	Average 1906-10.	1915.	1916.	1917.	1918.	1919.	1920.
Alcoholism (acute and chronic) .	61	58	44	58	52	27	16	10
Cirrhosis of the liver .. ..	144	143	125	123	114	95	79	71

From a table in "Mortality Statistics," 1918, can be gathered information as to 5,363 deaths in the United States Registrar area in which alcoholism was returned as a contributory cause of death. This occurred in 313 deaths from tuberculosis, 249 deaths from apoplexy, 911 deaths from diseases of the circulatory system, 1,117 deaths from pneumonia, 729 deaths from nephritis, 100 deaths from suicide, 714 accidental deaths, and 13 homicides. The total deaths ascribed to alcoholism as a primary cause in the same year numbered 2,193.

**Estimate of Mortality Due to Alcoholism.**—In 1913 alcoholism and cirrhosis of the liver, which is mainly alcoholic in origin, caused 5,527, and in 1920 these two conditions were the registered cause of 2,175 deaths in England and Wales. These figures greatly understate the total mortality attributable to alcoholic indulgence, directly and indirectly by favouring the occurrence of or a fatal termination to other diseases, such as pneumonia, tuberculosis and erysipelas. It is not improbable that five or even ten times as many deaths as are returned under headings recognized as alcoholic are caused by alcoholism; and this proportion would not include the mortality caused by destitution and neglect, especially of infants due to alcoholism.

A very considerable proportion of accidental deaths,

especially in traffic and in industries, is caused by alcoholism; and a large proportion of homicides and of acts of violence against other persons are due to the same cause. A large proportion, by some surgeons stated to be one-half of the infections with syphilis and gonorrhoea, are received when the person infected is under the influence of alcohol. The abolition of intoxicants would probably effect as much as any other single reform in diminishing these diseases.

**Occupational Mortality due to Alcoholism.**—For explanation of the term “comparative mortality figures” see page 313. The figures of occupational mortality in the report of the Registrar-General on “Occupational Mortality” are not comparable with figures published in 1908 for 10 years earlier.

The following figures relate to males engaged in the specified occupations aged 25–65, and give relative mortality rates for the period 1910–11–12:—

ENGLAND AND WALES.

*Deaths in Standard Population (Comparative Mortality Figures), 1910–12.*

	All Causes.	Alcoholism and Cirrhosis of Liver.
ALL MALES .. .. .	790	17
Clergymen .. .. .	443	4
Gardeners .. .. .	457	7
Medical profession .. .. .	693	27
Commercial travellers .. .. .	724	25
Dock labourers .. .. .	1,127	30
Costermongers .. .. .	1,507	35
Butchers .. .. .	885	48
Boerbottlers, cellarmen .. .. .	968	58
Brewers .. .. .	1,023	49
Waiters .. .. .	1,050	35
Inn, hotel servants .. .. .	1,173	51
Innkeepers, publicans .. .. .	1,265	156
Barmen .. .. .	1,724	112

The close connection between special occupations and excessive mortality from alcoholism is evident (see also p. 321).

In the following table the influence of specially alcoholic occupations in increasing the death-rate at successive ages is shown. For clearness the corresponding death-rate for all males at each age-period is given as 100:—

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## ENGLAND AND WALES.

*Rate of Mortality from All Causes of Those Engaged in Manufacture and Sale of Alcoholic Drinks at Four Age-Groups, in Proportion to that of All Males (= 100).*

	25-	35-	45-	55-
ALL MALES .. ..	100	100	100	100
Maltsters .. ..	48	67	65	94
Brewers .. ..	140	124	137	121
Publicans .. ..	167	178	167	140
Barmen .. ..	266	281	232	150

In the following table is similarly shown the relative mortality from certain diseases and groups of diseases, that of "all males" for the same cause at all ages being stated as 100 :—

## ENGLAND AND WALES, 1910-12.

*Mortality from Certain Diseases in Various Occupations, in Proportion to that of All Males (= 100).*

	All Causes.	Alcoholism.	Cirrhosis of Liver.	Diseases of Circulatory System.	Pneumonia.	Phthisis.	Suicide.
ALL MALES .. ..	100	100	100	100	100	100	100
Upper and middle class ..	88	100	146	89	71	85	105
Skilled workmen .. ..	96	75	84	95	86	109	84
Coal-miners .. ..	92	50	54	93	97	53	58
Textile workers .. ..	101	75	84	107	95	90	116
Farmers .. ..	63	75	85	61	65	40	105
Unskilled labourers ..	142	150	107	140	174	151	116
Dealers in food .. ..	92	125	154	95	86	77	126
Allshopkeepers .. ..	90	125	146	92	86	82	121
Engine and boiler-makers ..	95	50	84	96	94	93	74
Maltsters .. ..	73	75	161	97	77	45	79
Brewers .. ..	129	100	300	119	144	137	116
Publicans .. ..	160	390	900	135	157	139	200
Barmen .. ..	218	530	454	223	280	305	226

In the table all diseases of the circulatory system are grouped together, and for contemporaneous comparisons useful conclusions may be drawn. The table shows the striking excess of mortality under each of the above headings experienced by those engaged in the manufacture and sale of alcoholic drinks.

The above are relative figures. Death-rates per 1,000 living at various age-periods show similar results :—

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## ENGLAND AND WALES.

*Average Annual Death-rates from All Causes per 1,000 at Each Age-Period, 1910-12, in Various Occupations.*

	25-.	35-.	45-.	55-.	65-75.
ALL MALES .. ..	4.8	8.0	14.7	29.7	63.1
Skilled workmen .. ..	4.2	7.3	14.3	30.1	69.6
Coal-miners .. ..	4.4	6.7	12.7	30.1	82.3
Textile workers .. ..	4.2	6.9	14.7	34.7	88.0
Agricultural labourers .. ..	3.2	4.9	8.1	17.3	45.6
All shopkeepers .. ..	4.1	7.0	13.1	27.4	63.9
Publicans, innkeepers .. ..	8.0	14.3	24.5	41.8	85.4
Inn, hotel servants .. ..	8.3	14.4	23.1	33.5	60.2

According to the census figures for England and Wales, in 1911, 38,170 persons were engaged in the manufacture of alcoholic drinks, and 214,461 persons were engaged in their sale, to which number should be added 50,544 non-domestic waiters. The Registrar-General's figures deal with 168,900 men between 25 and 65, engaged as maltsters, brewers, publicans, waiters, barmen, beer-bottlers, cellarmen, etc. The number of deaths that would occur among 168,900 men of the entire community, distributed according to age like the members of the liquor trade, would have been 5,795 in the three years 1910-12. The actual number of deaths was 8,649, an excess mortality of 951 per annum. This, so far as men in the working years of life are concerned, is a minimum statement of the cost in life of making and distributing alcoholic drinks in England and Wales in the circumstances of 1910-12.

**Relation of Alcoholism to Tuberculosis.**—The occupational mortality figures of the Registrar-General show how excessive is the death-rate from phthisis among those engaged in the manufacture or sale of alcoholic drinks (see table on p. 321). The death-rate (corrected for age) is three times as high among barmen as in all males, and is relatively high (excess of 27 and 39 per cent. respectively) in brewers and publicans. In other occupations, e.g. in that of unskilled labourers, phthisis is excessive, and this cannot be dissociated from the alcoholic habits of unskilled labourers. To obtain comparable high figures we need to compare the above with figures for occupations in which the workers are exposed chronically to the effect of irritating dust (p. 321). The

influence of alcohol is twofold, lowering the resistance to infection, and increasing opportunities, in public-houses, etc., of exposure to frequent infection by tubercle bacilli. It is conceivable, though not in accord with common experience, that the average barman chooses that occupation in part because of his relative physical inferiority, and that this may explain some of the excess of mortality; but comparison with the statistics of workers in other light occupations does not suggest that much weight need be attached to this consideration (see also p. 319).

**Evidence from Life Insurance.**—In an investigation of the experience of the United Kingdom Temperance and General Provident Institution, which consists of abstainers and non-abstaining insured persons, the death-rates among non-abstainers (A) and abstainers (B) were as shown in Fig. 42, in which the death-rate in non-abstainers for each age-period is assumed to be 100, and the death-rate for non-abstainers (B) is stated in proportion to this. Except at ages under 20 and at ages 75–79, the abstainers show great superiority in prospects of continued life. Was this a real superiority due to the insured persons' habits as regards alcohol?

In Mr. Moore's paper is given a further table showing the rate of mortality for each quinquennial age-period among abstainers and non-abstainers respectively as compared with that of the  $O_{M_6}$  table of the Institute of Actuaries. The earlier and later ages have been omitted from Fig. 43 based on this table. The figure deals with the 290,226 abstainers and the 338,262 non-abstainers exposed to risk during nearly 60 years, between the ages of 20 and 85. In order to eliminate, in part at least, the influence of selection at the time of insurance, the table from which Fig. 43 is taken excludes the first five years of assurance for both abstainers and non-abstainers.

The superiority of the experience of abstainers at nearly all ages is evident.

There remains the possible source of error that the abstainers may represent to a larger extent than non-abstainers the experience of recent years, which would in itself mean a relatively low death-rate for them. A table on page 230 of Mr. Moore's paper, which compares the experience

of the recent years 1889-1901 among abstainers and non-abstainers respectively sets this doubt at rest.

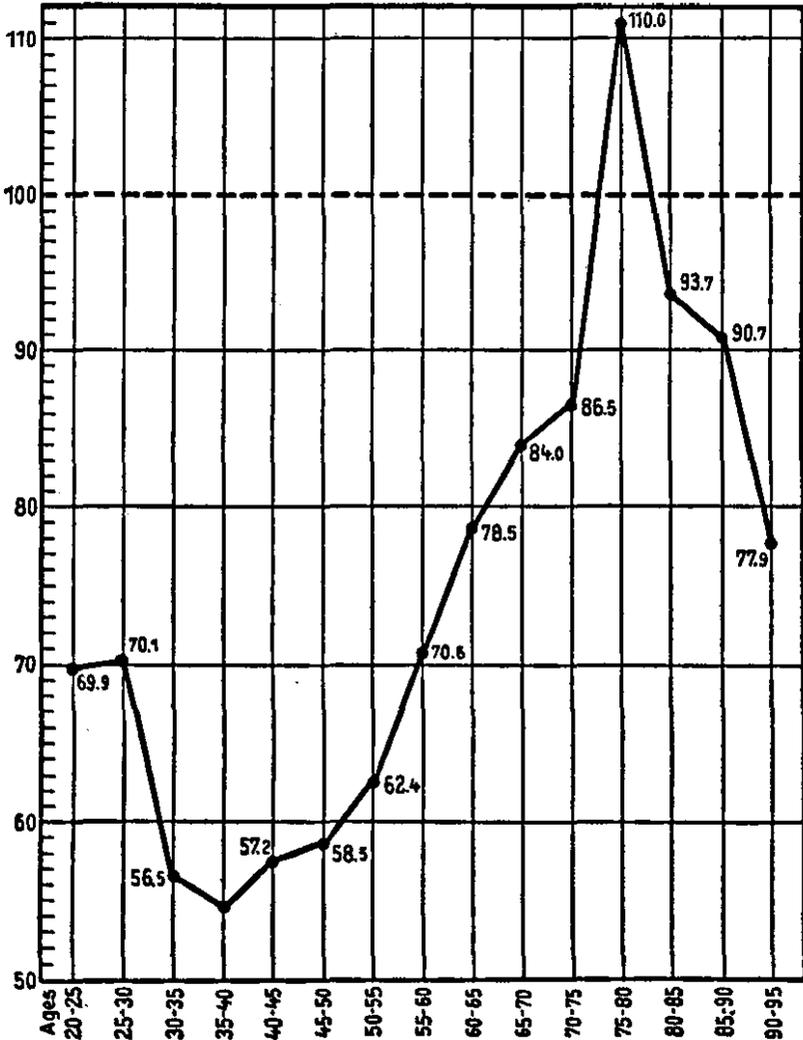


FIG. 42.—Relative Mortality Experience of Abstainers and Non-Abstainers, 1848-1901, at Successive Age-periods, that of Abstainers at Each Age-period being stated as 100.

100 = death-rate for each age in Non-Abstainers.  
 Corresponding death-rate in Abstainers shown in the curve.

Various factors may conceivably have contributed to the remarkable result shown in the two diagrams.

1. It may be that the decision to be an abstainer is determined by the superior health of members of this group, this constituting an initial selection.
2. Possibly when a person fails in health he becomes a non-abstainer, and is transferred from the abstaining to the non-abstaining group.
3. The non-abstaining group may be handicapped by

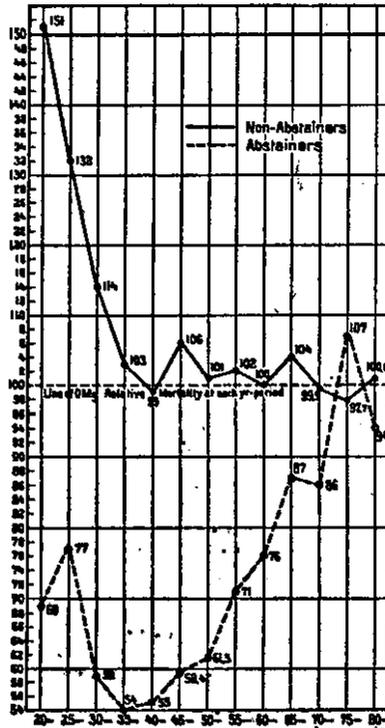


FIG. 43.—Relative Mortality Experience of Abstainers and Non-Abstainers, 1846-1901, at Successive Age-periods, the Experience of the  $O_M$  Table of the Institute of Actuaries for Each Age-period being stated as 100.

the inclusion of a number of intemperate persons, whose life record will necessarily be unfavourable.

4. The two groups may belong to different strata of society.

These objections, except possibly the first partially, have been met in Mr. Moore's paper, and there appears to be no reasonable doubt that the difference between the two groups shown in the figures is due in the main to the difference in

their alcoholic habits, or to some associated difference which runs parallel with these habits. For fuller details see the following papers :—

1. "On the Comparative Mortality among Assured Lives of Abstainers and Non-abstainers from Alcoholic Beverages," by R. M. Moore, Actuary. (*Journal of the Institute of Actuaries*, November 30, 1903.)

2. "The Possible Association of the Consumption of Alcohol with Excessive Mortality from Cancer," by A. Newsholme. (*British Medical Journal*, December 12, 1903.)

**Alcoholic Consumption and Cancer Mortality.**—In the contribution just quoted I analysed the experience of the National Provident Institution, whose experience has been quoted in the preceding paragraph for the three years 1891, 1896, and 1901, and the analysis may be quoted here as an example of a method of obtaining standardized death-rates. The number of years of life at risk in the abstainers' and non-abstainers' section is shown in the following table.

DEATH-RATE FROM CANCER PER STANDARD MILLION IN (A) ABSTAINERS' AND (B) NON-ABSTAINERS' SECTION OF THE UNITED KINGDOM AND GENERAL PROVIDENT INSTITUTION.

A. Abstainers' Section.

Age.	Number of Lives at Risk.		Number in a Standard Million of Population.		Actual Number of Deaths from Cancer among the Lives at Risk.		Calculated Number of Deaths from Cancer.
25-	5,926	is to	260,259	as	0	is to	0
35-	10,184	"	232,106	"	1	"	22·8
45-	11,884	"	199,912	"	14	"	235·5
55-	9,182	"	158,812	"	13	"	224·6
65-	4,912	"	102,196	"	13	"	270·5
75 & upwards	1,433	"	46,715	"	6	"	195·6
	43,521	"	1,000,000	"	47	"	949·2

B. Non-Abstainers' Section.

25-	2,980	is to	260,259	as	0	is to	0
35-	7,056	"	232,106	"	4	"	131·6
45-	10,764	"	199,912	"	12	"	222·9
55-	10,882	"	158,812	"	25	"	364·9
65-	6,500	"	102,196	"	33	"	518·8
75 & upwards	1,822	"	46,715	"	4	"	102·6
	40,003	"	1,000,000	"	78	"	1,340·8

Then follows a statement of the number of deaths from cancer at each age-period in each of these sections. In another column is given the standard population of the English Life-Table, No. 3, Persons. The number of deaths from cancer at ages 45-55 among abstainers being known to be 14, and these having occurred among 11,884 persons, it is easily calculated that the corresponding deaths from cancer among the 199,912 persons aged 45-55 in the standard population would be 235.5; and so for other age-periods. It will be seen that the death-rate in a standard million was 0.95 per 1,000 for abstainers and 1.34 for non-abstainers.

Similarly, it was found that the death-rate from all causes among the abstainers was 17.13, among the non-abstainers 23.52 per 1,000 lives at risk.

The facts which appear to show excessive mortality from cancer among non-abstainers are scanty, and no dogmatic conclusion is justifiable from them. There is need for further inquiry on similar lines, especially with a view to show whether the excess cancer occurs chiefly in the upper part of the alimentary canal. Alcohol increases cell-proliferation generally, predisposes to eczema, and lowers tissue vitality. Statistically the cancer figures are consistent with the figures for total death-rate. The original paper quoted above may be consulted for further particulars.

#### ILLUSTRATION.

**Example 13—Average Age at Death.**—Some years ago as the result of a collective investigation organized by the British Medical Association it was found that the—

Average age at death of total abstainers was 51 years and a few days.

Average age at death of persons habitually temperate was 63 years and a few days.

Average age at death of careless drinkers was 59 years and some days.

Average age at death of free drinkers was 57 years and 59 days.

This information naturally was distributed as a circular by a firm of distillers, and exhibited in public-house windows, etc.

*Observations.*—The method of statement is erroneous (see p. 243). Total abstinence is much more common in younger than in older men, and such deaths as occurred among abstainers would therefore occur at an earlier age. Similarly, the average age at death of curates would be lower than that of deans or canons, but no inference could be drawn as to the relative salubrity of these three offices in the Church.

## CHAPTER XXIX

### THE MEASUREMENT OF CHILD MORTALITY

In this country and in the United States the death-rate per 1,000 living in any given quinquennium of life is higher at ages 0-5 than at any later period before 65 (p. 204). The mortality for these five first years after birth needs further consideration. It is at this period that the greatest saving of life is possible in proportion to the number exposed to risk, because so large a portion of disease at this age-period is preventible; and also because in this country, with the possible exception of recent *post-bellum* experience, the age-group 0-5 comprises a larger number of human beings than any subsequent quinquennium of life. In England and Wales in 1911 of a million persons of all ages, there were 106,857 at ages 0-5, 102,488 at ages 5-10, the number then steadily declining as shown in Fig. 4 p. 59. There is the further motive for exhaustive study of the sickness and mortality rates of childhood that illness at this period of life, even when recovery occurs, is apt by its sequelæ to impair efficiency or health in later life. In fact, if to the consideration of child morbidity and mortality be added a similar study of the mother in pregnancy and parturition, we are concerned with the greatest potentialities of preventive medicine.

In studying child mortality a further subdivision of ages is needed if valid conclusions are to be drawn, comparable with results of other observers. This is necessary owing to the rapid decline of death-rate from the first week and the first month after birth to the end of the first year of post-natal life, and the further rapid rate of decline in the next four years of life. The table on page 338 illustrates these points.

There were nearly as many deaths on the day of birth as in the next six days, and nearly twice as many in the first week as in the next three weeks. Stated otherwise, of

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the total deaths in infancy deaths in the first week formed 27·0 per cent., in the next three weeks 15·6 per cent., in the next two months 18·0 per cent., a total of 60·6 per cent. in the first three months; in the second trimestrial period 16·9 per cent., in the third 12·2 per cent., and in the fourth trimestrium 10·3 per cent.

**Deaths in Proportion to Births.**—The reduction in the birth-rate has rendered it impracticable to estimate the number living at ages 0–5 by reference to the census enumerations, and the official method of estimating popula-

#### ENGLAND AND WALES, 1921.

*Number of Deaths in Each Part of Infancy and During the Next Four Years of Life.*

	Number of Deaths.	Death-rate per 1,000 Births.
Under one day .. .. .	9,150	} 35·25
1–7 days .. .. .	9,873	
1–4 weeks .. .. .	10,909	
4 weeks to 3 months .. .. .	12,598	
3–6 months .. .. .	11,897	14·84
6–9 months .. .. .	8,544	14·02
9–12 months .. .. .	7,279	10·07
	70,250	8·58
		82·76
1–2 years .. .. .	15,636	
2–3 years .. .. .	4,994	
3–4 years .. .. .	3,177	
4–5 years .. .. .	2,584	
Total under 5 years .. .. .	96,641	
Deaths at All Ages .. .. .	458,629	

tions at each year of age 0–5 depends on births and deaths alone. Census figures for these ages have always been relatively untrustworthy, in part owing to the frequent confusion between age next birthday and last birthday. From Mr. George King's life-table investigation it would appear also that there is considerable failure to enumerate children in the first two years of life. Births have a great advantage over estimates based on census enumerations, as they are always on record and up to date.

**Infantile Population.**—The universally adopted method

THE MEASUREMENT OF CHILD MORTALITY 339

is to state the deaths under one year per 1,000 births in the same year. Theoretically a proportion should be taken between the births of the current and of the preceding year, as about 70 per cent. of the infants under one dying in one year were born in the preceding year, but in normal times the number of births does not change rapidly from year to year, and the usual method as stated above should be adopted.

Either births or estimated population of infants serve to measure the infant death-rate; but if, as is recommended, the rate is based on births, it is considerably lower than when based on population, and *the rate thus obtained is not comparable with death-rates at higher ages.*

The method has temporarily given inaccurate results as the result of the Great War, the number of births in England and Wales in each of the years 1914-21 inclusive having been approximately as follows (in thousands): 879, 815, 786, 668, 663, 692, 958, 849. It consequently became necessary to correct the infant mortality rates to allow for the rapid change in the annual number of births. The method of doing this is described in the Annual Report of the Registrar-General, 1920, p. xxxi.

The possible extent of distortion is shown partially in the following comparison of standardized and crude rates for the years 1913-1920, taken from the same report:—

ENGLAND AND WALES.  
*Infant Mortality Rates.*

	1913.	1914.	1915.	1916.	1917.	1918.	1919.	1920.
Crude ..	108.4	104.6	109.7	91.2	96.5	97.2	89.1	79.9
Standardized.	108.9	104.4	105.8	91.1	91.1	97.9	93.2	84.5

It is displayed more accurately in the following statement illustrating the misleading character of the conventional infant death-rate in England and Wales in the exceptional circumstances of the four quarters of 1920 (Annual Report of the Registrar-General, 1920, p. xxxi), especially in its first quarter:—

	First Quarter.	Second Quarter.	Third Quarter.	Fourth Quarter.	Year.
Conventional rate .. ..	88	81	64	85	80
Corrected rate .. ..	109	87	63	79	85

These circumstances are exceptional, and for all practical purposes the use of the births of the current year as the denominator in obtaining the infant death-rate is satisfactory. Thus, if in a given community 5,000 births occur in a year, and in the same year 250 infants die under one year of age, the rate of infant mortality

$$= \frac{250 \times 1,000}{5,000} = 50 \text{ per } 1,000 \text{ births.}$$

Reference should be made to page 81 as to exclusion of still-births from the calculation and as to the definition of live-birth.

If the registration of births is incomplete, the infant death-rate cannot be accurately stated in terms of births (p. 75); a high rate may mean not a heavy mortality but poor birth registration. Hence the attempt to *state infant mortality in proportion to total mortality at all ages*. This is an unsatisfactory method, for either element in the proportion may change singly, or they may both change simultaneously; in the same or in opposite directions, and the interpretation of the proportion between the two is therefore dubious.

ENGLAND AND WALES.  
*Infant Mortality Stated as—*

Year.	Total Deaths at All Ages.	Deaths under 1 Year.	Births.	Proportion of Deaths under 1 Year to Total Deaths.	Deaths under 1 Year per 1,000 Births.
1911	527,810	114,600	881,138	Per Cent. 21.7	125
1918	611,961	64,278	662,661	10.5 A	97 B

The true infant mortality (column B) had declined

$$\frac{(125-97) \times 100}{125} = 22.4 \text{ per cent.}$$

The infant mortality stated as in column A had declined

$$\frac{(21.7-10.5) \times 100}{21.7} = 51.6 \text{ per cent.}$$

The greater apparent decline shown in column A is due to the facts that in 1918 (a) the total births, and therefore *ceteris paribus* the deaths in infancy were much fewer than in 1911, and (b) a most fatal epidemic of influenza occurred, causing a vast increase in total deaths at ages beyond infancy. The only safe plan for the elementary statistician is to avoid altogether comparisons based on ratios of

$$\frac{\text{deaths in group } a}{\text{deaths in total population}}$$

whether dealing with infant mortality, with occupational mortality, or other ratios.

**Infant Death-rate in Different Parts of Infancy.**—In order to ascertain and interpret the possibilities of preventive medicine, a further analysis of infant mortality is called for. Infancy can be conveniently divided as in the table on page 338, and the deaths in each of these sections of infancy may be stated per 1,000 births in the same year. This plan has been adopted in the English Registrar-General's Report for several years, and it thus becomes practicable to compare progress in more complete detail. The mortality in the first month is sometimes described as *neo-natal*, it being assumed that ante-natal circumstances or circumstances of birth itself are the chief causes of deaths at this period. The supposition is only partially correct, and it appears better to describe this death-rate as *the death-rate of infants under one month per 1,000 births*, a clumsy statement, but free from ambiguous hypothesis.

Every medical officer of health's annual report should give for a series of years the total death-rate in infancy and the death-rate under one month per 1,000 births.

**American Infant Mortality Statistics.**—These are given in a separate volume from "Mortality Statistics," being issued from the Bureau of the Census in a volume entitled *Birth Statistics for the Birth Registration Area of the United States*. The volume for 1920 is the Sixth Annual Report. This volume gives for the birth-registration area the infant

	First Quarter.	Second Quarter.	Third Quarter.	Fourth Quarter.	Year.
Conventional rate .. ..	88	81	64	85	80
Corrected rate .. ..	109	87	63	79	85

These circumstances are exceptional, and for all practical purposes the use of the births of the current year as the denominator in obtaining the infant death-rate is satisfactory. Thus, if in a given community 5,000 births occur in a year, and in the same year 250 infants die under one year of age, the rate of infant mortality

$$= \frac{250 \times 1,000}{5,000} = 50 \text{ per } 1,000 \text{ births.}$$

Reference should be made to page 81 as to exclusion of still-births from the calculation and as to the definition of live-birth.

If the registration of births is incomplete, the infant death-rate cannot be accurately stated in terms of births (p. 75); a high rate may mean not a heavy mortality but poor birth registration. Hence the attempt to *state infant mortality in proportion to total mortality at all ages*. This is an unsatisfactory method, for either element in the proportion may change singly, or they may both change simultaneously; in the same or in opposite directions, and the interpretation of the proportion between the two is therefore dubious.

ENGLAND AND WALES.  
*Infant Mortality Stated as—*

Year.	Total Deaths at All Ages.	Deaths under 1 Year.	Births.	Proportion of Deaths under 1 Year to Total Deaths.	Deaths under 1 Year per 1,000 Births.
1911	527,810	114,600	881,138	Per Cent. 21.7	125
1918	611,861	64,278	662,661	10.5 A	97 B

The true infant mortality (column B) had declined

$$\frac{(125-97) \times 100}{125} = 22.4 \text{ per cent.}$$

The infant mortality stated as in column A had declined

$$\frac{(21.7-10.5) \times 100}{21.7} = 51.6 \text{ per cent.}$$

The greater apparent decline shown in column A is due to the facts that in 1918 (a) the total births, and therefore *ceteris paribus* the deaths in infancy were much fewer than in 1911, and (b) a most fatal epidemic of influenza occurred, causing a vast increase in total deaths at ages beyond infancy. The only safe plan for the elementary statistician is to avoid altogether comparisons based on ratios of

$$\frac{\text{deaths in group } a}{\text{deaths in total population}}$$

whether dealing with infant mortality, with occupational mortality, or other ratios.

**Infant Death-rate in Different Parts of Infancy.**—In order to ascertain and interpret the possibilities of preventive medicine, a further analysis of infant mortality is called for. Infancy can be conveniently divided as in the table on page 338, and the deaths in each of these sections of infancy may be stated per 1,000 births in the same year. This plan has been adopted in the English Registrar-General's Report for several years, and it thus becomes practicable to compare progress in more complete detail. The mortality in the first month is sometimes described as *neo-natal*, it being assumed that ante-natal circumstances or circumstances of birth itself are the chief causes of deaths at this period. The supposition is only partially correct, and it appears better to describe this death-rate as *the death-rate of infants under one month per 1,000 births*, a clumsy statement, but free from ambiguous hypothesis.

Every medical officer of health's annual report should give for a series of years the total death-rate in infancy and the death-rate under one month per 1,000 births.

**American Infant Mortality Statistics.**—These are given in a separate volume from "Mortality Statistics," being issued from the Bureau of the Census in a volume entitled *Birth Statistics for the Birth Registration Area of the United States*. The volume for 1920 is the Sixth Annual Report. This volume gives for the birth-registration area the infant

death-rate per 1,000 births, for each of the first three days after birth, for the next three days together, for each week of the first month, and for three-monthly periods. For the possible errors associated with imperfect birth registration, see page 74.

For a comparison of infant death-rates in England, Scotland and Ireland, see page 348. This comparison may be further illustrated by a comparison of the average infant mortality (A) in 1891-1900 with that in 1921 (B). In England and Wales A was 153 and B 83, showing a reduction of 45 per cent. ; in Scotland A was 128 and B 90, showing a reduction of 29 per cent. ; and in Ireland A was 104 and B 77, showing a reduction of 25 per cent. These figures illustrate incidentally the importance in making comparisons between different communities of considering the percentage change in relation to the magnitude of the death-rate from which the change is calculated.

**Death-rates at Ages 1-5 Years.**—In the Annual Report of the Registrar-General, 1916, p. xxii, the following statement is made :—

This overstatement of population at 0-5 is due to the failure of the methods of estimation in use prior to 1916 to allow for the decrease in the proportion of the total population formed by children of these ages, as a consequence of the fall in the birth-rate. The population at these ages has accordingly been re-estimated for each year from 1911 onwards on a survivorship basis, starting with the births in the twelve months preceding the middle of each year and deducting the deaths of these infants during the same twelve months (which are found in all years to be little under or over 70 per cent. of the total infantile deaths of the period) to ascertain survivors aged 0-1, and similarly for later years of life, in which the deaths have to be taken as evenly distributed. This method, which entirely ignores the census enumeration, fails to allow for migration, and in the absence of any precise record of the ages of migrants no correction for the effects of migration can be applied to it. Probably, however, these effects are normally of minor importance in the first five years of life, and at the present time they must be especially insignificant.

The death-rates quoted in the following table are based on estimates of population thus obtained, giving the living at the middle of each year of life, and must not be confused with infant death-rates (under one year of age) per 1,000 births, or with death-rates for each of the next four years of life based on the numbers surviving at the beginning of each year.

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## ENGLAND AND WALES.

*Mortality per 1,000 Living in Each of the First Five Years of Life.*

	Ages 0-1.		1-2.		2-3.		3-4.		4-5.	
	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.
1911-14	132.1	104.5	35.1	32.4	13.7	13.4	8.3	8.1	6.1	6.1
1919	121.4	91.6	26.0	23.0	12.3	11.8	8.1	8.2	6.3	6.4
1920	100.5	76.4	27.7	25.3	11.0	10.5	7.2	7.0	5.9	5.7

In several official reports on "Child Mortality"<sup>1</sup> I stated the aggregate death-rate at ages 1-5 *per 1,000 survivors at the age of one*, this number being ascertained by subtracting infantile deaths from births. In a later report<sup>2</sup> the period 1-5 was subdivided, the death-rate at ages 1-2 being stated *per 1,000 survivors to age 1*, and the death-rate at ages 2-5 *per 1,000 survivors at age 2*.

The following table is taken from the last-named report (p. 16):—

### AVERAGE ANNUAL DEATH-RATES, 1911-14.

	England and Wales.	Larger Towns.	Rural Districts.
Infant mortality per 1,000 births	110	122	90
Death-rate per 1,000 survivors at each age—			
1-2 .. .. .	33.4	41.8	20.6
2-3 .. .. .	13.6	17.2	8.3
3-4 .. .. .	8.4	10.3	5.5
4-5 .. .. .	6.3	7.5	4.6
Death-rate per 1,000 births at all ages, 0-5 .. .. .	164	188	125

The rates, when thus calculated, should be lower than rates for the same period calculated on the population in the middle of each year of life. In the use of comparative statistics, the particular method adopted in calculating child death-rates should be defined, and care exercised to avoid comparing rates calculated on different bases.

<sup>1</sup> Report by the Medical Officer of the Local Government Board on "Infant and Child Mortality, 1910" (Cd. 5263).

Second Report by Ditto, 1913 (Cd. 6909).

Third Report by Ditto, and by Drs. Copeman, Farrar, Manby, and Lane-Clayton, 1914 (Cd. 7511).

<sup>2</sup> Report on "Child Mortality at Ages 0-5, 1916" (Cd. 8496).

## ILLUSTRATIONS.

**Infant Clinics.**—In a discussion with the Willesden Borough Council as to the value of their municipal clinics, the local branch of the British Medical Association chided the Council for having founded a statistical argument on an isolated figure, and stated that “the full mortality statistics for the last three years are as follows:—

	Clinic Babies.	Non-clinic Babies.	All Babies.
1918	46·1	161·6	97·0
1919	38·5	110·1	82·8
1920	43·0	75·0	65·0

“Thus the reduction in the infant mortality rate in 1920 has occurred entirely amongst babies not attending the clinics, while there has been an actual increase in the rate amongst the clinic babies. The Association does not suggest that the increased mortality in 1920 is caused by the activities of the clinics. Statistics are double-edged weapons. The apparently higher mortality among non-clinic babies is due to the inclusion of babies under four weeks which obviously do not attend the clinics. If these are excluded the non-clinic baby death-rate is much lower than the clinic baby death-rate.”

This quotation shows that the writers had some knowledge of the fallacies involved in comparing two groups of infants, without knowing the age (in weeks or months) of the infants in each group. A comparison like the above is also unjustifiable. The same objection does not hold to an equal extent against the Council's reference to the total infant mortality in the borough of 65 per 1,000 births, as failing to support the Association's statement that “the Council's present arrangements tend to neglect the preventive aspect of health work for the curative.”

To justify a comparison between clinic and non-clinic infants, it would be necessary to know the age in weeks of every infant who had died, whether it attended the clinic or not, and to compare this number with the total number of the same age attending the clinic or not attending the clinic, as the case may be. Evidently such data are difficult to secure; but in their absence argument may more properly be conducted without statistics.

**Infant Milk Depot.**—In a report on a Municipal Milk Depot, it was stated that 849 infants and children had been fed on its milk. The deaths were 59 or 69·5 per 1,000; but taking only those fed on the milk for as long as six months, the death-rate was 22·7. The general infant death-rate varied in the different wards of the borough from 111 to 200 per 1,000.

*Observations.*—1. The death-rate for children receiving the milk from the depot is stated per 1,000 of these, the general infant death-rate per 1,000 births. It is not justifiable to compare the two rates, as infants under one, or even under three, months of age are not likely to be fed with depot milk.

2. There is no statement of the age of the children fed from the depot; some probably were over 1 year old, few probably aged 0-3 months, when infant mortality is highest.

3. The death-rate (22·7) for infants who had attended at least

## THE MEASUREMENT OF CHILD MORTALITY 345

six months must have related chiefly, if not solely, to infants who began attendance when more than a month old. For England and Wales in 1919 the annual death-rates per 1,000 births were 17 at ages 4 weeks to 3 months, 13 at ages 3-6 months, and 21 at ages 6-12 months, and the figure 22·7 gives no evidence that the experience of the infants receiving the depot milk was favourable.

The statistical measurement of results of infant feeding on publicly supplied milk is beset with difficulties. Any statistical statement should be based on a preliminary list stating the age of each infant at the first and last attendance, whether attendance was regular or intermittent, and other facts bearing on each case. There is the further difficulty that the infants municipally supplied with milk may not be and probably are not legitimately comparable with the average infants of the town, but are likely to comprise an excessive proportion of delicate infants. The general rule is that the special group must be compared with some other special group circumstanced similarly except in respect of the item under investigation, or must itself be, so far as can be ascertained, an average sample of the general infantile population.

**Comparison of Incomparable Data.**—In the year 1917 infant mortality in New York was 89 and in Washington, D.C., was 97 per 1,000 births. Are these rates comparable?

*Remarks.*—Infant mortality is known to be higher in negro than in white families, and the true differences between these cities are shown as follows:—

	Number of Births.		Deaths under 1 Year.		Death-rate per 1,000 Births.		
	White.	Coloured.	White.	Coloured.	White.	Coloured.	Total.
New York City	138,231	3,003	12,039	529	87	176	89
Washington, D.C. ..	5,250	2,235	372	357	71	160	97

The infant mortality is at a lower rate, both among white and coloured infants, in Washington than in New York, although the death-rate, irrespective of colour, shows a reverse position.

**Infant Mortality and Order of Birth.**—In an investigation in 1913 of the reproductive history of 1,491 married mothers who had 5,617 births (Johnstown, Pa., U.S.A.) the following results appeared:—

Children.	Deaths per 1,000.
1st and 2nd born .. ..	138·3
3rd and 4th born .. ..	143·2
5th and 6th born .. ..	177·0
7th and 8th born .. ..	181·5
9th and later born .. ..	201·1

*Remarks.*—The table shows a much lower death-rate among first and second born than among later members of the family. The question whether earlier born children in a family have superior prospects of life should, strictly speaking, be decided by statistics in

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which first-born are compared with first-born, second-born with second-born, and so on for larger families, the families selected, so far as can be ascertained, being equal in other circumstances influencing health, as social position, parental care, etc. The figures to be compared should be derived from completed families.

**Infant Mortality and Size of Family.**—Dr. Alice Hamilton published the results of a study of 1,600 families in Chicago in 1910. The number of children live-born was compared with the number of children who reached the age of three. A table calculated from the data of all the families shows an ascending mortality-rate:—

Number in Family.	Child Mortality-rate.
4 children and less .. ..	118
6 children and more .. ..	267
7 children and more .. ..	280
8 children and more .. ..	291
9 children and more .. ..	303

*Remarks.*—Unless in all cases completed families were dealt with, or families completed to a corresponding extent, these figures are not completely comparable. Further similar remarks apply as in the last example. It is, of course, not improbable that smaller families may have better life-prospects, in so far as this implies the ability to secure improved nurture for each individual child.

**Erroneous Propaganda.**—The following statement from an English publication is quoted as purporting to come from an official American Health Bulletin:—

“The most striking evidence of the value of public health supervision is the decrease in the death-rate among children (in New York). Up to 1891 deaths of children under 5 years of age averaged about 100 per 1,000 of the population living at these ages. This means that about 10 per cent. of the children died before they were 5 years of age.”

It is improbable that the death-rate at 0-5 in New York reached 100, unless the rate was stated per 1,000 births. The highest in England was 69.1 per 1,000 population living at these ages in 1861-65. In 1900 the death-rate 0-5 in the Registration Area, United States, was 49.9, and in 1920 it was 29.1. According to the Life-Table for New York City, based on the deaths in 1909, 1910, and 1911, out of 1,000 male children at birth, 801 survive at the age of 5 years.

## CHAPTER XXX

### CHANGES IN CHILD MORTALITY

**Infant Mortality.**—Inquiry into historical changes in the rate of child mortality are a preliminary necessity to a study of the main influences affecting it. This historical statement should throw light on the factors of decline, though it will need to be followed by a contemporaneous comparison of child mortality under varying circumstances. Fig. 12 shows the experience of England and Wales, and the text accompanying that figure discusses fully the relationship between birth-rate and infant mortality rate, one of the fundamental considerations in the study of this subject.

The course of infant mortality is further summarized by the following annual rates for quinquennial periods per 1,000 births :—

148, 157, 156, 152, 151, 157, 153, 145, 139, 145, 151, 156, 138, 117, 110, 90.

The first figure, 148, relates to the quinquennium 1841–45, the last figure, 90, to 1916–20, and the intermediate figures to intermediate quinquennial periods in succession.

Since the end of last century a marked and continuous reduction of infant mortality has been experienced.

In the following figure the experience of the three parts of the British Isles is compared. In the uppermost three curves are shown the rates of infant mortality in each country. In the middle series the initial rate for the year 1896 in all three countries is stated as 100, and subsequent rates are given in proportion to this. These curves give relative changes showing the decline or increase year by year, but not the *rate of decline* or increase of these infant death-rates, which are shown in logarithmic curves in the lowest series (see also p. 585). The two upper series have been drawn to show the course of events on an approximately equal scale, and in the third series the range of curves for Ireland and Scotland

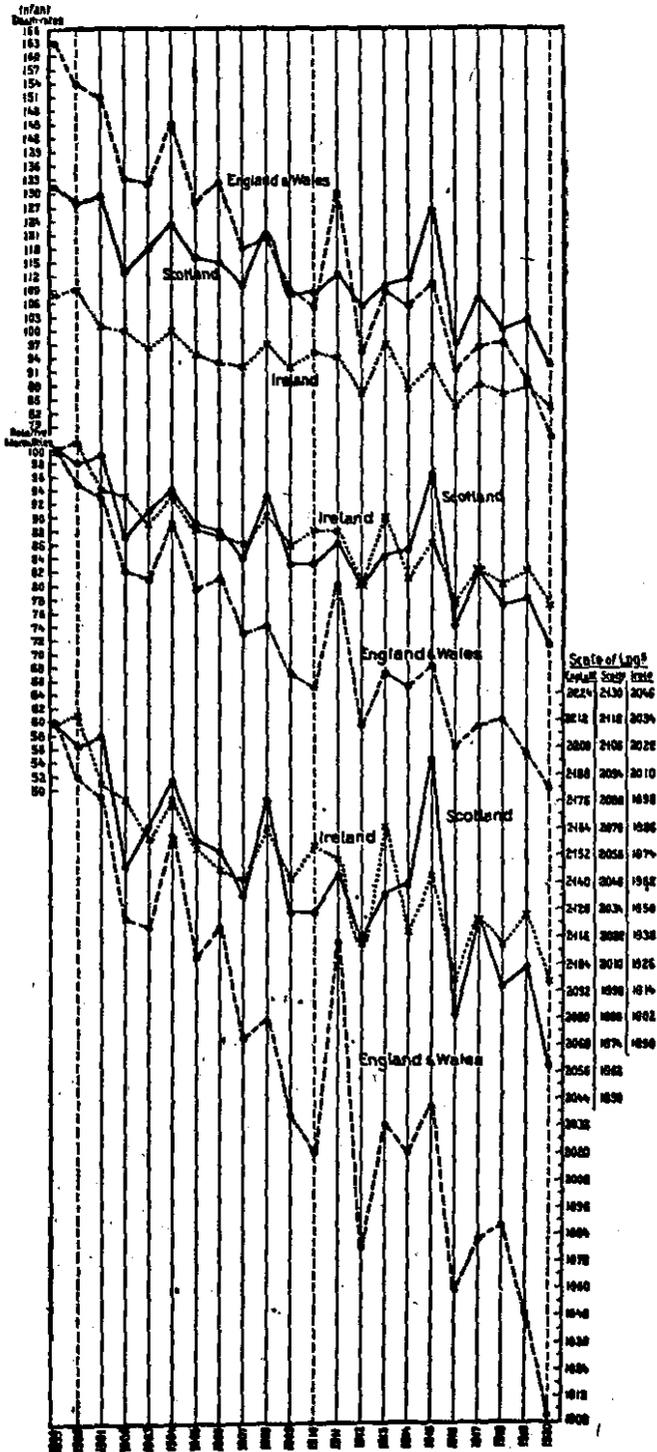


FIG. 44.—Relative Annual Death-rates of Infants and Logarithms of Death-rates Under One Year per 1,000 Births, 1896-1920, in England and Wales, Scotland, and Ireland.

comes within similar limits; but to show the greater rate of fall of infant mortality in England, a large extension of the vertical scale is required.

In Ireland, and to a less extent in Scotland, there has been a smaller decline than in England, both those countries having started with a lower death-rate than England (in 1896 rate of infant mortality: Ireland = 95, Scotland = 115, and England = 148).

Ireland as a whole, with the lowest sanitation, has until recently had the lowest infant mortality. Now, however, the rate in England is slightly lower than that in Ireland. Scotland, which at an earlier period had a more favourable experience, now has a higher death-rate than England. There can be little hesitation in relating the relative position of the three countries prior to 1900 to the relative amount of rural and urban life in the three countries. This is confirmed by the experience of the chief towns in the three countries.

In Australasia and in the United States the reduction of infant mortality has been as marked as in Great Britain, and the following table derived from the *Annuaire Internationale de Statistique II, Mouvement de la Population, Europe, 1917*, tells a similar story for European countries. It will be noted that the rates in this table are based on estimates of population from the various census enumerations, and are not therefore comparable with rates stated in terms of birth or stated in terms of survivorship from births, as given in the lower table on page 343. The general course of events is indicated by the table on page 350.

**Death-rates 0-5 and 1-5.**—The course of the death-rate at all ages under 5 per 1,000 of the estimated population at this age-period for England and Wales is given in Fig. 45 for the two sexes together. For further details see Table 3 of the Annual Review of the Registrar-General, 1921, Part I. The death-rates given in the diagram are relative, the average death-rate 0-5 for the period 1838-1920 (= 56.4) being taken as 100. In the same diagram is shown the relative infant mortality for each successive quinquennium, the average infant death-rate per 1,000 births (= 141) for 1838-1920 being taken as 100. From the scale and the two rates given above, the actual death-rate for any period can be calculated. Thus

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## CHILD MORTALITY IN VARIOUS COUNTRIES.

*Death-rates per 1,000 Inhabitants at Each Age.*

	Periods.	0-1.	1-5.
Prussia .. .. .	1876-85	275	37
	1886-95	258	33
	1896-1905	235	23
	1906-14	189	16
Denmark .. .. .	1876-84	160	20
	1885-94	161	20
	1896-1905	136	11
	1906-15	108	7
France .. .. .	1877-86	226	29
	1886-95	218	27
	1896-1908	168	16
	1908-13	128	13
England and Wales .. .	1876-85	167	29
	1886-95	176	26
	1896-1905	172	23
	1906-15	130	16
Scotland .. .. .	1876-85	136	29
	1886-95	143	27
	1896-1905	143	22
	1906-15	130	19
Ireland .. .. .	1876-85	118	20
	1886-95	117	19
	1896-1905	123	17
	1909-12	111	14
Italy .. .. .	1877-85	271	64
	1886-95	244	55
	1896-1905	192	39
	1907-1914	168	31
Norway .. .. .	1881-85	106	24
	1886-95	102	20
	1896-1905	92	12
	1906-15	72	8
Netherlands .. .. .	1875-84	216	30
	1885-94	194	26
	1895-1904	166	18
	1905-14	119	13
Sweden .. .. .	1876-85	136	26
	1886-95	115	19
	1896-1905	102	15
	1906-13	79	9
Switzerland .. .. .	1876-85	233	20
	1886-95	196	17
	1896-1905	169	12
	1906-15	124	9
Bavaria .. .. .	1876-85	425	31
	1886-95	368	31
	1896-1905	321	20
	1907-14	241	15

in 1896-1900 the relative infant mortality was 111, the actual infant death-rate was  $\frac{111 \times 141}{100} = 156$ . In the same period the death-rate 0-5 was  $\frac{56.4 \times 102}{100} = 57.6$ .

The curve for 0-5 shows the influence of the infant mortality curve on the total death-rate, 0-5; but even so,

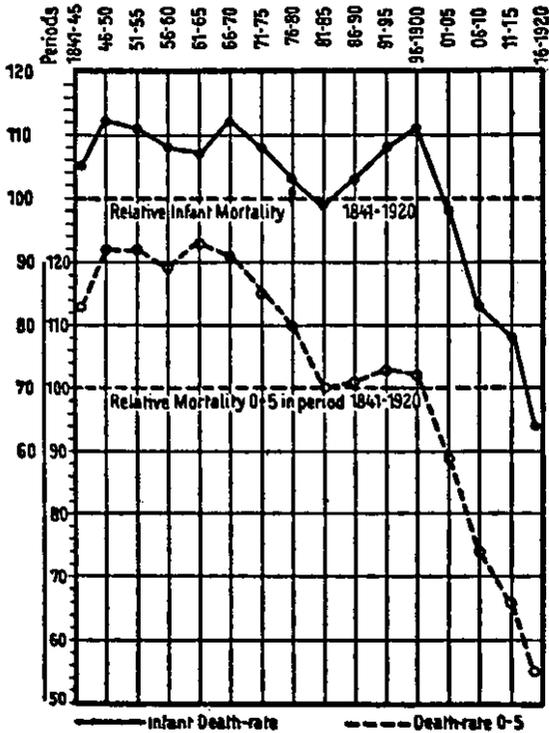


FIG. 45.—England and Wales: Relative Annual Infant Mortality (0-1) per 1,000 Births and Death-rate 0-5 per 1,000 Living, for Quinquennial Periods 1841-5 to 1916-20.

the great decline at ages 0-5 beginning 1871-75 is not followed by appreciable increase in the last decade of the nineteenth century, unlike the curve of infant mortality. It may be inferred that circumstances favouring reduction of mortality at ages over one arose earlier than and are to some extent separate from circumstances favouring a low infant mortality.

This is brought out more clearly by the following diagram (Fig. 46), which give relative mortality figures for each of

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the first five years of age in nine successive quinquennia. Note that these are relative figures only, the death-rate in 1871-75 for each year of age, being stated as 100, and subsequent years in proportion to this.

The actual rates on which these relative mortality figures are based were as shown in table on page 353.

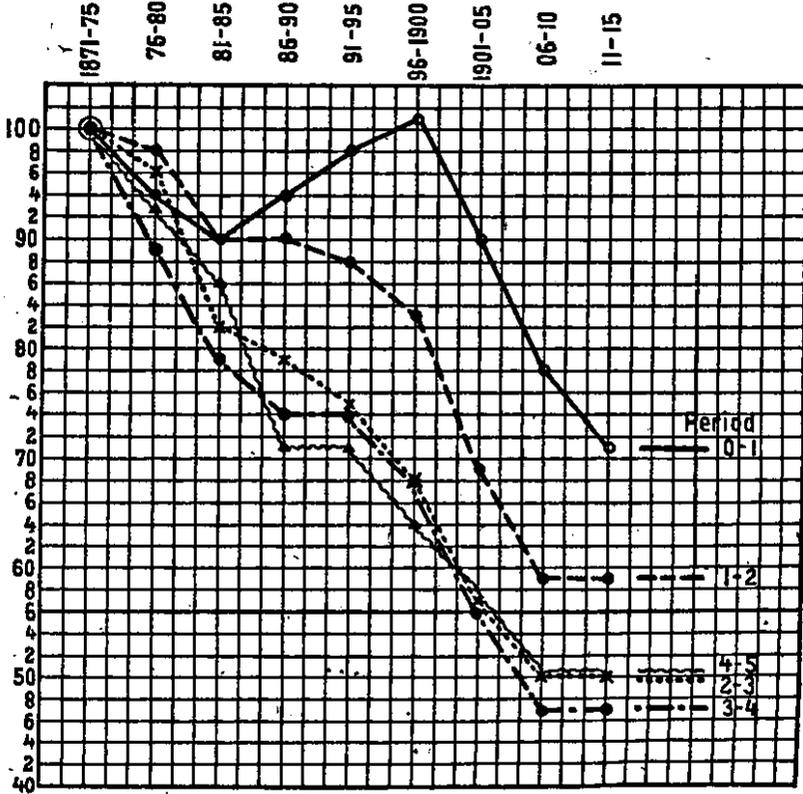


FIG. 46.—England and Wales: Relative Death-rates for Each of the First Five Years of Life, in Quinquennial Periods from 1871-75 to 1911-15, the Death-rate at Each Age in 1871-75 being stated as 100.

This figure shows that the decline of the death-rate in the third, fourth, and fifth years of life began earlier, and was much greater than in the first year of life, and that the experience of the second year of life was intermediate between these. The figures for 1921 show that the mortality at ages 1-5 continues to fall with great rapidity.

# CHANGES IN CHILD MORTALITY

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## ENGLAND AND WALES.

*Average Death-rates for Each of the First Five Years of Life per 1,000 at Each Age.<sup>1</sup>*

Period.	0-1.	1-2.	2-3.	3-4.	4-5.
1871-75	154	59	28	19	14
1876-80	145	58	27	17	13
1881-85	139	53	23	15	12
1886-90	146	53	22	14	10
1891-95	151	52	21	14	10
1896-1900	156	49	19	13	9
1901-05	138	41	16	11	8
1906-10	117	35	14	9	7
1911-1915	110	35	14	9	7
1921	85	19	9	6	4

<sup>1</sup> From Report on "Child Mortality" (Cd. 8496), p. 12, except figures for 1921, which are taken from the Registrar-General's Report.

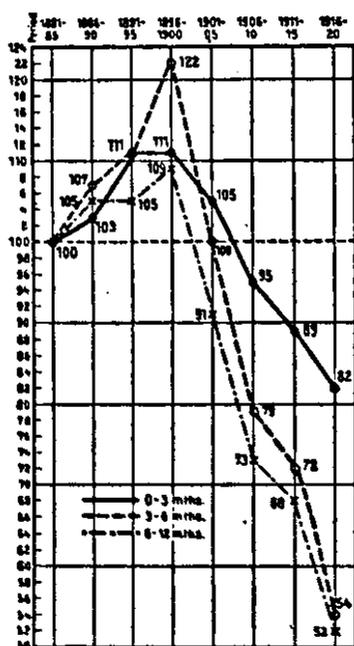


FIG. 47.—England and Wales: Relative Death-rates for Ages 0-3, 3-6 and 6-12 months in Quinquennial Periods 1881-85 to 1916-20.

NOTE.—For 1881-85 death-rate 0-3 months = 67  
 3-6 " = 28  
 6-12 " = 44 } Each of these is taken as 100 in the diagram.  
 per 1,000 Births

**Distribution of Decline of Infant Mortality According to Age.**—The steady decline of infant mortality in England began in 1902 (Fig. 12). How is this decline distributed in the various months of infancy? A table on page xxviii of the English Registrar-General's Annual Report, 1920, gives the death-rate per 1,000 births in each week of the first month after birth and for each of the twelve first months of extra-uterine life, and a similar table appears in several earlier reports. With this table may be compared a corresponding table of American statistics, e.g. on page 29 of "Birth Statistics," 1920.

But to obtain a bird's-eye view, more compact figures

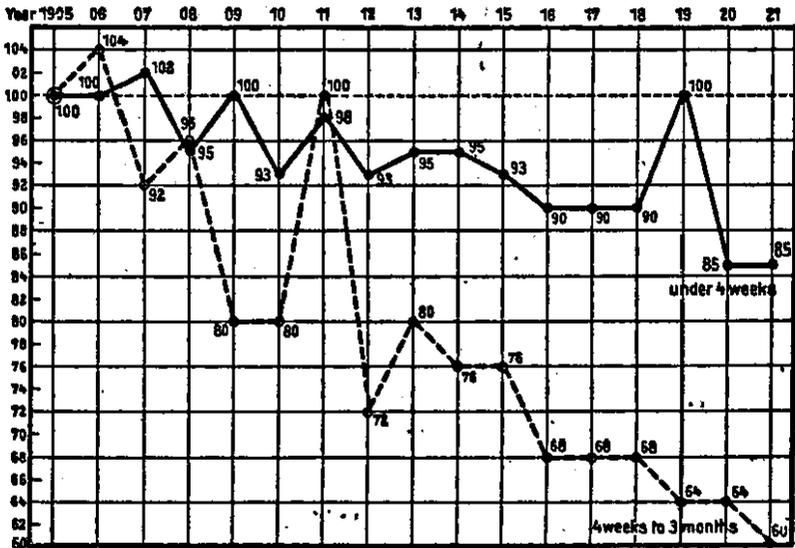


FIG. 48.—England and Wales: Relative Death-rates for ages under 4 weeks, and 4 weeks to 3 months, from 1905 to 1920, each death-rate in 1905 being taken as 100.

NOTE.—The death-rate under 4 weeks in 1905 was 41, and at ages 4 weeks to 3 months was 25 per 1,000 births.

are needed, as well as figures for a longer series of years. A table on page xxxix of the Registrar-General's Annual Report, 1920, gives the necessary material. First we may compare the course of infant mortality in the first three, the second three months and the last half of infancy. This is done in Fig. 47, in which the average death-rate for each of these three periods in 1881-85 is stated as 100, and death-rates for subsequent quinquennial periods in ratio to this.

Evidently the death-rate at ages 0-3 months has declined much less than that in the rest of infancy, while the course of events at ages 3-6 is almost the same as at ages 6-12 months. Between 1881-85 and 1916-20 the decline at 0-3 months was 18 per cent., and in subsequent months 46-48 per cent.

The Registrar-General's table already quoted enables a further comparison to be made for a short series of years between infant death-rates under 4 weeks old and 4 weeks to 3 months old (Fig. 48).

In the aggregate of the second and third months of infancy the rate of mortality declined between 1905 and 1920 to the extent of 36 per cent. The decline for the first four weeks of infancy was 15 per cent. for the same years. The great rise during 1919 in infant mortality for the first four weeks is discussed by Dr. Stevenson in the 1919 Report of the Registrar-General. It may have been partly due to the influenza pandemic, or to some *post-bellum* condition. That the circumstances causing it were temporary is shown by the markedly lower death-rate both in the first and in the next two months of life in 1920.

**Preventibility of Early Infant Mortality.**—The decline displayed in Fig. 48 proves that the mortality in early infancy is partially avoidable, although, so far, the change experienced in early infant mortality is relatively small. More exhaustive statistical examination confirms this conclusion, as it shows that the death-rates in the first week of life and in the first month of life vary greatly in communities all possessing a complete system of registration of births and deaths. The following examples may be given. A complete study is embodied in my Second Report to the Local Government Board on "Infant and Child Mortality" (Cd. 6909).

DEATH-RATES PER 1,000 BIRTHS.

In First Week after Birth.		In First Month after Birth.	
Dewsbury .. ..	41·4	Workington .. ..	61·0
Batley .. ..	37·5	Blyth .. ..	58·0
Bradford .. ..	30·7	Todmorden .. ..	54·7
Stepney .. ..	20·3	Doncaster .. ..	31·0
Teyton .. ..	17·8	Penge .. ..	27·2
Hornsey .. ..	16·2	Watford .. ..	25·9

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Stated otherwise, the death-rate for the first week in 241 urban areas varied from 70 per cent. above to 33 per cent. below the average; for the first month it varied from 52 per cent. above to 36 per cent. below the average.

A valuable later study of these local variations in early infant mortality is given on page xlii of the Annual Report of the Registrar-General, 1920. The summary may be quoted here, but the death-rates for each county and county borough should be studied by the public health officials concerned.

### ENGLAND AND WALES.

*Infant Mortality per 1000 Births in the First Week and the First Four Weeks after Birth in 1920 in Various Divisions and Subdivisions of the Country.*

	North.		Midland.		South.		Wales.	
	A.	B.	A.	B.	A.	B.	A.	B.
All Areas ..	24.8	40.7	21.1	33.5	18.8	29.4	23.0	37.5
County Boroughs	24.5	40.9	22.8	35.2	19.3	30.3	21.6	36.0
Other Urban Dis- tricts .. ..	25.0	40.8	20.1	31.9	19.1	28.9	22.5	37.7
Rural Districts..	25.4	39.8	21.8	33.5	20.0	29.6	24.9	38.0

A = death-rate under 1 week of age.

B = death-rate under 4 weeks of age.

Both in town and country the northern areas have a much higher mortality than the other divisions. The extent of the difference between north and south and between urban and rural areas, although great, is partially hidden in the average rates for a large number of areas given in the table; and to derive the public health lessons thus concealed it is necessary to refer to the death-rates for individual areas given later in the same report. Thus the death-rate of infants under 4 weeks varied from 19 per 1,000 births in Oxford to 56 in Barnsley, from 43 in the aggregate rural districts of Middlesex to 109 in those of Durham, where the population is collected largely in mining villages, with some of the worst, though steadily improving, urban characteristics.

Similar differences are seen in the United States. Thus, in a paper by Dr. L. I. Dublin on "The Mortality of Early Infancy" (*American Journal of Hygiene*, vol. 3, May 1923), infant death-rates in the first month are given for various

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American cities varying from 34 to 54 per 1,000 births; and the importance of the time element is emphasized, there being much more room for the play of environmental factors in the subsequent eleven months than in the first month.

**Relative Infant Mortality in the Two Sexes.**—The following table enables a comparison to be made between death-rates in male and female and in legitimate and illegitimate infants.

ENGLAND AND WALES, 1920.

*Infant Mortality by Sex and Legitimacy.*

		Deaths per 1,000 Births.				Percentage Excess of—			
		Legitimate Infants.		Illegitimate Infants.		Mortality of Illegitimate over that of Legitimate Infants.		Mortality of Male over Female Infants.	
		Male.	Fem.	Male.	Fem.	Male.	Fem.	Legiti- mate.	Illegiti- mate.
All Cases	Under 4 weeks .. ..	38·3	29·2	69·0	55·6	+ 80	+ 91	+ 31	+ 24
	4 weeks-8 months .. ..	17·8	12·2	37·5	28·3	+ 117	+ 131	+ 41	+ 33
	8-6 months .. ..	13·1	10·2	31·3	25·2	+ 138	+ 149	+ 30	+ 24
	6-9 months .. ..	9·7	7·6	19·8	19·1	+ 104	+ 143	+ 24	+ 4
	9-12 months .. ..	7·6	6·4	13·6	12·2	+ 79	+ 91	+ 19	+ 12
Total under 1 year ..		88·0	65·8	171·2	140·4	+ 99	+ 113	+ 31	+ 22
All Ages under One Year	Whooping cough .. ..	2·0	2·4	2·9	3·4	+ 45	+ 41	- 17	- 14
	Other common infectious diseases .. ..	2·0	1·8	3·6	3·2	+ 78	+ 81	+ 14	+ 12
	Influenza .. ..	0·7	0·4	0·5	0·6	- 20	+ 42	+ 44	- 17
	Diarrhœa and enteritis ..	8·6	6·0	22·6	18·6	+ 163	+ 207	+ 42	+ 22
	Premature birth .. ..	19·2	15·6	31·0	29·6	+ 61	+ 90	+ 23	+ 6
	Congenital defects .. ..	6·1	5·0	7·2	6·6	+ 17	+ 33	+ 23	+ 6
	Atrophy, debility, and marasmus .. ..	9·6	6·8	24·6	16·8	+ 154	+ 149	+ 42	+ 46
	Tuberculosis .. ..	1·6	1·2	3·1	3·0	+ 91	+ 152	+ 37	+ 3
	Convulsions .. ..	6·2	4·6	10·5	8·6	+ 71	+ 88	+ 35	+ 23
	Bronchitis and pneumonia .. ..	19·3	14·4	29·2	22·3	+ 51	+ 54	+ 34	+ 31
	Other causes .. ..	10·7	7·6	36·0	27·7	+ 237	+ 263	+ 40	+ 30

The foregoing table shows that at all periods of infancy the rate of infant mortality is higher for male than for female infants. This applies even during the first week after birth (see table on p. 207). It will seem also that this excess holds good for nearly every cause of death, the chief exception being whooping cough. The rule applies to both legitimate and illegitimate infants. During the next four years of life the death-rates for the two sexes approximate.

At ages 5-10 (see p. 204) the death-rate of males in 1911-14 was 2 per cent. higher, and at ages 10-15 was 4 per

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Stated otherwise, the death-rate for the first week in 241 urban areas varied from 70 per cent. above to 33 per cent. below the average; for the first month it varied from 52 per cent. above to 36 per cent. below the average.

A valuable later study of these local variations in early infant mortality is given on page xlii of the Annual Report of the Registrar-General, 1920. The summary may be quoted here, but the death-rates for each county and county borough should be studied by the public health officials concerned.

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	A.	B.	A.	B.	A.	B.	A.	B.
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County Boroughs	24.5	40.9	22.8	35.2	19.3	30.3	21.6	36.0
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		Deaths per 1,000 Births.				Percentage Excess of—			
		Legitimate Infants.		Illegitimate Infants.		Mortality of Illegitimate over that of Legitimate Infants.		Mortality of Male over Female Infants.	
		Male.	Fem.	Male.	Fem.	Male.	Fem.	Legiti- mate.	Illegiti- mate.
All Causes	Under 4 weeks .. ..	38.8	29.2	69.0	55.6	+ 80	+ 91	+ 31	+ 24
	4 weeks-3 months .. .	17.8	12.2	37.5	28.3	+117	+131	+41	+38
	3-6 months .. ..	13.1	10.2	31.3	25.2	+138	+149	+30	+24
	6-9 months .. ..	9.7	7.8	19.8	19.1	+104	+143	+24	+ 4
	9-12 months .. ..	7.6	6.4	13.6	12.2	+ 79	+ 91	+19	+12
Total under 1 year ..		86.0	65.8	171.2	140.4	+ 99	+113	+31	+22
All Ages under One Year	Whooping cough .. ..	2.0	2.4	2.9	3.4	+ 45	+ 41	- 17	- 14
	Other common infectious diseases .. ..	2.0	1.8	3.6	3.2	+ 78	+ 81	+14	+12
	Influenza .. ..	0.7	0.4	0.5	0.6	- 20	+ 42	+44	-17
	Diarrhoea and enteritis ..	8.6	6.0	22.6	18.6	+163	+207	+42	+27
	Premature birth .. ..	19.2	15.6	31.0	29.6	+ 61	+ 90	+23	+ 6
	Congenital defects .. ..	6.1	5.0	7.2	6.6	+ 17	+ 33	+23	+ 8
	Atrophy, debility, and marasmus .. ..	9.6	6.8	24.6	16.8	+156	+149	+42	+46
	Tuberculosis .. ..	1.6	1.2	3.1	3.0	+ 91	+152	+37	+ 3
	Convulsions .. ..	6.2	4.6	10.5	8.6	+ 71	+ 88	+35	+23
	Bronchitis and pneumonia .. ..	19.3	14.4	29.2	22.3	+ 51	+ 54	+34	+31
Other causes .. ..	10.7	7.6	36.0	27.7	+237	+263	+40	+30	

The foregoing table shows that at all periods of infancy the rate of infant mortality is higher for male than for female infants. This applies even during the first week after birth (see table on p. 207). It will seem also that this excess holds good for nearly every cause of death, the chief exception being whooping cough. The rule applies to both legitimate and illegitimate infants. During the next four years of life the death-rates for the two sexes approximate.

At ages 5-10 (see p. 204) the death-rate of males in 1911-14 was 2 per cent. higher, and at ages 10-15 was 4 per

cent. lower than that of female children. At subsequent ages the excess of male over female mortality increased, until the period 65-75 was reached.

**Mortality in Illegitimate Infants.**—The table on page 357 further shows the great excess of mortality among illegitimate infants. For the entire year it is more than double that for legitimate infants. The distribution of the excess among various causes of death is shown in the table. The study of this excess has great public health importance. No arrangements for the care of the infants of unmarried mothers can be regarded as satisfactory which do not, whenever possible, by subsidized efforts if necessary, retain the mother as nurse of her own infant.

**Relation of Infant Mortality to Mortality at Higher Ages.**—In the first official report, already quoted, page 343, it was shown that the English counties having high infant mortalities continue in general to suffer somewhat excessively throughout the first 20 years of human life, and that counties having low infantile mortalities usually continue to have relatively low death-rates in the first 20 years of life, though the superiority is not so great at the later as at the earlier ages.

The general conclusion, using the county of Durham in illustration, was stated as follows: "If natural selection during infancy in the county of Durham has left a 'juvenile' population less prone to disease, the effect of this selection is most effectively and completely concealed by the evil environment in that county, which causes the hypothetically stronger survivors to suffer from excessive mortality, so long as they can be traced through life." Mr. Udny Yule contributed to the same report a mathematical study of the data which may be consulted with advantage. He concluded that there was little evidence of selection beyond the second year of life, and that after the third year environmental influences appeared to preponderate over any possible selective influence. Professor K. Pearson has written on the same subject in "The Intensity of Natural Selection in Man" (*Proceedings of the Royal Society, B.*, Vol. 85, 1912), and the considerable discussion of the problem which has since appeared is summarized in a paper by Dr. J. Brownlee on "The Relation of Infantile Mortality to Mortality in

Subsequent Life" (*Journal of the Royal Statistical Society*, March 1917).

I have discussed some errors in Professor Pearson's communication in my Second Report on "Infant Mortality," p. 48 (Cd. 6909), which may be consulted by those interested. They arose from not bringing information as closely up to date as was possible, and from comparing rates obtained on a differing basis.

The statistics so far mentioned gave the actual experience of communities at succeeding age-periods, and failed to trace the same groups of individuals at successive ages. Even were this practicable, there remains the further difficulty of ensuring that these individuals were subjected to a constant environment.

Dr. E. C. Snow (*Draper's Research Reports*, VII) has attempted to trace children at successive ages; but it is noteworthy that Dr. Snow and Dr. Brownlee (*Journal of the Royal Statistical Society*), after elaborate inquiry, have obtained the one negative and the other positive correlations between death-rates 0-1 and 1-5. Dr. Brownlee concludes that the result of his inquiry "has been to throw doubt on every method which has been proposed to measure the influence of the death-rate as a selective agent." He rightly emphasizes the fact that previous investigators have failed to give weight to the epidemiological concomitants of different years.

There the matter may rest for the present. But the conclusion arrived at in my official report stands. Environment has a preponderant influence in determining the magnitude of infantile and child mortality in a community; and the increasing efforts of hygienists to improve environment need not be embarrassed by suggestions that such efforts may exert an inimical influence on the quality of mankind.

**The Causes of Child Mortality.**—Hitherto the individual diseases causing death, in childhood as in the rest of life, have not been discussed. They form part of the study of epidemiology, which is concerned with the investigation of the statistical incidence of disease on communities. Child mortality, as a chief enemy of public health, cannot be fully considered without a short analysis of the main causes of death in childhood, and of the conditions producing them; this is given below. Although death is merely the end-

product of unfavourable conditions of life, investigation of the pathological conditions causing death enables measures to be taken to prevent sickness, which may or may not prove fatal, and thus tends to elevate the general standard of health. There is no adequate justification, under the circumstances of civilized life, for the belief that modern medicine and surgery, by enabling a large proportion of the population to survive to and beyond early adult life, has lowered the average health of the community. But beyond the work of curative medicine, and of preventive medicine so far as it concerns itself merely in the prevention of endemic and epidemic diseases, there are also possibilities of increasing human resistance to disease by diet and other hygienic measures on a physiological basis, some of which are becoming realizable. These do not at present lend themselves to statistical statement, and under present conditions the greatest potentiality for raising the national standard of health consists in measures for diminishing current diseases.

Although the consideration of causes of infant mortality anticipates later chapters in this volume, a short résumé of more important items may conveniently be given at this point.

The social causes or alleged causes of excessive infant mortality are mentioned in other chapters. For the influence of the birth-rate see page 112; on race see page 265; on density of population and overcrowding see page 275; on poverty, page 292; on housing, page 307; on alcoholism, page 324. The most important of all is social status, as evidenced by occupation of the parents, on which see page 112.

The chief diseases producing infantile death are given in the table on page 361. The largest single headings in 1920 were bronchitis and pneumonia 19·3, premature birth 19·2, and atrophy, etc., 9·6 deaths of male infants per 1,000 male legitimate births.

Tables 9-13 in the Registrar-General's Annual Report for 1921 give very full information, and Tables II and III in "Birth Statistics" United States for 1920, give similar information for the birth-registration states. In the corresponding volume of "Mortality Statistics" (p. 67 of vol. for 1920) are given similar statistics stated "per 1,000 estimated mid-year population under one year of age."

The following table taken from the Registrar-General's Annual Report, 1921, summarizes for reference the chief groups of diseases, which should be supplemented by study of the death-rates for each disease :—

ENGLAND AND WALES, 1921.  
*Proportion of Deaths to 1,000 Births.*

	Under 4 Weeks.	4 Weeks to 3 Months.	3-6 Months.	6-9 Months.	9-12 Months.	Total under 1 Year.
Common Infectious diseases . . . . .	0·11	0·67	0·72	0·93	1·20	3·63
Tuberculous diseases ..	0·02	0·15	0·43	0·48	0·46	1·54
Diarrhoea and enteritis ..	1·19	3·33	4·85	2·74	1·68	13·79
Developmental and wast- ing diseases . . . . .	26·17	4·36	1·67	0·52	0·28	33·00
Bronchitis and pneu- monia .. . . .	1·23	3·16	3·61	3·45	3·33	14·78
Other causes (remainder)	6·53	3·17	2·74	1·95	1·63	16·02
All causes . . . . .	35·25	14·84	14·02	10·07	8·58	82·76

The group of "Developmental and Wasting Diseases" comprises a number of miscellaneous conditions, some ill-recognized. It may be divided into three: the first group comprising "debility, atrophy and marasmus," which merely veil lack of knowledge; the second congenital defects; the third premature birth. There has undoubtedly been transference between these three groups in the course of years, a fact strongly suggested by the diagram on the next page. The first and third of these groups are now placed in the International List under the title of "Congenital Debility, Icterus and Sclerema."

The course of events according to death certificates does not justify the conclusion, sometimes stated, that death from prematurity is becoming more common; the apparent increase may be due to the fact that the recorded death-rate under the heading of vague terms is decreasing. Furthermore, in 1920 the death-rate under the head of prematurity was lower than in any previous recorded year. It is unfortunate that our knowledge of the pathology of mortality in the first week and month after live-birth is so imperfect; for the present, in view of this defective knowledge, the total

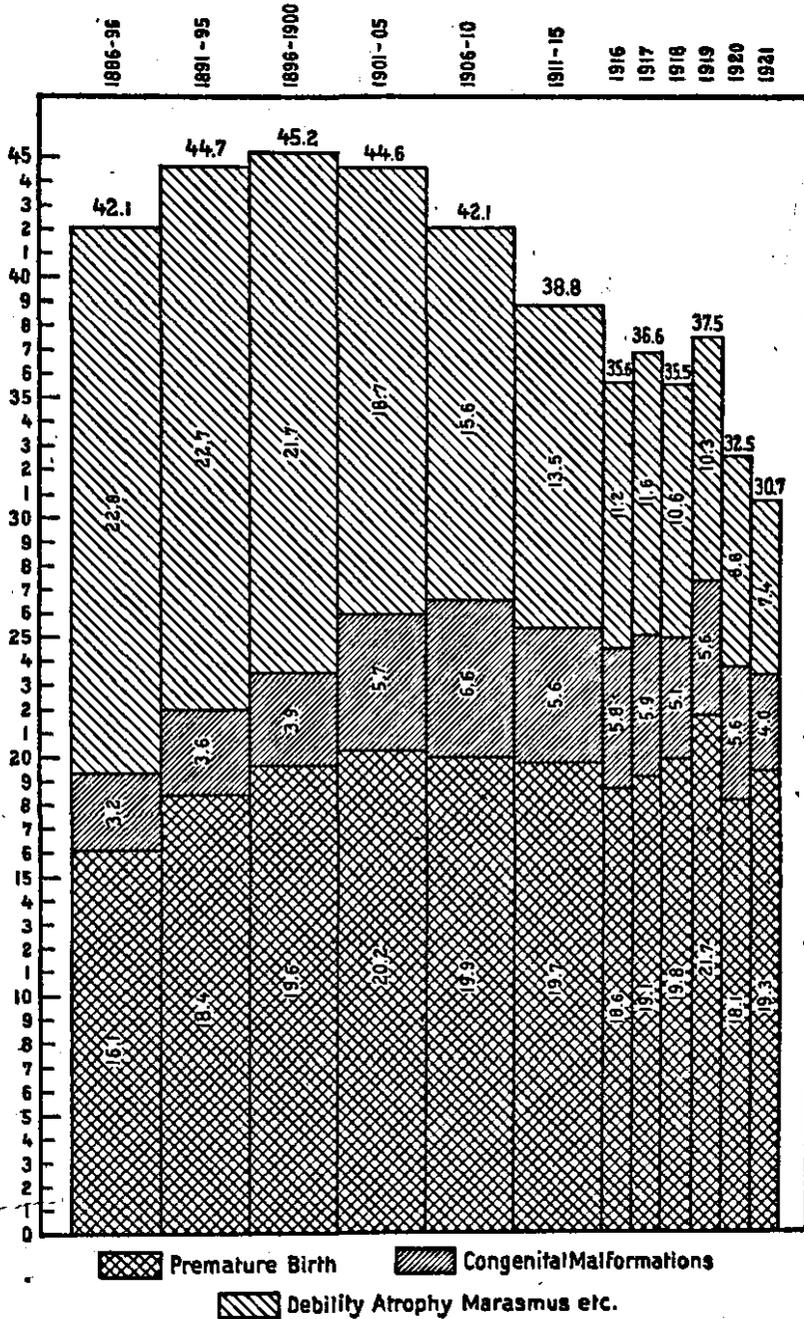


FIG. 49.—England and Wales: Death-rate per 1,000 Births from Debility etc., from Congenital Defects, and from Premature Births in quinquennial Periods 1886-90 to 1911-15, in Single Years to 1921.

death-rate in the first week and first month of life is much more trustworthy than any differentiation by causes of death ; and the general course of events for the entire country, including the great variations in local total death-rates for the first week and the first month after birth indicate the preventibility of a large share of this early mortality.

**Death-rates at Ages 1-5.**—The rapid decline of the death-rate after the first year of life is seen in the table on page 353.

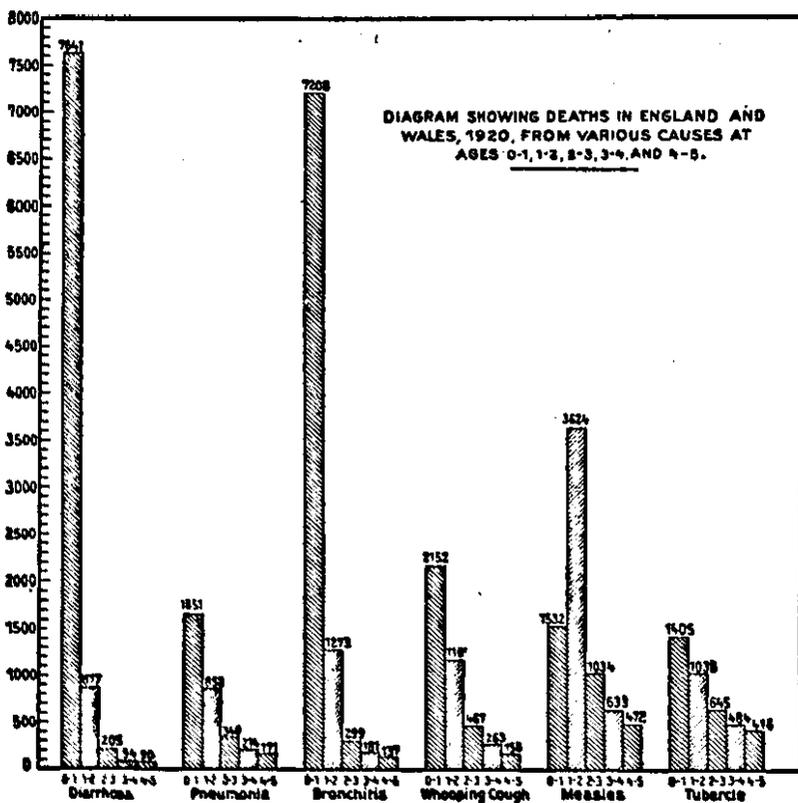


Fig. 50.—Diagram Showing the Actual Number of Deaths in England and Wales, 1920, from Various Causes at Ages 0-1, 1-2, 2-3, 3-4, and 4-5.

The extent to which some of the more common causes of death contribute to the death-toll in each year of age is shown in Fig. 50.

At all ages under five, the greatest number of deaths are caused by congenital conditions, diarrhoea and enteritis and pneumonia ; bronchitis, measles and tuberculosis also being serious causes of death. The greatest mortality from con-

genital conditions and diarrhoea is in the first year of life; in the second year pneumonia takes the lead, followed by measles and diarrhoea; and in the next three years of life measles commonly heads the list, pneumonia and tuberculosis coming next.

### ILLUSTRATIONS.

**1. Fallacy of Average Rates.**—Dr. Brend, in *Health and the State*, gives tables derived from the Annual Report of the Registrar-General, 1911, showing that per 1,000 births the death-rate of infants from premature birth and other developmental conditions is "remarkably constant throughout . . . and these appear to bear almost no relation to the external environment of the mother."

*Comments.*—The death-rate from premature birth in 1911 was 20·0 in county boroughs and 17·1 in rural districts; it was 13·8 for the upper and middle classes, and 20·3 for miners. These are not insignificant differences, and they suggest a marked environmental influence. There is no "constancy" in the death-rates. All the above quoted rates are average rates, representing the fusion of higher and lower rates; and when further subdivided for locality and for social conditions, much more marked differences are seen (p. 355). The facts available do not justify any statement further than that the range of preventibility for infantile deaths in the first month after birth appears to be less extensive than for that in the later months of infancy.

**2. Are Infant Centres Very Useful?**—Dr. L. Findlay, in a contribution to "The Mortalities of Birth, Infancy, and Childhood" (Special Report Series, No. 10, 1918, Medical Research Committee), states: "During the past 10 or 15 years several municipalities have inaugurated schemes for Milk Depots or for Infant Cliniques, with the hope of reducing the infant mortality. A study of the infantile death-rates in towns where such measures have been adopted, e.g. Liverpool, Bradford, Poplar, and Glasgow, does not, however, support the contention that these methods are of much value in seriously decreasing the evil. . . . The various curves (for England, Scotland, and Ireland) follow practically the same course and are unaffected by the introduction of the measures above mentioned."

*Comments.*—As to the last statement see p. 348.

The statement as to Milk Depots and Infant Cliniques implies failure to appreciate the difference between kind and amount of a given effort. To adduce the statistics of an entire city is to submerge the point at issue in a mass of conflicting circumstances, and some dissection must be made before the question of "much" or little "value" can be decided. To justify this statement, comparison between infants attending these centres and other infants must confirm it; the comparison must, furthermore, be made between infants circumstanced similarly except as regards these centres.

**3. Air Pollution and Infant Mortality.**—"Dirtiness of the air appears to be the one constant accompaniment of a high infant mortality; purity of the atmosphere is the one great advantage which the agricultural labourer of Wiltshire, etc., enjoys over the resident in the town."

This statement is derived from page 16 of a contribution by Dr. W. A. Brend to the above-quoted report, which gives infant death-rates for a number of towns and other areas in support of the statement. The statement is not justified by accurately arranged differential statistics, which show (a) enormous differences in infant mortality in areas in the same town exposed to the same dirtiness of air; (b) similar differences in towns and districts of semi-rural character; (c) German and other experiences with a higher rural than urban infant mortality.

Atmospheric pollution and resultant loss of sunlight are doubtless inimical to health; but other factors, as thriftlessness, ignorance, alcoholism, overcrowding, and opportunities for human organic poisoning and infection can be shown to have greater potency than dirty air.

**4. Inherited Conditions the Chief Cause of Excessive Infant Mortality.**—In connection with the general thesis that environment, including domestic sanitation and food, have relatively little influence in determining the amount of infant mortality, it is suggested that the excessive death-rate in artificially fed infants is due to inherited weakness.

*Remarks.*—It can be agreed (a) that the infants of weakly parents are severely handicapped. How much is due to their ante-natal environment and how much is strictly hereditary is difficult to determine. It can be agreed (b) that infants born prematurely from any cause, or whose mother has died in confinement, or who are twins, are likely to have their chances of survival much reduced. Also (c) that statistics are seldom satisfactorily compiled comparing infants artificially fed and infants naturally fed, whose other circumstances are, so far as can be ascertained, equal. An approximation to such figures is comprised in a paper by Dr. R. M. Woodbury on "The Relation between Breast and Artificial Feeding and Infant Mortality" (*American Journal of Hygiene*, vol. ii, November 1922), which should be consulted. The investigation is concerned with 22,422 infants, the number of months lived by infants receiving each type of feeding being stated. The figures show a mortality 3·9 times as high among artificially fed as among breast-fed infants. When plural births, prematurely born, and orphans were excluded, the excess mortality is only reduced to 3·4 times.

Although impeccable statistics are deficient, no experienced physician would hesitate to state that artificial feeding is an important factor in prejudicing nutrition and in increasing the risk of death for infants who are in no wise handicapped by inherited weakness or by maternal weakness. This is strikingly seen in the experience of successive children in the same family subjected to different methods of feeding, in whom the food appears to be the sole varying factor.

This subject is discussed in a "Study of the Data provided by a Baby Clinic in a Large Manufacturing Town," by Mary N. Karn and K. Pearson, F.R.S. (*Studies in National Deterioration*, x, 1922), and the conclusion reached is that "the influence of breast-feeding on baby's health is not so important as is generally asserted; it is largely a secondary result of artificial feeding being associated with poor health in the mother."

The reasons for artificial feeding of infants vary greatly, and statistics which do not distinguish between artificial feeding necessitated by death or illness or ill-health of the mother, and artificial feeding arising from fashion or social or occupational differences, can scarcely

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give trustworthy indications. Hence the importance of the individual experience of medical practitioners, which can scarcely receive numerical expression, but which is nevertheless less unsatisfactory than massed statistics in which the many factors involved are not and often cannot be segregated from each other. The dubious character of the data on which the statement quoted above is made is suggested by the further statements of divergent results in the two sexes: "The female infant's weight is more intimately associated with the method of feeding than that of the male infant. . . . Its weight is more closely associated with its feeding than its health is, exactly the reverse of what we find in the case of boys. . . . It appears as if girls were more subject to environmental influences" (than boys).

## CHAPTER XXXI

### CAUSES OF DEATH

IN preceding chapters vital statistics have been discussed, in the main, irrespective of individual causes of death. In dealing with these the principles laid down for general death-rates from all causes should be followed. The death-rate for any given disease must be stated in terms of the population at risk; and whenever practicable, the death-rate should be stated for each age-group in terms of the population at that age-group. If a composite picture is required of the death-rate from a given disease at all ages in contrasted communities, this should be for a standard population, the direct method being usually employed (p. 222). If the factorial method (p. 228) is employed, a different factor is required for each cause of death. For some causes of death standardization makes much and for others little difference in rates. If such standardization is impracticable, the possibility of a considerable margin of error in comparisons should be remembered.

The magnitude of each cause of death is measured by the death-rate caused by it at all ages and at each age-period. But for comparisons between deaths from different causes *in the same community*, it is sometimes convenient to know

$$\frac{\text{deaths from the given cause} \times 100}{\text{total deaths from all causes}}$$

and for some purposes it is also desirable to know

$$\frac{\text{deaths from the given cause at age } x - y \times 100}{\text{deaths from the same cause at all ages.}}$$

The above fractions merely state the proportion of deaths from any cause per cent. of deaths from all causes, and of deaths at any age-period per cent. of deaths at all ages.

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Such ratios cannot be employed safely for comparing the weight of a given cause of death in two communities (see p. 202), but they are useful in considering the relative importance of different causes of death in a given community.

The first of the two processes is illustrated in the following table :—

### ENGLAND AND WALES, 1920.

	Death-rate per Million Persons from Certain Causes or Groups of Causes.	Proportion per Cent. of Total Mortality from All Causes.
Cancer .. .. .	1,161	9.4
Tuberculosis (all forms) .. .. .	1,131	9.1
Pneumonia .. .. .	991	8.0
Bronchitis .. .. .	992	8.0
All other respiratory diseases .. .. .	164	1.3
Heart diseases .. .. .	1,413	11.4
Diseases of bloodvessels .. .. .	1,097	8.8
Diarrhoeal diseases .. .. .	303	2.5
Measles .. .. .	191	1.5
Diphtheria .. .. .	150	1.2
Whooping cough .. .. .	117	1.0
Enteric fever .. .. .	14	0.1
Violence .. .. .	474	3.8
All other causes .. .. .	4,190	33.9
	12,388	100.0

The above table contrasts the most common causes of death and the more fatal acute infectious diseases. Cancer heads the list, tuberculosis coming second, and pneumonia—to which should be added a share of the deaths attributed to bronchitis (p. 183)—comes third. These three diseases as registered caused, in 1920, 26.5 per cent. of deaths from all causes. In 1921 the corresponding proportion was 26.9 per cent. Syphilis, which does not appear in the above list, on Osler's authority (p. 482), ought to rank with these three as one of the four chief causes of death in this country, were it practicable to assign each death to its original cause. It will be noted that the four chief infectious acute diseases of this country only caused 6.2 per cent. of the total deaths in 1920.

Heart diseases might be added to the above four. It is regarded as so far an entity that the International List groups nearly all deaths from cardiac diseases under one heading, "organic heart disease." On this see page 180.

Deaths in different stages of life represent unequal loss to the community. Deaths between 20 and 55 may be regarded as representing the greatest loss. The contrast between tuberculosis and cancer in this respect is shown in Fig. 51, and in Fig. 52, p. 370.

In Fig. 51 is shown for tuberculosis and for cancer the male death-rate at each successive age-period as indicated in the diagram. Incidentally the diagram shows the decrease and the age-incidence of the decrease in the male death-

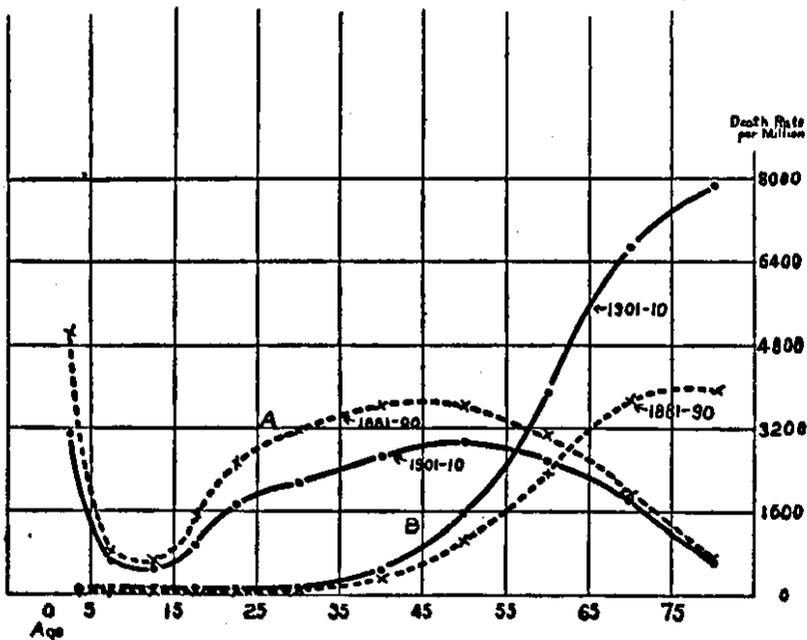


FIG. 51.—England and Wales: Death-rate per Million Males at Different Age-periods in 1881-90 and 1901-10.

A, Tuberculosis (all forms).  
 B, Cancer.

rate from tuberculosis, and the increase and the age-incidence of the increase in the male cancer death-rate. In this figure the deaths are stated per million living at each age-period.

For some purposes, however, it is necessary to know the proportion of total deaths from a given disease which occurs in each period of life. This is shown for tuberculosis and cancer during the decennium 1901-10 in Fig. 52.

In A is shown the percentage of total mortality from each cause at each successive age-period, the maximum number of deaths from tuberculosis occurring at ages 0-5 and 25-35 and from cancer at ages 55-65. Thus tuberculosis evidently has a double maximum in childhood and in early adult life; while cancer kills chiefly after middle life. In B this is shown more clearly. In this diagram the aggregate percentage of total deaths at all ages is shown for all ages below the period indicated on the diagram. Thus by the time the age 45

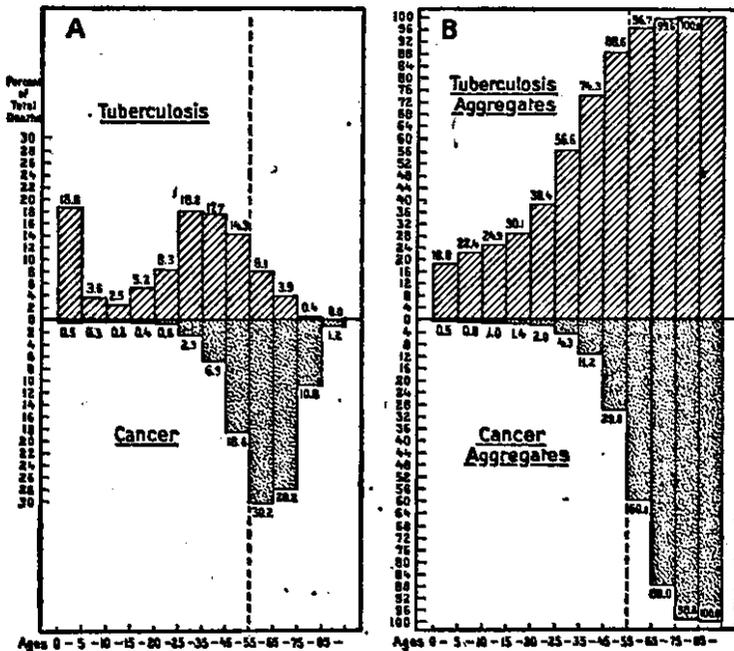


FIG. 52.—England and Wales, 1901-10: A, Percentage of total male deaths at all ages from Tuberculosis and Cancer which occur at each Age-period. B, Ditto at each and all lower Age-periods.

has been reached tuberculosis has already caused 74.3 per cent. of the total deaths from this disease; at the same age only 11.2 per cent. of the total deaths from cancer have occurred.

For convenience a table is given here, showing the relative incidence of deaths at different age-periods from diseases in which public health administration is or should be largely concerned.

# CAUSES OF DEATH

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ENGLAND AND WALES, 1901-10.

*Proportion of Total Male Deaths from Each Disease Occurring at Different Ages.*

	Under 5.	5-15.	15-25.	25-45.	45-65.	65 and over.	All Ages.
All causes .. ..	35.0	3.6	4.2	12.6	20.8	23.8	100
Measles .. ..	94.0	5.6	0.2	0.2	—	—	100
Scarlet fever .. ..	60.7	32.5	4.4	2.1	0.3	—	100
Whooping cough .. ..	97.5	2.5	—	—	—	—	100
Diphtheria .. ..	61.7	35.0	1.6	1.1	0.5	0.1	100
Enteric fever .. ..	3.3	12.0	27.2	42.8	13.3	1.4	100
Diarrhoeal diseases .. ..	88.2	1.0	0.6	2.0	3.5	4.7	100
Pneumonia (all forms) <sup>1</sup>	45.9	3.2	4.0	14.2	19.9	12.8	100
Pulmonary tuberculosis .. ..	4.7	2.8	14.7	45.2	28.5	4.1	100
Total tuberculosis .. ..	18.8	6.1	13.5	35.9	22.4	3.3	100
Rheumatic fever .. ..	3.7	26.3	20.9	29.0	16.1	4.0	100
Cancer .. ..	—	—	0.2	8.2	50.5	41.1	100
Bronchitis .. ..	37.7	0.6	0.4	2.9	19.4	39.0	100
Cirrhosis of liver .. ..	0.2	0.3	0.5	18.7	59.6	20.7	100
Valvular disease of heart .. ..	0.5	3.8	5.8	16.8	37.6	35.5	100

<sup>1</sup> The proportion of total deaths under 5 years of age from lobar pneumonia was 22.9, from broncho-pneumonia 79.1 per cent.

The converse of the above table, showing the relative importance of the chief causes of death at different ages, is set out in a table on page clxxv of the Decennial Supplement of the Registrar-General, 1901-10, and should be studied with the above table.

**Death-rates from Groups of Diseases.**—In past official reports a statement of the death-rate from the seven chief infectious diseases, known as the *zymotic death-rate*, has figured prominently, and comparisons have been made between the experience of different years and places on the basis of this rate. It is evident, however, that a rate comprising deaths from measles and enteric fever, from small-pox and whooping cough, along with other diseases, gives a different view of the sanitary condition or administration of the area concerned, according as the excess of mortality is caused by one or other of these diseases. Happily, this conglomerate rate is now seldom stated, and it disappeared from the Registrar-General's returns some years ago.

As stated on page 183, similar objections hold to a varying degree against inferences drawn from the course of the death-rate from the sum of nervous, or of respiratory, or of

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circulatory diseases (p. 179). This may be illustrated by the following list, in which the pre-1911 classification is adopted in both columns:—

ENGLAND AND WALES.  
*Crude Annual Death-rates per Million Living.*

	1906.	1920.
Diseases of the nervous system <sup>1</sup> .. ..	1,032	574
Diseases of heart .. .. .	1,420	1,413
Diseases of bloodvessels <sup>2</sup> .. .. .	874	1,097
Diseases of respiratory system (excluding pneumonia) <sup>3</sup> .. .. .	1,263	1,156
Diseases of digestive system .. .. .	870	646
Causes ill-defined or not specified .. ..	1,475	905
Old age .. .. .	970	668

<sup>1</sup> Excluding cerebral hæmorrhage, apoplexy, hemiplegia.

<sup>2</sup> Including cerebral hæmorrhage, apoplexy, hemiplegia.

<sup>3</sup> Excluding diarrhœa, but including gastro-enteritis and enteritis not returned as infective.

The four largest changes in death-rates shown in the above list are due mainly to improvements in certification. The fall in nervous diseases is chiefly in respect of "convulsions"; the increase in diseases of bloodvessels probably means transfer from the two last items in the list, old age and other ill-defined causes of death. The fall in diseases of the digestive system is due to miscellaneous causes. For respiratory diseases the group may be more accurate than its separate constituents (see p. 183).

In the International List, cerebral hæmorrhage and apoplexy, which are respectively newer and older terms for the same condition, as well as cerebral embolism, are tabulated among nervous diseases, in the Registrar-General's reports among circulatory diseases. In 1906 under the first heading the death-rate per million was 459, and under the second 257; the corresponding rates in 1920 being 583 and 146. Cerebral embolism is commonly due to valvular heart disease, another instance of difficulty whether the isolated condition or the group to which it is apportioned is used statistically. In England a large number of deaths which formerly would have been certified as apoplexy are now returned as arterio-sclerosis. The entire group of circulatory diseases (heart and bloodvessels) is heterogeneous. It includes a large amount of disease due to syphilis (p. 484),

to the rheumatic fever virus, to septic infections, and to the retention of toxic tissue products; and to draw inferences from the group as a whole is to invite confusion.

DEATH-RATES FROM CERTAIN SPECIAL CAUSES OF MORTALITY.

**Arterio-sclerosis.**—The 1916 Annual Report of the Registrar-General gives a study of this disease as illustrating the influence of vogue in certification. The title was only included in the official classification in 1911, as a subdivision of No. 81 in the International List; but in 1911 there were 3,675 and in 1916 there were 8,012 deaths attributed to this cause in England and Wales. Dr. Stevenson of the General Register Office has suggested that this may in part be due to the attention drawn by me to arterial disease in my Annual Report to the Local Government Board 1912, or to the interest in the subject which this report illustrated. The transfer to this heading is in part also ascribable to the realisation by doctors of the inadequacy of "old age" as a form of death certificate. In 1911 the male deaths in England per 1,000 total deaths at ages over 75 which were ascribed to old age were 346; in 1916 this proportion had become 267.

An illustration of increasing accuracy in certification and possibly also of actual increase in the disease is furnished by

**Diabetes.**—This subject is discussed by Dr. F. L. Hoffman,<sup>1</sup> who quotes death-rates from diabetes per million of population, varying from 38·4 in Malta, 16·4 in the United States registration area, 14·6 in New Zealand, and 11·8 in England and Wales, to almost *nil* in other communities.

The English statistics are as follows:—

ENGLAND AND WALES.  
*Annual Death-rate from Diabetes Mellitus per Million of Population (Standardized).*

	1861-70.	1871-80.	1881-90.	1891-1900.	1901-10.	1911-20.
Males .. ..	43	54	74	90	104	135 <sup>2</sup>
Females .. ..	21	28	46	64	84	117 <sup>2</sup>

<sup>1</sup> "The Mortality from Diabetes," *Boston Medical and Surgical Journal*, July 27, 1922.

<sup>2</sup> Crude rates.

Though the absolute amount is less, the increase in the registered death-rate has been much greater for females than for males, the former rate having quadrupled, while the latter has increased about  $2\frac{1}{2}$  times (standardized rates).

That much of this great increase is fictitious, being due to improved diagnosis and certification, is suggested by the specially great increase of registered diabetes in old age, a period of life at which death certification has been less satisfactory than at any part of life except in infancy. A relation between assumed increase of stress and strain in modern life and the increased mortality from diabetes has been suggested. This is not confirmed by the very definite excess of mortality from this disease in the rural counties of England.

It may be suggested that retirement of invalids to the country may partially explain this rural excess; but there are much stronger reasons inducing tuberculous patients to live (and die) in the country, where, nevertheless, the tuberculosis death-rate is lower than that in towns.

**Appendicitis** is a disease now much more frequently diagnosed than in the past. It was first separately tabulated in the Registrar-General's Reports in 1901, and in the following table is given the crude annual death-rate from this disease and from peritonitis (non-puerperal) for consecutive quinquennial periods. Non-puerperal peritonitis itself is an indefinite cause of death. It may be pneumococcal or be due to unrecognized tuberculosis or cancer of the peritoneum, more often to perforated gastric or duodenal ulcer, or to appendicitis, which may be regarded as synonymous with perityphlitis. Much of the decrease under the heading of peritonitis is due to transfer to various forms of infection, especially puerperal. Some of the decrease is probably caused by transfer to appendicitis.

It would be easy to conclude from the following table that most of the increase in mortality registered from appendicitis is due to transfer from other headings, and especially from peritonitis. This would ignore the important fact that appendicitis is now usually recognized in an operable and curable stage, and that even a stationary death-rate probably means a large increase in the case-rate for this disease

Clinicians are generally convinced that appendicitis has greatly increased, and hospital statistics confirm this opinion.

ENGLAND AND WALES.

*Average Annual Death-rates per Million Persons from Peritonitis and Appendicitis.*

	1891-95.	1896-1900.	1901-05.	1906-10.	1911-15.	1916-20.
Peritonitis (not puerperal) ..	79	63	33	19	15	12
Appendicitis ..	—	—	50	62	69 <sup>1</sup>	67 <sup>1</sup>

<sup>1</sup> The above rates are for persons. As some doubt attaches to rates for males for this period, owing to uncertainty as to the male civilian population, it may be added that the female death-rate from appendicitis in 1911-15 was 57·9, and in 1916-20 it was 57·2.

The following statement of proportionate age distribution of deaths (not death-rates) from appendicitis and peritonitis is taken from the Decennial Supplement of the Registrar-General.

ENGLAND AND WALES.

*Of the Total Male Deaths in 1901-10 from Each Cause the Proportion per Cent. below the Stated Ages was as follows:—*

The Proportion Dying before Reaching the Age of—	Appendicitis.	Peritonitis.
5 years .. .. .	3·6	22·9
15 years .. .. .	31·5	37·5
20 years .. .. .	46·6	44·0
35 years .. .. .	71·4	56·1
45 years .. .. .	81·3	63·5

Appendicitis as a fatal disease occurs chiefly in youth and early manhood.

**Appendicitis in U.S.A.**—With the preceding death-rates per million the following average annual death-rates for the registration area of the United States may be compared:—

Period.	Appendicitis.	Simple Peritonitis.
1901-5 .. .. .	110	108
1906-10 .. .. .	112	61
1915-18 .. .. .	124	21
1920 .. .. .	134	19

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The higher figures for the United States registration area than for England tend to confirm the view that appendicitis is an increasing cause of mortality, notwithstanding the vast number of cases which are diagnosed during life and are prevented by operation from adding to the mortality statistics.

## CHAPTER XXXII

### DEATHS FROM VIOLENCE

INJURY may be said to cause all deaths, excepting death from normal old age. Infectious diseases and diseases caused by errors of metabolism and by cancer alike produce death

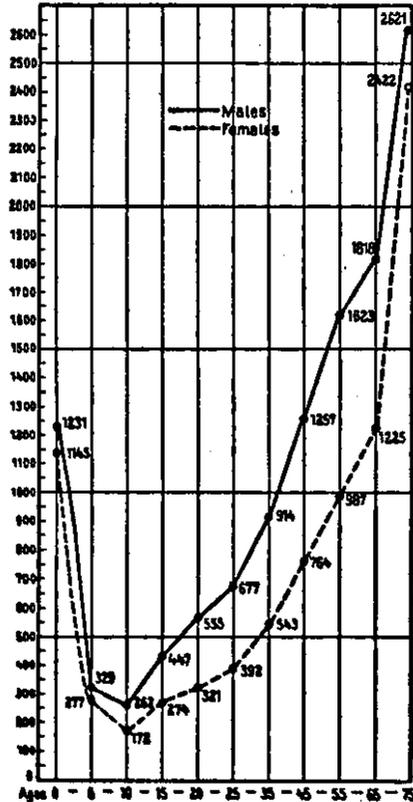


FIG. 53.—England and Wales: Annual Death-rate from Violence, 1901-10, per Million Living at Each Age-period in Each Sex.

by injury. Violence produces death by injury, as the result of accident, battle, suicide or homicide; and it is with violence in this limited sense that the present chapter is concerned. The place of violence in the international classification can

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be seen on page 380. Deaths from suicide, which are included in the following table, are also discussed separately (p. 380).

ENGLAND AND WALES.  
*Annual Standardized Death-rate from Violence per Million Living at All Ages.*

	1861-70.	1871-80.	1881-90.	1891-1900.	1901-10.
Males .. ..	1,169	1,108	957	934	827
Females .. ..	349	340	323	357	329

In 1921 the rates per million from various forms of violence were as follows:—

ENGLAND AND WALES.  
*Crude Annual Death-rates per Million Living of Each Sex at All Ages from Various Forms of Violence.*

	Male.	Female.
<b>Suicide—</b>		
Poisons and corrosive substances ..	11	9
Poisonous gas .. ..	13	7
Hanging or strangulation .. ..	37	8
Drowning .. ..	32	16
Firearms .. ..	14	1
Cutting or piercing instruments ..	33	6
By other means .. ..	13	3
	<hr/>	<hr/>
	153	50
<b>Non-suicidal and non-homicidal violent deaths—</b>		
Poisoning .. ..	7	6
Burns .. ..	38	45
Mechanical suffocation .. ..	23	15
Drowning .. ..	86	17
Injury by fall .. ..	83	56
Injury in mines and quarries ..	37	0
Injury by machinery .. ..	11	0
Injury by other forms of crushing	154	36
Wounds of war .. ..	6	—
Excessive heat .. ..	7	6
Homicide .. ..	7	7
Other external violence .. ..	10	3
	<hr/>	<hr/>
	622	241

The age-distribution in each sex of deaths from violence including suicide and execution in 1901-10 is shown in Fig. 53.

The age-incidence varies greatly for various forms of violence. Falls are especially fatal in old age, burns and

## DEATHS FROM VIOLENCE

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scalds in childhood, vehicles and horses in youth and up to middle ages; drowning also is a cause of death chiefly at the same ages as vehicular traffic.

In the following table American and English experiences are compared:—

RATES PER MILLION OF POPULATION, 1920.

	United States Registration Area.	England and Wales.	Number of Entry in International List, 1910.
Suicide .. .. .	102	91	155-183
Accident, or undefined <sup>1</sup> .. .. .	714	374	164-181 and 185-6
Homicide .. .. .	71	8	182-184
Burns and scalds .. .. .	76	47	167
Drowning .. .. .	57	50	169
Fall .. .. .	118	77	172
Mines, etc. .. .. .	26	26	173
Crushing by .. .. .	225	102	175
Railways .. .. .	73	18	—
Tramcars .. .. .	20	5	—
Motor cars .. .. .	104	51	—
Other vehicles .. .. .	19	20	—

<sup>1</sup> "Undefined" is the equivalent of "open verdict," e.g. in cases of "found drowned." In both countries such cases are classed as accident. Their numbers are given separately in the English report.

The difference in respect of homicide is striking. So also is the doubled death-rate in America from accident. Some of the causes of this excess are shown above. The nearly equal death-rate from drowning in the States, in view of its continental extent, appears to represent a much higher rate of accidental drowning among those exposed to the risks of water than in England.

A report of the American National Safety Council (quoted in the Statistical Bulletin of the Metropolitan Life Insurance Company) gives the following statistics relating to 5,600 deaths in 1921 and 5,779 in 1920 from traffic accidents:—

DEATH-RATES PER MILLION LIVING IN 50 AMERICAN CITIES.

	Injury by—				
	Automobiles.	Street Railway.	Steam Railway.	Other Vehicles.	All Vehicles.
1920	150	32	44	12	238
1921	155	24	34	13	226

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be seen on page 380. Deaths from suicide, which are included in the following table, are also discussed separately (p. 380).

### ENGLAND AND WALES.

*Annual Standardized Death-rate from Violence per Million Living at All Ages.*

	1861-70.	1871-80.	1881-90.	1891-1900.	1901-10.
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In 1921 the rates per million from various forms of violence were as follows:—

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*Crude Annual Death-rates per Million Living of Each Sex at All Ages from Various Forms of Violence.*

	Male.	Female.
<b>Suicide—</b>		
Poisons and corrosive substances ..	11	9
Poisonous gas .. ..	13	7
Hanging or strangulation .. ..	37	8
Drowning .. ..	32	16
Firearms .. ..	14	1
Cutting or piercing instruments ..	33	6
By other means .. ..	13	3
	<b>153</b>	<b>50</b>
<b>Non-suicidal and non-homicidal violent deaths—</b>		
Poisoning .. ..	7	6
Burns .. ..	38	45
Mechanical suffocation .. ..	23	15
Drowning .. ..	86	17
Injury by fall .. ..	83	56
Injury in mines and quarries ..	37	0
Injury by machinery .. ..	11	0
Injury by other forms of crushing	154	36
Wounds of war .. ..	6	—
Excessive heat .. ..	7	6
Homicide .. ..	7	7
Other external violence .. ..	10	3
	<b>622</b>	<b>241</b>

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## DEATHS FROM VIOLENCE

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Accident, or undefined <sup>1</sup> .. ..	714	374	164-181 and 185-6
Homicide .. .. .	71	8	182-184
Burns and scalds .. .. .	76	47	167
Drowning .. .. .	57	50	169
Fall .. .. .	118	77	172
Mines, etc. .. .. .	26	26	173
Crushing by .. .. .	225	102	175
Railways .. .. .	73	18	—
Tramcars .. .. .	20	5	—
Motor cars .. .. .	104	51	—
Other vehicles .. .. .	19	20	—

<sup>1</sup> "Undefined" is the equivalent of "open verdict," e.g. in cases of "found drowned." In both countries such cases are classed as accident. Their numbers are given separately in the English report.

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DEATH-RATES PER MILLION LIVING IN 50 AMERICAN CITIES.

	Injury by—				
	Automobiles.	Street Railway.	Steam Railway.	Other Vehicles.	All Vehicles.
1920	150	32	44	12	238
1921	155	24	34	13	226

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For the whole of England and Wales the number of deaths occurring in connection with vehicles and horses in 1920 was 94 per million persons. The magnitude of vehicular accidents as a cause of death, is seen by comparing 94 with 191 for measles, 150 for diphtheria, 14 for enteric fever, cancer 826, pneumonia 991 (per million living in each case). In 1920, 32.9 per cent. of the total deaths from automobile accidents in the United States were of children under 15 years of age; showing that additional safeguards for the pedestrian as well as caution on his part are needed ("Mortality Statistics," 1920, p. 63).

**Suicide.**—From the study of suicide included in Part III of the Supplement to the Seventy-fifth Annual Report of

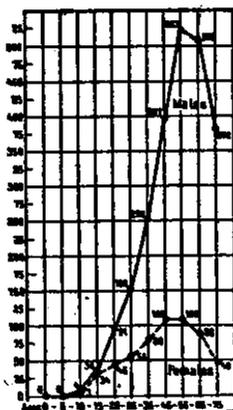


FIG. 54.—England and Wales: Annual Death-rate per Million Living of Each Sex from Suicide in Age-periods, 1901-10.

the Registrar-General (1901-10) the following particulars are taken :—

### ENGLAND AND WALES.

*Annual Deaths from Suicides per Million Living at All Ages (Standardized) in Successive Decennial Periods.*

	1861-70.	1871-80.	1881-90.	1891-1900.	1901-10.	1911-20.
Males ..	105	115	128	144	157	117 <sup>1</sup>
Females ..	35	36	39	44	47	42 <sup>1</sup>

<sup>1</sup> Approximate.

In 1914 the male-rate was 157, the female 48; in 1917 the male-rate was 100, the female 38; in 1920 the male-rate was 135,

the female 51; in 1921 the male death-rate was 153, the female 50 per million living. The age incidence of suicide is shown in Fig. 54.

The highest suicide-rate occurs at ages 55-65. The difference in the suicide-rate of the two sexes increases with age. At ages over 75 in 1901-10 the male-rate was nearly eight times that of females. Prior to the Great War there was a fairly steady but diminishing rate of rise in the suicide-rate. Comparing 1861-70 with 1909-10 the following increase per cent. of the suicide-rate occurred at successive ages :—

## ENGLAND AND WALES.

*Percentage Increase of Suicide-rate Comparing 1861-70 with 1901-10.*

	All Ages.	10-	15-	20-	25-	35-	45-	55-	65-	75-
Males.. ..	+54	0	+20	+54	+63	+55	+51	+39	+42	+52
Females .. ..	+34	0	+10	+45	+60	+51	+30	+25	+ 6	-30

In the United States death-registration area in 1920 the suicide-rate for persons was 102 per million of population, as compared with 160 in 1910. Attention is drawn in "Mortality Statistics" to some possible transfer to suicide from indefinite headings. Some of the chief forms of suicide are stated on page 378.

The Decennial Supplement already quoted gives for 1901-10 the following information as to the proportion of deaths from suicide by different methods.

## ENGLAND AND WALES, 1901-10.

*Proportion out of 1,000 Deaths from Suicide.*

Caused by -	Males.	Females.
Railway and other vehicles .. ..	51	24
Weapons and implements .. ..	278	117
Burns, scalds, explosion .. ..	1	7
Poisons and poisonous vapours .. ..	142	277
Drowning .. ..	188	327
Suffocation (hanging, etc.) .. ..	288	182
Jumping from height .. ..	21	36
Otherwise or not stated .. ..	31	30
	1,000	1,000

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Women resort more often than men to suicide by poisoning and by drowning, the more passive forms of suicide ; and less than men to suicide by weapons, e.g. firearms, which they have less at command than have men.

The occupational incidence of suicide varies greatly. Among coal-miners the number of deaths in the standard population 1910-12 (p. 321) was 11, in printers and in agricultural labourers 12, in teachers 14, in builders 18, in brewers 22, in inn-servants and lawyers 29, in doctors 33, in publicans 38, in druggists 40, and in barmen 43.

## CHAPTER XXXIII

### THE STATISTICS OF INFECTIOUS DISEASES

INFECTIOUS diseases have been the chief study of epidemiologists, and the material in this department of vital statistics is exceptionally rich. In the study of the epidemiology of an infectious disease and in forecasting the likelihood of its recurrence *a long series of statistics of annual incidence of the disease is indispensable*; and it is unfortunate that this need is commonly not met in statistical reports. Such statistics should be available for every sanitary area, as well as corresponding information of seasonal incidence. *Aggregate rates* for counties and still more for the entire country often *represent the fusion* of a number of epidemic curves, the peaks and troughs of which do not coincide, and differentiation, not average statement, is needed most in an epidemiological study.

Summary statements for groups of years or for groups of communities are necessary as expressions of experience, but they throw relatively little light on epidemiological problems.

**Methods of Stating Experience.**—This depends on the object in view.

(1) For medical purposes the *proportion of deaths to persons attacked* by a given disease is often required. By this means the degree of violence of the disease can be ascertained, and indications may be obtained as to the effect of particular methods of treatment. Certain cautions are needed in inferences from percentages thus obtained.

(a) The number of facts included in the experience is often so small as not to warrant exact conclusions. Conclusions either as to virulence of a disease or as to therapeutical results advanced on the strength of percentages

from a small number of cases must be accepted with caution (see also p. 606).

The proportion of deaths to cases is sometimes erroneously called the death-rate. It should always be described as the *case mortality* or *fatality* of the disease.

(b) The fatality of nearly all diseases is largely influenced by the age and sex of the patients, and especially by age. Thus in Murchison's *Treatise on Continued Fevers*, 1884 typhus fever is stated to have a fatality varying from 2.28 per cent. at ages 10-15 and of 3.59 at ages 5-10, to 49.62 per cent. at ages 50-55, and still greater at higher ages. Similarly, the fatality of enteric fever varied in the same experience from 11.28 per cent. at ages 5-10, to 26.61 at ages 40-45, and 45 per cent. at ages 55-60. Again, whooping cough is more fatal among female than among male children (see p. 357).

Hence fatalities should for purposes of accurate investigation be stated for males and females of corresponding age-periods, and this is now practicable, as the regulations for notification require age and sex to be stated.

(c) When this is done the number of individual facts at each age-period is reduced, and thus the fallacy due to paucity of data may be introduced, a possibility which is preferable to the lumping together of incomparable facts. In stating percentages *the number of facts on which they are founded should always be given*, as their trustworthiness can then be gauged.

Changes in the fatality of a disease at all ages in the aggregate sometimes occur during the course of an epidemic. These changes may be due either to changes in virulence or in the age-incidence of attacks; to test this point it is necessary to give fatalities for age-periods, in which the experience of different parts of a great epidemic is separately stated.

Fatality rates for all ages and for age-periods depend for their accuracy on the completeness with which cases of the disease in question are notified. The importance of the above points is emphasized in the following extract from the Public Health Reports of the United States Public Health Service (June 9, 1922), which give a large number of fatality statistics :—

## THE STATISTICS OF INFECTIOUS DISEASES 385

It should be kept in mind that a relatively large number of reported cases of a communicable disease as indicated by a high case-rate (and more especially when accompanied by a relatively small number of deaths, as indicated by a low fatality-rate) usually means that the health department of that city is active, and that the cases of the disease are being well reported by the practising physicians. It does not usually mean that the disease is more prevalent in that city than in other cities. A high fatality-rate may mean that the disease was unusually virulent in a city, that the physicians did not treat the disease in that city with the success usual elsewhere, or that the practising physicians did not report all of their cases to the health department. On the other hand, an unusually low fatality-rate may be due to the fact that the disease in the city was unusually mild, that the physicians treated it with unusual success, that the practising physicians reported their cases satisfactorily, or that the registration of deaths was incomplete, or the assignment of the causes of death inaccurate.

In the South of England the fatality-rate of diphtheria is always much lower than in the north. This may be due to more complete notification of slight and "carrier" cases in the south, or to the prompter administration of diphtheria antitoxin, or to the occurrence of a milder type of disease, or to all of these factors.

(2) The mortality from a given disease may be stated by its *proportionate mortality*. This method constitutes a form of the error discussed on pages 202 and 340, and should only be adopted in default of the possibility of using other methods. The two factors concerned between which a ratio is sought—the mortality from the disease in question and the mortality from all other causes—are both variable. The possibility of error is illustrated in the following theoretical example:—

	Town A.	Town B.
Population .. .. .	100,000	100,000
Total deaths in year .. .. .	2,000	1,250
Deaths from phthisis .. .. .	200	125
General death-rate per 1,000 .. .. .	20·0	12·5
Death-rate from phthisis per 1,000 .. .. .	2·0	1·25
Proportionate mortality from phthisis per cent .. .. .	10·0	10·0

The two towns, as concerns phthisis—assuming the same

from a small number of cases must be accepted with caution (see also p. 606).

The proportion of deaths to cases is sometimes erroneously called the death-rate. It should always be described as the *case mortality* or *fatality* of the disease.

(b) The fatality of nearly all diseases is largely influenced by the age and sex of the patients, and especially by age. Thus in Murchison's *Treatise on Continued Fevers*, 1884, typhus fever is stated to have a fatality varying from 2.28 per cent. at ages 10-15 and of 3.59 at ages 5-10, to 49.62 per cent. at ages 50-55, and still greater at higher ages. Similarly, the fatality of enteric fever varied in the same experience from 11.28 per cent. at ages 5-10, to 26.61 at ages 40-45, and 45 per cent. at ages 55-60. Again, whooping cough is more fatal among female than among male children (see p. 357).

Hence fatalities should for purposes of accurate investigation be stated for males and females of corresponding age-periods, and this is now practicable, as the regulations for notification require age and sex to be stated.

(c) When this is done the number of individual facts at each age-period is reduced, and thus the fallacy due to paucity of data may be introduced, a possibility which is preferable to the lumping together of incomparable facts. In stating percentages *the number of facts on which they are founded should always be given*, as their trustworthiness can then be gauged.

Changes in the fatality of a disease at all ages in the aggregate sometimes occur during the course of an epidemic. These changes may be due either to changes in virulence or in the age-incidence of attacks; to test this point it is necessary to give fatalities for age-periods, in which the experience of different parts of a great epidemic is separately stated.

Fatality rates for all ages and for age-periods depend for their accuracy on the completeness with which cases of the disease in question are notified. The importance of the above points is emphasized in the following extract from the Public Health Reports of the United States Public Health Service (June 9, 1922), which give a large number of fatality statistics :—

## THE STATISTICS OF INFECTIOUS DISEASES 385

It should be kept in mind that a relatively large number of reported cases of a communicable disease as indicated by a high case-rate (and more especially when accompanied by a relatively small number of deaths, as indicated by a low fatality-rate) usually means that the health department of that city is active, and that the cases of the disease are being well reported by the practising physicians. It does not usually mean that the disease is more prevalent in that city than in other cities. A high fatality-rate may mean that the disease was unusually virulent in a city, that the physicians did not treat the disease in that city with the success usual elsewhere, or that the practising physicians did not report all of their cases to the health department. On the other hand, an unusually low fatality-rate may be due to the fact that the disease in the city was unusually mild, that the physicians treated it with unusual success, that the practising physicians reported their cases satisfactorily, or that the registration of deaths was incomplete, or the assignment of the causes of death inaccurate.

In the South of England the fatality-rate of diphtheria is always much lower than in the north. This may be due to more complete notification of slight and "carrier" cases in the south, or to the prompt administration of diphtheria antitoxin, or to the occurrence of a milder type of disease, or to all of these factors.

(2) The mortality from a given disease may be stated by its *proportionate mortality*. This method constitutes a form of the error discussed on pages 202 and 340, and should only be adopted in default of the possibility of using other methods. The two factors concerned between which a ratio is sought—the mortality from the disease in question and the mortality from all other causes—are both variable. The possibility of error is illustrated in the following theoretical example:—

	Town A.	Town B.
Population . . . . .	100,000	100,000
Total deaths in year . . . . .	2,000	1,250
Deaths from phthisis . . . . .	200	125
General death-rate per 1,000 . . . . .	20.0	12.5
Death-rate from phthisis per 1,000 . . . . .	2.0	1.25
Proportionate mortality from phthisis per cent. . . . .	10.0	10.0

The two towns, as concerns phthisis—assuming the same

sex and age distribution of population—have a relative position shown by the difference between 2.0 and 1.25; by the proportionate mortality method they appear to be equal.

It is useful to know the proportionate weight of a given cause to all causes of death (see p. 368); but this method cannot be employed without risk of error in comparing one community with another, and not very safely in comparing the records of the same community in successive years.

(3) *The crude rate per 1,000 of the population* may be given either for notified cases or for deaths from each infectious disease. Tables on this basis are found in the Registrar-General's reports. Table 5 in his Annual Review for 1921 gives the death-rates per million living for males, females, and persons for every infectious disease separately, and for a number of other diseases, and for 11 years in succession. By reference to older reports, a long series of death-rates can be obtained for each disease. Table 6 in the same report gives similar rates for the chief epidemic diseases from the commencement of registration onwards, those for the last 50 years being stated for individual years.

Local reports of medical officers of health often contain similar long period series of death-rates for special infectious diseases, and a collection of series of this nature is indispensable for epidemiological studies. When the object is to determine the broad trend of epidemic waves, the detailed rates for age-groups mentioned in the next paragraph are not needed.

When case-rates and death-rates from a disease are given, always state the numbers on which they are based. In a hamlet with 200 inhabitants, one imported fatal case of typhoid fever would imply a death-rate of 5 per 1,000, which to the uninitiated would suggest a devastating epidemic.

(4) For accurate comparisons, it is necessary to state the deaths or cases of an infectious disease *per 1,000 of the population living at the same age-group* as the patients. The importance of this rule will be appreciated from a study of the following table, in which this rule is not followed :—

# THE STATISTICS OF INFECTIOUS DISEASES 387

ENGLAND AND WALES, 1901-10.

*Proportion Between Deaths in Some Age-periods and Total Deaths at All Ages from Certain Infectious Diseases.*

	0-5.	5-10.	10-15.	15-25.	All higher Ages.	Total.
Measles .. ..	94.0	5.3	0.3	0.2	0.2	100
Scarlet fever ..	80.7	26.9	5.6	4.4	2.4	100
Whooping cough ..	97.5	2.4	0.1	—	—	100
Diphtheria .. ..	81.7	29.9	5.1	1.6	1.7	100
Diarrhoeal diseases	88.2	0.7	0.3	0.6	10.2	100
Enteric fever ..	3.3	5.2	6.8	27.2	57.5	100

This table indirectly shows why comparison of the death-rate per 1,000 at all ages from measles or whooping cough in a residential district in which there are few young children with the corresponding rate in an industrial town with a high birth-rate would introduce an element of error. For purposes requiring great accuracy it is necessary to know the population at risk and the number of deaths in each age-period, and base rates on these data, or to give standardized rates for all ages from such rates.

The Registrar-General in Table 6 of his Annual Report gives death-rates per million living from each of the chief epidemic diseases in this country, and in addition death-rates from :—

Measles	}	Per million living at ages
Scarlet fever		
Diphtheria and whooping		
cough		
		under 15 years.

The standardized death-rate takes account not only of differences in compared populations at ages 0-5, at which 94 to 98 per cent. of the total deaths from measles and whooping cough occur, but at other ages also. In the following table are shown death-rates from these diseases, (a) crude, and (b) standardized for all ages, (c) for ages 0-5, and (d) for ages 0-15 per million living at these ages, and the accuracy of the methods (a), (c), and (d) can be tested by a comparison of the different percentage declines of death-rate in the lowest line of the table :—

sex and age distribution of population—have a relative position shown by the difference between 2·0 and 1·25; by the proportionate mortality method they appear to be equal.

It is useful to know the proportionate weight of a given cause to all causes of death (see p. 368); but this method cannot be employed without risk of error in comparing one community with another, and not very safely in comparing the records of the same community in successive years.

(3) *The crude rate per 1,000 of the population* may be given either for notified cases of or for deaths from each infectious disease. Tables on this basis are found in the Registrar-General's reports. Table 5 in his Annual Review for 1921 gives the death-rates per million living for males, females, and persons for every infectious disease separately, and for a number of other diseases, and for 11 years in succession. By reference to older reports, a long series of death-rates can be obtained for each disease. Table 6 in the same report gives similar rates for the chief epidemic diseases from the commencement of registration onwards, those for the last 50 years being stated for individual years.

Local reports of medical officers of health often contain similar long period series of death-rates for special infectious diseases, and a collection of series of this nature is indispensable for epidemiological studies. When the object is to determine the broad trend of epidemic waves, the detailed rates for age-groups mentioned in the next paragraph are not needed.

When case-rates and death-rates from a disease are given, always state the numbers on which they are based. In a hamlet with 200 inhabitants, one imported fatal case of typhoid fever would imply a death-rate of 5 per 1,000, which to the uninitiated would suggest a devastating epidemic.

(4) For accurate comparisons, it is necessary to state the deaths or cases of an infectious disease *per 1,000 of the population living at the same age-group* as the patients. The importance of this rule will be appreciated from a study of the following table, in which this rule is not followed :—

THE STATISTICS OF INFECTIOUS DISEASES 387

ENGLAND AND WALES, 1901-10.

*Proportion Between Deaths in Some Age-periods and Total Deaths at All Ages from Certain Infectious Diseases.*

	0-5.	5-10.	10-15.	15-25.	All higher Ages.	Total.
Measles .. ..	94.0	5.3	0.3	0.2	0.2	100
Scarlet fever ..	80.7	26.9	5.6	4.4	2.4	100
Whooping cough ..	97.5	2.4	0.1	—	—	100
Diphtheria ..	81.7	29.9	5.1	1.6	1.7	100
Diarrhoeal diseases	88.2	0.7	0.3	0.6	10.2	100
Enteric fever ..	3.3	5.2	6.8	27.2	57.5	100

This table indirectly shows why comparison of the death-rate per 1,000 at all ages from measles or whooping cough in a residential district in which there are few young children with the corresponding rate in an industrial town with a high birth-rate would introduce an element of error. For purposes requiring great accuracy it is necessary to know the population at risk and the number of deaths in each age-period, and base rates on these data, or to give standardized rates for all ages from such rates.

The Registrar-General in Table 6 of his Annual Report gives death-rates per million living from each of the chief epidemic diseases in this country, and in addition death-rates from :—

Measles	} Per million living at ages under 15 years.
Scarlet fever	
Diphtheria and whooping cough	

The standardized death-rate takes account not only of differences in compared populations at ages 0-5, at which 94 to 98 per cent. of the total deaths from measles and whooping cough occur, but at other ages also. In the following table are shown death-rates from these diseases, (a) crude, and (b) standardized for all ages, (c) for ages 0-5, and (d) for ages 0-15 per million living at these ages, and the accuracy of the methods (a), (c), and (d) can be tested by a comparison of the different percentage declines of death-rate in the lowest line of the table :—

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ENGLAND AND WALES.

*Death-rates per Million.*

	Measles.				Whooping Cough.			
	All Ages.		0-5.	0-15.	All Ages.		0-5.	0-15.
	Crude.	Standardized.			Crude.	Standardized.		
1861-70	443	377	3,011	1,221	580	450	3,782	1,475
1901-10	309	318	2,601	973	277	286	2,426	876
Percentage decline	30	16	13	20	47	36	36	40

The standardized death-rate being taken as the basis of comparison, it is evident that the crude death-rate from both measles and whooping cough greatly overstates the decrease in the death-rate between 1861-70 and 1901-10, a result following naturally from the decreased birth-rate and older population. The death-rate based on population and deaths at ages 0-15 for measles and whooping cough also overstates the decline, but to a smaller extent. The death-rate at ages 0-5 states approximately the general trend of events.

The International Rule for Classification of Diseases separates deaths from "Diarrhoea and Enteritis under 2 Years" from deaths similarly certified at all ages, and these deaths in the Registrar-General's reports are stated in terms of births, as the most convenient indication of the population at risk (see also p. 338)....

The following death-rates are stated *per 1,000 births* :—

1. Total deaths and deaths from individual diseases under 1 year of age.
2. Deaths from diarrhoea and enteritis under 2 years.
3. Deaths of mothers from diseases and accidents of pregnancy and parturition.
4. Deaths from puerperal sepsis separately stated.

Attention is drawn on page 371 to the undesirability of a combined rate for a number of infectious diseases, sometimes called the zymotic death-rate.

**Periodicity of Epidemic Diseases.**—Although it is impracticable within the scope of this work to give more than

## THE STATISTICS OF INFECTIOUS DISEASES 889

a few references under the head of different diseases, the study of the laws governing the prevalence of various infectious diseases by statistical methods is perhaps the most fascinating, as it is also the most elusive in vital statistics. Ransome,

ANNUAL MORTALITY PER MILLION LIVING. MAXIMUM AND MINIMUM  
IN EACH DECENNIUM.  
*England and Wales.*

	1871-80.		1881-90.		1891-1900.		1901-10.		1911-20.	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
Smallpox	1,012	21	119	0	49	0	75	0	1	0
	in	in	in	in	in	in	in	in	in 3	in 7
	1871	1879	1881	1890	1893	1897	1892	1908	years	years
Measles <sup>1</sup>	517	257	602	347	570	314	392	232	462	96
	in	in	in	in	in	in	in	in	in	in
	1874	1875	1887	1888	1896	1899	1902	1910	1915	1919
Scarlet fever <sup>1</sup>	1,050	515	548	218	235	113	148	66	77	22
	in	in	in	in	in	in	in	in	in	in
	1874	1872	1881	1888	1893	1898	1902	1910	1914	1917
Diphtheria <sup>1</sup>	150	93	189	121	318	173	273	120	165	118
	in	in	in	in	in	in	in	in	in	in
	1874	1872	1889	1881	1893	1891	1901	1910	1915	1912
Whooping cough <sup>1</sup>	710	411	579	393	468	315	353	203	296	71
	in	in	in	in	in	in	in	in	in	in
	1878	1873	1882	1883	1891	1895	1904	1909	1918	1919
Typhus fever	121	21	36	5	5	1	2	0	0	0
	in	in	in	in	in	in	in	in		
	1871	1880	1882	1890	1891	1900	1902	1910		
Enteric fever	377	231	236	172	229	137	155	53	67	14
	in	in	in	in	in	in	in	in	in	in
	1872	1879	1884	1888	1893	1892	1901	1910	1911	1920

*United States Death Registration Area, Average Annual Death-rates per Million living.*

	1901-5.	1906-10.	1920.
Smallpox .. ..	34	2	6
Measles .. ..	90	108	88
Scarlet fever .. ..	110	106	46
Diphtheria and croup	296	224	153
Whooping cough ..	109	115	125
Typhus fever .. ..	less than 1 per		million
Enteric fever .. ..	320	256	78
Dysentery .. ..	86	65	41
Tetanus .. ..	35	27	17

<sup>1</sup> In the Registrar-General's Annual Report are given annual death-rates for these four diseases for 50 years, enabling a more accurate comparison to be made.

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Whitelegge, Brownlee, W. H. Frost, Greenwood, Hamer, and others have done much to render this study more scientific, and their contributions, as well as numerous papers in the *Proceedings of the Epidemiological Section of the Royal Society of Medicine* and in official reports deserve careful study. In such studies in epidemiology it is particularly dangerous to compare the mean death-rate of two cities or other places for periods of years which do not coincide in the two instances. Even when an average is struck for the same periods in the two places, there remains the fallacy that one place may have happened to have, say, three epidemics and another four during the given term of years. It might thus happen, for instance, that if two or three additional years had been added to the series, the place of the two cities would have been reversed as regards their average death-rate from the disease in question (see Fig. 17, p. 434).

As already pointed out, average case-rates or death-rates should not be trusted alone, and for certain purposes it is necessary to know not only the annual but also the weekly or monthly incidence of the infectious disease under study.

In the tables on page 389 the mortality from some of the chief infectious diseases in England and in the United States is shown.

For the English decennial periods the maximum and minimum death-rates are stated rather than average death-rates; for the United States this has not been practicable.

The Annual Reports of the Metropolitan Asylums Board give valuable information as to the experience of London. The following table gives a comparison between early and recent years:—

	Mortality per Cent. (Fatality) of Patients Treated in M.A.B. Hospitals.			London Death-rate per 1,000 of Estimated Population from Each Disease.		
	Scarlet Fever.	Diphtheria.	Enteric Fever.	Scarlet Fever.	Diphtheria.	Enteric Fever.
1870-74	10.5	—	16.1	0.73	0.09	0.26
1875-79	13.5	—	21.3	0.67	0.13	0.24
1880-84	11.7	—	18.4	0.55	0.20	0.23
1885-89	9.1	39.1	14.8	0.24	0.28	0.10
1916-1920	1.4	8.0	12.7	0.03	0.14	0.23

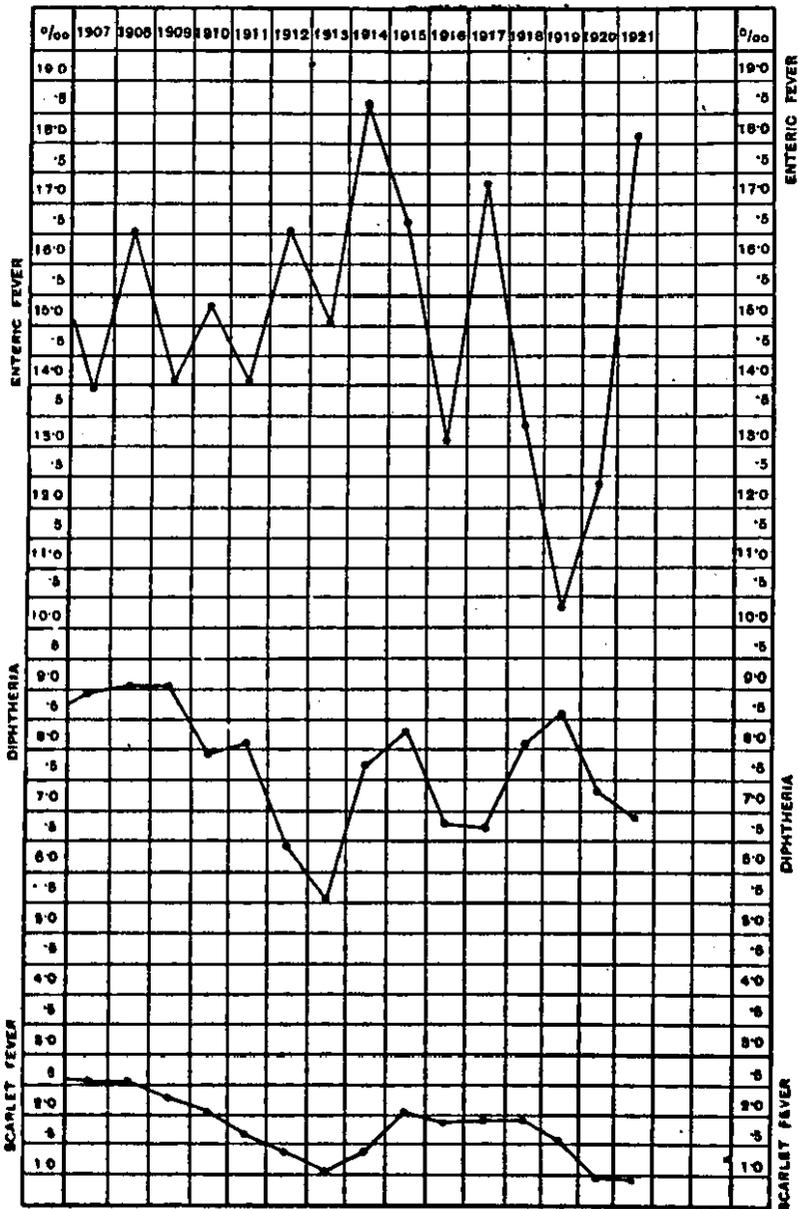


FIG. 55.—Case Mortality (Fatality) from Scarlet Fever, Diphtheria, and Enteric Fever in London, 1901-20. (By courtesy of the Metropolitan Asylums Board.)

In the above table the fatality experiences in successive periods may not be entirely comparable. Possibly in the earlier years, when a smaller proportion of the total cases

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was isolated in hospital, this proportion included chiefly the more severe cases. In view of this possibility the fatalities shown in Fig. 55 are to be preferred, as they include the experience of patients treated at home and in institutions other than those of the Metropolitan Asylums Board. They represent, however, the combined experience of all ages. The change in fatality among all known patients suffering from these three diseases from 1901 onwards is shown in Fig. 55.

**Fatality in Hospital and in Home Experience.**—Hospital treatment gives better nursing and medical treat-

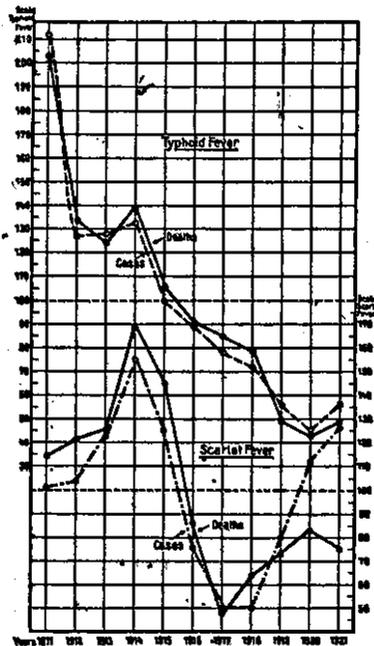


FIG. 56.—England and Wales: Cases of and Deaths from Enteric Fever and from Scarlet Fever, 1911-21, per Million of Population, the Average Case-rate and Death-rate in 1911-21 each being stated as 100.

ment than home treatment in the majority of cases. On the other hand, hospital treatment implies some risk of inter-current infections. In comparing hospital with home experience, it is important that the groups compared should be of similar social status, have an equality of distribution according to age and sex, and that they should relate to the same epidemic.

## THE STATISTICS OF INFECTIOUS DISEASES 393

**Infectious Diseases—Notifications and Deaths.**—That mortality statistics give an imperfect view of the changes in the incidence of an infectious disease may be seen in the comparison of cases of and of deaths from scarlet fever in England and Wales in 1911–21. The degree of correspondence between the two is shown in Fig. 56, in which the number 100 represents the average annual number of cases (2,884) and the number of deaths (46) from scarlet fever in 1911–21, and the rates in each year are stated in proportion to these average rates. Similarly, the average death-rate from enteric fever in 1911–21 was 33, and the case-rate 180 per million of population.

The average death-rates and case-rates which are given above for scarlet fever and enteric fever, in conjunction with the data in the diagram, will enable the student to calculate the case- and death-rates for each year and from these the corresponding fatality.

For each of the 10 years, death-rates and case-rates for enteric fever are related with fair uniformity to each other. This is so also for scarlet fever, except in 1920–21, when a great increase of cases notified occurred coincidentally with no commensurate increase in deaths. To ascertain whether this difference in 1920–21 is due to attenuated virus or to altered age-incidence of the disease would require detailed statistics of age-incidence of cases and deaths.

It would be a mistake to infer from Fig. 56 that there is a fairly steady relationship between deaths and cases of infectious diseases. Smallpox varies greatly in fatality in different epidemics, whether in vaccinated or unvaccinated, though the differences in fatality between these two selected populations persist, as do also the differences in fatality according to age. Scarlet fever and diphtheria both have remarkable *changes of fatality*, however produced; enteric fever, on the other hand, has varied relatively little in virulence.

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evidence and nine volumes embodying reports of special inquiries made on behalf of the Commission. The final report of the Commission (Cd. 8270) was issued in 1896, and comprises a complete account of the most important statistics as to smallpox.

The annual death-rate from smallpox in England and Wales since 1881 is given in Table 6 of the Annual Report of the Registrar-General, and for years since 1837 in earlier reports of the Registrar-General, and on page 32 of the Final Report of the Royal Commission. A summary of some of the more important statistics is given in *Half a Century of Smallpox and Vaccination*, by Dr. J. C. McVail (1919); and Dr. McVail's earlier work, *Vaccination Vindicated*, may still be consulted with advantage. No disease exemplifies better than smallpox the error caused by arguing from average death-rates for series of years. Smallpox is a disease the spread of which is subject like influenza to cyclical influences of unknown character, causing violent explosions of disease on a large scale. In the past the infection of smallpox, which in these pandemics presumably thus became enhanced in infectivity and virulence, was endemic in this country; in recent years it has always been of imported origin. For influenza, it is still debatable whether endemic influenza needs to be reinforced by exotic infection to produce a serious epidemic or not.

The death-rate per million from smallpox in England varied as follows, maximal and minimal years being indicated in succession :—

Period.	Maxima.	Minima.
1837		
1881-50	400 (in 1848)	170 (in 1842; records of 4 years wanting)
1851-60	400 (in 1852)	120 (in 1856)
1861-70	370 (in 1864)	70 (in 1861 and 1869)
1871-80	1,012 (in 1871)	21 (in 1879)
1881-90	119 (in 1881)	0 (in 1890)
1891-1900	49 (in 1893)	0 (in 1897)
1901-10	75 (in 1902)	0 (in 1907 and 1908)
1911-20	1 (in 3 years)	0 (in 7 years)

Changes in the age-incidence of smallpox mortality are described on page 398.

**Smallpox in the Pre-registration Period.**—A curve

Measles and whooping cough are negligible as causes of death over 10 years of age. Both scarlet fever and diphtheria have taken their chief toll of life below 10, though they remain serious up to early adult life. Enteric fever causes its highest death-rate at ages 15-45; and smallpox at the present time is chiefly a cause of death in adults.

As regards sex, measles, whooping cough, and diphtheria (enteric fever to a less degree) cause a higher death-rate at ages 5-10 in female than in male children. The same holds good for whooping cough at ages under 5. The comparison can be extended to individual years of early life in the Registrar-General's reports.

**Changes in Age-Incidence.**—The proportionate mortality at various ages for a number of diseases is given on page 387. The death-rates for each age-group in successive decennial periods are given for England and Wales in the Decennial Supplement, and from the tables in this report, the table which follows and the diagrams in the following pages are drawn.

The standardized death-rate at all ages for each disease in each decennium is taken as 100, and the death-rates at each age-period given in the Decennial Supplement are stated *in proportion to* 100. In the last column of the table are given the standardized death-rates for each disease at all ages; and from these the corresponding death-rate at any age-period can be calculated. Thus it is required to find the death-rate at ages 5-10 from smallpox in 1861-70:—

100 is equivalent to 149

$$98 \text{ " " " } \frac{149 \times 98}{100} = 146$$

which is the required death-rate from smallpox at age 0-5 in 1861-70.

An alternative method of stating the relative mortalities would have been to state the death-rate, say, at age 0-5 as 100, and give the death-rates at other age-periods in proportion to 100. But this would take no account of the sizes of the age populations to which the rates apply.

Measles and whooping cough persist as special children's diseases. It is only in communities from which these diseases have been absent for many years that they become serious diseases of adults.

## CHAPTER XXXIV

### AGE AND SEX IN INFECTIOUS DISEASES

No statistics of infectious diseases are satisfactory which do not differentiate age and sex, even if the study be merel from the administrative standpoint. Thus, if in an outbreak of enteric fever a large number of cases occurred unde 15 years of age, one common source of infection, oysters might be ruled out; and an excess of cases of scarlet feve among women and children in a given area may sugges an investigation of milk supplies.

**Death-rates According to Age and Sex.**—Although for determining the weight of mortality from a given disease in relation to total mortality from all causes in the same age-period, a statement of proportionate deaths is valuable (p. 368), for accurate work and for comparison with other areas death-rates according to age should be calculated. The Decennial Supplement of the Registrar-General is the most valuable reservoir of information for this and many other purposes (1901-10, Cd. 8002).

The following comparison of age and sex distribution of death-rates relates to 1901-10 :—

#### ENGLAND AND WALES, 1901-10.

*Average Annual Death-rate per Million Living at All Ages and at Eleven Groups of Ages for Persons of Each Sex.*

All Ages (standard- ized).	Smallpox.		Measles.		Scarlet Fever.		Whooping Cough.		Diphtheria.		Enteric Fever.	
	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.
	16	10	327	309	110	107	254	317	178	189	109	74
0- ..	21	24	2,695	2,507	588	553	2,170	2,683	961	942	32	30
5- ..	8	7	180	188	275	273	56	91	498	603	52	59
10- ..	0	6	10	10	60	69	1	3	88	95	71	81
15- ..	7	6	4	5	34	25	0	1	20	20	137	100
20- ..	11	7	2	3	17	18	0	0	11	10	179	99
25- ..	16	10	2	3	10	13	0	0	7	9	178	97
35- ..	26	12	2	3	5	6	0	0	6	7	142	86
45- ..	27	8	1	1	2	2	0	0	5	6	104	67
55- ..	18	6	0	1	1	1	0	1	6	8	80	50
65- ..	17	7	0	1	0	1	1	1	7	7	40	29
75- ..	17	4	1	1	1	1	3	2	7	4	17	10

Measles and whooping cough are negligible as causes of death over 10 years of age. Both scarlet fever and diphtheria have taken their chief toll of life below 10, though they remain serious up to early adult life. Enteric fever causes its highest death-rate at ages 15-45; and smallpox at the present time is chiefly a cause of death in adults.

As regards sex, measles, whooping cough, and diphtheria (enteric fever to a less degree) cause a higher death-rate at ages 5-10 in female than in male children. The same holds good for whooping cough at ages under 5. The comparison can be extended to individual years of early life in the Registrar-General's reports.

**Changes in Age-Incidence.**—The proportionate mortality at various ages for a number of diseases is given on page 387. The death-rates for each age-group in successive decennial periods are given for England and Wales in the Decennial Supplement, and from the tables in this report, the table which follows and the diagrams in the following pages are drawn.

The standardized death-rate at all ages for each disease in each decennium is taken as 100, and the death-rates at each age-period given in the Decennial Supplement are stated *in proportion to 100*. In the last column of the table are given the standardized death-rates for each disease at all ages; and from these the corresponding death-rate at any age-period can be calculated. Thus it is required to find the death-rate at ages 5-10 from smallpox in 1861-70:—

100 is equivalent to 149

$$98 \text{ " " " } \frac{149 \times 98}{100} = 146$$

which is the required death-rate from smallpox at age 0-5 in 1861-70.

An alternative method of stating the relative mortalities would have been to state the death-rate, say, at age 0-5 as 100, and give the death-rates at other age-periods in proportion to 100. But this would take no account of the sizes of the age populations to which the rates apply.

Measles and whooping cough persist as special children's diseases. It is only in communities from which these diseases have been absent for many years that they become serious diseases of adults.

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## CHAPTER XXXIV

### AGE AND SEX IN INFECTIOUS DISEASES

No statistics of infectious diseases are satisfactory which do not differentiate age and sex, even if the study be merely from the administrative standpoint. Thus, if in an outbreak of enteric fever a large number of cases occurred under 15 years of age, one common source of infection, oyster might be ruled out; and an excess of cases of scarlet fever among women and children in a given area may suggest an investigation of milk supplies.

**Death-rates According to Age and Sex.**—Although for determining the weight of mortality from a given disease in relation to total mortality from all causes in the same age-period, a statement of proportionate deaths is valuable (p. 368), for accurate work and for comparison with other areas death-rates according to age should be calculated. The Decennial Supplement of the Registrar-General is the most valuable reservoir of information for this and many other purposes (1901-10, Cd. 8002).

The following comparison of age and sex distribution of death-rates relates to 1901-10 :—

#### ENGLAND AND WALES, 1901-10.

*Average Annual Death-rate per Million Living at All Ages and at Eleven Groups of Ages for Persons of Each Sex.*

All Ages (standard- ized).	Smallpox.		Measles.		Scarlet Fever.		Whooping Cough.		Diphtheria.		Enteric Fever.	
	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.
	18	10	327	309	110	107	254	317	178	189	109	7
0- ..	21	24	2,695	2,507	586	553	2,170	2,683	961	942	32	3
5- ..	3	7	160	188	275	273	55	91	493	603	52	5
10- ..	6	6	10	10	10	69	1	3	88	85	71	3
15- ..	7	6	4	5	34	25	0	1	20	20	137	10
20- ..	11	7	2	3	17	18	0	0	11	10	179	9
25- ..	16	10	2	3	10	13	0	0	7	9	178	9
35- ..	26	12	2	3	5	6	0	0	6	7	142	8
45- ..	27	8	1	1	2	2	0	0	5	6	104	6
55- ..	18	6	0	1	1	1	0	1	5	8	80	5
65- ..	17	7	0	1	0	1	1	1	7	7	40	2
75- ..	17	4	1	1	1	1	3	2	7	4	17	1

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As regards sex, measles, whooping cough, and diphtheria (enteric fever to a less degree) cause a higher death-rate at ages 5-10 in female than in male children. The same holds good for whooping cough at ages under 5. The comparison can be extended to individual years of early life in the Registrar-General's reports.

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An alternative method of stating the relative mortalities would have been to state the death-rate, say, at age 0-5 as 100, and give the death-rates at other age-periods in proportion to 100. But this would take no account of the sizes of the age populations to which the rates apply.

Measles and whooping cough persist as special children's diseases. It is only in communities from which these diseases have been absent for many years that they become serious diseases of adults.



Scarlet fever, although in 1901-10 it only causes a death-rate one-eighth the magnitude of that of 1861-70, showed a proportional mortality at ages under 10 almost identical in the two decennia. In diphtheria with some increase in total death-rate in 1901-10 there occurred a marked increase in the proportional mortality at ages under 10. Diphtheria has become to a decreasing extent a disease of persons aged 10 and upwards.

The group of diarrhoeal diseases is large, and there is little doubt that in 1871-80 it included a larger proportion

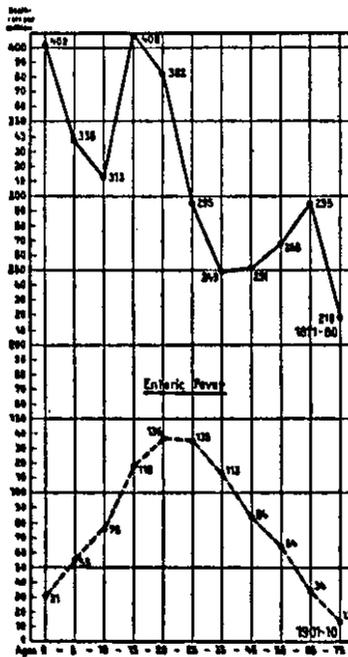


FIG. 57.—England and Wales: Enteric Fever. Average Annual Death-rate per Million Living at Each Age-period in 1871-80 and 1901-10.

than in 1901-10 of deaths from causes other than infective enteritis. The higher mortalities at ages 45 and over are significant on this point. Diarrhoea is a fatal disease chiefly in childhood, to a less extent in old age.

Enteric Fever as registered has markedly changed its age-incidence, as shown in the table on page 396 and in Fig. 57. This disease was first tabulated separately from typhus fever in official reports in 1871, and confusion with typhus must have continued for some years. It is the rates in childhood

which appear to have declined to a disproportionate extent. The decline between 1871-80 and 1901-10 for all ages (standardized rate) was 71 per cent. ; but at ages 0-5 it was 92 per cent., and at ages 5-10 it was 84 per cent. A part of the greater decline in childhood is almost certainly due to the fact that in 1861-70 many deaths at ages 0-5 described as typhoid fever were tuberculosis and other conditions wrongly diagnosed. The middle peak in the two curves in Fig. 57 corresponds fairly well with the known incidence of enteric fever in recent years, and it is probable that this part of the curve has been less subject to the influence of errors of certification than the earlier part of the curve.

**Smallpox.**—The marked inversion in the age-incidence of the death-rate from smallpox is not thus explicable, smallpox when a fatal disease being nearly always readily recognizable. These changes are set out in two ways in Fig. 58.

By method A the difference in magnitude of each death-rate in the three periods is shown ; by method B all three curves are reduced to the same scale, so that differences in age-distribution of death-rate alone are shown. Both methods show a marked shifting of death-rate from earlier to later ages, fatal smallpox becoming to an increasing extent a disease of middle life as the present time is approached. Various explanations of the remarkable change shown above have been given:—

(1) In view of the easy recognition of fatal smallpox, neither changes of fashion nor improvement in diagnosis can explain the phenomenon.

(2) It has been suggested that possible confusion between chicken-pox and smallpox may have affected the age-distribution of the death-rate from smallpox, chicken-pox, while rarely fatal, being so almost exclusively in childhood. In inter-epidemic years for smallpox this might cause some slight distortion ; in other years the registered mortality from chicken-pox, which never exceeds three per million living at all ages, is insignificant.

(3) Another suggestion has been that sanitary improvements are responsible for the changed age-incidence of smallpox, these affecting young children more than others. The changed incidence of enteric fever, as shown in the preceding table, has been adduced in support of this view ; but the

explanation is highly improbable. Smallpox, like measles, in a community unprotected by previous attack or by vaccination attacks persons of all ages indiscriminately; and the chief improvement in public health administration which can prevent the spread of smallpox, viz. meticulously precise personal precautions benefits persons of all ages alike.

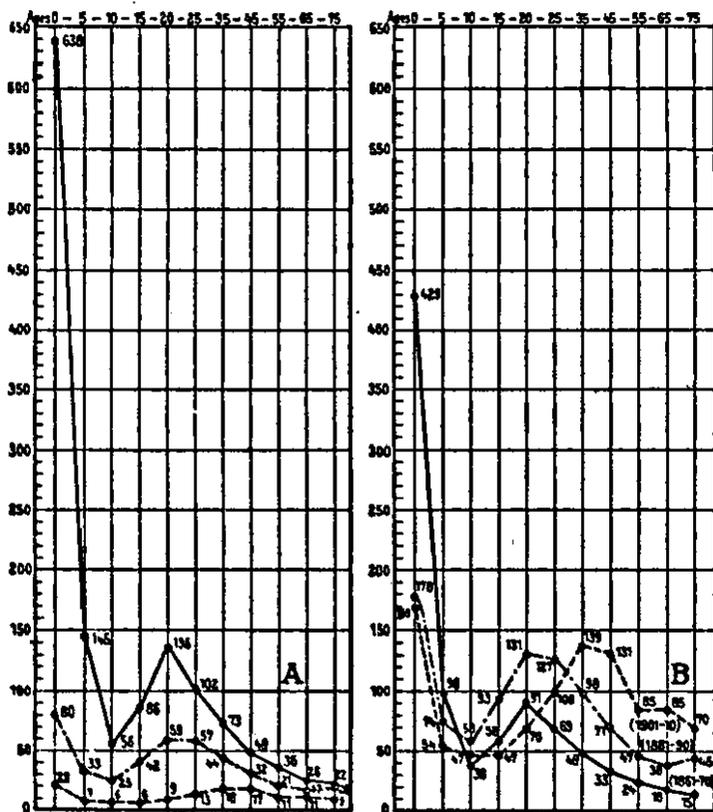


FIG. 58.—Age-Distribution of Death-rate from Smallpox in England and Wales in Three Decennial Periods 20 Years apart from each other. In A the actual Death-rates per Million at each Age-period are plotted out to scale; in B the Standardized Death-rate per Million Living at all ages in each decennium is taken as 100, and Death-rates at the different Age-periods are stated in ratio to 100.

In denying any connection between insanitation and smallpox, an exception must be made in respect of overcrowding. Like other infectious diseases, smallpox is most easily spread when the most frequent opportunities exist for personal intercourse. It is, therefore, most often met

with, and greater in amount, in busy centres of population than in scattered rural districts. The most noteworthy feature of the last 60 years has been the rapidly increasing urbanization of the population and the immense extension of travelling facilities. And yet, notwithstanding the increase of these adverse influences, the smallpox death-rate declined to a remarkable extent.

(4) The cessation of inoculation for smallpox, and its replacement by vaccination, irrespective of any merits in vaccination, meant the cessation of a steady source of endemic infection, the presence of which would ensure infantile attacks of natural smallpox. But inoculation was made illegal in the year 1840, and the English statistics which are compared in the preceding table are for 1861-70 and 1901-10.

This point as to the interval between epidemics is, however, important, as the periodicity of the disease (see p. 408) for the unvaccinated largely governs the age-incidence of mortality from smallpox. The admixture of vaccinated with unvaccinated diminishes the risk of infection, even for the unvaccinated, and therefore diminishes the number of epidemics, and raises the average age of attack. In the eighteenth century (when there was no vaccination) McVail states that 80 per cent. of deaths from smallpox occurred under 5 years of age; while in the years 1881-87, only 39 per cent. of the deaths from smallpox in the unvaccinated (3,099 in number) were under 5 years of age. During the same time 100 deaths occurred from smallpox in the vaccinated, of whom only 9 were under 5 years of age.

The question as to whether the longer intervals between epidemics explain the altered age-incidence of the smallpox death-rate can only be settled by collateral evidence. The effect of vaccination furnishes the necessary explanation, and it fits in with the entire body of experience concerning smallpox from whatever angle it is examined. The table on page 394 shows an age-incidence of deaths from smallpox which agrees with the absence of compulsory re-vaccination and with the gradual wearing out of the protection afforded by infantile vaccination. Other lines of evidence, converging to the same conclusion, are given on page 413.

**Influenza.**—A serious difficulty in studying the age-incidence of death from influenza consists in the facts that

in non-epidemic periods many deaths probably not due to influenza are ascribed to it, and that in epidemic periods the deaths attributed to this disease are only a part of the total mortality due to it. The methods of partial correction for this are given in the *Report on the Mortality from Influenza in England and Wales during the Epidemic of 1918-19* (Supplementary to Eighty-first Annual Report of the Registrar-General, Cd. 700), from which many of the facts quoted hereafter are taken. By ascertaining the excess of deaths under other headings during an epidemic of influenza, especially under bronchitis, pneumonia, heart disease and phthisis, in which there was reason to conclude that influenza was the primary cause of death or hastened death from already established disease, the following results were obtained. In London in the influenza outbreaks of 1892, 1895, and 1900, during the six or eight weeks of serious epidemic prevalence, 70 per cent. of the deaths presumably caused by influenza were certified under other headings; while in 1918-19 only 25 per cent. of them were so certified.

It follows that it is not justifiable to assume that the epidemic of 1918 was six times as fatal as, though probably it exceeded in severity, any other recorded epidemic in the registration period.

## ENGLAND AND WALES.

*Recorded Death-rate per Million Population from Influenza.*

1847	..	..	..	285
1848	..	..	..	460
1890	..	..	..	157
1891	..	..	..	574
1892	..	..	..	533
1899	..	..	..	389
1900	..	..	..	504
1918	..	..	..	3,128
1919	..	..	..	1,217
1920	..	..	..	283

It is certain that deaths from influenza are understated in the earlier part of an epidemic, and possibly they are overstated when it is nearly past. It is also certain that in the last epidemic, when influenza was the primary cause of death, this was much more generally stated in death certificates than in previous epidemics.

The preceding paragraph is needed to appreciate the possibility that the age-incidence of influenza as tabulated for one period may not be comparable with that of another period. As stated in the above-named report, "there is no certainty that the age-incidence tabulated is truly characteristic of the period, since more deaths really due to influenza may be attributed to other causes at one time of life than at another." The considerations named above probably only very partially alter the age-distribution of deaths from influenza in different epidemics, and the following proportions taken from the official report show the general trend of events. The method adopted is a statement of the proportionate deaths from influenza at certain age-groups; but apart from any change in the real age-incidence of influenza, this proportion might vary owing to changes in the age-distribution of the population. This has been corrected in the following table from the above report by calculating the number of deaths at each age-period in a standard population, that of 1901. Female deaths are given as being free from the disturbance of male statistics during the Great War.

INFLUENZA IN ENGLAND AND WALES.

*Standardized Deaths at Certain Ages in Females per 1,000  
Deaths at All Ages.*

Age-groups.	1847-48.	1891-92.	1899-1900.	1918.
0-15 .. ..	229	96	90	249
15-35 .. ..	61	118	90	454
35-55 .. ..	110	213	176	176
55-75 .. ..	364	394	405	98
75 and upwards ..	236	179	239	23
	1,000	1,000	1,000	1,000

The proportion of total deaths from influenza which occur at ages under 15 has varied greatly in different epidemics, the experience of 1847-48 and of 1918 corresponding in their lack of resemblance to that of 1891-91 and 1899-1900. But the experience of 1918 makes a completely new record. The deaths from influenza at ages over 55 were only 12.1 per cent.; in the three preceding outbreaks they formed 57.3 to 64.4 per cent. of the total, and the

change centred in the ages 15-35, in which 45.4 per cent. of the <sup>th</sup> recorded influenza mortality occurred in 1918, as compared with 6.1 to 11.8 per cent. in the preceding epidemics.

This real altered age-incidence of influenza is probably unparalleled in the history of any other disease, except smallpox, in which vaccination and the greater intervals

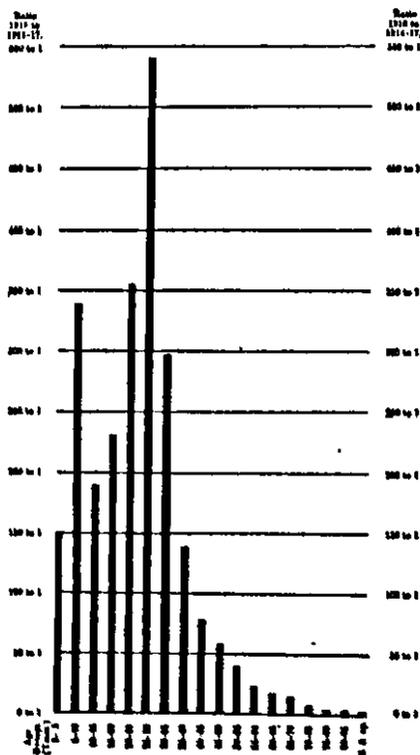


FIG. 59.—Comparison of the Mortality of Females of Various Ages allocated to Influenza in the Fourth Quarter of 1918 with that of the Same Age in the Fourth Quarters of 1914-17.<sup>1</sup>

<sup>1</sup> These ratios are based on rates per million.

between epidemics amply explain the change. It is so marked as to raise the question whether the influenza of 1918 was the same disease as earlier influenza; but medical testimony denies any change in the identity of the disease.

As pointed out in the official report of the Registrar-General, attempts at partially explaining the change have

failed. (1) Although there was much aggregation of young women in munition works in 1918, that is no reason why infection should fail to be spread with lightning rapidity to every section of the population as in former epidemics. (2) The alteration of age-incidence occurred in many countries, in which circumstances differed greatly from those of England. (3) The change occurred suddenly during the month of June 1918, and has continued, though to a less degree, in subsequent years. (4) The evidence collected in the *Report of the Pandemic of Influenza, 1918-19*, issued by the Ministry of Health, appears to show that the degree of immunity acquired by a preceding attack is slight and transient; and cases occurred of second attack during the second or third wave of the 1918-19 pandemic. It is clear, therefore, that the changed age-incidence is not explained by supposed immunity derived from influenza acquired in 1889-91. The change in age-incidence is shown more graphically in the diagram on page 403 taken from the Registrar-General's report.

At ages 25-30 the mortality in the fourth quarter of 1918 was 540 times greater than in the corresponding quarters of 1914-17, the excess decreasing with advancing years. Below the age of 25 the proportion varied from 150 times the previous mortality at 0-5 to 354 times at 20-25.

The genesis of the change with the onset of the 1918 epidemic can be seen in Fig. 60 derived from data in the official report.

The first curve, A, shows the old type, in which the chief victims were the old. The second, B, giving the experience April to June 1918, is transitional, showing the peaks of both periods. In the third and fourth quarters the stress of mortality now falls on young adults. In both types children under 5 suffer more than persons aged 5-15. The first epidemic of influenza in 1918 started near the end of the second quarter of the year, a fact which explains the double peak. The facts here outlined are set out more fully in the official report.

The cause of this remarkable change in the age-incidence of fatal influenza in the pandemic of 1918—a change which persists into 1922 to a less extent—is unknown; it remains an unsolved problem in epidemiology.

**Fatality and Age-Incidence.**—It is only possible here to give a few outstanding facts. For further details the reports of the Metropolitan Asylums Board and of some of the largest 'ever hospitals in England and of Scotland should be consulted. The following statement of case-rates and fatality-rates is taken from the Report of the Medical Officer to the

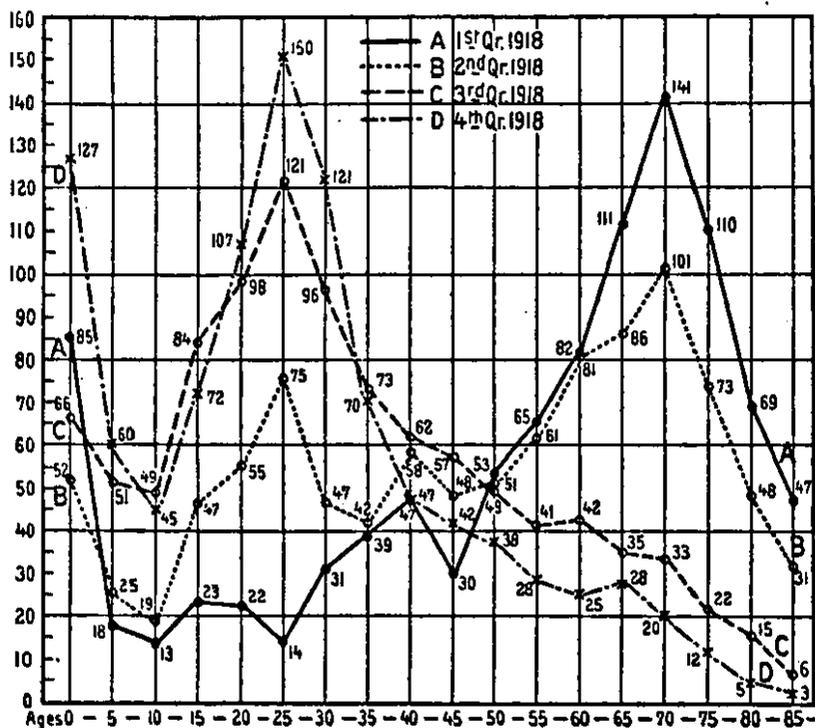


FIG. 60.—Proportion of Female Deaths from Influenza at Different Ages to Total Deaths from Influenza at all ages during Each of the Four Quarters of 1918.

London County Council for 1911. The heaviest age-incidence of scarlet fever in that year was in the fifth year of life, the fourth and sixth years of life coming next. Diphtheria also had its maximum age-incidence in the fifth year of life; the third and fourth years came next in order. Enteric fever showed its greatest incidence at ages 15–25. These case-rates should be compared with the average death-rates according to age given on page 394. The fatality-rates for both scarlet fever and diphtheria were low in 1911, and have become lower since (table, p. 406). The maximum fatality

## 406 THE ELEMENTS OF VITAL STATISTICS

for scarlet fever was in the third year; for diphtheria in the second year of life. The fatality of enteric fever increases with age, but the numbers involved are somewhat small.

LONDON, 1911.

*Case-rates per 100,000 Population and Case-Mortalities (Fatalities) per 100 Cases at Each Age-period—Males.*

Ages.	Case-rates per 100,000 Population.			Case-Mortality per Cent.		
	Scarlet Fever.	Diphtheria.	Enteric Fever.	Scarlet Fever.	Diphtheria.	Enteric Fever.
0 .. ..	120	196	} 7 }	6.8	25.0	} 5.9 }
1 .. ..	441	623		4.5	24.3	
2 .. ..	665	699		7.0	12.7	
3 .. ..	955	846		2.9	8.4	
4 .. ..	1,030	895		1.9	7.8	
5 .. ..	965	581	32	1.3	6.0	2.9
10 .. ..	376	177	33	0.9	1.7	9.1
15 .. ..	133	68	44	0.4	2.3	7.1
20 .. ..	60	41	43	0.9	—	14.6
25 .. ..	31	23	30	1.8	2.4	22.4
35 .. ..	9	12	22	—	5.9	18.7
45 .. ..	3	6	18	—	7.7	28.2
55 and upwards .	—	3	6	—	—	21.4
All ages ..	228	163	26	2.0	8.3	14.2

## CHAPTER XXXV

### SMALLPOX AND MEASLES

THE numerical insignificance of smallpox during recent years is shown in the following table:—

#### ENGLAND AND WALES.

*Sickness-rate (No. of Cases Notified) per Million of Population.*

	1911.	1912.	1913.	1914.	1915.	1916.	1917.	1918.	1919.	1920.	1921.
Smallpox	10	0	0	0	0	0	0	0	10	10	10
Scarlet fever	2,900	2,980	3,580	4,470	3,590	2,100	1,450	1,440	2,290	3,190	3,640
Diphtheria	1,330	1,240	1,390	1,610	1,520	1,500	1,280	1,310	1,500	1,861	1,760
Enteric fever	380	230	230	240	180	160	140	130	100	80	100
Cerebro-spinal fever	*	*	10	10	70	40	40	20	20	20	10
Poliomyelitis	*	*	20	10	10	20	10	10	20	10	10

NOTE.—0 means a death-rate under 0·5 per million, while — signifies that no deaths occurred.

\* Not generally notifiable.

The death-returns show similarly how insignificant smallpox has become as a cause of death. In the years 1911–21 in sequence it caused the following annual number of deaths in England and Wales (note, not death-rates):—

23, 9, 10, 4, 13, 18, 3, 2, 23, 30, 5.

In fact, so far as concerns the British Isles, smallpox has become an exotic disease, only spreading when cases are imported, and usually only when the recognition of these cases is belated. But around smallpox vast statistical controversies have been waged; in no other disease have deductions from figures been so contradictory; bias or prejudice, medical or anti-medical, as well as ignorance, being responsible for these results. The entire subject of smallpox in relation to vaccination was investigated by the Royal Commission on Vaccination, which issued six volumes of

## CHAPTER XXXIV

### AGE AND SEX IN INFECTIOUS DISEASE

No statistics of infectious diseases are satisfactory which do not differentiate age and sex, even if the study be merely from the administrative standpoint. Thus, if in an outbreak of enteric fever a large number of cases occurred under 15 years of age, one common source of infection, oysters, might be ruled out; and an excess of cases of scarlet fever among women and children in a given area may suggest an investigation of milk supplies.

**Death-rates According to Age and Sex.**—Although for determining the weight of mortality from a given disease in relation to total mortality from all causes in the same age-period, a statement of proportionate deaths is valuable (p. 368), for accurate work and for comparison with other areas death-rates according to age should be calculated. The Decennial Supplement of the Registrar-General is the most valuable reservoir of information for this and many other purposes (1901-10, Cd. 8002).

The following comparison of age and sex distribution of death-rates relates to 1901-10 :—

#### ENGLAND AND WALES, 1901-10.

*Average Annual Death-rate per Million Living at All Ages and at Eleven Groups of Ages for Persons of Each Sex.*

All Ages (standard- ized).	Smallpox.		Measles.		Scarlet Fever.		Whooping Cough.		Diphtheria.		Enteric Fever.	
	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.
	16	10	327	309	110	107	254	317	178	189	109	74
0- ..	21	24	2,095	2,507	586	553	2,170	2,683	961	942	32	30
5- ..	8	7	160	188	275	273	56	91	493	603	52	59
10- ..	6	6	10	10	60	69	1	3	88	95	71	81
15- ..	7	6	4	5	34	25	0	1	20	20	137	100
20- ..	11	7	2	3	17	18	0	0	11	10	179	99
25- ..	16	10	2	3	10	13	0	0	7	9	178	97
35- ..	25	12	2	3	5	6	0	0	6	7	142	86
45- ..	27	8	1	1	2	2	0	0	5	6	104	67
55- ..	18	6	0	1	1	1	0	1	5	8	80	50
65- ..	17	7	0	1	0	1	1	1	7	7	40	29
75- ..	17	4	1	1	1	1	3	2	7	4	17	10

of the annual death-rate from smallpox since 1837, when civil registration of all deaths in England and Wales began, or, apart from this, a study of the maximum and minimum rates given above, shows that there has been a decrease of smallpox mortality during the period for which there are official records in England. A study of smallpox, which is confined to these 80 years, does not, however, give an adequate conception of the remarkable fall in smallpox mortality which has occurred.

Smallpox reached its highest point in 1796 (two years before the date of Jenner's *Inquiry*), when  $18\frac{1}{2}$  deaths out of every 100 total deaths are stated to have been caused by smallpox. In the pre-vaccination period smallpox caused 7 times as many deaths as measles and  $7\frac{1}{2}$  times as many as whooping cough (McVail).

Dr. W. A. Guy, in investigating the history of smallpox, applied the term epidemic to any outbreak causing one-tenth or more of the total deaths from all causes in any year. He found that in London there were 10 such epidemics of smallpox in 48 years of the seventeenth century, 29 in the eighteenth century, and none in the nineteenth century. If the standard be reduced to  $7\frac{1}{2}$  per cent. of the total deaths, then, according to McVail, 14 epidemics occurred in the seventeenth century, 60 in the eighteenth, 4 in the nineteenth. The above figures relate to London. The worst year in the registration period in London was 1871, in which barely  $4\frac{1}{2}$  per cent. of the total deaths were due to smallpox, a proportion which was exceeded in the eighteenth century 93 times.

For further particulars the reader may be referred to the contribution by me on "The Epidemiology of Smallpox in the Nineteenth Century" and other contributions in the Jenner centenary number of the *British Medical Journal* of May 23, 1896. The international history of smallpox up to the present date has been summarized in a report by Dr. Bruce Lowe to the Local Government Board. To what circumstances is the diminished death-rate from smallpox in the present and recent decades to be ascribed?

**Causes of Decline of Smallpox.**—(1) The abolition of inoculation may have had some influence; for against its good effect in producing commonly a milder type of disease

than natural smallpox must be set its supply of an almost constant endemic source of infection.

(2) There is no satisfactory evidence that relative immunity, at least from death from smallpox, has been acquired by a process of natural selection. The evidence for this in smallpox, as also in measles, is not convincing. In communities in which both these diseases have prevailed for ages, major epidemics occur at irregular intervals, in which the power to spread and the virulence of infection, with increased fatality, are both greatly enhanced. The occasional excessive virulence of smallpox and of measles in "virgin" soils, although consistent with the absence of past selective influence, is also explicable by collateral circumstances of crowding, of massive infection, of bad sanitation and treatment, or of cyclical variations of virulence.

(3) Has there been a gradual decrease of virulence of smallpox? The evidence on this point is summarized in Dr. McVail's *Half a Century of Smallpox and Vaccination*. It is fairly consistent with the conclusion that smallpox gradually increased in virulence during the eighteenth century, and that in the pandemic of 1870-73 its fatality and infectivity culminated, since which time they have declined. The following examples (as seen in the table on opposite page) of case-mortality may be given. With the exception of the lowest on the list they are derived from the above source.

With some evidence of fairly general decrease of fatality remarkable contemporary differences in case-mortality are shown in the above table. These differences might be caused by—

- (a) The prevalence of different types of smallpox; or
- (b) The varying proportion of vaccinated and unvaccinated in the different communities; or
- (c) Varying age-distribution of the attacks of smallpox.

In any considerable outbreak of smallpox it is unlikely that the last-named cause would seriously vitiate comparisons; but for accurate work *case-mortalities for each day period should be given.*

**Types of Smallpox.**—There is abundant evidence that

irrespective of the effect of vaccination, at least two types of smallpox have prevailed in recent years, and possibly earlier, without adequate recognition. The severity of attack

		Number of Cases.	Fatality, per Cent.
Pandemic	London Hospital for Smallpox and Vaccination, 1836-51, (Marson) .. .. .	5,982	21.4
	Metropolitan Asylums Board, 1870-72.. .. .	13,721	18.6
	Glasgow, 1871-74 .. .. .	4,328	18.1
	Cork Street Hospital, Dublin, 1871-73.. .. .	746	21.6
Local outbreaks	Sheffield, 1887-88 .. .. .	4,677	10.1
	Bristol, 1887-88 .. .. .	327	11.3
Widely epidemic	Metropolitan Asylums Board, 1892-95.. .. .	4,759	8.0
	Birmingham, 1893-95 .. .. .	3,153	7.9
	Salford, 1892-5 .. .. .	173	12.7
	Manchester, 1892-94 .. .. .	996	6.8
Widely epidemic	Metropolitan Asylums Board, 1901-2 .. .. .	9,659	16.8
	York, 1902-4 .. .. .	39	17.9
	Swansea, 1902 .. .. .	187	17.1
	Liverpool, 1902-3 .. .. .	2,280	7.0
	Nottingham, 1903-5 .. .. .	479	3.5
U.S.A. (incomplete returns), 1901-3 .. .. .		144,644	3.2
London, <sup>1</sup> 1911-20 .. .. .		170	13.5
Remainder of England and Wales, <sup>1</sup> 1911-20 .. .. .		1,293	8.6

<sup>1</sup> Official returns.

is measured chiefly by proportion of deaths to attacks, and there is always the possibility that in one area a much larger proportion of cases may escape notification than in another.

The table on page 412 is abstracted from a table in the valuable paper by Dr. C. V. Chapin on "Variation in Type of Infectious Disease as shown by the History of Smallpox in the United States 1895-1912" (*Journal of Infectious Diseases*, September 1913).

It is unlikely that variations in completeness of notification in each area or alteration in age-incidence can explain the remarkable reduction of fatality shown above in persons attacked by smallpox. The experience of the City of New York is interesting. In the 3 years 1898-1900, the cases

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notified numbered 272, with a fatality of 11·4 per cent. ; in 1901-2, the cases were 2,566, fatality 28·0 per cent. ; in 1903-10, cases 363, fatality 12·1 per cent. The evidence in detail shows the prevalence of at least two types of small-pox, one of which may be regarded as a mutation from the other. The mild type has spread from the Southern States right across America, causing a fatality usually below 1 per cent. It has invaded England more than once, and the varying fatalities shown in the table on page 411 may be due to the prevalence of different types of smallpox, although it will be noted that the difference in fatality between vaccinated and unvaccinated patients, although on a lower grade,

UNITED STATES (PART OF).  
Cases and Fatality of Smallpox, 1895-1912.

Years.	Number of Cases.	Fatality per Cent.
2 years, 1895-96 .. .. .	4,578	20·2
2 years, 1897-98 .. .. .	4,252	5·9
2 years, 1899-1900 .. .. .	31,097	4·0
2 years, 1901-02 .. .. .	102,210	3·1
4 years, 1903-06 .. .. .	85,083	3·1
6 years, 1907-12 .. .. .	139,107	0·79

is still maintained. In parts of America in touch with Mexico or Europe the severe type is found, while in other parts mild cases occur. Variations occur in both types, with reversion to the opposite type occasionally during epidemic; but the majority of cases breed true as to type. Vaccination protects against attack by either type. The relation of these two types to "alastrim" is still somewhat dubious. The mutation of natural smallpox should not be confused with the varioloid or mitigated smallpox occurring in persons partially protected by vaccination. This may cause severe or fatal smallpox in an unvaccinated person.

In view of the fact that natural smallpox may vary in virulence, the influence of vaccination in preventing attack and in mitigating the severity of attack must be examined by comparison of vaccinated and unvaccinated in the same epidemic according to age, and in the case of the vaccinated according to the interval since vaccination. Infantile vaccination is obligatory in this country, subject to exemption on

making a statutory statement of conscientious objection. This exemption came into operation in 1908, and the percentage of vaccinations to births, which had varied between 66·4 and 75·8 from 1899 to 1907, decreased steadily from 63·2 in 1908 to 40·6 per cent. in 1919. Allowing for children who have died, it would appear that of the children born in the 10 years 1910-19, there remain 2½ million children under 12 years of age who are unprotected by vaccination (Memorandum on Smallpox and Vaccination, Ministry of Health).

The causation of the altered age-incidence of death from smallpox is discussed on page 398. The evidence that it is due largely to vaccination can now be given in some detail.



FIG. 61.

**Local Variations of Age-Incidence.**—The Report of the Royal Commission on Smallpox embodies a number of facts which are summarized in Fig. 61.

The proportion of *deaths* from smallpox under 10 years of age to total deaths from smallpox at all ages varied in the epidemics of this disease, which were specially investigated on behalf of the Commission, from 22·5 in Warrington to 66·6 per cent. in Leicester. The relative proportion of *cases* under 10 years of age varied from 9·8 per cent. of the total number at all ages in Warrington to 35·7 per cent. in Gloucester. In conjunction with these variations of age-incidence of smallpox we have the facts that in Warrington and Sheffield the percentage of the population unvaccinated was very small. In the 10 years 1883-92 the vaccination returns for

the union of Warrington (which includes the borough) show that 4·8 per cent. of the births were not accounted for. In London, in 1883, the percentage of births left unaccounted for was 6·5, gradually increasing to 16·4 per cent. in 1891. In Dewsbury the number not accounted for increased from 12·6 per cent. in 1882 to 37·7 per cent. in 1892. In Leicester the percentage unaccounted for increased from 43·8 in 1883 to 80·1 in 1892; in Gloucester from 10·6 in 1885 to 85·1 in 1894.

**Fatality in Vaccinated and Unvaccinated.**—The variations in age-incidence of smallpox cases and deaths, given above, occurred in outbreaks which were almost contemporary, in which considerable variations in the age constitution of the respective populations are improbable. They are very suggestive of varying degrees of protection of the respective populations by vaccination, but the evidence needs to be checked by experience of incidence of attack and of fatality from attack on vaccinated and unvaccinated respectively.

**Fatality of Smallpox.**—In fatality statistics, unless the number of facts on which the percentage is based is substantial, the percentage can carry little weight; nor are they of great value unless allowance has been made for variations in the age of persons attacked, which affect fatality greatly.

Furthermore, smallpox, like most other infectious diseases, varies in virulence and therefore in fatality in different epidemics. In the six towns already mentioned, it is not unlikely that persons over 20 years of age were in about the same average condition as regards vaccination, but the fatality among persons aged 20 and over attacked by smallpox was: Gloucester, 14·0; Sheffield (to date of census), 10·9; Warrington, 10·3; Dewsbury, 8·0; London, 7·0; and Leicester, 2·2 per cent. It becomes necessary for accuracy to contrast experiences according to age and vaccinal condition.

It has been asserted that the classification into vaccinated and unvaccinated groups cannot be relied upon as accurate. Every care was, however, taken in obtaining accurate statistics for the six above towns, and it cannot reasonably be maintained that transference from one group to the other has occurred on a scale which would materially alter the broad result shown below.

In the six towns together, 2,321 unvaccinated persons were attacked, of whom 35·4 per cent. died (Fig. 62).

Among the 8,744 vaccinated persons at all ages who were attacked, 5·2 per cent. died.

Among the unvaccinated, 1,449 attacks were at ages under 10, with a fatality of 36·0 per cent.; 870 were over 10, with a fatality of 34·3 per cent. Among the vaccinated, 589 attacks were at ages under 10, with a fatality of 2·7 per cent.; 8,131 attacks were at ages over 10, with a fatality of 5·4 per cent.

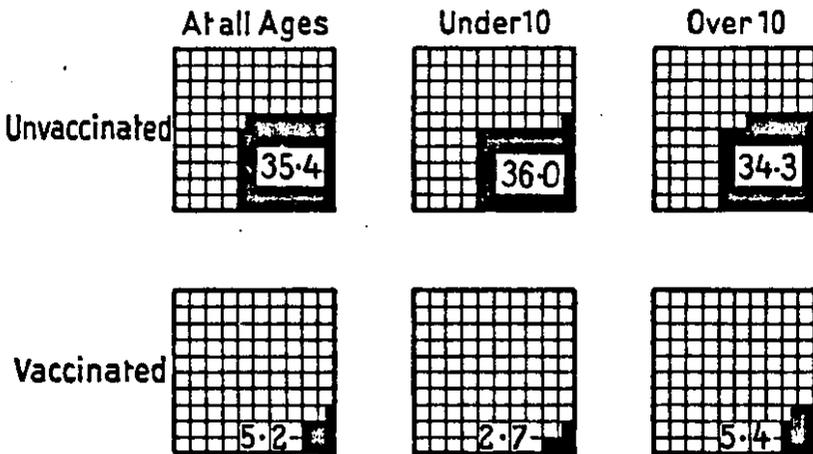


FIG. 62.—Percentage Fatality (Case-Mortality) in Six Towns among Unvaccinated and Vaccinated under 10 and over 10 Years of Age.

In the following table the detailed facts for each of six towns, as given on pages 55–58 of the Commissioners' Report, are summarized:—

	Sheffield. <sup>1</sup>	London	Dewsbury.	Warrington.	Leicester.	Gloucester.
Vaccinated cases under 10	353	110	44	33	2	26
Fatality per cent. . . . .	1·7	0·0	12·2	6·0	0·0	3·8
Unvaccinated cases under 10	228	228	174	32	107	680
Fatality per cent. . . . .	45·0	26·7	32·1	67·5	14·0	41·0
Vaccinated cases over 10	3,774	1,643	577	560	197	1,185
Fatality per cent. . . . .	5·1	2·3	2·6	6·4	1·0	10·0
Unvaccinated cases over 10	322	181	192	26	51	88
Fatality per cent. . . . .	54·2	20·0	18·7	33·8	7·8	39·7

<sup>1</sup> Up to the date of Dr. Barry's census.

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If the preceding figures are approximately true, it is clear that even with a liberal margin for possible mistakes vaccination is followed by an immense improvement in the prospect of recovering from attack of smallpox.

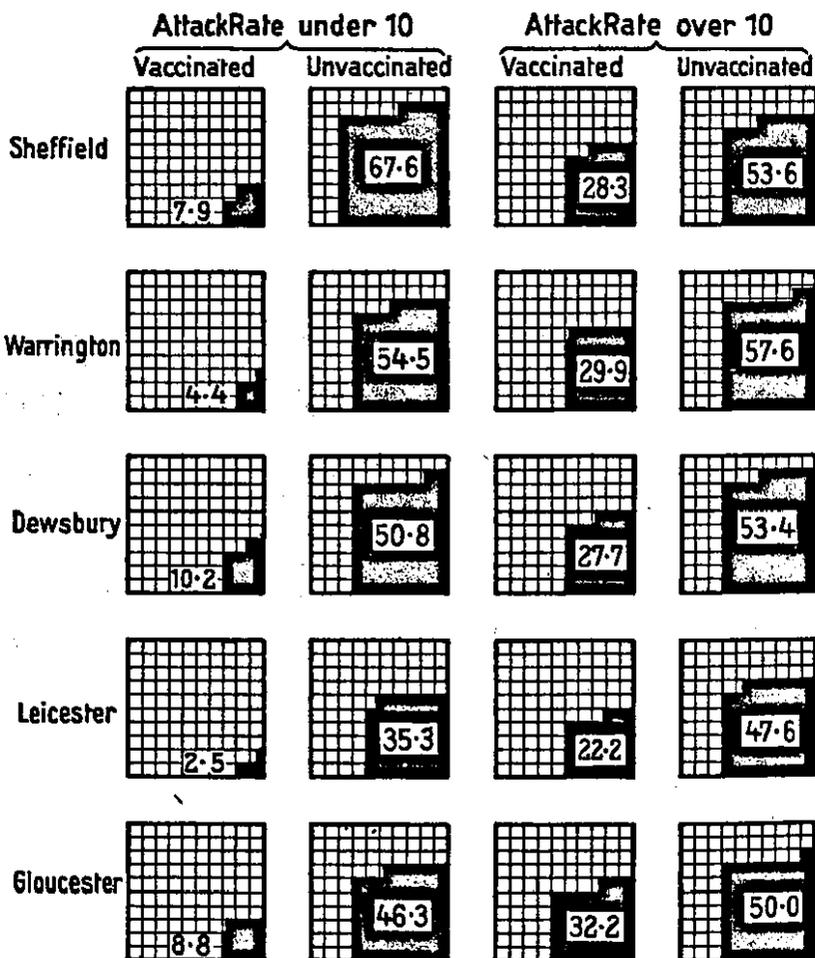


FIG. 63.—Rate of Attack per 100 Persons Living in Houses Invaded by Smallpox among Vaccinated and Unvaccinated, under 10 and over 10 Years of Age.

Gloucester and Leicester have been quoted as showing that some cause apart from vaccination can adequately account for the great variation in the smallpox fatality among the children of the above six towns, inasmuch as among Gloucester children attacked by smallpox the fatality was

39·7 per cent., and among children in Leicester was only 14 per cent., and yet in both towns there was "practically no vaccination." That this contention is sound can be shown by comparing unvaccinated children attacked by smallpox in the two towns, their respective fatalities being 14·0 and 41·0. Evidently the two epidemics varied greatly in virulence. But the contention ignores the difference between the experience of vaccinated and unvaccinated children. The facts for the two vaccinated children who had smallpox in Leicester are too small to form the basis of a comparison, but in Gloucester there is the marked difference between 3·8 and 41·0 for children under 10.

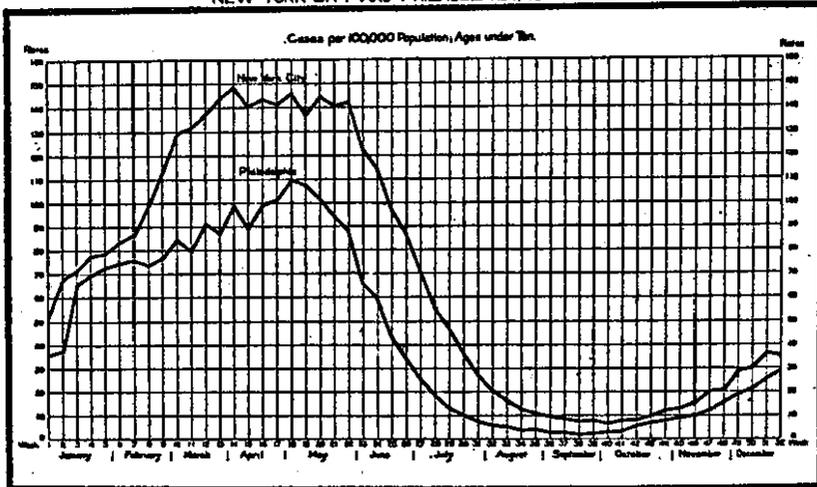
**Attack-rate among Vaccinated and Unvaccinated.**— Fig. 63, embodying the figures given on page 65 of the Report of the Royal Commission on Smallpox, shows the greater liability to attack by smallpox of the unvaccinated, and brings out the fact that the protection against attack imparted by vaccination decreases with the increasing interval after vaccination. The liability to attack depends primarily on contact with or proximity to sources of infection. Fig. 63 gives the percentage of attacks occurring *among persons living in infected houses*, classified according to vaccination and according to age under and over 10. The facts illustrated in Fig. 63 are based on all the houses from which the required information could be obtained. Their proportion to the total number of infected houses varied in different towns. Thus the information was available at Warrington for 437 out of 457 houses invaded, at Dewsbury for 544 out of 648 houses invaded, at Leicester for all invaded houses, at Gloucester for 899 out of a total of 1,097 invaded houses.

The almost complete immunity from smallpox enjoyed by re-vaccinated nurses in smallpox hospitals is valuable evidence of the protection afforded by vaccination. Thus, in the experience of the staff of the Metropolitan Asylums Board Hospitals, in the six years 1890–95, out of a staff varying from 1,160 to 2,514, the number who contracted scarlet fever, diphtheria, or typhoid fever during each year varied from 4·0 to 7·3 per cent. of the total staff; while out of a staff varying from 64 to 320, the percentage attacked by smallpox was nil, except in 1892, when it was 1·4, and in 1893, when it was 1·9. Not less convincing is the practice

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in some towns of treating recently vaccinated children with chicken-pox in wards containing smallpox patients, without any infection from the smallpox cases.

AVERAGE WEEKLY CASE RATES FROM MEASLES  
NEW YORK CITY AND PHILADELPHIA, 1906-1912



AVERAGE WEEKLY CASE RATES FROM WHOOPING COUGH  
NEW YORK CITY AND PHILADELPHIA, 1906-1912

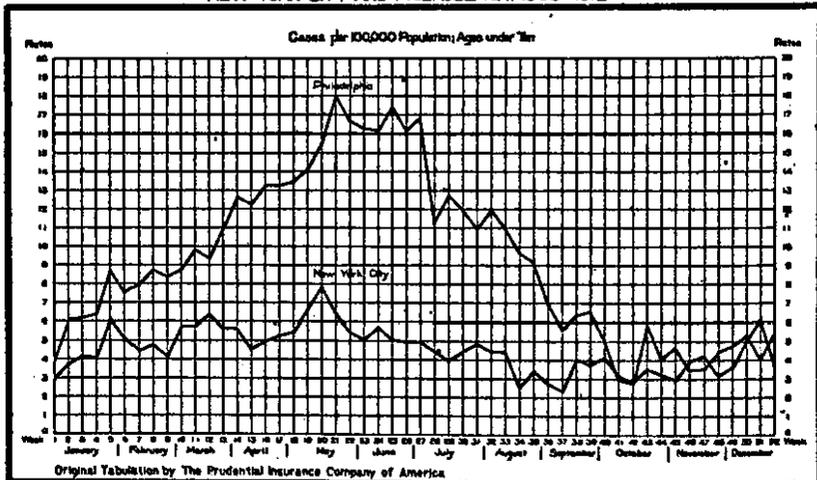


FIG. 64.—Average Weekly Case-rates from Measles and Whooping Cough 1906-12, in New York and Philadelphia. (By courtesy of Dr. Hoffman of the Prudential Insurance Company, of America.)

Measles.—The death-rate from measles has already been given (p. 394), as also the proportion of total mortality caused

by it (p. 368). The average seasonal mortality in London is shown on page 270.

The average seasonal incidence of the case-rates of measles and of whooping cough in New York and Philadelphia, based on the experience of 1906-12, is shown in Fig. 64.

The curves for measles in both cities have a similar maximum in March to June; for whooping cough the failure of the New York curve to rise materially in the spring, unlike that for Philadelphia, is interesting. These curves should be compared with those given on pages 270 and 271.

A comparison of the death-rate from measles and whooping cough in different parts of infancy follows:—

## ENGLAND AND WALES, 1921.

*Proportion of Deaths to 100,000 Births.*

	Under 4 Weeks.	4 Weeks to 3 Months.	3-6 Months.	6-9 Months.	9-12 Months.	Total Under 1 Year.
Measles .. ..	2	3	6	18	36	65
Whooping cough	6	53	60	65	68	252

The mortality from measles is highest in the second year of life. This is shown by the following table, which gives for England and Wales the proportion at different ages of total deaths from measles at all ages during the decennium 1901-10:—

Age .. ..	Under 1 Year	1-.	2-.	3-.	4-.	5-10.	10 and Upwards.	All Ages.
	22.6	40.8	16.1	8.8	5.3	5.9	0.5	100

This age-distribution of deaths might be due to the greater number attacked in the second year after birth, or to a higher fatality at this age or both. That in the experience of Aberdeen a larger number are attacked in the second than in the first year of life is shown by the diagram on page 420.

The attack-rate is about equal from the second to the seventh year of life; subsequent attacks are rare in urban

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communities, immunity having been acquired by attack or otherwise.

The value of accurately observed and recorded statistics is well illustrated by the diminishing fatality of measles and whooping cough, with each increasing year of life, as shown in Fig. 66.

The case-mortality figures are derived like the above from Aberdeen's experience.

The fatalities from whooping cough are closely similar to those of measles, and need not be separately stated. The

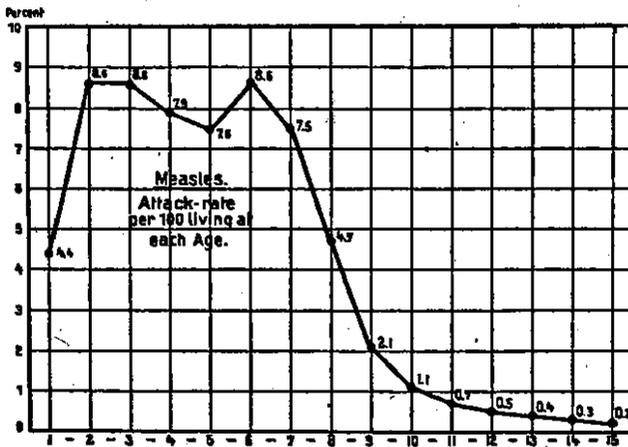


FIG. 65.—Average Annual Attack-rate from Measles per 100 Living at Each Age in Aberdeen, based on Dr. G. N. Wilson's Report on Experience of Notification of Measles in that City during the 20 Years, 1883-1902.

diagram teaches plainly the importance of postponing attack by measles (and by whooping cough) to an age when it is a less fatal disease.

In different outbreaks measles varies greatly in severity of attack irrespective of differences of age. The statistical consideration of these variations and of the general question of periodicity of attacks cannot be undertaken in the available space in this work. The reader should consult papers by Sir B. A. Whitelegge (*Epidemiological Society's Transactions*, vol. xii, 1892-3), by Dr. Ransome in earlier volumes of these Transactions, and by Dr. J. Brownlee (*Proceedings of the Royal Society of Medicine*, 1919, vol. vii, pp. 77-117).

There is a valuable critical résumé of the subject in Sir W. H. Hamer's Annual Report to the London County Council, 1919.

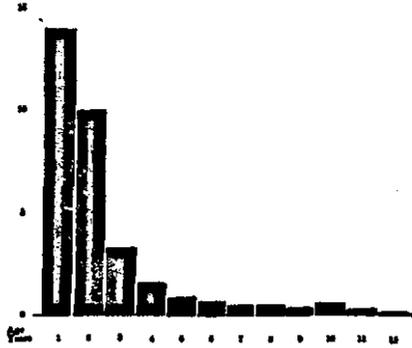


FIG. 66.—Approximate Number of Deaths per 100 Attacks from Measles at Each Year of Life up to 12 Years.

#### ILLUSTRATIONS.

**Smallpox and Vaccination.**—The Secretary of the National Anti-Vaccination League sent to the *Lancet* (November 25, 1922) a letter, giving the following summarized figures for smallpox deaths in 10-yearly periods from 1851:—

1851-1860 .. .. .	41,939
(First compulsory Vaccination Act passed in 1853.)	
1861-70 .. .. .	34,212
(Second compulsory Vaccination Act passed in 1867.)	
1871-80 .. .. .	57,046
1881-90 .. .. .	12,279
1891-1900 .. .. .	4,058
(First and most indifferent Conscience Clause, 1898.)	
1901-10 .. .. .	4,286
(Second Conscience Clause, 1907.)	
1911-1920 .. .. .	140
(Between 1908 and 1920, 3,532,176 children were exempted in England and Wales.)	

The suggestion, of course, is that with increasing reduction of enforcement of vaccination, smallpox has become less prevalent and less fatal. Such a suggestion should be accompanied by a summary of the history of smallpox when vaccination became first available (p. 409). It is possible to keep smallpox under control, after widespread protection of the majority of the population has been secured, by measures, including vaccination, which influence only persons exposed, or likely to be exposed, to infection. The above-quoted statement fails to indicate the great difference in the incidence and fatality of attack of vaccinated and unvaccinated respectively.

**Infant Mortality and Vaccination.**—In a recent anti-vaccination circular the statement is made that "the death-rate of children under one year of age did not decline to any extent until a great decrease in vaccination took place in the year 1909."

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*Observations.*—The erroneousess of this statement, and the suggestion implied in it that diminished vaccination and lowered infant mortality were related, can be seen in Fig. 12, p. 115. It is further shown in the following statement of average infant death-rates. The grouping is arranged so as to make 1909 the beginning of a new period.

### ENGLAND AND WALES.

#### *Rates of Infant Mortality per 1,000 Births.*

Period .. .. .	1886-90 (5 years).	1891-95 (5 years).	1896- 1900 (5 years).	1901-05 (5 years).	1906-08 (4 years).	1909-13 (5 years).	1914-20 (5 years).
Death-rates .. .. .	145	151	156	138	123	109	98
Percentage Increased (+) or decreased (-) as compared with the pre- ceding period.. .. .	—	+4.1	+3.3	-11.5	-10.8	-11.3	-10.0

## CHAPTER XXXVI

### DIARRHOEAL DISEASES AND ENTERIC FEVER

In the English Registrar-General's Annual Report for 1920, in accordance with the International List (1911) as adapted for use in England and Wales, diarrhoea and enteritis was subdivided into—

- (a) Infective enteritis.
- (b) Diarrhoea—not returned as infective.
- (c) Enteritis—not returned as infective.
- (d) Gastro-enteritis—not returned as infective.
- (e) Dyspepsia—under 2 years.
- (f) Colic.
- (g) Ulceration of intestines.
- (h) Duodenal ulcer.

(These were Numbers 104 and 105 in the old list.)

In the new International List (1921) the corresponding numbers are 113, 114, and headings are—

Diarrhoea and Enteritis.

- (a) Ulceration of the intestines (not including duodenal ulcer).
- (b) Colitis.
- (c) Other diseases included under 113 and 114.

It is evident that much caution is needed in classifying deaths returned as due to diarrhoea or to enteritis. In past official reports many changes have occurred in the causes of deaths included among diarrhoeal diseases. Cholera is not included; in the revised International List "Asiatic Cholera" and "Cholera Nostras" still appear separately, although cholera nostras should be merged with diarrhoea. "Cholera Infantum" is classed with diarrhoea. The headings in the International List are:—

- A, Diarrhoea and Enteritis (under 2 years of age).
- B, Diarrhoea and Enteritis (over 2 years of age).

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A is usually regarded as synonymous with the acute infantile summer diarrhoea which occur epidemically in hot summers; and comparisons of death-rates for successive years should be based on deaths under A stated per 1,000 births.

In the short International List (p. 179) only deaths from "diarrhoea and enteritis under 2" are separately stated; in the complete list these and deaths registered as from diarrhoea and enteritis are separately tabulated. Of the total deaths registered as diarrhoea and enteritis in England in 1920, 65.3 per cent. occurred under one year and 72.8 per cent. under 2 years of age; and as it is probable that many deaths recorded under this heading at higher ages are different in nature, the rule of separation adopted in the International Classification is a sound one. If there is complete registration of births, these deaths under 2 should be stated per 1,000 births.

Further particulars as to changes in classification of deaths from diarrhoea are given in the Registrar-General's Annual Report (Decennial Supplement), 1901-10, p. lxxxvii, and an extensive study of epidemic diarrhoea by the author was contributed to *Public Health*, December 1899.

"Diarrhoeal Diseases" is a heading which has appeared for many years in the Registrar-General's reports. It includes a few more items than "Diarrhoea and Enteritis," but its general course is similar to that of these diseases.

ENGLAND AND WALES.  
*Death-rates from Diarrhoeal Diseases.*

	At all Ages (standardized) per 100,000 of Total Population.	At Ages under 5, per 100,000 of Population of that Age.	At Ages 5-10, per 100,000 of Population of that Age.
1871-80 ..	97	619	13
1881-90 ..	76	491	11
1891-1900 ..	107	780	11
1901-10 ..	87	621	14
1911-15 ..	70 <sup>1</sup>	?	?
1916-20 ..	35 <sup>1</sup>	?	?

<sup>1</sup> Not standardized.

In 1911 occurred an exceptionally severe epidemic of diarrhoea (death-rate 128 per 100,000); the nearest approach to this in recent years was 116 per 100,000 in 1906. Since

## DIARRHOEAL DISEASES AND ENTERIC FEVER 425

1911, the highest diarrhoeal death-rate has been 69 in 1913 and 27 in 1910.

In Fig. 67 the general course of total infant mortality and of the part of it due to diarrhoeal diseases since 1883 is shown.

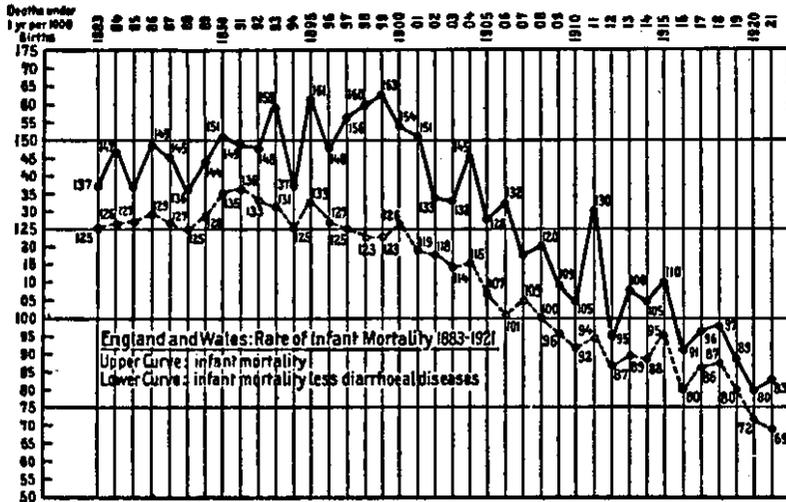


FIG. 67.—England and Wales: Infant Mortality per 1,000 Births, 1883–1921. Total Infant Mortality and Infant Mortality due to Diarrhoeal Diseases under 1 Year. (The distance between the two curves shows the diarrhoeal mortality.)

The decrease in diarrhoeal diseases in successive quinquennial periods in the course of infant mortality is seen in the following table:—

### ENGLAND AND WALES.

*Decrease or Increase per cent. of (a) Diarrhoeal Infant Mortality, (b) Mortality from All Other Causes of Infant Mortality in Quinquennial Periods.*

Period.	(a) Diarrhoeal Diseases.	(b) Other Causes of Infant Mortality.
1871–75 to 1876–80 ..	–15	– 3
1876–80 to 1881–85 ..	–12	– 3
1881–85 to 1886–90 ..	+22	+ 3
1886–90 to 1891–95 ..	+18	+ 3
1891–95 to 1896–1900 ..	+55	– 4
1896–1900 to 1901–05 ..	–26	– 8
1901–05 to 1906–10 ..	–21	–14
1906–10 to 1911–15 ..	+ 6	– 8
1911–15 to 1916–20 ..	–52	–10

Diarrhœal diseases are more prone to variations than other causes of infant mortality in the aggregate; but they are among the most amenable to special hygienic precautions.

The curves in Fig. 67 being based on figures for each single year, the years in which diarrhœa was exceptionally prevalent can be seen.

The highest diarrhœal death-rates (that is, in this table deaths from diarrhœal diseases under 1 year per 1,000 births)

prior to 1900 were	28 in 1893
	37 in 1898
	40 in 1899
since 1900 were	32 in 1901
	31 in 1906
	36 in 1911

Since 1911 this diarrhœal death-rate has never exceeded 19 per 1,000 births, and in 1912-20 averaged 12 per 1,000 births.

**Causation of Summer Diarrhœa.**—The amount of epidemic or summer diarrhœa varies directly with the summer temperature and inversely with the amount of rainfall in the summer months. In recent years diarrhœa has been controlled to an extent which means that the response to climatic conditions is on a lower grade than formerly. As both the above climatic factors usually concur, and are largely interdependent, it is difficult and scarcely necessary to apportion their respective value. This subject is dealt with more fully in *Public Health*, December 1899. Dr. O. H. Peters's contribution on "Season and Disease" (*Proceedings of the Royal Society of Medicine*, 1908-9, vol. iii, pp. 1-58) should also be read.

There is much evidence as to the association of diarrhœa with infection of domestic source.

In my report to the Local Government Board on "Child Mortality," 1916 (Cd. 8496), will be found numerous illustrations of the association between excessive diarrhœa and the insanitary conditions often associated with housing of the industrial classes. The contrasts given below illustrate the extreme preventibility of diarrhœa:

LOWEST AND HIGHEST DEATH-RATES IN 1911-14 FROM DIARRHŒAL DISEASES AT AGES 0-5, STATED PER 1,000 BIRTHS.

Aggregate rural districts ..	15	Great Towns:—	
Aggregate great towns ..	32	Reading .. ..	14
Aggregate smaller towns ..	28	Burnley .. ..	55
Metropolitan Boroughs:—		Smaller Towns:—	
Hampstead .. ..	11	Brighouse .. ..	9
Shoreditch .. ..	51	Farnworth .. ..	74

## DIARRHOEAL DISEASES AND ENTERIC FEVER 427

Similar and more recent contrasts are shown for the *death-rate from diarrhoea and enteritis under 2 years per 1,000 births* (Table 13 of the Annual Report of the Registrar-General, 1920).

Administrative Counties :—		County Boroughs :—	
Berkshire .. .. .	1·31	Ipswich .. .. .	1·99
Cambridgeshire .. ..	1·49	Eastbourne .. ..	2·03
Durham .. .. .	13·84	Kingston-upon-Hull ..	21·71
London .. .. .	9·59	Middlesbrough .. ..	24·60
Yorkshire, West Riding ..	13·61	Barnsley .. .. .	28·62

**Diarrhoea and Enteritis in the United States.**—Owing to incomplete registration of births in some of the death-registration States, the diarrhoeal death-rates in the death-registration area in the Federal statistics are stated in terms of the entire population.

### REGISTRATION AREA, UNITED STATES.

#### *Diarrhoea and Enteritis Under 2 per 100,000 of Population.*

	1906-10.	1911.	1912.	1913.	1914.	1915.	1916.	1917.	1918.	1919.	1920.
U.S.A.	96·2	77·5	70·4	75·8	68·1	59·8	65·8	64·8	58·7	44·2	44·0

Drs. J. Brownlee and M. Young ("The Epidemiology of Summer Diarrhoea," *Proceedings of the Royal Society of Medicine*, August 1922) favour the view that summer diarrhoea is a mixture of two epidemics, an early and a later type; for the study of this hypothesis the reader is referred to the above paper. There is some likelihood that a number of deaths recorded under diarrhoea and enteritis are really dysentery. The proportion of these deaths to total deaths from diarrhoea is probably small.

**Dysentery.**—Under this heading each year a considerable number of deaths are annually returned in England and Wales. Prior to the war the actual annual numbers varied since 1906 from 194 to 296. In 1914 the number was 275. In the next seven years the successive numbers were :—

612, 548, 897, 838, 435, 254, 261 (in 1921),

showing a marked increase during the war. Many of the cases during the war were of imported disease. As many as 25 per cent. of the total male and 79 per cent. of the total female deaths from dysentery occurred in lunatic asylums.

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There is little doubt that a considerable number of deaths returned as "ulcerative colitis" are due to dysentery.

In the Registrar-General's Annual Report for 1921 deaths from dysentery are subdivided into amœbic, bacillary, and other or unspecified, 233 out of the total 261 being returned under the last-mentioned heading.

**Enteric Fever.**—The incidence of enteric fever as measured by case-rates is given on page 146; its age-incidence on page 395 and its present proportionate weight in total mortality on page 368.

### ENTERIC FEVER.

*Average Annual Death-rate per Million Persons.*

	1901-5.	1906-10.	1911-15.	1916.	1917.	1918.	1919.	1920.	1921.
U.S. Registration Area ..	320	256	166	138	195	126	92	78	?
England and Wales ..	113	70	47	30	28	26	16	14	16

The average rates, although convenient as giving a bird's-eye view, conceal epidemic peaks, some of which are given in the table on page 389. The general course in both countries is highly satisfactory; the disease approaches the point of almost complete disappearance from England and Wales, which has already been reached by typhus fever. In England the enteric fever rate is highest in the smaller towns. It is much higher in the north than in the south of England. The official notification returns show that the decline in mortality is almost entirely due to decline in prevalence of the disease, the fatality in England in 1911-20 having varied only between 17.6 and 19.4 per cent.

The epidemiology of enteric fever cannot be discussed in detail; but reference may be made to conclusions based on curves of annual incidence of typhoid mortality. Compare, for instance, the two charts for Lawrence (1887-1909) and Lowell, Massachusetts (1891-1905), taken from a valuable address by Dr. A. J. McLaughlin, of the United States Public Service.

The rough coincidence of the abrupt decline in the curve for Lawrence and the installation of the filter plant for its water supply appears to show a causal relation between the two facts, though some decline of enteric occurred prior

## DIARRHOEAL DISEASES AND ENTERIC FEVER 429

to the installation. The Lowell curve illustrates the difficult case in which the greater part of the decline of enteric had occurred before the change of water supplies, and in which therefore the information supplied by the curve needs to be supplemented by such additional facts as the following: (1) What other sanitary improvements had been initiated, especially prior to the altered water supply? (2) Was the improved water supply supplied to all parts of the city? (3) If not, what was the incidence of enteric in parts not so

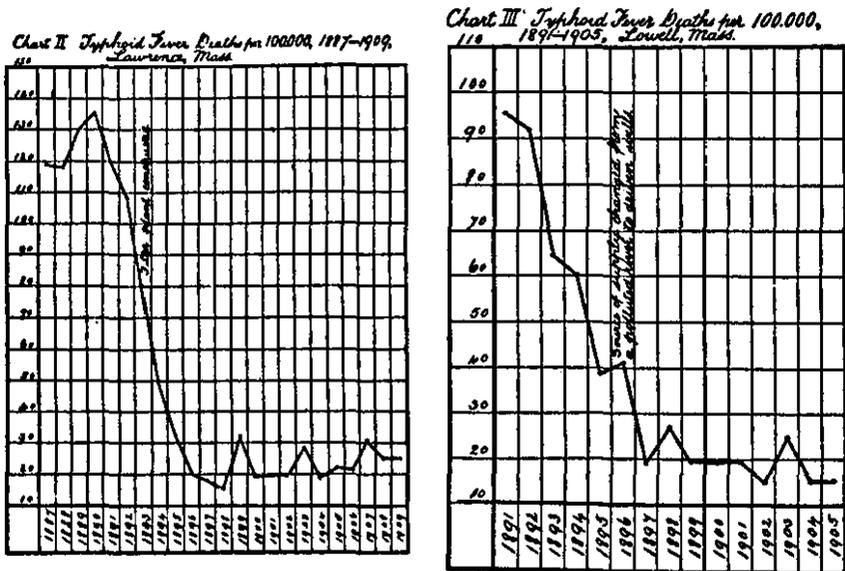


FIG. 68.—Death-rate from Enteric Fever per 100,000 in Lawrence and Lowell.

supplied as compared with the rest of the city? (4) Was the fall of enteric fever fairly equal in different parts of the city provided with the improved supply; and did the improvement begin at the same time in all those areas? (5) Was there a similar fall in other cities in which the water supply for the entire city had remained uniform throughout? For additional information the original paper should be consulted.

The importance of comparing local curves with curves for other areas, when the supposed influence of a given factor on illness is under consideration, cannot be exaggerated. A good illustration is furnished by the following example from a contribution on "Typhoid Fever in the South" (*Old*

*Dominion Journal of Medicine and Surgery*, November 1908), by Drs. E. C. Levy and A. W. Freeman.

The influence of adequate storage of drinking water in reservoirs in reducing its capacity for causing enteric fever is well known. In the diagram below is shown the disappointing experience of Washington, in view of increasing storage capacity and filtration of water. The true significance of the experience is elucidated by the comparison with that of Richmond, the water supply of which was unaltered throughout the 28 years. The two experiences from 1885 onwards

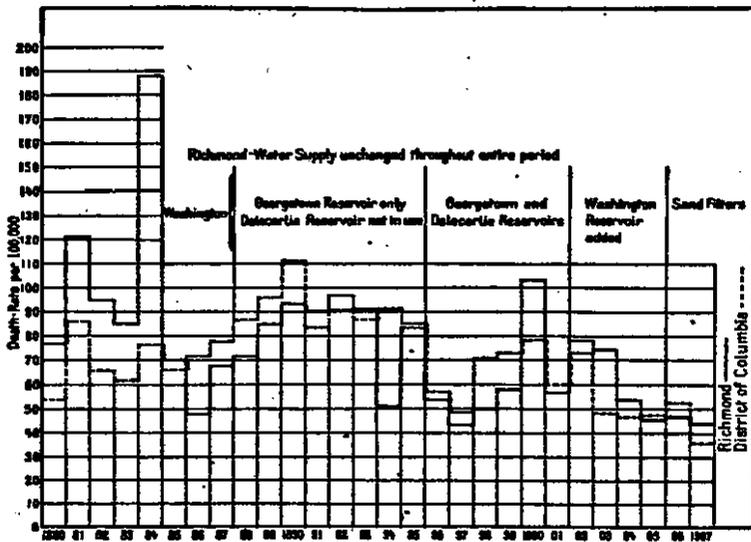


FIG. 69.—Enteric Fever Death-rates, 1880-1907, in Richmond, Va., and Washington, D.C.

run on similar lines, and it is highly probable that similar conditions in both cities, excluding water supply at its source, continue to cause a considerable amount of endemic typhoid. The nature of these circumstances could not be further ascertained by reference to mass statistics for each city. An epidemiological inquiry into the circumstances of each case was needed to enable accurate comparisons of the circumstances of those who escaped attacks to be studied.

#### Hazen's Theorem and the Mills-Reincke Phenomena.

—These were fully discussed in a paper in 1910 by Sedgwick and MacNutt (*Journal of Infectious Diseases*, August 1910), to which reference should be made for the complete evidence.

## DIARRHOEAL DISEASES AND ENTERIC FEVER 431

Mr. H. F. Mills found in 1893-4 that after purification of the water supply of Lawrence, Massachusetts, the reduction in death-rate was not confined to enteric fever. Dr. J. J. Reincke made a similar observation in Hamburg; and in 1904 Mr. A. Hazen, extending these observations, stated that "where one death from typhoid fever has been avoided by the use of better water, a certain number of deaths, probably two or three, from other causes have been avoided." The reduction of diseases other than enteric fever doubtless occurred, and the only question is as to whether the purified water supply was partially or wholly responsible for this. Dr. C. V. Chapin has pointed out that the period 1889-94 was one of influenza epidemics, and that reduction of the death-rate from pneumonia, phthisis, etc., might reasonably be expected to follow this experience. He refers to the experience of Albany in which the death-rate from acute respiratory diseases fell precipitately after 1891, eight years before the water supply of Albany was filtered. There is the further point that a heavy death-rate from enteric fever means an increased mortality from other causes among those who survive an attack of this disease, as Dr. Dublin has shown in insurance experience. It is not unlikely, however, that water supply may be responsible for reduction in some causes of mortality, the association of which with water-infection has not been proved. There is needed study of a series of comparative historical specific death-rates for communities in some of which water purification has taken place and in others not.

## CHAPTER XXXVII

### SCARLET FEVER AND DIPHThERIA

THESE two diseases were not distinguished in the Registrar-General's reports until 1855, and there can be little doubt that in the earlier years following 1855 there was confusion between them in the death returns. The general course of events as recorded is shown in Fig. 70.

It is likely that the earlier scarlet fever was oftener complicated by diphtheria than the scarlet fever in recent years, though many of the malignant sore throats occurring in scarlet fever in the earlier years were non-diphtheritic.

The general course of the two diseases in groups of years is summarized in the following table, which, however, disguises the actual heights of each successive epidemic, shown in Fig. 70.

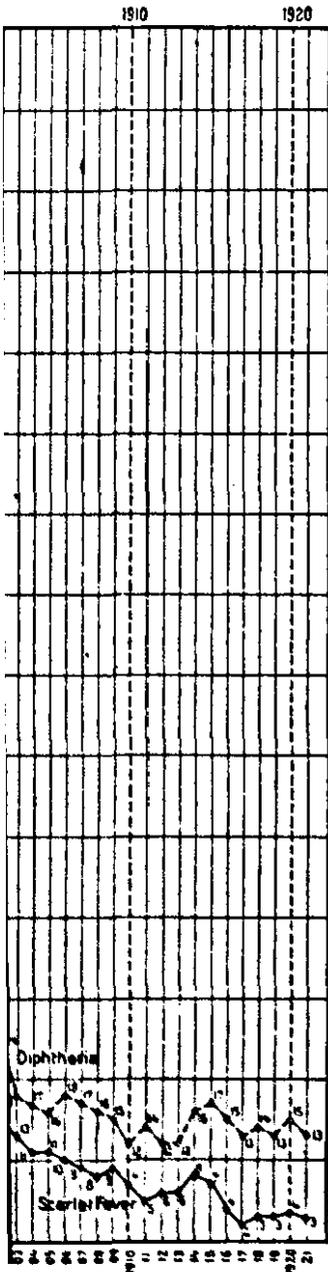
#### ENGLAND AND WALES.

*Average Annual Death-rates per Million (Standardized except for 1911-20).*

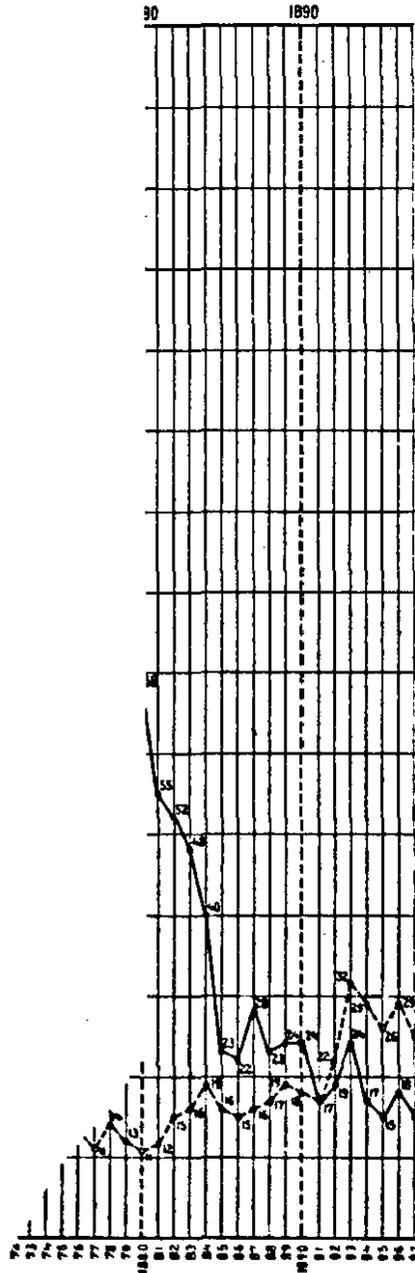
	1861-70.	1871-80.	1881-90.	1891-1900.	1901-10.	1911-15.	1916-20.
Scarlet Fever ..	857	625	300	152	109	61	32
Diphtheria ..	166	108	148	254	183	140	142

**Scarlet Fever.**—Scarlet fever during the registration period has become a much less serious cause of mortality, and now is almost insignificant when compared for instance with whooping cough or measles. The influence of cycles of increasing and decreasing virulence of scarlet fever is mentioned on page 434.

The proportion of total deaths from scarlet fever and from diphtheria which occur at different ages is given on page 396, the death-rates from these diseases at different ages on page 394, and the year of minimum and maximum mortality



(o--o--o) and Scarlet Fever



also: Death-rates per 100,000 from Diphtheria (●—●—●) in the Years 1855 to 1920

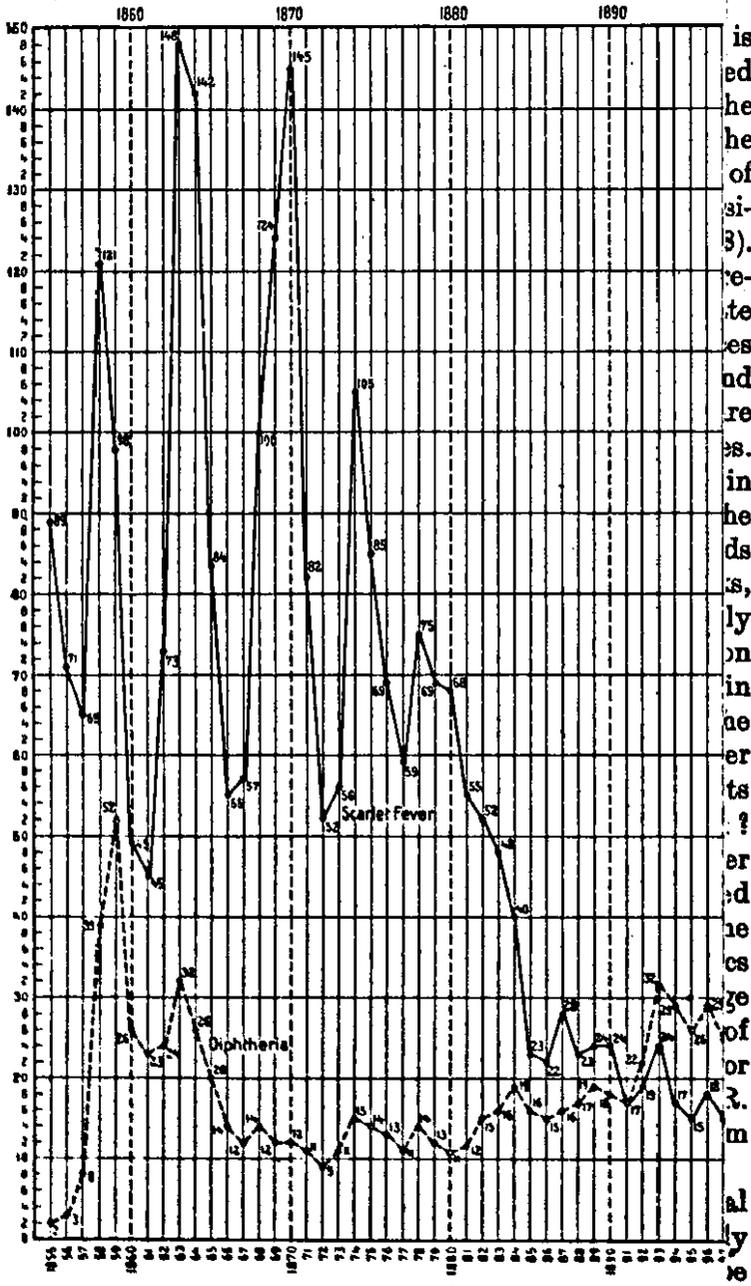


FIG. 70.—England and Wales: Death-rates per 100,000 from Diphtheria (●—●—●) in the Years 1855 to 1905

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#### ENGLAND AND WALES.

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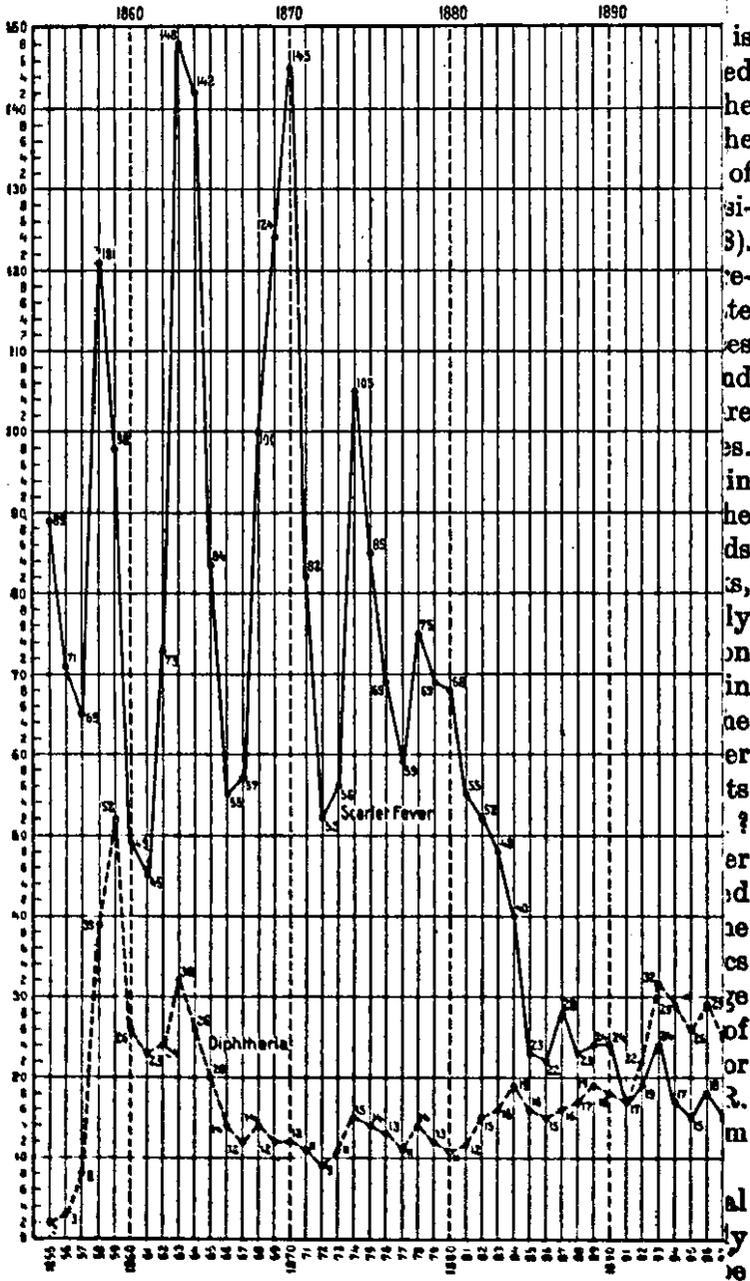


FIG. 70.—England and Wales: Death-rates per 100,000 from Diphtheria (●—●—●) in the Years 1855 to 1895

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from each disease on page 389, and in Fig. 72 on page 435 the case-rates for the last 11 years are given.

The causation of the reduced fatality of scarlet fever is a subject of controversy. It may reasonably be ascribed in large part to the improved hygienic conditions, to the removal of the more severe cases to hospitals, and to the general precautions which must have reduced the dosage of infection as well as its occurrence. There remains the possibility of recurrence of a more virulent type of disease (p. 438).

The Utility of Isolation Hospitals as a means of preventing the spread of infection is difficult to demonstrate statistically owing to the complexity of circumstances involved. Their value as centres of treatment is beyond doubt, as is also their utility in saving domestic expenditure and the inconvenience of quarantine and other measures. Although they do not succeed in urban communities in stopping the disease, in individual families removal of the first patient, like his strict isolation at home, often succeeds in preventing further attacks. Such secondary attacks, failing isolation, may not be so numerous as is usually supposed; and in this respect the need of hospital isolation for scarlet fever may have been exaggerated. But in attempting to ascertain the truth as to this, based on the experience of different towns, there are many pitfalls. Other circumstances must be fairly equal. Isolation of patients is not the only factor. Are the patients all promptly notified? Is isolation promptly effected? Are contacts kept under equally strict surveillance, and overlooked cases searched for with equal assiduity in the compared towns? Were the compared towns experiencing the same number of epidemics during the period of comparison? Comparisons of average rates are treacherous in this respect. For an illustration of this see a valuable paper on "How far do Statistics Prove or Disprove the Utility of Hospital Isolation?" by D. J. R. Kaye (*Public Health*, May 1902), from which the diagram on page 434 is taken.

Group I comprised towns which had isolated in hospital 64 per cent. of their known cases, while in Group II only 16 per cent. had been isolated. If the period 1891-99 be taken, the towns in Group II had less scarlet fever, while if the entire period 1887-1901 is included, the towns which

isolated the majority of their cases fared best. The factors involved are too numerous to enable hospital isolation to be thus appraised, and for some of the factors statistical tests are unavailable. Another possibility which Dr. Chapin has suggested is the probable influence of hospital isolation in preventing the spread of severer types of scarlet fever, and thus enabling the preponderantly milder types to cause immunity. In the past, recurrent virulence of scarlet fever has been observed, irrespective of the influence of hospital treatment; but the cause of diminished virulence suggested above, although it cannot at present be statistically proved, is one to have in mind.

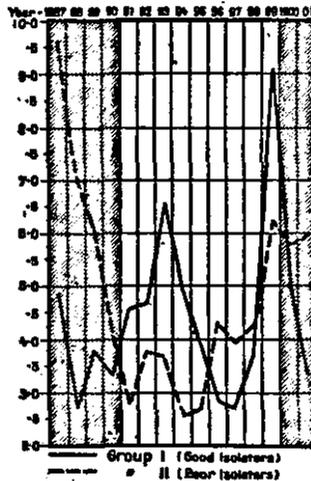


FIG. 71.—Comparison of the Case-rate of Scarlet Fever in Two Groups of Towns, 1887-1901, and 1891-99, showing the Fallacy of the Comparison for 9 Years only, omitting the Shaded Parts.

Dotted lines—towns with little hospital isolation.

Black lines—towns with much hospital isolation.

Many international figures as to scarlet fever will be found in Dr. J. W. Wilson's monograph on the subject (*Public Health*) and in a contribution by me (*Epidemiological Society Transactions*, February 15, 1901).

The student should consult Sir W. Hamer's Report to the London County Council, 1914, for an account of his hypothesis of the correlation between the incidence of flea-marks and the curves of weekly cases of scarlet fever in school children. His Report for 1920 (p. 86) gives further particulars of the coincidence between the two curves.

**Diphtheria.**—The distribution of diphtheria historically and geographically is described in *Epidemic Diphtheria: A Research on the Origin and Spread of the Disease from an International Standpoint* (1898), by the present author, and in *The Bacteriology of Diphtheria* by various authors

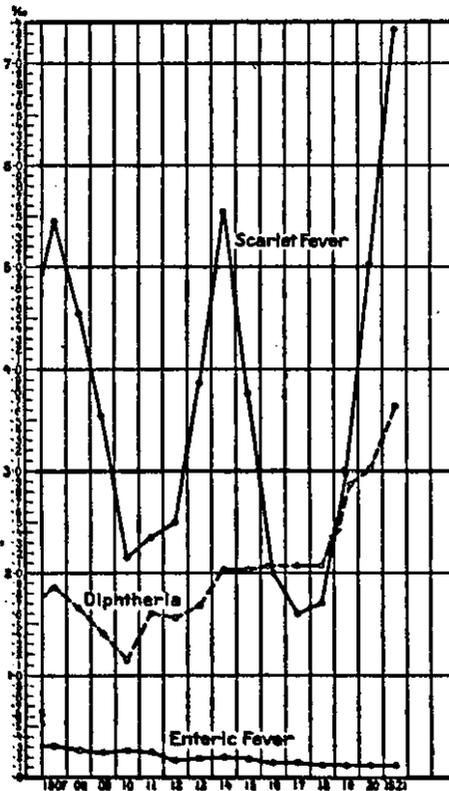


FIG. 72.—Annual Incidence of Notified Cases of Scarlet Fever, Diphtheria and Enteric Fever per 1,000 of Population in London, 1907-1921. (From the Annual Report of the Metropolitan Asylums Board.)

(Cambridge University Press, 1908), to which reference may be made.

Prior to the year 1898 the death-rate and the variations in the death-rate from diphtheria were enormously greater in the United States than in England. Thus the highest death-rate in England was not much more than half the lowest death-rate in Massachusetts.

The experience of some of the great towns brings out this

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point. The comparison given below ends with 1897, and the earlier dates vary with the length of available records :—

DIPHTHERIA.

Death-rates per 100,000.

	Highest.	Lowest.
Boston (1861-95) .. ..	218 in 1881	35 in 1872
Providence (1868-95) .. ..	357 in 1877	25 in 1868
New York (1868-95) .. ..	276 in 1877	68 in 1868
St. Louis (1868-95) .. ..	357 in 1887	25 in 1868
Buenos Ayres (1888-95) .. ..	388 in 1888	61 in 1895
England and Wales (1859-94) ..	52 in 1859	9.4 in 1872
London (1859-94) .. ..	76 in 1893	8 in 1872
Eastbourne (1883-96) .. ..	229 in 1890	15 in 1894
Portsmouth (1861-96) .. ..	159 in 1881	4 in 1867
Birmingham (1872-96) .. ..	37 in 1895	9 in 1891
Salford (1860-95) .. ..	106 in 1889	6 in 1873
Berlin (1869-96) .. ..	242 in 1883	34 in 1896
Christiania (1860-93) .. ..	329 in 1887	17 in 1871

In the following table some more recent death-rates from diphtheria are shown :—

DIPHTHERIA.

Death-rates per 100,000.

Per 100,000 Population.	Average 1906-10.	1911.	1912.	1913.	1914.	1915.	1916.	1917.	1918.	1919.	1920.
Philadelphia	34	31	24	22	19	19	23	25	22	24	23
Baltimore..	15	12	16	15	15	13	10	9	11	20	14
Boston	27	20	16	28	24	30	26	38	30	20	20
New York City ..	39	26	23	27	20	24	20	22	23	22	19
London	9	14	10	9	16	16	14	14	16	18	22
Birmingham..	18	13	12	19	30	15	13	13	18	14	22
Manchester	17	12	13	14	15	14	9	8	8	5	9

The general course of diphtheria, as also of scarlet fever and enteric fever, as shown by the number of notified cases per 1,000 of population, is indicated in Fig. 72 for 15 years.

There is shown in the last few years a rising epidemic of diphtheria. The course of diphtheria in England (Fig. 70) shows smoothed curves, as epidemic maxima in different

districts do not correspond in time. The experience of London in the period 1869 to 1911, which also is somewhat composite, consisting of the separate experience of many metropolitan areas, differs from that of England as a whole, as is shown by comparison of the following figure with Fig. 70.

Diphtheria.

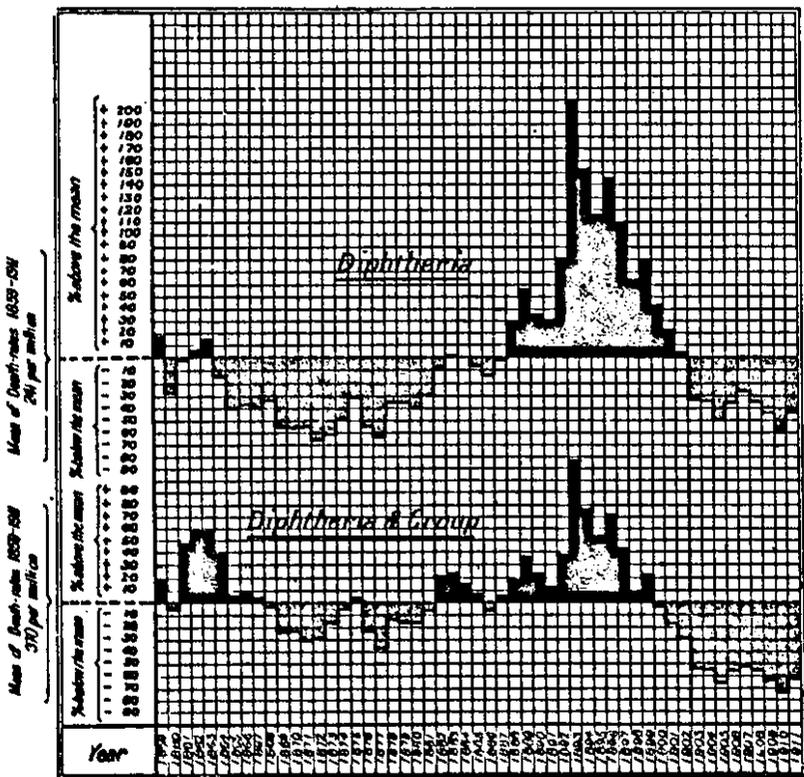


FIG. 73.—Death-rates from Diphtheria and from Diphtheria plus Croup in London, 1859-1911, Stated as Annual Percentage Deviations from the Mean for the Entire Period (from Sir S. Murphy's Annual Report to the London County Council, 1911).

For the whole of England and Wales the highest death-rate from diphtheria and croup (65 per 100,000) occurred in 1858-60; in London the maximum death-rate occurred in 1893. Both curves show two great epidemics, the first culminating in 1859 and the second in or about 1893. The

rise shown in Fig. 70 is on a much smaller scale, the highest death-rate for England and Wales being 17 per 100,000 in 1916, and in London 22 in 1920.

The available statistical evidence shows that diphtheria both in America and Europe is an endemic disease, subject to occasional epidemic increases, and to less frequent pandemic prevalence on a large scale.

The recorded death-rate from diphtheria in pre-antitoxin days was smallest in Great Britain, Ireland, and New Zealand; the endemic mortality was much heavier in European continental cities, and still more so in American cities than in this country. The evidence collected by me showed no instances of a succession of wet years in which diphtheria was epidemic, and in most instances epidemics of diphtheria were on the largest scale when three or more years of deficient rainfall immediately followed each other. Furthermore, where the comparison was practicable, it was found that in a given country the amount of diphtheria was greatest in the parts having the least rainfall. The coincidences summarized above are necessarily based on the statistical experience of a limited number of years; but they agree with similar results obtained for rheumatic fever and scarlet fever.

**Periodic Changes in Fatality.**—Marked changes have occurred in the virulence and consequent fatality of *scarlet fever* within registration periods. Prior to this, Graves of Dublin (*Clinical Medicine*, 1843, p. 492) states that in Dublin in 1801–4 scarlet fever was terribly fatal, that in the next 27 years it “was always in the simple or mild form,” and that it again became destructive in 1834–5. The experience of Christiania between 1861 and 1897 showed great increases and decreases in fatality, the maximum fatality occurring in 1868. Further evidence is given in the paper by me quoted on page 434. Although variations in completeness of notification may have occurred, the evidence appears to justify the conclusion that ebbs and flows occur in the virulence of the scarlet fever virus or of infections intimately associated with it.

Diphtheria, as shown in the table on page 390 and in Fig. 55, has become much less fatal per 100 attacked by it. The change in fatality might be—(a) a periodic phenomenon, like

that in scarlet fever, the extent of periodic change in the prevalence and fatality of both diseases, due to unknown causes, having been accentuated by better medical treatment; (b) due to the introduction of diphtheria antitoxin as a remedy; or (c) due to both of these factors in unknown proportions.

**Influence of Antitoxin.**—That the therapeutic use of diphtheria antitoxin has greatly reduced the fatality of attack by diphtheria is certain.

Many observations show the value of antitoxin, which is proportional to the promptitude of administration. Kolmer, as quoted by Fitzgerald, gives the following results, based apparently on a large series of cases, though the number is unstated.

PHILADELPHIA, Pa., 1910-14.

*Case Mortality per 100 Cases, according to the Duration of the Disease when Antitoxin was given.*

Day.	1st.	2nd.	3rd.	4th.	5th.	6th.	7th or Later.
Deaths per 100 cases ..	1.1	5.6	6.8	7.7	9.2	9.3	11.4

As these were contemporaneous cases, no fallacy arises from time variations in virulence of the disease. The use of antitoxin dates from Roux's announcement of its value in 1894. In 1889-94 the case mortality in metropolitan hospital treated cases varied between 40.7 and 29.3 per 100 cases. In 1896 it had become 21.2, in 1904 10 per cent., and in the years 1916-20 it averaged 8.0 per cent. Here the possibility of time variation in virulence arises, though against this is the continuing high fatality in cases in which neglect to administer antitoxin arises. Much statistical confusion has arisen in attempts to show that if the death-rate from diphtheria increases in a population notwithstanding antitoxin treatment of patients, it follows that antitoxin treatment is valueless. Obviously, with a rising epidemic of diphtheria, it may happen that the number of deaths per 100 attacked may be decreasing, as the result of prompt administration of antitoxin, although the number of cases increases and the number of deaths increases, and with it the death-rate per 1,000 persons in the community.

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**Susceptibility to Attack.**—The Schick test has made it possible to ascertain the proportion of persons at different ages who are susceptible to diphtheria, and the following table from Park (*Public Health and Hygiene*, 1920) gives some of the results already obtained in New York, based on tests applied to over 20,000 persons:—

	Age at Birth.	0-3 Months.	4-6 Months.	7-9 Months.	9-12 Months.	1-2 Years.	2-3 Years.	4-5 Years.	6-10 Years.	11-20 Years.	Over 20 Years.
Average susceptibility per cent.	10	15	30	60	75	75	65	40	30	25	20
Per cent. variation in range of positive Schick reaction	0-15	0-15	20-30	60-74	65-75	60-78	50-70	15-50	8-40	5-40	5-42

The ascertainment of this reaction makes it possible to immunize the susceptible by administration of toxin-anti-toxin.

With these figures should be compared the valuable tables given in reports for Providence, R.I., by Dr. C. V. Chapin, showing the proportion attacked at different age-periods in families exposed to the infection of diphtheria. Similar facts are given by him for scarlet fever.

**Diphtheria and Croup.**—There was some confusion between diphtheria and croup in the earlier statistical returns. Some deaths returned as laryngitis may also have been due to diphtheria. The remarkable reduction in the death-rate from croup confirms the view that most of it was really diphtheria.

### ENGLAND AND WALES.

*Average Annual Death-rate per Million from Diphtheria, Croup, and Laryngitis in Groups of Years.*

Period.	Diphtheria.	Croup.	Laryngitis.
1858-60 <sup>1</sup>	372	275	?
1861-70	166	211	47
1871-80	108	144	44
1881-90	148	128	51
1891-1900	254	50	44
1901-10	183	13	34
1911-15 <sup>1</sup>	140	1	25
1916-20 <sup>1</sup>	142	1	20

<sup>1</sup> All the death-rates except for the years marked <sup>1</sup> are standardized.

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The deaths from membranous laryngitis (not diphtheritic) are omitted from consideration, as they are too few to affect the question of possible transfer. Under the revised international classification Croup has been transferred to Laryngitis.

## CHAPTER XXXVIII

### MORTALITY FROM TUBERCULOSIS

TUBERCULOSIS is so often the subject of statistical investigation, and the conclusions derived from these statistical studies are so discrepant, furthermore this disease has such great public health importance, that a specially detailed consideration of it is justified. In the space at disposal only the salient points can be given, and reference should be made to the English and other official Government reports, and to various local reports for further data.

**Economic and Social Loss from Tuberculosis.**—In the following table are given the death-rates and proportionate mortality from tuberculosis and other chief causes of death in England and Wales, and in the registration area of the United States in the year 1920 :—

Cause of Death.	Death-rates per 100,000 of Population.		Deaths Under Each Heading per 1,000 Deaths from All Causes.	
	Registration Area, U.S.A., 1920.	England and Wales, 1920.	Registration Area, U.S.A.	England and Wales.
Measles .. .. .	9	19	7	15
Whooping cough .. .. .	13	12	10	9
Influenza .. .. .	71	28	54	23
Phthisis, pulmonary tuberculosis .. .. .	101	87	77	72
Other forms of tuberculosis .. .. .	13	26	10	19
Cancer .. .. .	83	116	64	94
Organic heart disease .. .. .	142	141	109	105
Bronchitis .. .. .	13	99	10	82
Pneumonia .. .. .	83	99	63	80
Other diseases of respiratory system .. .. .	66	17	51	13
Old age .. .. .	14	67	11	57
Violence, including suicide .. .. .	89	47	68	38
Other causes .. .. .	609	481	466	393
<b>Total .. .. .</b>	<b>1,308</b>	<b>1,239</b>	<b>1,000</b>	<b>1,000</b>

Thus in both countries tuberculosis is the registered cause of 1 in 11 or 1 in 12 of all deaths. Owing to the share which tuberculosis takes in producing death from other diseases and to the occasional occurrence of unrecognized cases of tuberculosis, its real share may be higher than these figures indicate, especially in old age; although in most instances of double certification tuberculosis takes precedence in classification over other diseases (p. 176). It has to be remembered, furthermore, that persons suffering from tuberculosis may die from some other disease, e.g. cardiac disease, and yet the death would be classified as tuberculosis if this were named in the death certificate. The importance of these figures is enhanced by the high proportion of total mortality from tuberculosis which occurs at working years of life. In this respect comparison with cancer is interesting (see p. 370).

Pulmonary tuberculosis caused more than half of the total deaths due to it at ages 20-45; at the same ages only one-tenth of the deaths from cancer occurred.

At the age of 55, 85.5 per cent. of all deaths from consumption, and at the same age only 27.6 per cent. of all deaths from cancer, have already occurred.

The loss has also been reckoned in terms of years of life lost in a life-table or stationary population. The late Dr. T. E. Hayward, calculating by his modified short method a life-table based on the experience of England and Wales, 1881-90, found that at the age of 55 out of a million males at birth, 61,072 more would be living than in accordance with current experience, if phthisis were eliminated, and the corresponding saving for females would be 56,299 lives. By eliminating phthisis the expectation of life at birth was increased by 2.58 years (males) and 2.57 years (females). The exclusion of all forms of tuberculosis meant an increased expectation of life at birth of 3.86 years (males) and 3.72 years (females).

Dr. L. I. Dublin has supplied the American figures (seen in the table on page 444), which teach a similar lesson.

It has not been thought necessary to attempt to assess the money value of the lives lost at different ages from tuberculosis, of the expense of the treatment of these patients, of the maintenance of dependent relatives who survive, and so on. For illustrations of this aspect of the loss from tuber-

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culosis see the author's *Prevention of Tuberculosis* (Methuen), chaps. i and ii, and an article by Lieut.-Colonel F. E. Fremantle, M.P., on "The Economics of Health" (*British Medical Journal*, August 26, 1922).

In the year 1920, tuberculosis was the recorded cause of 99,916 deaths in the death registration area of the United States, or 1.14 per 1,000 of the population, as compared with 1.69, the average rate for 1906-10, and 1.50 in 1911-15.

Pulmonary tuberculosis caused 88 per cent. of total recorded deaths from tuberculosis in the United States, and 77 per cent. in England and Wales.

### EXPERIENCE OF METROPOLITAN LIFE INSURANCE COMPANY, INDUSTRIAL POLICY HOLDERS, 1911-16.

*Of 1,000 Males Born Alive, the Number Surviving at Successive Exact Ages under Present Conditions, and the Number were Tuberculosis Excluded.*

Age.	White Persons.		Coloured Persons.	
	Present Conditions.	Tuberculosis Excluded.	Present Conditions.	Tuberculosis Excluded.
At Birth .. ..	1,000	1,000	1,000	1,000
20 .. .. .	794	805	672	713
25 .. .. .	770	791	633	691
35 .. .. .	698	746	546	632
45 .. .. .	592	668	449	551
55 .. .. .	463	547	336	433
65 .. .. .	301	370	204	274

**Age and Sex Distribution of Mortality from Tuberculosis.**—The standardized death-rate at all ages from tuberculosis fell steadily through a long series of years. Comparing the quinquennial periods 1871-75 and 1909-13, and thus avoiding the disturbing influence of war, the following decreases are shown. The results for pulmonary are more trustworthy than for total tuberculosis, because for non-pulmonary tuberculosis there has been considerable change in certification. (See table on p. 445.)

Comparisons of male death-rates for phthisis during the war are difficult owing to disturbances of the civilian population. For females Table xxxiii on page 50 of the Annual Statistical Review of the Registrar-General, 1921, shows that

after a continuous decline of the annual death-rate only interrupted in 1911, the phthisis death-rate (standardized) began to increase in 1914 (to 839 from 807 in 1913); it became 887 in 1916, 893 in 1916, 949 in 1917, and 1,037 in 1918, the death-rate per million in the three subsequent years being 824, 733, and 754. It is noteworthy that the peak of excess of non-pulmonary tuberculosis occurred in 1917, that for pulmonary tuberculosis in 1918. This latter may have been due to super-imposed influenza; and it appears likely that both in the United States and in this country, "the wave of increased mortality from pulmonary tuberculosis . . . began to decline well before the major influenza epidemics occurred" (statement of U.S. Public Health Service quoted in the Annual Statistical Review of the Registrar-General, 1921, p. 55). This fact increases the

## ENGLAND AND WALES.

*Average Annual Death-rates per Million from Tuberculosis (all forms) and from Pulmonary Tuberculosis 1871-75 and 1909-13.*

	Total Tuberculosis.		Pulmonary Tuberculosis.	
	Male.	Female.	Male.	Female.
1871-75	3,148	2,782	2,452	2,219
1909-13	1,618	1,236	1,178	854
Percentage Decline in 38 years ..	48.6	55.5	51.9	61.5

difficulty in ascribing the increased death-rate from phthisis entirely to the hardships of war.

In the following diagrams the male and female death-rates at different age-periods from tuberculosis (all forms) in England and Wales are shown for the average of 1912-14, and for 1920. The years of the Great War are avoided, owing to abnormal circumstances as to both population and deaths. The details for males in 1920 at ages 15-45 are not given in the Registrar-General's Report for 1920, owing to the disturbance of age-distribution figures produced by the war. In the same diagram are given corresponding rates for the registration area of the United States for 1911, the last year available.

Comparing male and female mortality from tuberculosis in 1912-14, it will be seen that at all ages, except 5-20, the male was much higher than the female death-rate. At ages 45-65 for equal numbers living the male is double the female death-rate, and at ages 15-45 the male and female death-rates per 100,000 were 168 and 134 respectively. The male maximum death-rate was reached at the age-period 45-55; the female

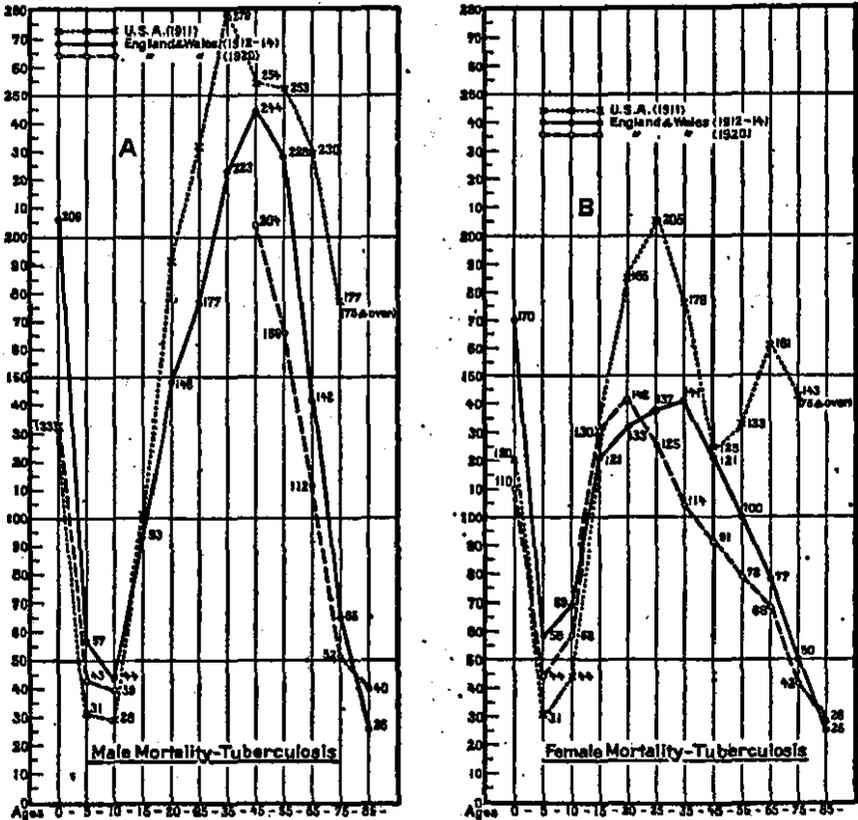


FIG. 74.—A, Male, B, Female Death-rate from Tuberculosis (All Forms) per 100,000 Living at Successive Age-periods, England and Wales, 1912-14 and 1920, and the United States Registration Area, 1911.

death-rate was highest at ages 35-45, but was then little higher than in the preceding 15 years of life. In 1920 the maximum of the female death-rate from tuberculosis occurred at the age-period 20-25.

The experience of the United States in 1911 shows marked differences from that of England. The male and female

maximum death-rates were both reached earlier and were higher, and the death-rate at older ages was markedly higher at ages over 55, and somewhat lower in childhood than in England. The possible causes of these differences cannot be discussed here. A fuller discussion of the English figures will be found in the Registrar-General's Reports for 1919, 1920, and 1921.

The preceding curves relate to total tuberculosis. When pulmonary tuberculosis is considered alone, the following age-distribution is seen.

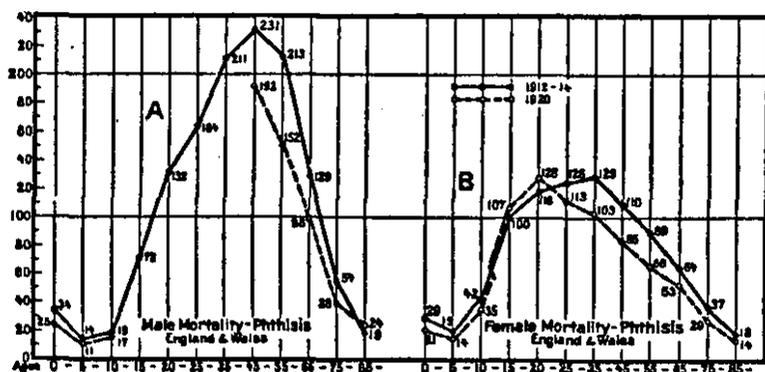


FIG. 75.—A, Male, B, Female Death-rate from Pulmonary Tuberculosis (Acute and Chronic Phthisis) per 100,000 Living at Successive Age-periods, England and Wales, 1912-14 and 1920.

The differences in height and shape of the curves for the two sexes should be studied. The *post-bellum* increase in the death-rate of females at ages 15-25 associated with a decreased death-rate at higher ages is noteworthy.

The large death-rate from tuberculosis (total) in childhood shown in Fig. 74 will have been noted. In earlier periods of civil registration the death-rate from tuberculosis was higher at age 0-5 than at any subsequent period of life. In the table on page 448 the death-rate from tuberculosis at age 0-5 is compared with the highest death-rate in any subsequent age-group in five successive periods of years.

In each successive decennium the death-rate from tuberculosis was higher at ages 0-5 than the maximum death-rate (given above) for any other age-period in the same decennium. Only since 1910 has this become altered, as seen in Fig. 74. Evidently, then either some cause or causes have

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been diminishing this early death-rate more than the later death-rates, or material changes in allotment of deaths to the non-pulmonary forms of tuberculosis have occurred. The result may be ascribable in part to greater caution in certification of deaths ; but this will scarcely furnish a complete explanation. Every infant born forms an addition to that part of the population which is extremely susceptible to the infection of tuberculosis ; and in recent years there has been a steady diminution of opportunities for, and of dosage of, infection, both bovine

### ENGLAND AND WALES.

*Death-rates from Tuberculosis (All Forms) per 1,000 Living at Ages 0-5, and per 1,000 Living at the Subsequent Age-period in which the Tuberculosis Death-rate was at its Maximum (\* and † give the reference to this age-period).*

	1861-70.	1871-80.	1881-90.	1891-1900.	1901-10.	At Ages
Males	6.02	5.80	5.00	4.35	3.13	0-5
	4.2*	4.2*	3.68*	3.30†	2.93†	{ 35-45* 45-55†
Females	4.92	4.66	3.99	3.52.	2.64	0-5
	4.48*	3.63*	2.93*	2.26†	1.71†	{ 25-35* 35-45†

and human, owing to active preventive measures and improvements in personal conduct, thus allowing time for the acquirement of relative immunity. Diminished infection of bovine origin has borne a part in the result ; but as bovine tuberculosis is found in only a minority of the total cases of fatal tuberculosis in childhood, the result is mainly caused by elimination of infection of human origin.

It is too little recognized that in childhood tuberculosis is specially lethal in the first year after birth. This is shown by the following table from the Decennial Supplement to the Seventy-fifth Annual Report of the Registrar-General of England and Wales, Part III, Table 14.

### ENGLAND AND WALES.

*Death-rates from Tuberculosis (All Forms) in Children under 5, 1906-10.*

Deaths Under 1 Year per 1,000 Births.	Deaths per 1,000 Survivors at the Commencement of Each Year.			
	1-2.	2-3.	3-4.	4-5.
4.41	3.4	1.82	1.21	0.93

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The death-rate from tuberculosis at ages under 5 has followed a course which does not differ very greatly from that of total tuberculosis at all ages. This is shown by the following relative figures :—

### ENGLAND AND WALES.

*Relative Mortality from A, Tuberculosis (all forms), B, Pulmonary Tuberculosis, and C, Non-pulmonary Tuberculosis in Successive Decennial Periods.*

		1851-60.	1861-70.	1871-80.	1881-90.	1891-1900.	1901-10.
A	{ At ages 0-5	100	95	91	78	68	50
	{ At all ages..	100	94	83	70	58	47
B	{ At ages 0-5	100	75	59	42	32	36
	{ At all ages..	100	94	84	66	51	41
C	{ At ages 0-5	100	101	100	89	79	57
	{ At all ages..	100	95	92	90	85	71

NOTE.—In 1851-60 the average annual death-rate from tuberculosis at all ages was 348 per 100,000 at all ages, and at ages under 5, 578 per 100,000. From these rates and the data in the table, the death-rate from tuberculosis for any of the periods in the table can be calculated.

The comparative figures for phthisis have been added. The very rapid drop in phthisis at age 0-5 in the earlier periods appears to point to some measure of change in certification of death.

It is likely that the delay in the decline of total tuberculosis in early life as compared with that of tuberculosis at all ages may have been due in part to changes in certification; but, even allowing for this, the remarkable reduction under 5 years of age, at a time of life when the relative immunity referable to small-dosed infection is in process of acquirement, is best explained by reduced dosage of infection. There is substantial evidence that each succession of infants in respect of tuberculosis is in the same position as savage races when first exposed to this disease.<sup>1</sup>

In the following table (from the Decennial Report of the Registrar-General, 1901-10) is given a comparison of the death-rate per 1,000 persons living at ages 0-5 from the varieties of non-pulmonary tuberculosis in successive decades :—

<sup>1</sup> See Dr. G. E. Bushnell's *Study of the Epidemiology of Tuberculosis* (W. Wood, New York, 1920).



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## MALE MORTALITY.

*Percentage Decline in Successive Decennial Periods at Ages 0-5  
and at Successive Age-periods.*

At Ages 0-5.						
A	Total mortal- ity, all causes ..	+ 1.4	- 6.9	-10.0	+ 1.8	-20.2
B	Tuberculosis ..	- 4.8	- 3.7	-13.7	-13.1	-28.0
C	Phthisis ..	-25.4	-20.8	-29.7	-20.3	-20.4
At Ages 5-10.						
A	.. ..	- 3.8	-18.1	-20.3	-19.4	-18.7
B	.. ..	-16.0	-12.5	- 9.2	-13.7	- 9.8
C	.. ..	-17.7	-21.0	-25.7	-31.5	-21.3
At Ages 10-15.						
A	.. ..	- 8.2	-17.3	-20.4	-17.1	-16.1
B	.. ..	-18.4	-16.8	-15.8	-17.3	-11.1
C	.. ..	-20.4	-20.6	-28.8	-32.0	-26.9
At Ages 15-20.						
A	.. ..	- 7.5	-15.1	-17.8	-12.2	-18.5
B	.. ..	- 9.6	-22.0	-18.7	-18.3	-19.2
C	.. ..	- 8.4	-23.3	-23.3	-23.0	-24.0
At Ages 20-25.						
A	.. ..	- 4.0	-13.1	-22.1	-11.7	-17.4
B	.. ..	- 5.0	-20.1	-21.8	-16.5	-17.0
C	.. ..	- 3.9	-20.2	-24.7	-19.4	-19.4
At Ages 25-35.						
A	.. ..	+ 3.8	- 6.0	-16.9	-13.0	-17.6
B	.. ..	+ 1.0	-10.0	-16.4	-19.7	-15.1
C	.. ..	+ 2.1	- 9.7	-18.2	-22.0	-17.0
At Ages 35-45.						
A	.. ..	+ 8.0	+ 2.3	-10.2	- 7.2	-20.4
B	.. ..	+ 3.0	- 1.1	-12.3	-11.8	-19.3
C	.. ..	+ 3.8	- 0.8	-13.5	-13.5	-21.0
At Ages 45-55.						
A	.. ..	+ 7.3	+ 4.2	- 3.5	- 2.2	-14.4
B	.. ..	+ 0.3	- 1.0	- 8.1	- 8.7	-11.0
C	.. ..	+ 1.0	- 0.4	- 9.3	-10.3	-13.4
At Ages 55-65.						
A	.. ..	+ 7.4	+ 5.2	- 0.5	+ 0.7	- 9.0
B	.. ..	- 1.3	- 4.3	- 7.9	- 8.6	- 7.0
C	.. ..	- 1.0	- 3.2	- 8.9	-10.3	- 9.1
At Ages 65-75.						
A	.. ..	+ 2.7	+ 3.9	+ 1.1	- 0.1	- 7.9
B	.. ..	-15.5	- 6.9	- 5.5	-10.8	- 1.2
C	.. ..	-14.9	- 5.4	- 5.4	-13.1	- 4.0
At All Ages.						
A	.. ..	+ 2.1	- 3.4	- 8.3	- 2.4	-15.0
B	.. ..	- 3.5	- 8.3	-13.8	-14.0	-17.2
C	.. ..	- 3.0	- 9.7	-16.7	-16.9	-16.8
Period between .						
		1851-60 and 1861-70	1861-70 and 1871-80	1871-80 and 1881-90	1881-90 and 1891-1900	1891-1900 and 1901-10

tables in the Registrar-General's Decennial Supplement. At ages 0-5, as already indicated, one may reasonably suspect, both for pulmonary and total tuberculosis, that changes in medical certification bear a share in the changes. At most higher ages it is likely that the figures approximate to the facts, except after the age of 55, when the amount of tuberculosis may be somewhat understated.

The death-rate from tuberculosis has almost without exception declined each decade more than the general death-rate, usually much more, except between 1891-1900 and 1901-10, when the decline in the general death-rate nearly overtook that from tuberculosis. The difference between the two would have been increased, had the comparison been between the death-rate from tuberculosis and that from all causes excluding tuberculosis.

What has caused the decline in the death-rate from phthisis? This chief form of tuberculosis is taken for further examination because, almost without exception, it is due to infection from other human cases of tuberculosis. In other forms of tuberculosis, especially of glands, bones and joints, infection from cows' milk is responsible in a substantial minority of cases for the disease.

**Causes of Decline in Phthisis.**—This intricate medical problem has been the subject of much controversy, and a short statement of the views held appears desirable as statistics on this subject form a large part of public health literature. A reduced mortality may be due to reduced infection, or to increased resistance to infection, or both. Infection is needed before tuberculosis can be produced; and the most ardent anti-contagionist will not deny that with changes in national habits and in methods of treatment of phthisis there has been great reduction in opportunities of large-dosed infection. But the inquiry still remains: what social, domestic, or occupational changes have been experienced which would lead to diminished infection or increased resistance to infection? At this stage a study is desirable of the comparative experience of different communities in respect of their death-rate from phthisis, and of changes in urbanization, housing conditions, dusty occupation, education of patients and of the general public leading to diminution of indiscriminate expectoration, and in respect of

segregation of patients at home or in hospitals in the most infective periods of their illness. For a study of these points reference may be made to the author's *Prevention of Tuberculosis*, 1909.

Further complications are possible: it may be that changes of a cyclical character have occurred in the life-history of the tubercle bacillus. Such changes appear to have occurred in the history of scarlet fever, why not also of tuberculosis? Historical facts give little support to this view, severe and slight attacks of tuberculosis occurring as in past medical experience.

Or the present inhabitants of this country, and of other countries which have experienced a reduced death-rate from phthisis, may have recently acquired relative immunity against tuberculosis, after their forebears had failed to do so during a long series of centuries. This would be a fantastic view, even did we not know that in some countries with an equally long experience of tuberculosis little or no reduction of the death-rate from phthisis has occurred.

Two explanations of the reduced phthisis death-rate remain for consideration, both probably comprising factors which have borne a share in the result, viz. the small-dosed infection by minimal doses of tubercle bacilli, and improvements in hygiene and social conditions which have not only reduced massive infection but also aided resistance to infection.

**Possible Vaccinal Influence of Minute Infections.**—It is agreed that in the absence of tubercle bacilli no infection can occur. It is also probable that in order to produce the disease tuberculosis, the dose of infection required to overcome the high degree of immunity which the majority of mankind after childhood enjoy varies in different individuals, and varies in the same individual according to his health, being lowered by dissipation, alcoholism, prolonged fatigue, or the presence of other diseases, as syphilis, or such acute infectious diseases as measles, influenza, enteric fever. The vast majority of mankind in large communities have been tuberculized by repeated small infections, without any or without appreciable disease. It appears likely that each child surviving in large communities is thus rendered relatively immune. If the infant is exposed to larger doses of infection,

there ensues the heavy mortality from acute tuberculosis experienced in the first three years of life.

Doubt still exists as to whether the survivors from infection in early life suffer from adolescent or adult tuberculosis owing to resuscitation of latent tuberculous lesions in the stress and strain of life, or whether adult infection is due to newly received infection in the same circumstances. Probably each of these views represents part of the truth, childhood infection being, perhaps, responsible for the greater amount of adult tuberculosis. Whether this be so or not, to diminish the still terrible mortality from child mortality, as well as in the interest of adults, it is of supreme importance to prevent exposure to considerable or to protracted infection during the first four or five and especially during the first two years of life.

The vaccinal view of immunity against phthisis implies, what is probably the fact, that small-dosed infection in childhood confers temporary immunity, while large-dosed infection causes death. On this supposition, adults having been partially immunized in childhood resist more successfully adult infection, which again with improved hygiene is reduced in amount. Or, if adult disease be regarded as a late result of infection in childhood, there is demanded the hypothesis of an intermediate quantity of infection in childhood, from which disease develops in adult life. Thus it may be assumed that massive doses kill in childhood, intermediate doses produce adult disease, smaller doses cause no disease. Dosage is a personal matter, the result in every instance being the resultant of two forces, infection and reduced resistance to infection.

It is unlikely that any practicable preventive measures will succeed in preventing small-dosed infection in large communities, and a return to the "virgin soil" condition of some uncivilized races need not therefore be feared.

Heredity has in the past been regarded as the most potent influence in causing tuberculosis, and there is nothing unreasonable in the belief that in certain families there is a special proclivity to be victimized by tuberculosis.

Earlier medical writings emphasized the inheritance of a predisposition to phthisis, and the occurrence of phthisis in 25 per cent. or even more of the parents of consumptive

patients was quoted as favouring this view. A chief dissentient was Dr. W. H. Walsh (*Diseases of Lungs*, 1871), who appreciated the invalidity of any conclusion from such figures unless one had for comparison a corresponding statement for the entire population or for a random sample of it. "This ratio of 26 per cent. might be, and probably is, no higher than that of the tuberculized portion of the population generally." In fact, on the post-mortem evidence the inference is unavoidable that there exists an almost universal family taint of tuberculosis; and the question remaining for settlement is whether the greater incidence of new attacks in consumptive families is due to greater infection, or implies a special inherited predisposition. Professor Pearson concludes: "I feel fairly confident that for the artisan class the inheritance factor is far more important than the infection factor, because in a very large proportion of cases it does not lie in the power of the individual to maintain in the stress of urban life a wholly safe environment" (*A First Study of the Statistics of Pulmonary Tuberculosis*, 1907).

The validity of this conclusion is extremely doubtful. It is certain that without infection there can be no tuberculosis, and the evidence of heredity in tuberculosis given in statistical investigations is usually vitiated by the possibility of intimate contact and infection, the results of which may not emerge for many years. To my mind it is doubtful, in view of the widespread prevalence of tuberculosis, so great that few families can claim freedom from cases, whether heredity plays a considerable rôle in the causation of tuberculosis. Much importance, as showing the potency of heredity, appears to be attached to the absence of evidence of marital infection; but on this see the remarks on page 543.

A favourite view is that nutritional conditions determine the incidence of tuberculosis. Defective nutrition, like hereditary proclivity, can, however, at most play only a subsidiary part, for tuberculosis is an infectious disease. This is shown in the not infrequent explosion of acute tuberculosis in athletes and other well-nourished persons. Curves of the price of wheat and of the death-rate from phthisis for many years ran a parallel course in this country and in Germany, but in France and Ireland there was no such parallelism (see

pp. 231 to 243 of *Prevention of Tuberculosis*). Stated as coefficients of correlation, the connection was very significant, + .90 in England, + .55 in Prussia, but in Ireland it was - .80. Again, in 1919 and 1920, when prices (including price of bread) were soaring, the phthisis mortality was falling rapidly.

A somewhat similar relationship was found to exist between figures representing the total cost of living and phthisis mortality. At the same time also real wages had been increasing. But the relation between nutrition (as measured above) and phthisis, while it held good in Great Britain, Massachusetts and Germany, was found not to apply to Ireland and Norway, in which countries phthisis mortality did not decline, while food had cheapened and other conditions had also steadily improved, though possibly on a lower scale. Contemporaneously also extreme poverty in rural life may be associated with a low phthisis death-rate. Although there is no reason to doubt that good nutrition increases resistance to phthisis and facilitates recovery from it, other factors must be regarded as even more important, unless the statistics of Ireland and Norway are to be rejected. This rejection is not justifiable. In Ireland it is not unlikely that from 1877-1901 (for which period the correlation between total cost of food and phthisis death-rate was - .49) the registration of deaths from phthisis became increasingly accurate; but if it is to be assumed that the discrepancy in the course of the phthisis death-rate and of the cost of food is to be thus explained, it remains unexplained why the death-rate from phthisis in Ireland should slowly decline with improving registration, as it has done from 1906 onwards.

*Have diminution of overcrowding and of the collateral circumstances of human fouling caused the diminution of tuberculosis?* To doubt the importance of these factors in increasing tuberculosis, by favouring infection and by lowering the resistance to it, would be contrary to a mass of unmistakable medical and public health experience. And yet, although the population of most countries has become increasingly aggregated in densely populated towns, and although this urbanization, almost without exception, has meant much denser housing, much

more domestic overcrowding, and a change for the vast majority of the male population from outdoor to indoor occupations, the death-rate from phthisis in the entire population has steadily declined, and has become nearly as low in urban as in rural populations. The main facts as to increasing urbanization are set out in Chapters XXIV and XXVI. There has always been excess of phthisis death-rate in towns, but this excess has gradually diminished. This is illustrated by figures from the Decennial Supplement of the Registrar-General for 1901-10 shown in Fig. 76. The urban counties whose statistics are included in the rates shown in this diagram had a mean population in 1901-10 of 18½ millions, and the rural counties of 4½ millions. The list of counties is given on page x of the Supplement; the urban group consists of the counties containing many towns, including the main centres of industry, and the rural group of counties, although comprising some towns, were mainly rural in character.

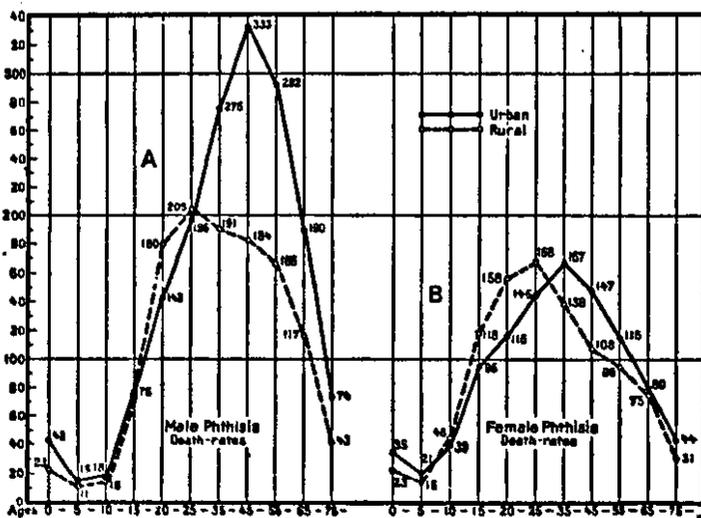


FIG. 76.—England and Wales: Comparison of Phthisis Death-rates per 100,000 in Males and Females at Different Ages in Urban and Rural Groups of Counties, 1901-10.

The marked contrast between male and female death-rates shown in these curves throws some doubt on the great, if not preponderant, influence sometimes ascribed to inheritance as influencing death-rate from phthisis. The same contrast

throws doubt on defective nutrition as a very important cause of tuberculosis, for women are usually less well fed than men.

The fact that the female urban death-rate is not markedly higher, and this only at ages 35 onwards, than the female rural rate shows that the maleficent influence of urban life in increasing phthisis does not show itself markedly in women. Industrial and social conditions, including alcoholism, are to be thought of in this connection (see pp. 318 and 329).

It will be noted that the rural mortality from phthisis both in males and females reaches its maximum earlier than in the urban groups. Both in 1891-1900 and in 1901-10 the rural mortality from phthisis exceeded the urban amongst females at all ages from 10 to 35; and a similar excess applied to rural males aged 15-25 in 1891-1900, and to males aged 20-35 in 1901-10, a result probably due to migration into towns of the more healthy members of the population at these ages. The important disturbing influence exercised by migration over the distribution of death by phthisis has been emphasized by Sir W. H. Hamer.

The essential facts emerge—

- (a) That the death-rate from phthisis has always on the average been higher in urban than in rural districts;<sup>1</sup>
- (b) That the proportion of the total population exposed to urban conditions has steadily increased decade by decade;
- (c) But that the total phthisis death-rate has steadily declined, notwithstanding the increasing extension of urbanization.

As regards overcrowding in dwellings, see Chapter XXVI. Urban life means a larger proportion of smaller dwellings and of overcrowded bedrooms, which form one of the chief factors in the evil influence of urbanization.

In Ireland, until a few years ago, a progressive improvement in housing was taking place without reduction of the phthisis death-rate (see Newsholme, p. 226, *Prevention of Tuberculosis*). Evidently, then, notwithstanding the

<sup>1</sup> Dr. Greenhow's generalization may be quoted in this connection: "In proportion as the male and female populations are severally attracted to indoor branches of industry, in such proportion, other things being equal, their respective death-rates by phthisis are increased" (Reports to the General Board of Health and Privy Council, 1859-62).

unfavourable influence of an increasing proportion of indoor occupations and of congested housing, some influence is at work in England preventing the excessive tuberculosis which these conditions should provoke. Evidently, also, in Ireland, increased or stationary phthisis until a few years ago has been associated with improvement in housing, to the extent to which increased urbanization has not neutralized this influence.<sup>1</sup> (For further discussion of housing see p. 308.)

What is this countervailing influence? That it is not entirely improved nutrition of the population appears evident from the facts already adduced.

Is it the increasing immunity conferred by gradual elimination of persons and peoples especially prone to tuberculosis? If it were so, then one might reasonably expect that Norway and Ireland, for instance, as also France, in which little decline of tuberculosis has been experienced, would share with Great Britain, America, and Germany their great decline in phthisis. If, again, the explanation consisted in a gradual reduction of infectivity or virulence of the human tubercle bacillus, as part of a cyclical change in the history of the disease, it is strange that certain nations should show this cyclical change while in others it fails to appear.

At this point reference should be made to Dr. J. Brownlee's *Investigation into the Epidemiology of Phthisis in Great Britain and Ireland* (Special Report Series, No. 18, of Medical Research Council), in which, after analysing the historical incidence of phthisis in these countries, he concludes that phthisis is a group of three diseases: (1) A type chiefly affecting the young adult, the commonest age at death being between 20 and 25 years; (2) a type chiefly affecting persons at middle age, the commonest age at death in males being between 45 and 55 years; (3) a type which chiefly attacks persons over 55.

Dr. Brownlee's report on the whole subject should be studied. Here it is only practicable to indicate the following reasons for disagreeing with his conclusions:—

(1) Bacteriologically, after protracted investigation, only

<sup>1</sup> Emigration has been held responsible for the special experience of Ireland, which has been depleted of the best part of its population. But in the United States the death-rates from phthisis in the Irish part of its population are exceptionally high.

two types of tubercle bacillus, bovine and human, have been identified as dangerous to life in man. (2) The differences in age-incidence of phthisis at different periods and in different communities are, I think, equally well or better explained on the assumption that, as the control over the disease increases, two results occur: (a) the age at death comes later, and (b) the difference between the male and female phthisis death-rate becomes greater. The disease tuberculosis is the product of two sets of circumstances—an adequate dosage of infection, and conditions favouring or impeding successful invasion of the disease; and as both dosage of infection and circumstances favouring its development vary greatly in different communities and social strata, differences in age and sex distribution of the disease will occur, and the hypothesis of three types of disease is unnecessary, and therefore not to be entertained until strong evidence in its favour is adduced.

We come lastly to inquire what circumstances during the last 50 years have been operating to reduce tuberculous infection of human origin.

(1) There has been a great improvement in the cleanliness of the population, domestically and industrially, especially in regard to expectoration. The magnitude of this improvement it would be difficult to exaggerate. It amounts to a revolution in personal habits, the exceptions to this statement being few as compared with the experience of a few decades ago. (2) Along with this has proceeded a great improvement in the treatment of disease generally, and of tuberculosis, both at home and in hospitals. Carefully closed and warm bedrooms occupied in common by sick and well have been replaced largely by separate and well aerated bedrooms for the sick; and a steadily increasing proportion of the sick are treated in hospitals. The last-named improvement can be statistically measured, though somewhat crudely. In the author's *Prevention of Tuberculosis* various means of testing the extent of segregation of consumptives were attempted, as for instance the number of indoor paupers and the proportion of institutional to total deaths from all causes, though all these measures are necessarily inadequate. In the following table (see also Fig. 37) is set out the increasing proportional treatment of disease in institutions and the course of the phthisis death-rate:—

## ENGLAND AND WALES.

Period.	Proportion per Cent. of Total Deaths from All Causes occurring in Public Institutions.	Death-rate from Tuberculosis of Respiratory System per 100,000 of Population.
1869-70	8.3	244
1871-75	8.8	222
1876-80	9.6	204
1881-85	10.5	183
1886-90	11.2	164
1891-95	12.2	146
1896-1900	13.7	132
1901-05	16.5	122
1906-10	19.4	111
1911-14	21.2	103
1915-18	24.4	121 <sup>1</sup>
1919-20	24.3	92

<sup>1</sup> War years.

The earlier evidence that a large proportion of the hospital treated cases are phthisis, and that a large proportion of cases of phthisis receive in the aggregate very prolonged hospital treatment, is given in *Prevention of Tuberculosis*. In the year 1920, 36.2 per cent. of the total male and 26.5 per cent. of the total female deaths from phthisis in England and Wales occurred in hospitals, commonly after prolonged and often repeated stay of the patients in these hospitals.

Even though it may be accepted that the segregation of consumptives, especially of advanced cases, has greatly reduced infection, the circumstances associated with the historical reduction in the death-rate from phthisis appear to be too complex to permit of more than a qualitative statement of the case, unless figures be used as a pointer of the direction of events. The course of the death-rate from phthisis is the resultant of a number of forces, some of the more important of which are as follows :—

*Factors Making for Reduction.*

1. Gradual substitution of small-dosed and infrequent in lieu of large-dosed and frequent infection, and especially—
  - (1) Increased cleanliness in personal habits (spitting, etc.).
  - (2) Reduction of dust and of infection in industrial life.
  - (3) Better care and segregation of the sick.
2. Increased resistance by improvement of general hygienic conditions, including improved nutrition.
3. Provision of means for prompt diagnosis and continued treatment of tuberculosis. Dispensaries. Residential Institutions, Open-air Schools, etc.

*Factors Opposing Reduction.*

1. Steady increase of town life.
2. Increasing replacement of outdoor by indoor occupations.
3. The reduction in house-room which goes with town life.

In view of these opposing factors even a stationary death-rate from tuberculosis would mean the operation of a beneficent factor or factors; and the fact that in England three-fourths and in America over half of the population live in towns, and that notwithstanding the evil tendencies of urban life and industrialism, the death-rate from tuberculosis has declined, constitutes one of the greatest triumphs of medicine and hygiene.

It is satisfactory to note that in international conferences held recently "hospital treatment on an adequate scale of acute advanced and hopeless cases of tuberculosis" is held to be a "fundamental and indispensable" factor in an organized campaign against tuberculosis. It has, in fact, been regarded as such for twenty years or more both in America and England. This consensus as to practical action confirms the conclusion that historically, before its rationale was understood, and when hospital treatment was being given solely for humanitarian reasons, this hospital treatment played an important part in reducing the death-rate from tuberculosis.

**ILLUSTRATION.**

**Comparison of Incomparable Items.**—In 1918 the death-rate from phthisis in New York City was 155, and in Richmond, Va., it was 187 per 100,000. To what is this difference due?

*Remarks.*—As it is notorious that phthisis prevails more seriously in negroes than in the white population, it is first necessary to analyse the above death-rates as follows:—

	Population.		Deaths from Phthisis.		Death-rate per 100,000 in Each Group.		
	White.	Coloured.	White.	Coloured.	White.	Coloured.	Entire Population.
New York City ..	5,488,000	116,840	8,143	537	148	460	155
Richmond, Va. ..	100,700	86,000	117	176	116	314	187

It is seen that the death-rate from phthisis in Richmond is lower both in the white and the coloured population than in New York. It is assumed in this example that the age and sex distributions of the two populations are equal. It would not be inconsistent with the above death-rates if it were found that notwithstanding its higher phthisis death-rate more is being done to contravene phthisiogenic factors in New York than in Richmond, these factors on this assumption being greater in the first-named city.

## CHAPTER XXXIX

### PNEUMONIA

PNEUMONIA is a chief cause of mortality, coming third or fourth in order of magnitude. But it does not represent a single entity. Acute lobar pneumonia may be caused by the pneumococcus, or as during the 1918-19 pandemic of influenza by streptococcic invasion. Broncho-pneumonia may occur as a primary disease, but is commonly secondary to simple bronchitis, measles, whooping cough, or diphtheria. There is the further complication that many deaths now certified as due to pneumonia were ascribed to bronchitis in former years. It is subject to these dubious elements that the statistics of pneumonia require study. Deaths from pneumonia are separately tabulated under three headings in the Registrar-General's reports, and the relative proportion of these is shown below:—

#### ENGLAND AND WALES.

*Proportion per Cent. of Deaths from Various Forms of Pneumonia to Total Pneumonia Deaths.*

Period.	Lobar Pneumonia.	Broncho-pneumonia.	Pneumonia not otherwise defined.
1901-05	8.4	42.1	49.5
1914	22.0	46.9	31.1
1920	22.6	50.2	27.2

Pneumonia undefined generally means lobar pneumonia.

The death-rates from pneumonia (all forms) and from bronchitis for a series of years are shown below:—

#### ENGLAND AND WALES.

*Annual Death-rate (Standardized) per 100,000 of Population.*

		1861-70.	1871-80.	1881-90.	1891-1900.	1901-10.
Males	{ Pneumonia ..	114	112	126	146	147
	{ Bronchitis ..	178	229	218	188	121
Females	{ Pneumonia ..	85	77	83	99	106
	{ Bronchitis ..	159	205	195	171	109

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It appears likely that both the increase shown in pneumonia and the decrease shown in bronchitis are largely fictitious. When the two rates are added together, there is seen some decrease in the combined mortality from inflammations of the lungs and bronchi.

Crude death-rates for a large part of the period 1911-20 are profoundly influenced by the influenza epidemic. This is shown below :—

### CRUDE ANNUAL DEATH-RATES PER 100,000 OF POPULATION.

(1) *England and Wales.*

	1911.	1912.	1913.	1914.	1915.	1916.	1917.	1918.	1919.	1920.	1921.
Influenza . .	12	15	17	16	29	25	21	313	122	28	24
Pneumonia	104	102	103	108	136	107	114	185	106	99	92
Bronchitis	101	109	107	109	144	125	125	123	124	101	89
(2) <i>United States Registration Area.</i>											
Influenza . .	16	10	12	9	16	26	17	301	99	71	?
Pneumonia	134	132	132	127	133	137	150	286	124	137	?
Bronchitis	20	19	18	17	17	16	16	16	13	13	?

There is evidence not only of excessive mortality from pneumonia, and to a less extent from bronchitis, during the 1918-19 epidemic of influenza, but also of marked excess of these two diseases in 1915 when influenza was not being specially observed, although in that year there was some excess of influenza in old people.

**Historical Changes in Prevalence of Pneumonia.**—The accuracy of such comparisons must be suspected in view of the changes in the form of certification indicated above, between various forms of pneumonia, and probably between bronchitis and pneumonia.

**Geographical Distribution of Pneumonia.**—Pneumonia is much more fatal in the North than in the South of England, and less fatal in rural than in urban districts, as shown by the following average experiences in 1919 (see table at top of p. 465). The county boroughs in the south suffer less than the rural districts in the north.

Dr. Stevenson points out (Annual Report of the Registrar-General, 1912) that the range of mortality is extreme. It is almost four times as high for males in the county boroughs of the north as for females in the rural districts of the south, and three times as high when males alone are compared.

# PNEUMONIA

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ENGLAND, 1919.

*Crude<sup>1</sup> Death-rates per Million Civilian Population.*

Region.	London.	County Boroughs.	Other Urban Districts.	Rural Districts.
North .. ..	—	1,567	1,219	1,067
Midlands .. ..	—	1,119	795	684
South .. ..	1,062	785	661	629

<sup>1</sup> Standardization for sex and age constitution does not affect very materially the crude rates for pneumonia.

A study of the geographical distribution of the death-rate of bronchitis and pneumonia combined in children under 5 years of age is contained in my "Report on Child Mortality at Ages 0-5 in England and Wales," 1916 (Cd. 8496). The death-rates given in that report are for the years 1911-14. They are stated per 1,000 births. The following extreme examples may be quoted:—

**DEATH-RATES FROM PNEUMONIA PLUS BRONCHITIS IN CHILDREN UNDER 5 PER 1,000 BIRTHS.**

	Lowest.	Highest.
Metropolitan Boroughs—		
Hampstead .. ..	19	Stepney .. .. 37
Great Towns—		
Hornsey .. ..	13	Middlesbrough .. .. 61
Smaller Towns—		
Reigate .. ..	11	Ince-in-Makerfield .. .. 62

Evidently, as Dr. Stevenson says, "pneumonia is to a large extent a preventible disease, and the North of England has still much to learn with regard to its prevention."

In part, the differences noted above may be due to varying prevalence of measles and whooping cough, but that this is only a partial explanation is shown by a detailed study of local statistics.

The experience of the town of Middlesbrough is exceptional, the death-rate from pneumonia in this town having been much higher than that of other towns in England for many years. In this town there is a great excess of pneumonia among men engaged in the local foundries, but the death-rate from this disease in most years is higher at ages under 15 than in adults, and in children it varies from ward to ward of the town. The death-rate from pneumonia and

bronchitis among children under 5 varied in 1911-14 from 35 to 84 per 1,000 births in different wards of the town. In the production of this excessive mortality, the dust

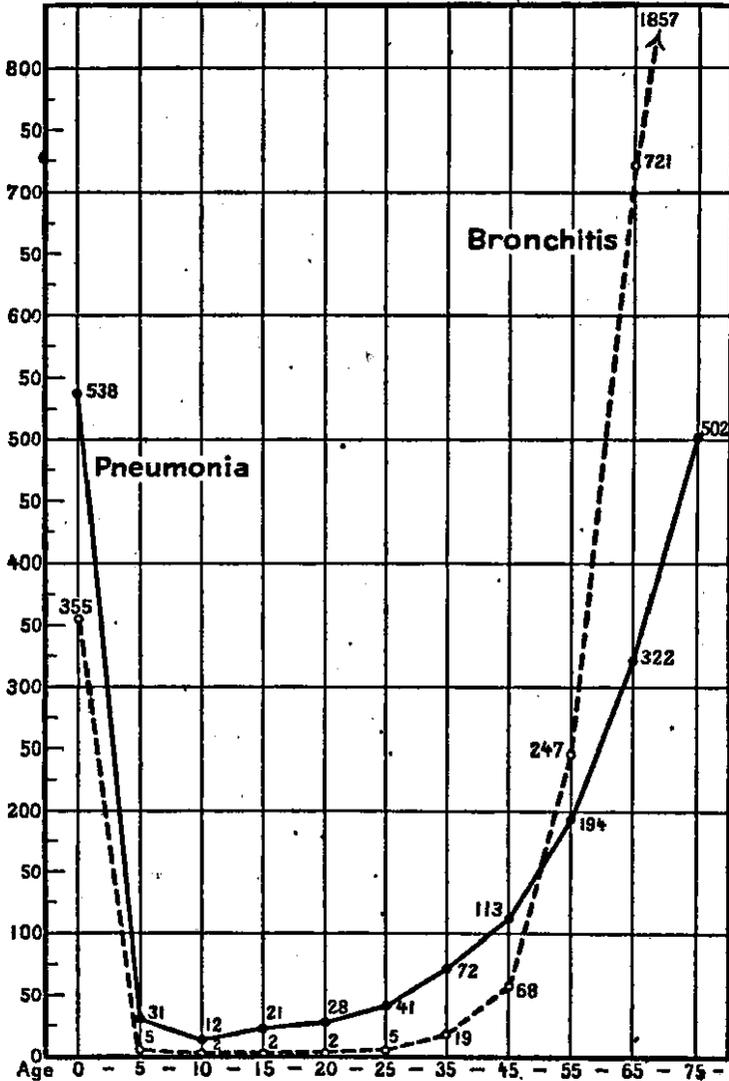


Fig. 77.—England and Wales, 1901-10: Average Annual Death-rate per 100,000 Living in Each Age-period from Pneumonia, ●—●—●, Bronchitis, ○---○---○.

and grit of the air of this town bear their part; but that this is not the chief factor is indicated by the ward-differences, as well as by the age-incidence of the mortality. Bad

housing and unfavourable social circumstances have great influence; but in the report quoted above I record the conclusion that "if the public-houses in the town, and within a few miles of it, could be closed for six months, the high proportion of the population of Middlesbrough who are now living under conditions of housing inimical to health and to self-respect would secure an immense improvement in health and efficiency even in their present houses, and would at the end of the trial period be in a financial position to combine to secure the building of new and satisfactory houses in the outskirts of the town."

**Age Distribution of Pneumonia and Bronchitis.**—The death-rates from bronchitis and pneumonia at successive age-periods during the decennium 1901–10 are shown in Fig. 77.

Both diseases cause their heaviest death-rates at the two extremes of life. In childhood deaths from these causes are largely preventible; in middle life the same statement holds good, as may be inferred in part from the social and industrial variations in the death-rate from these diseases (p. 321). Both diseases are commonly secondary to other infections, as measles and influenza. Osler has described pneumonia as the friend of the aged, and in old age it may be regarded as a mode of euthanasia as much as a cause of death.

The question of transfer between bronchitis and pneumonia taken together and phthisis may be considered here as bearing on the trustworthiness of the statistics of all three diseases. The course of events may be inferred approximately from curves given in Newsholme's *Prevention of Tuberculosis*, 1908, p. 28, which can be brought more recently up to date by the student from the rates published in the Decennial Supplement, 1901–10. The general result is to show that no transfer of deaths between bronchitis *plus* pneumonia and phthisis has occurred to an extent sufficient to disturb the similar age-distribution of death-rates in 1861–70 and 1901 respectively (see Fig. 77).

**Sex-Distribution of Pneumonia.**—For both diseases the death-rate at every age-period is higher in males than in females, except at ages 5–10 for bronchitis, as judged by English experience in 1901–10. For pneumonia the differ-

ence between the two sexes is greatest at ages 15-65, the chief working years of life. The male excess of mortality from bronchitis at the working years of life is relatively small. It will be noted that at ages 5-15 male and female mortality from pneumonia are practically equal; and at the same ages female is greater than male mortality from bronchitis (see Fig. 78).

**Pneumonia in U.S.A.**—Pneumonia in the United States registration area appears to be a much heavier cause of death than in England. A comparison of the death-rates from bronchitis in the two countries, however, renders it likely that bronchitis is more frequently returned as a cause of

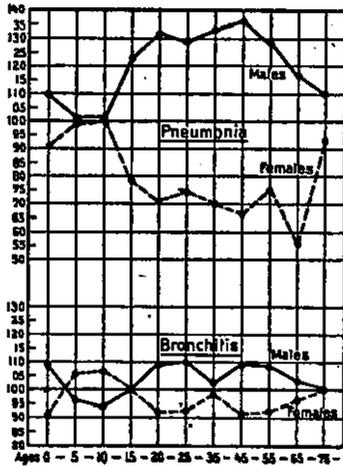


FIG. 78.—England and Wales, 1901-10: Relation of the Male to the Female Death-rate from Pneumonia and Bronchitis, the Death-rate for Persons at Each Age-period being stated as 100, for Each Disease.

death in acute respiratory disease in England than in the United States, when pneumonia would have been more accurately certified (see Fig. 19). It may be, however, that the difference is real, and is associated with the different climatic conditions in the two countries. The higher death-rate from cerebro-spinal meningitis and from acute poliomyelitis in the United States may be recalled in this connection. There is a close correspondence in the experience of the two countries as regards influenza and its effect on the death-rate from pneumonia.

## CHAPTER XL

### MORTALITY IN CHILDBEARING

CHILDBEARING being a physiological process, the deaths occurring in connection with it are accidental in character, due to infection or injury manifesting itself by one of the many conditions enumerated below. A share of this mortality is caused by rachitic or other deformity of the pelvis, the result usually of disease in the childhood of the mother. Subject to more detailed examination of the causes of death in childbearing in each community, the rate of mortality per thousand confinements should be regarded as one of the best tests of the stage of sanitary civilization attained by the community, a large share of the mortality and the still larger amount of disablement arising from pregnancy and parturition being preventable when efficient aid is given to the mother. Thus the rate of puerperal mortality stands side by side with the amount of hospital provision in a community as a reliable index of communal enlightenment.

The list of conditions included under the head of mortality in the puerperal state is shown in the following extract from the Registrar-General's Annual Report, 1921 :—

#### ENGLAND AND WALES, 1921.

International List Number.		Number of Deaths.
143	Accidents of pregnancy—	
	(a) Abortion .. .. .	107
	(b) Ectopic gestation .. .. .	83
	(c) Other accidents .. .. .	144
144	Puerperal hæmorrhage .. .. .	469
145	Other accidents of childbirth .. .. .	382
146	Puerperal sepsis .. .. .	1,171
147	(1) Phlegmasia alba dolens not returned as septic .. .. .	64
	(2) Embolism and sudden death .. .. .	262
148	Puerperal albuminuria and convulsions .. .. .	604
149	Childbirth not assignable to other headings (puerperal insanity) .. .. .	29
150	Puerperal diseases of the breast .. .. .	7
	Total .. .. .	3,322

Prior to 1911, the deaths returned as due to puerperal nephritis and uræmia, or as "puerperal albuminuria and Bright's disease," were not included under the head of puerperal mortality, as is now done in accord with the International Rules. For this reason, in order to secure comparability, these items are excluded from the tables on pages 472 and 473.

A further point should be noted. A disease may occur and may prove fatal which is not due to pregnancy or parturition, but complicates these conditions. This is so most often in heart disease, next in frequency being pneumonia, influenza, tuberculosis, and Bright's disease. A list of such non-puerperal deaths, 1,086 in number, occurring in the puerperal period is given on page lxxxviii of the Registrar-General's Annual Report, 1920. The inclusion of these would have raised the puerperal mortality in that year from 4.12 to 5.46 per 1,000 births.

**Methods of Stating Puerperal Mortality.**—The rate employed will depend on the purpose for which it is to be employed. If it is desired to show the importance of this cause of death as a factor in the total female death-rate, the first method given below is indicated. If it is required to measure the danger of childbirth, a rate per 1,000 confinements is indicated, including abortions and miscarriages; but this is unobtainable, and the best method in practice is stated in 4 below.

The following methods have been employed:—

1. A crude annual death-rate per 1,000 living, or per 1,000 of the female sex, as given in Table 5 of the Registrar-General's Annual Report, 1921, should not be used for comparing (except in the limited sense indicated above) either rates in successive years or in different communities.

2. A statement in terms of total women of childbearing age, say 15–45, is to be deprecated. In residential districts having a very high proportion of unmarried women, including domestics, this method would understate the index of puerperal mortality.

3. A rate based on the number of married women aged 15–45 gives a somewhat more accurate statement than the two preceding rates, but comparison by this method of a

district having a low, with a district having a high, birth-rate would still give misleading results.

4. For practical purposes puerperal mortality is best stated per 1,000 live-births. Restriction to live-births as a denominator gives the most accurate results for Britain, in which birth registration of live-births is complete, while notification of still-births (i.e. after the seventh month of gestation) is incomplete to an extent which varies greatly in different localities (see p. 83). In international comparisons the attempt to state puerperal mortality in terms of live- *plus* still-births causes confusion, owing to the varying law as to registration of still-births and the varying degree of enforcement of the law.

Thus in New York State still-births include infants born dead after five months of utero-gestation. In Indiana the limiting period is seven months, and in most States the term "still-birth" is not defined. Hence the soundness of the advice that "interpretation of the data relating to still-births must be made with extreme caution" (*Birth Statistics for the Birth Registration Area of the United States, 1918*, p. 28). On this point see also page 83.

Although method 4 in practice is the method which gives the nearest approximation to accuracy, a refinement may be adopted if in any localized experience completely accurate data are available. (1) The deaths occurring in connection with live-births stated per 1,000 of live-births; (2) the deaths in connection with the birth of still-born infants and abortions stated per 1,000 total abortions and births of still-born infants. But the second condition is impracticable, as no system of notification of all abortions is administratively possible, and the ordinary death certificate does not state whether the offspring of the deceased was born alive. If still-births and abortions bore a constant ratio to total pregnancies, these and live-births in method 4 would be as good an index as live-births alone and no better, for although the rates obtained would differ, their movements would be identical, as in the analogous case of standardized death-rates based on different standards. But the definition of still-births varies greatly, and the degree of official notification of these is even more erratic.

In stating puerperal mortality according to method 4,

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the error arising from multiple births is corrected approximately by using the multiplying factor 0.99. In practice this may be neglected.

In the Decennial Supplement of the Registrar-General (1901-10), page xc, is given the following table :—

### ENGLAND AND WALES.

*Mortality from Total Diseases and Accidents of Pregnancy and Childbirth Stated per Cent. of that in 1861-70.*

	Ratio Based on Rate per 1,000 Females (Standardized).	Ratio Based on Rate per 1,000 Births.
1861-70	100	100
1871-80	103	100
1881-90	93	101
1891-1900	88	108
1901-10	60	85

The rates calculated per 1,000 total females, when standardized only for age-distribution, overstate the decline in puerperal mortality. The more accurate rates per 1,000 births showed no decline prior to the last decennium in the table.

In the following table is given the puerperal mortality in U.S.A. and in England for a series of years :—

### DISEASES AND ACCIDENTS OF PREGNANCY AND CHILDBIRTH.

#### A. Annual Death-rate per 100,000 Persons Living.

	1901-5.	1906-10.	1915.	1916.	1917.	1918.	1919.	1920.
U.S. Death Registration Area ..	14.2	15.5	15.2	16.3	16.7	22.4	17.0	19.2
England and Wales ..	12.0	9.8	9.1	8.7	7.3	7.1	7.6	10.5

#### B. Annual Death-rate per 1,000 Live Births.

	1901-5.	1906-10.	1915.	1916.	1917.	1918.	1919.	1920.
U.S. Birth Registration Area ..	—	—	6.1	6.2	6.6	9.2	7.4	8.0
England and Wales ..	4.3	3.7	3.9	3.9	3.7	3.6	4.1	4.1

Some possible error arises in the estimate of civilian population in England for the war years 1915-18; but even in earlier years it is impossible to say from the above table A whether the declining puerperal death-rate in England and the slightly increasing rate in the United States are due to changes in the population at risk—i.e. parturient women measured by number of births—or to changes in the efficiency of the respective services for care of parturient women in the two countries. The second half of the table, B, enables a fair comparison to be made of the recent experience of the two countries, assuming similar allocation of deaths and equal accuracy of birth returns. In the United States mortality in the puerperal state differs greatly in the white population (7·6) from that in the coloured population (13·9 per 1,000 live births in 1919).

**Years of Special Excess of Puerperal Fever.**—In the past there have been remarkable excesses of mortality from puerperal fever in certain years. The highest death-rate registered from this cause was in 1874 (3·7 per 1,000 births). The next maximum was 3·1 in 1882; then 3·4 in 1893. Since then there has been fairly steady decline in the English death-rate from puerperal fever until 1914 and 1920, when two epidemic peaks are seen. The course of events from 1871 onwards is shown in Fig. 79, which also compares the course of puerperal sepsis with that of other complications of childbearing.

In the following table the same events are shown in condensed form for part of the period since 1871:—

## ENGLAND AND WALES.

*Mortality of Women in Childbirth and Pregnancy per 1,000 Infants Born Alive.*

Causes of Death.	1801-95.	1896-1900.	1901-05.	1906-10.	1911-15.	1916-20.
Sepsis .. ..	2·60	2·12	1·95	1·56	1·50	1·59
Other causes ..	2·89	2·57	2·32	2·18	2·31	2·29
	5·49	4·69	4·27	3·74	3·81	3·88

The classification is that in use before 1911. Sepsis is equivalent to "puerperal fever."

These average rates conceal the annual course of events. Longstaff (*Studies in Statistics*) has shown that in the years

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in which puerperal fever and erysipelas were most prevalent, there was deficient rainfall, and similar relationships have been observed in respect of scarlet fever, diphtheria, and rheumatic fever. The nature of this relationship is obscure. For puerperal sepsis, this being a wound infection, the coincidence should cease if surgically aseptic midwifery were generally maintained.

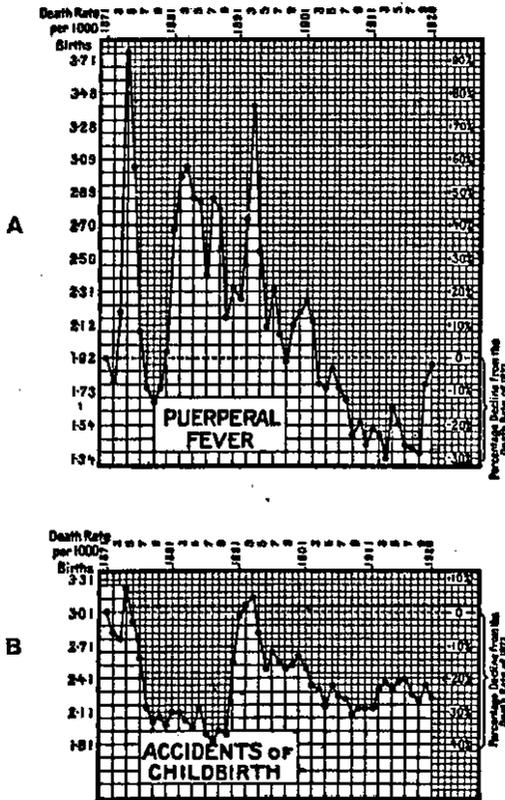


FIG. 79.—England and Wales: Annual Death-rates per 1,000 Births Registered, 1871–1920, from: A, Puerperal Sepsis; B, Other Accidents and Diseases of Pregnancy and Childbirth (Classification as in Use before 1911).

A study of the two curves in Fig. 79 shows some correspondence in their course, and the coefficient of correlation between the death-rates (A and B in Fig. 79) for the years 1905–19 is 0.92. This factor tells less than an examination of the curves, in which the course of events can be studied. Nor does it necessarily show more than that coincident

factors are operating for both groups of puerperal mortality. The interpretation of the course of events must be chiefly medical, checked by the comparative experience of different districts. In the *ante-bellum* period, the mortality from puerperal conditions, presumably non-septic, was not declining when that from sepsis was declining. The position for both A and B in Fig. 79 cannot be regarded as satisfactory.

**Trustworthiness of Figures.**—In interpreting the course of events respecting puerperal mortality, it must be noted that medical practitioners have often been unwilling to return deaths as related to parturition, and that puerperal mortality may be thus understated. The special instructions given to medical practitioners to record childbirth whenever death occurs within a month after it are stated on page 165. In recent years probably certification has improved. The improvement has been aided by the system of medical inquiries initiated in 1881 (p. 164). Many deaths in women of childbearing age, referred for instance to pyæmia, blood-poisoning, peritonitis, or pneumonia, have been transferred to puerperal sepsis as the result of these inquiries. A further improvement has resulted from wider recognition of the septic nature of many deaths in the puerperium. These points need remembering in interpreting the course of events in Fig. 79, and in reading the following figures taken (except for 1911–20) from the last Decennial Supplement of the Registrar-General, page xc. If the death-rate in England and Wales per 1,000 births from A, puerperal sepsis, and B, other puerperal causes in 1861–70 be stated as 100, then in—

	A.	B.
1861–70 .. ..	100	100
1871–80 it was ..	128	85
1881–90 it was ..	158	68
1891–1900 it was	139	91
1901–10 it was ..	104	75
1911–20 it was ..	91	73

**Notification of Puerperal Fever.**—The pelvic infection occurring in connection with parturition is not a specific infection, and may have many sources, and be due to a number of different micro-organisms. But it has held its place in the Registrar-General's reports, in part because medical practitioners continue to enter it on death-certifi-

cates, still more because "puerperal fever" is one of the diseases requiring to be notified under the Notification of Infectious Diseases Acts.

In the *Nomenclature of Diseases* drawn up and published in 1906 on behalf of the Royal College of Physicians it was noted (p. 7) :—

The term "Puerperal Fever" has been removed from the Nomenclature. Pyæmia, septicæmia, or septic intoxication occurring in puerperal women should be described as "puerperal septicæmia," or "puerperal pyæmia," "puerperal septicæmia," or "puerperal septic intoxication" respectively. Other conditions formerly included under the term "puerperal fever" should be returned under affections consequent on parturition, the word "puerperal" being in all cases prefixed to the word denoting the local process.

To this should be added the advice given in the official books of forms of certificates of death: "That whenever child-birth has occurred within one month before death, this fact should be registered in connection with the cause of death."

Although "puerperal fever" is a bad term for any individual case of disease, it has merits as a name for a group of septic diseases which in 1921 caused 1,171 deaths in England and Wales; and it may be questioned whether the substitution of the name "puerperal sepsis" in the Registrar-General's Annual Report, 1921, may not lead to some avoidance of certification of this condition.

The notification of cases of "puerperal fever" is much more unsatisfactory than its certification after death. The Obstetrical Society of London, in response to a request for advice from the Society of Medical Officers of Health, stated that an inclusive definition should be added after the words "Puerperal Fever" in the following terms :—

That is septicæmia and pyæmia, including peritonitis, and all cases of acute pelvic inflammation in connection with childbirth.

That the notification of puerperal fever is incomplete to a varying extent is shown by the fact that in 1920 there were 473 deaths from this condition to every 1,000 cases notified, 508 to 1,000 cases in county boroughs, 706 in other urban districts, and 812 in rural districts. In the rural districts of Wales the proportion of deaths from puerperal fever to cases notified was 1,364 to 1,000!

Notification of cases being so incomplete, study of the

incidence of puerperal sepsis on a large scale must be by means of death-rates.

A fairly complete account of the local incidence of the two great groups of causes of puerperal mortality is contained in my "Report on Maternal Mortality in Connection with Childbearing," 1915 (Local Government Board Reports, Cd. 8085). In the five years 1911-14 the death-rate from puerperal fever per 1,000 births varied only between 1.38 and 1.48 in different divisions in England, whereas the death-rate from other complications of pregnancy and parturition was only 1.58 in London, as compared with an average of 2.59 in the total administrative counties of England and Wales.

The Welsh counties had the highest death-rate under both headings. In 8 Welsh counties the total puerperal mortality averaged 6.60 per 1,000 births; in Westmorland it was 5.62, in Durham 4.46, and in London only 3.06. In large towns the total puerperal mortality varied from 8.54 to 2 or 3 per 1,000 births; and the only conclusion possible from the total data was that a large part of the mortality was preventible. Altogether in the 5 years in question 14,045 deaths in England and Wales were the result of pregnancy and parturition, whereas had the death-rate been as low as that in London, 3,306 lives of mothers would have been saved.

"Mortality Statistics," United States, 1920, contains useful figures on this subject, prefaced by the necessary warning that the rates are too high whenever birth registration is defective. The birth registration area was not established until 1915, and then included only 10 States and the district of Columbia. Comparing the entire birth registration area in 1915 and 1920, the death-rate from all puerperal causes varied from 6.1 in 1915 to 8.0 per 1,000 births in 1920; in the white population it varied from 6.0 to 8.9 (1918), and in the coloured population from 10.6 to 13.9 (1918). Of the total puerperal death-rate in 1920, A and B (see p. 474) caused a death-rate 2.6 and 5.0 in the white and 4.0 and 8.8 in the coloured populations respectively.

The same report is able to give a valuable table of the incidence of puerperal mortality according to the age of the mother, which unfortunately cannot be ascertained in Eng-

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land until our registration system is altered, so that the ages of mothers at the birth of their infants can be registered.

### UNITED STATES REGISTRATION AREA.

*Death-rate in 1920 per 1,000 Births at Age of Mother of—*

	10-19 Years.	20-29 Years.	30-39 Years.	40 Years and Over.
Puerperal septicæmia ..	2·8	2·3	3·1	4·2
Other puerperal causes ..	5·0	4·1	6·9	10·6

Similar rates are given for each of the 4 years 1917-20. They indicate that the risk of puerperal septicæmia is highest in the earliest and latest parturitions, the greatest risk from puerperal causes other than sepsis being at ages over 40.

In the United States, as in England, the death-rate from puerperal causes in 1918 was very excessive, which must be referred to the influenza epidemic of that year. The following rates are taken from the above-named American report :—

#### RATES OF MORTALITY FROM PUERPERAL CAUSES PER 1,000 BIRTHS IN 1920.

	A. <sup>1</sup>	B. <sup>1</sup>
United States Birth Registration Area..	2·7	5·3
Total foreign (i.e. not United States) ..	2·4	4·4.
Austria .. .. .	2·3	3·9
Hungary .. .. .	3·1	3·5
Canada .. .. .	2·4	6·1
Denmark, Norway and Sweden .. .. .	1·8	5·7
England, Scotland, and Wales .. .. .	3·4	5·5
Ireland .. .. .	3·0	6·8
Germany .. .. .	3·3	5·5
Italy .. .. .	1·9	3·7

<sup>1</sup> A, Puerperal septicæmia. B, Other puerperal causes.

In the table from which the above rates are extracted "adjusted" rates are also given, corrected on the basis of a standard million births of 1917. The births are distributed in each country to a million mothers of differing age as in 1917, thus adjusting for variations of puerperal death-rate due to the age of the mother. In the above figures this correction is not given; but it is unlikely that this or the variation in classification of deaths in practice is so great as to render the above rates incomparable. Greater doubt may

be entertained as to completeness of registration of births in some countries; but this would obviously have much less influence in impairing comparability than incomplete statement of puerperal deaths.

Dr. O. R. Eichel, in a report to the New York State Department of Health (June 1922) on "The Geographical Distribution of Maternal Mortality and Still-births in New York State," gives rates of mortality from all puerperal causes in 1916-20, varying in different districts from nil to 10.9 per 1,000 births, including still-births. The death-rate from puerperal septicæmia varied from 6.5 to nil. The percentage of still-births to total births varied in different districts from 1.2 to 7.7, illustrating the additional (though owing to the change being in the denominator the relatively insignificant) source of incomparability introduced by including still-births.

## CHAPTER XLI

### VENEREAL DISEASES

**Syphilis.**—The recorded death-rate from syphilis for a series of years is shown below :—

#### ENGLAND AND WALES.

*Average Annual Death-rate from Syphilis per Million Living of Each Sex.*

	1871-80.	1881-90.	1891-1900.	1901-10.	1911-15.	1916-20.
Males .. ..	77	75	68	58	65	74
Females .. ..	70	68	56	45	44	42

The majority of these recorded deaths occur in childhood. Thus per million persons living at each age-period, the death-rate in 1901-10 at ages 0-5 was 332, the highest at any subsequent age-period being 32 at ages 45-55.

The above rates understate the facts to an extent which cannot be accurately determined; but three other diseases need to be brought into the scale, which even then is too light. These are general paralysis of the insane, locomotor ataxy, and aneurism, which are caused by syphilis. In the Registrar-General's reports, general paralysis of the insane was first separated from non-puerperal insanity, and locomotor ataxy from "paraplegia, diseases of the cord," in the year 1901.

#### ENGLAND AND WALES.

*Average Annual Death-rate per Million Living of Each Sex from—*

	General Paralysis of the Insane.		Locomotor Ataxy.		Aneurism.	
	Male.	Female.	Male.	Female.	Male.	Female.
1901-5	106	32	25	5	53	12
1906-10	104	30	28	6	53	12
1911-15	102	22	34	6	52	12
1916-20	100	17	39	5	46	10

In the official American statistics aneurism is tabulated with "diseases of arteries and atheroma," which must be noted in reading the following table for persons :—

UNITED STATES REGISTRATION AREA.  
Annual Death-rates per Million Persons.

	1901-05.	1906-10.	1915-18.
Syphilis .. .. .	41	54	95
General paralysis of insane ..	68	55	71
Locomotor ataxy .. .. .	24	26	24
Diseases of arteries .. .. .	177	94	239

The smallness of the official figures is to be contrasted with Osler's statement, based on wide experience and careful judgment, that syphilis is more destructive of life than tuberculosis, cancer, or pneumonia, which rank highest in mortuary tables. An indeterminate proportion of deaths of the insane, and of deaths under such headings as heart disease, paralysis, cerebral hæmorrhage, premature birth, cancer of the tongue, and others would need to be added to obtain a correct total. To attempt to add these to the total returned as syphilis under present medical conditions would be to create additional confusion, irrespective of the unwillingness of certifying practitioners to enter syphilis as a remote probable cause of death (see also p. 170); but it may eventually become practicable to apply the same rule to syphilis as to acute infectious diseases (p. 486). It would be erroneous to assume that a system of secret certification of causes of death would remove more than a portion of the difficulty implied in the present position (p. 166).

It has already been noted that most of the recorded deaths from syphilis occur in infancy. In 1871-80 the deaths from syphilis 0-1 were 76.9 per 100 deaths from the same cause at all ages; in 1915-16 the proportion had fallen to .62.7 per cent., in accordance with the fall in the birth-rate. For a complete study of the registration of deaths from syphilis, see page lxvi *et seq.* of Dr. Stevenson's contribution to the Registrar-General's Annual Report, 1916.

**Infant Mortality from Syphilis.**—In England and Wales the number of deaths registered as due to syphilis under 1 year of age varied between 1.31 and 1.73 per 1,000 births

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**Infant Mortality from Syphilis.**—In England and Wales the number of deaths registered as due to syphilis under 1 year of age varied between 1.31 and 1.73 per 1,000 births

in the years 1906-14. It increased to 1.78 in 1914, but had declined to 1.27 in 1920. Even at this age there is some excess of male over female syphilis; thus in 1920 the death-rate under 1 per 1,000 births was 1.66 in male and 1.35 in female infants. The geographical distribution of infantile syphilis varies greatly, as measured by the statistics. In 1920 in the North of England it was 30 per cent. higher than the average for England and Wales. In county boroughs it was 74 per cent. higher than the average in the north, 54 per cent. higher in Wales, and 46 per cent. higher in England and Wales. In the smaller urban districts it was 50 to 20 per cent. lower, and in rural districts it was 60 to 40 per cent. lower than the average for the whole country.

Syphilis illustrates better than any other disease the difficulty of accurate certification of causes of death. Although according to Osler it ought to rank as one of the four chief causes of death, in 1920 it was the registered cause in England and Wales of only 2,023 deaths, or 0.43 per cent. of the total deaths from all causes. Even when tabes dorsalis, general paralysis of the insane, and aneurism are added, the total becomes only 5,101, as compared with 466,130 from all causes.

Of the total 2,023 deaths registered as due to syphilis, 1,511 occurred in children under 5. It might be concluded, therefore, that adults escape lightly. This is erroneous; for the three diseases named above, which, excepting possibly a small proportion of deaths from aneurism, are entirely due to syphilis, are chiefly adult diseases; and syphilis is the primary cause of death in a large number of instances in which this is not revealed in death certificates.

(1) A considerable proportion of abortions and still-births are caused by syphilis.

(2) Much infant mortality, which appears under many indefinite headings, is caused by syphilis. The registered share of syphilis in infant mortality can be seen in the tables on pages 41-42 of the Annual Report of the Registrar-General, 1920. In 1906 the number registered under this heading was 1,133, in 1920 the number was 1,443. These two figures correspond to an infant mortality per 1,000 births of 1.23 and 1.51, the total infant mortality in the same years being

117·62 and 79·93. But in the same two years "atrophy, debility, and marasmus" caused 15·83 and 8·80 deaths per 1,000 births, many of which deaths were probably due to syphilis.

Of the total deaths under 1 year of age in 1920, 40 per cent. occurred in the first month after birth. A high proportion of these is probably due to syphilis, though their statement as such is impracticable.

(3) Osler, in an address to the Medical Society of London (*Transactions*, vol. 40, 1917), regarded syphilis as showing the truth of the axiom that "Men do not die of the diseases that afflict them." This may be illustrated by diseases of the nervous system (so-called, and so grouped for convenience). Locomotor ataxy (tabes dorsalis) and general paralysis of the insane have already been named as due entirely to syphilis. Many cases of meningitis are also syphilitic. Deaths from cerebral hæmorrhage before the age of 50 are commonly due to syphilis, as are also many deaths from "softening of the brain," various paralyses, and insanity.

In "Mortality Statistics," 1920, an attempt is made on the lines of Osler's suggestions to "get nearer the truth regarding syphilis as a cause of mortality." The table on page 484 shows the method adopted and the results for the year 1920

The percentages given in this table represent the share of each of the causes of death recorded in the table considered to be due to syphilis.

With the total death-rate of 119·5 thus estimated may be compared the recorded death-rate in the same year from all forms of tuberculosis 114·2, cancer 83·4, pneumonia 82·7.

But as stated on page 486 some misapprehension is possible. With no practicable system of medical certification of death would it be possible to obtain statistical results approaching the above deduced from pathological probabilities. The amount of certification of syphilis—in the extended sense indicated in the table on the next page—depends on the extent to which physicians recognize the hidden hand of syphilis; and any statistical comparison of deaths from different causes must be between deaths the cause of which is (a) recognized, and (b) certified. There remains much difference of opinion as to the part played by syphilis as the remote cause of

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many deaths. The Wassermann test, if adopted for all cases of illness, would not completely solve the difficulty; for even if, say, 25 per cent. of patients subsequently dying from heart disease gave a positive reaction, this result would need to be checked against the result of the Wassermann test in a random sample of the population, homogeneous with the fatal cases in respects other than the heart disease.

### UNITED STATES REGISTRATION AREA.

#### *Deaths Ascribable to Syphilis, 1920.*

Cause of Death.	Total.	Death-rate per 100,000 of Population.
All causes (under 1 year); 22 per cent. ..	12,714	45.1
Syphilis (1 year and over), 100 per cent. ..	1,774	6.3
Locomotor ataxia (1 year and over), 100 per cent. ..	623	2.2
Other diseases of the spinal cord (1 year and over), 53 per cent. ..	935	3.3
Cerebral hæmorrhage, apoplexy (25 to 54 years), 81 per cent. ..	2,922	10.4
Softening of the brain (1 year and over), 35 per cent. ..	85	0.3
Paralysis without specified cause (1 year and over) 17 per cent. ..	227	0.8
General paralysis of the insane (1 year and over), 100 per cent. ..	1,820	6.5
Organic diseases of the heart (30 to 59 years), 29 per cent. ..	3,555	12.6
Diseases of the arteries, etc. (1 year and over), 54 per cent. ..	4,756	16.9
Epilepsy, other diseases of the nervous system, and broncho-pneumonia (1 year and over), 30 per cent. ..	4,265	15.1
Total .. .. .	33,676	119.5

**Experience of United States Registration Area.**—In “Mortality Statistics,” 1920, is given a table from which part of the following information is extracted (see table on p. 485).

**Gonorrhœa.**—This disease is not a very heavy direct cause of mortality, but it is one of the chief preventers of life, being an important cause of sterility. If the deaths due to the remote results of gonorrhœa, e.g. pyosalpinx and stricture of the urethra, were added, its lethal power would be shown to be much greater than appears from official figures.

The registered death-rate from gonorrhœa in England and Wales for a series of years has been about 1 per million

of population. In the United States registration area "gonococcus infection" was credited with a death-rate of 8 per million in 1920 and 4 per million in 1910. Gonococcal infection may include gonococcal endocarditis or other lesions; just as pneumococcal infection may cause death, apart from pneumonia. The certification of these rarer deaths from gonococcal or pneumococcal infection must depend on a degree of accuracy in pathological diagnosis not usually secured. It is impossible here to summarize all the statistical evidence

SYPHILIS.

*Death-rates per 100,000 of Population in England and Wales and in the Registration States of America Constituted as in 1900.*

	Syphilis.		Locomotor Ataxy.		General Paralysis of the Insane.	
	England and Wales.	U.S.A.	England and Wales.	U.S.A.	England and Wales.	U.S.A.
1910	4.6	5.4	1.6	2.8	6.2	6.7
1911	5.1	5.7	1.8	3.0	6.0	7.9
1912	5.1	5.7	1.8	2.8	6.2	7.8
1913	5.7	6.6	2.0	3.0	5.8	8.2
1914	5.8	7.4	1.9	2.8	6.1	8.3
1915	5.3	8.1	2.1	2.8	6.2	8.6
1916	5.5	9.3	2.3	2.7	5.8	8.9
1917	6.1	9.6	2.2	2.6	6.5	8.5
1918	5.8	9.1	2.0	2.5	5.6	8.1
1919	5.0	7.8	1.8	2.4	4.4	6.8
1920	5.4	8.3	1.6	2.2	4.0	6.5

as gonorrhœa and syphilis. Much further information on the subject will be found in the Final Report of the Royal Commission on Venereal Diseases, 1916 (Cd. 8189).

**Bearing on Certification of Causes of Death—(a) Gonorrhœa.**—For similar reasons to those applying to syphilis, the actual mortality caused by the gonococcus is not measured by official figures.

The inclusion in the revised International List of "Gonococcal Infection (ophthalmia excepted)" as a separate heading implies an advanced stage in general medical diagnosis and certification which has not yet been reached. Presumably deaths due to gonococcal arthritis, endocarditis, pleurisy, etc., when returned as such, will be separated from deaths from diseases of the same organs not thus differentiated.

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Epilepsy, other diseases of the nervous system, and broncho-pneumonia (1 year and over), 30 per cent. ..	4,265	15.1
Total ..	33,676	119.5

**Experience of United States Registration Area.**—In "Mortality Statistics," 1920, is given a table from which part of the following information is extracted (see table on p. 485).

**Gonorrhœa.**—This disease is not a very heavy direct cause of mortality, but it is one of the chief preventers of life, being an important cause of sterility. If the deaths due to the remote results of gonorrhœa, e.g. pyosalpinx and stricture of the urethra, were added, its lethal power would be shown to be much greater than appears from official figures.

The registered death-rate from gonorrhœa in England and Wales for a series of years has been about 1 per million.

of population. In the United States registration area "gonococcus infection" was credited with a death-rate of 8 per million in 1920 and 4 per million in 1910. Gonococcal infection may include gonococcal endocarditis or other lesions; just as pneumococcal infection may cause death, apart from pneumonia. The certification of these rarer deaths from gonococcal or pneumococcal infection must depend on a degree of accuracy in pathological diagnosis not usually secured. It is impossible here to summarize all the statistical evidence

SYPHILIS.

*Death-rates per 100,000 of Population in England and Wales and in the Registration States of America Constituted as in 1900.*

	Syphilis.		Locomotor Ataxy.		General Paralysis of the Insane.	
	England and Wales.	U.S.A.	England and Wales.	U.S.A.	England and Wales.	U.S.A.
1910	4.6	5.4	1.6	2.8	6.2	6.7
1911	5.1	5.7	1.8	3.0	6.0	7.9
1912	5.1	5.7	1.8	2.8	6.2	7.8
1913	5.7	6.6	2.0	3.0	5.8	8.2
1914	5.8	7.4	1.9	2.8	6.1	8.3
1915	5.3	8.1	2.1	2.8	6.2	8.6
1916	5.5	9.3	2.3	2.7	5.8	8.9
1917	6.1	9.6	2.2	2.6	6.5	8.5
1918	5.8	9.1	2.0	2.5	5.6	8.1
1919	5.0	7.8	1.8	2.4	4.4	6.8
1920	5.4	8.3	1.6	2.2	4.0	6.5

as to gonorrhoea and syphilis. Much further information on the subject will be found in the Final Report of the Royal Commission on Venereal Diseases, 1916 (Cd. 8189).

**Bearing on Certification of Causes of Death—(a) Gonorrhoea.**—For similar reasons to those applying to syphilis, the actual mortality caused by the gonococcus is not measured by official figures.

The inclusion in the revised International List of "Gonococcal Infection (ophthalmia excepted)" as a separate heading implies an advanced stage in general medical diagnosis and certification which has not yet been reached. Presumably deaths due to gonococcal arthritis, endocarditis, pleurisy, etc., when returned as such, will be separated from deaths from diseases of the same organs not thus differentiated.

This is to the good, if they are kept in juxtaposition to the entry of diseases of the organs in question; but if they are referred to the general heading of "gonococcal infection," a loss of comparability is implied, as well as the detail of the localization of the disease.

Similar remarks would apply to a proposal to include pneumococcal infection, wherever localized, to a single general heading, unless subdivisions showing the number of different localizations were given.

(b) Syphilis.—Dr. Stevenson in the Annual Report of the Registrar-General, 1916, has discussed whether it is practicable to bridge a portion of the enormous gap still left between deaths attributed to syphilis or to some lesion which is known to be syphilitic in origin, and the view that syphilis is more destructive to life than tuberculosis, pneumonia, or cancer. The certification of death can never be so theoretically complete in respect of syphilis as to bridge this gap. Under the rules for certification (p. 170), if the death is caused by a local lesion which has outlasted the disease causing it—in this instance by many years—the death should be ascribed to the local lesion. This rule would apply to death from nephritis caused by an attack of scarlet fever two years earlier, or to death from endocarditis due to rheumatic fever five years earlier. The case is different for tuberculosis, in which the certifying physician recognizes the persistent presence in the local lesion of the tuberculosis infection. It is different also for death caused by syphilitic gumma of the brain, which, if recognized, is returned as syphilis. There are dangers, as pointed out in the above report, in encouraging the return of the more remote cause of death. In non-infectious diseases this might lead to certification on evidence not within the personal knowledge of the certifying physician. It is true that the spirochæte of syphilis can be found in old syphilitic lesions, given the possibility of pathological aid and adequate skill in examination, but to certify, for instance, the death of a man aged 40, suffering from cerebral hæmorrhage, as due to cerebral syphilis, in the absence of evidence of persistent syphilitic disease, would increase confusion. Inadequate certification of syphilis due to insufficient privacy of certification can be remedied by the means indicated on page 166; but the

reference of deaths remotely due to syphilis to this cause must come, if at all, by the action of the medical profession. It is doubtful if hasty action in this direction is desirable. *Certification by surmise is a retrograde step* when contrasted with certification of the proximate lesion at the time of death. As stated in the above quoted report :—

Whatever appeals or suggestions are addressed to the practitioner, habit in such matters is so strongly rooted that in many cases it probably never occurs to him that "cerebral hæmorrhage" is not always in itself a perfectly adequate form of certification. If the gross defects in the national statistics of syphilitic mortality to which various leaders of the medical profession have recently directed much attention are to be removed, the reform must come from within the profession itself, and mainly in connection with a general reform in medical certification.

### ILLUSTRATIONS.

1. In a standard book on Nervous Diseases some years ago it was pointed out that among the lower classes 80 per cent. of tabetics have been infected with syphilis, and therefore the preponderating cause is syphilis.

2. In a recent contribution to a weekly medical journal it is stated that in a statistical examination of a large number of cases of epilepsy there were equal numbers with and without ancestral neuropathic disorders, and an inference against hereditary influence is drawn.

*Remarks.*—In both these instances the only conclusions that can be drawn are that many tabetics have previously had syphilis, and that many epileptics are and many others are not the offspring of neuropathic parents. It is not justifiable to infer that heredity has borne a part in half the cases of epilepsy or has borne no part in their causation, or that the preponderating cause of tabes dorsalis is syphilis. To justify the probable conclusion that neuropathic inheritance has a share in the causation of epilepsy, or syphilis in that of tabes, it is necessary to show either that these diseases are confined to patients with these respective antecedents, or that the proportion of patients affected with these antecedent conditions is markedly higher in the patients than in a random sample of the population, constituted similarly to the patients, except in respect of the disease in question.

3. *Inadequacy of Evidence.*—The following statement has been made: in one of the largest clinics for venereal disease, about 25 per cent. of the cases treated for venereal disease had used immediate self-disinfection. What is the bearing of these figures on the value of self-disinfection?

*Comments.*—It would appear that 75 per cent. of the patients at this clinic had not used self-disinfection, while 25 per cent. of these patients had used it unsuccessfully. The best, but unfortunately not a practicable, method of demonstrating arithmetically whether prompt self-disinfection protects against venereal infection would be to ascertain the total persons in a group A (disinfectors) and in a group B (non-disinfectors), who had indulged in promiscuity, and the number in each group who developed disease. To make the experi-

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ment free from error, further conditions would need to be fulfilled. Were members of group A and of group B exposed to an equal extent to infection in proportion to their numbers? were the members of group A sufficiently sober to use disinfectants satisfactorily? and did they use them in the proper strength and in the proper manner, and so on?

Apart from statistics there is no dispute on the point, that disinfection efficiently employed will greatly diminish the risk of infection; but in experience is it likely to be so employed, and are other objections to widespread teaching of methods of disinfection sufficiently weighty to outweigh the partial success of disinfection in actual experience?

4. **Inadequacy of Evidence.**—In the towns of Portsmouth and Birmingham (the population of Birmingham is about four times that of Portsmouth) the number of new cases of venereal disease treated at the official clinics was as follows:—

Year.	Birmingham.	Portsmouth.	Percentage Increase (+), or Decrease (—) on the Previous Year.	
			Birmingham.	Portsmouth.
1919	2,615	556	+67.0	+54.4
1920	2,510	571	—4.0	+2.7
1921	1,652	383	—34.2	—32.7

In Portsmouth information is issued on the routine of self-disinfection in preventing venereal infection; in Birmingham this is not advocated, and the "packet" system is practically unknown; but a similar decrease in the number of patients coming for treatment has occurred in both places. Before concluding that instruction in self-disinfection has had no influence on events, it would be necessary to ascertain whether the two towns differ in other respects, e.g. as regards changing possibilities of infection, but such evidence obviously is difficult to secure. Meanwhile—assuming again that decrease of patients at the clinics in both towns indicates a corresponding decrease in the amount of disease—one cannot conclude or disprove that energetic instruction in self-disinfection has influenced the course of events.

## CHAPTER XLII

### CANCER MORTALITY

CANCER in civilized countries presents problems in vital statistics of great importance. In all countries the registered death-rate from this disease has steadily increased, and the question arises as to whether this increase is due to— (1) improved diagnosis, and, still more, to improved certification of cause of death; or (2) to the population being on the average older than in the past, or to both of these influences; or (3) is an actual increase apart from these factors.

#### ENGLAND AND WALES.

*Annual Death-rate per Million Living (Standardized) Population from Cancer of All Forms.*

	1851-80.	1861-70.	1871-80.	1881-90.	1891-1900.	1901-10.	1911-15. <sup>1</sup>	1916-20. <sup>1</sup>
Males ..	207	255	333	465	639	784	916	957
Females	440	522	619	739	882	942	998	996

<sup>1</sup> For method of calculating the standardized rates for males and females for these years, see Registrar-General's Annual Report, 1913, page xx.

To eliminate the second source of error, a method of standardization illustrated on page 335 was employed in a paper contributed by George King and A. Newsholme to the *Proceedings of the Royal Society*, vol. liv, 1893, on "The Alleged Increase of Cancer." The standardization of the various death-rates changed the relative position of some countries as regards cancer mortality, and the position of female in relation to male mortality. In the above table this source of error has also been eliminated, all the death-rates being calculated in terms of a population distributed like that of England and Wales in 1901, which is more accurate for comparative purposes than death-rates standardized by reference to an artificial life-table population.

If this method of comparing cancer death-rates is difficult to secure, then death-rates, for each sex separately, should be calculated for each age-period of life.

The above table shows that in 1916-20 the recorded male cancer death-rate was nearly five times as high and the recorded female death-rate more than twice as high as the corresponding rates in 1851-60. Below the age of 45 the rate of increase of registered cancer death-rate had been much less than at higher ages (see Fig. 51, p. 369). Cancer as recorded is becoming to an increasing extent a disease of old age as measured by years of life.

The following facts favour the view that the increased mortality registered from cancer is explicable by improved certification of deaths :—

(1) In the paper by King and Newsholme (1893) statistics of cancer mortality in Frankfort-on-Main were examined. These were the only figures then available in which deaths from cancer were distinguished according to the site of disease. Examination of these figures showed that cancer of "accessible" parts, likely to be more generally recognized, had not increased in the course of years, while inaccessible cancer had increased. The original paper was reprinted in the *Journal of the Institute of Actuaries*, vol. 36, p. 120. Dr. F. L. Hoffman in *The Mortality from Cancer throughout the World* (1915), which is a monumental compilation of cancer data, has published some more recent statistics of crude cancer death-rates for various parts of the body which, he states, do not support the previous results of King and Newsholme. On the other hand, Professor W. F. Willcox, in an important contribution on "The alleged Increase of Cancer" (*Journal of Cancer Research*, vol. ii, July 1917), has brought the original investigation of the Frankfort mortality statistics up to the year 1913, with the result shown in Fig. 80. There is, it will be seen, no evidence of increase in cancer of "accessible" sites, either in males or females, but "inaccessible" cancer has increased greatly.

At the time of the earlier Frankfort investigation "accessible" cancer was made to include cancer of the tongue, mamma, uterus, and vagina. Cancer of the larynx and of the rectum were not included in this group, but if they had been added the figures were such that the addition

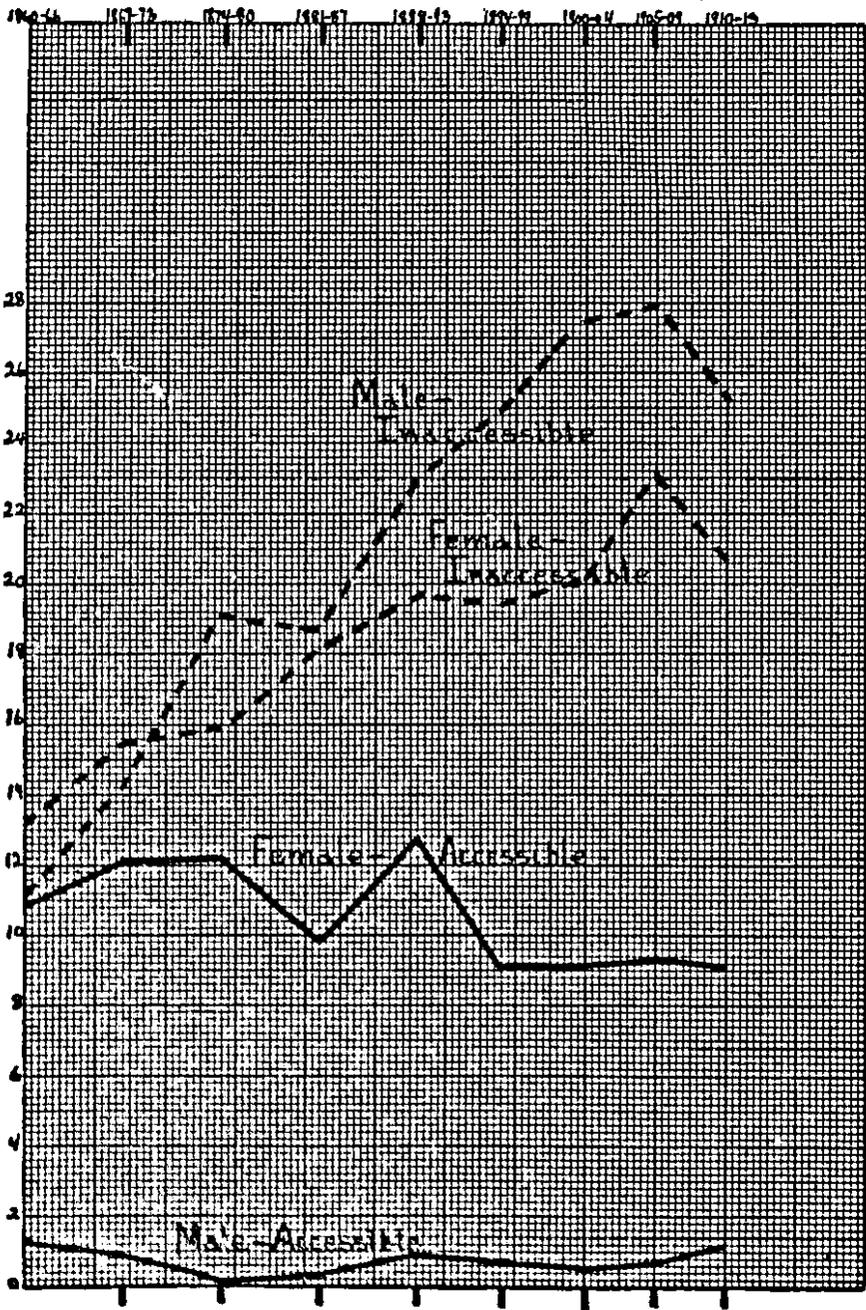


FIG. 80.—Death-rates from Cancer, Accessible and Inaccessible, Frankfort-on-Main, 1880-1913. (From Professor Wilcox's contribution to *Journal of Cancer Research*).

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would not have affected the argument. Cancer of the mouth, skin, and testis were not separately tabulated in the returns. Professor Willcox has examined the same material for a doubled period which trebles the material, and has applied the same method of standardizing the death-rates as was employed in the earlier investigation (for this see p. 335), with the result already stated.

On the other hand, Dr. Stevenson has obtained the following results from the English official statistics on which comment is made in a later paragraph.

*Standardized Cancer Death-rates per Million of Population aged 35 and over, 1901-10 and 1915.*

	Males.		Females.	
	1901-10.	1915.	1901-10.	1915.
Cancer of accessible parts .. .. .	609	723	1,429	1,535
Cancer of inaccessible parts .. .. .	1,463	1,723	1,287	1,422
Cancer of all parts .. .. .	2,343	2,721	2,941	3,166

In this table the population of 1888 was used as a standard.

(2) The increase in cancer death-rate is greatest in the older ages, at which diagnosis in the past has been specially defective.

(3) In 1871-80 the standardized female was nearly twice as high as the corresponding male death-rate from cancer; in 1911-15 the female excess was little more than 4 per cent. The recorded male death-rate had increased 197 per cent., and the female death-rate only 60 per cent. between 1871-80 and 1916-20. With this must be associated the fact that the excess of female cancer is chiefly in respect of cancer of the reproductive organs, in which diagnosis is relatively easy.

(4) A considerable share of increased cancer mortality is ascribable to fewer returns of deaths from "old age," and from ill-defined and indefinite causes.

(5) The steadily increasing proportion of hospital treatment of serious illness in large communities, with adequate pathological facilities for ante-mortem and post-mortem examination of material, has led to the discovery of an increased

number of cases. Dr. Bashford, in an investigation on behalf of the Imperial Cancer Research Fund, reported on 9,488 deaths in hospitals in the year 1909 attributed to cancer, which were checked by autopsies. Of these 8.0 per cent. proved not to be cancer; but in the same period and at the same hospitals 1,801 other deaths, not attributed to cancer, were shown post-mortem to be due to this disease. Thus in hospitals having every facility for correct diagnosis during life the number diagnosed as cancer, whether rightly or wrongly by clinical means, was only .90 per cent. of the deaths actually due to this disease. For cancer of inaccessible parts the number of deaths determined by clinical examination was only 68 per cent. of the true number. (*Lancet*, 1909, ii, p. 694).

The subject is developed in further detail in Professor Willcox's paper, who arrives at the following conclusion:—

The cumulative evidence that improvements in diagnosis and changes in age composition explain away more than half and perhaps all of the apparent increase in cancer mortality rebuts the presumption raised by the figures and makes it probable, although far from certain, that cancer mortality is not increasing.

The contributions of Dr. Stevenson to the annual reports of the Registrar-General, however, give important data which necessitate reconsideration of the earlier conclusion reached by King and Newsholme, and confirmed by Professor Willcox. These contributions point to the possibility that there may be increase of cancer of some parts of the body and not of others. The official English figures show that the mortality of females from cancer of the part of the alimentary canal above the stomach is a small fraction only of that of males, but females suffer more than males from intestinal cancer. Cancer of the stomach and rectum attacks males principally, but the excess in males is not so overwhelmingly great as for cancer of the œsophagus, pharynx, and mouth. The excess of cancer mortality in the female sex is due to disease of the breast and generative organs. If such deaths are excluded, the total deaths from cancer in 1916 would be reduced for females from 22,843 to 13,873, for males only from 17,787 to 16,978. It is noteworthy, further, that the cancer rates for males and females (standardized) in England and Wales are now nearly equal, and closely approxi-

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mate to 1 per 1,000 persons. There has been no further growth in the rate of cancer mortality during the last six years. In 1921 the cancer death-rate per million (unstandardized) was 1,215, as compared with 1,218 in 1918.

**Relative Importance of Cancer of Different Sites.**—The following table from the Registrar-General's Annual Report, 1920, gives the more important sites of fatal cancer and the death-rate per million from cancer of each site:—

### CANCER.

*Death-rates per Million Living at All Ages, 1920.*

Site of Cancer.	England and Wales.	
	Male.	Female.
Tongue .. .. .	63	6
Œsophagus .. .. .	73	22
Stomach .. .. .	228	182
Liver and gall bladder .. .. .	103	125
Intestines .. .. .	125	152
Rectum .. .. .	117	78
Uterus .. .. .	—	207
Breast .. .. .	2	228
Skin .. .. .	39	20
All the above .. .. .	750	1,020
Crude death-rate from all forms of cancer .. .. .	1,097	1,219

In the United States death registration area the recorded cancer death-rate in 1920 was 834 per million, having increased 32.4 per cent. since 1900. It was 680 in the rural part of registration States and 998 in cities. The following table compares cancer death-rates per million persons for certain "accessible" parts in 1900 and 1920, adjusted for age and sex distribution:—

Cancer of	1910.	1920.
The buccal cavity .. .. .	14	29
The breast .. .. .	50	92
The skin .. .. .	19	25

In the Annual Report of the Registrar-General for 1909 (p. xciii) is given a table of death-rates per million living aged 35 and upwards from cancer of several parts of the body, and from this table the following has been summarized:—

ENGLAND AND WALES.

*Cancer Death-rates per Million at Ages over 35.*

Part of Body.	Year						Percentage Increase between 1888 and 1909.	
	1868.	1888.	1909.	1868.	1888.	1909.	Males.	Females.
	Males.			Females.				
Face and lip ..	63·8	71·4	81·5	21·1	24·9	29·6	14	19
Mouth and jaw ..	31·5	70·9	110·9	17·4	18·4	28·8	56	54
Tongue ..	46·5	77·5	152·5	17·5	12·5	15·0	97	20
Æsophagus ..	14·2	71·4	185·8	12·1	31·4	53·7	160	71
Stomach ..	283·7	346·2	547·8	193·5	277·8	468·2	58	69
Liver and gall bladder ..	06·1	215·1	303·0	103·9	298·5	409·0	41	37
Intestines ..	32·3	06·4	233·1	33·4	124·6	286·8	142	130
Rectum ..	63·8	129·0	247·4	69·9	112·1	195·1	92	75
Bladder and urethra ..	16·6	44·9	82·6	9·1	18·0	29·9	84	66
Vagina, uterus, ovary ..	—	—	—	617·5	737·3	717·2	—	2
Breast ..	1·6	3·1	3·9	394·5	428·2	550·9	26	29

In most instances a marked increase is shown, which it may be added cannot be entirely explained by transfer from cancer undefined in regard to position in the earlier returns. The only instance of a decrease between the years 1888 and 1909 is that of uterine cancer. The increase in cancer of tongue and breast is in contrast with the stationary death-rate from cancer of tongue and other forms of "accessible" cancer in the experience of Frankfort.

In view of the fact that prolonged local irritation is an important factor in the causation of cancer, it is not improbable that cancer may be increasing in certain parts of the body, and not in others. There is reason to suspect that both syphilis and tobacco may be responsible for the excessive cancer of tongue in males; and these and possibly also alcohol (see p. 336) may play an important part in producing the general excess of male cancer in the upper digestive tract and mouth.

**Cancer Houses.**—A number of inquirers have suggested the association of cancer to an exceptional extent with

particular groups of houses. The statistical inquiry into these statements is beset with difficulty. The number of cases in the suspected area is always small, and correction of data for age and sex distribution of population may be impracticable. The frequent occurrence of local groups of deaths from cancer is to be expected, even if infection or other suspected cause of special house-incidence be eliminated. The total annual death-rate from cancer probably is considerably over 1 per 1,000 of population, and the allegation of special cancer houses based on deaths from this disease is to be considered along with the fact that the proportion of deaths from cancer to all deaths is high. Thus:—

## ENGLAND AND WALES, 1901-10.

*One Death from Cancer Occurred to Every x Deaths from All Causes.<sup>1</sup>*

At Ages.. .. .	45-	55-	65-	75-
Males .. .. .	11	8	10	11
Females .. .. .	5	6	8	17

<sup>1</sup> These can be turned into percentages. Thus at ages 45-55 the percentage of total deaths due to cancer was 9.1 in males and 20 per cent. in females.

In these circumstances the frequent recurrence of cases of cancer may be entirely fortuitous.

**Heredity in Cancer.**—Given a certain probability of death from cancer, and knowing the number of a family, it is easy to calculate the probability of one, two, or more of them dying of cancer quite independently of heredity. Even if heredity were proved to be absolutely inoperative, it is certain that there would be families among whom numerous deaths from cancer would occur. It does not prove heredity to show that in one family five deaths, say, occurred from cancer. This might happen from mere chance, and in fact such cases must occur without heredity at all. De Morgan worked out the probability of 1,000 successive heads being thrown in tossing a coin, and he showed that given a sufficient number of people starting to toss coins, at least one of them would toss 1,000 consecutive heads. So, given a sufficient number of families, it is a certainty, even if there be no such thing as heredity, that of at least one family,

say 10 members, will die of cancer. The only absolute proof of heredity would be to show that cancer occurred frequently in certain families, and practically in no others; short of this, the probability of heredity of cancer is increased if it can be shown that cancer is much more frequent in certain families than in the average for the whole community, due allowance being made for variations in age and sex distribution.

Experiments on mice made for the Imperial Cancer Research Fund by Dr. J. A. Murray have shown some excess of cancer in special strains of mice.

**Cancer and Social Position.**—Dr. Hoffman (*op. cit.*) refers to official cancer statistics for Edinburgh, the gist of which is that of the total deaths from cancer in the city one-third occurred in the houses of the well-to-do, while less than one-fifth of the deaths from tuberculosis occurred in these houses. No conclusion from these data as to the relation of social position to cancer or to tuberculosis is free from possible error. The deaths from each disease should have been stated in terms of the populations at risk, and the standardized death-rate obtained in each instance, or (notwithstanding possible paucity of data) the death-rate for each age-period should have been given.

A similar fallacy lurks in Heron's conclusion (*On the Relation of Fertility in Man to Social Status, etc.*, 1906). He found a correlation<sup>1</sup> of  $+0.404 \pm 0.109$  between female cancer rates and proportion of domestic servants (taken as an index of social status), and concluded that the "results seem to indicate that the conditions of prosperity and culture which lead to a low birth-rate also conduce to a high cancer death-rate."

Messrs. J. W. Brown and M. Lal ("An Inquiry into the Relation between Social Status and Cancer Mortality," *Journal of Hygiene*, vol. 14, No. 2, 1914) repeated the investigation, and found, when working also with metropolitan data, that the correlation between the *crude* cancer rates and proportion of domestic servants was  $+0.562 \pm 0.087$ ; but that with *standardization* of the cancer death-rates the correlation between these and the number of domestic servants became  $-0.032 \pm 0.127$ . Evidently, as the authors of this paper state, "Heron's coefficients do not measure what he seems

<sup>1</sup> As to correlations, see p. 517.

to have supposed them to measure," and the case is a clear warning that the use of refined methods of analysis of data will not compensate for, and is indeed less important than, the use of arithmetically comparable death-rates.

**Cancer and Childbearing.**—In the ten years 1911–20 in England and Wales cancer of the uterus, vagina and vulva, and of the ovaries and Fallopian tubes, caused 21·6 per cent., and cancer of the breast 17·7 per cent. of the total deaths from cancer among females, the chief incidence being on the uterus and breast. In man cancer of the breast, of the penis and scrotum, of the prostate and testes, caused altogether only 4·6 per cent. of the total male mortality from cancer. There are remarkable differences in the experience of married and unmarried. In the three years 1911–13 (Registrar-General's Annual Report, 1913) the standardized death-rate of single women was approximately double that of the married and widowed, their death-rate from mammary cancer being 45 per cent. in excess of that for those who had been married, while from cancer of the uterus the mortality among those who had been married was 73 per cent. in excess of that of the single. In the report of the Registrar-General for 1922 comparative death-rates may be expected for 1911–20. It would appear that some factor concerned with failure to function may predispose to excess of cancer of the breast in the unmarried, while traumatism may be regarded as bearing an important part in the causation of uterine cancer; and that, furthermore, a greater prevalence of lactation following childbirth might reduce cancer of the breast, even though some risk was incurred of increased uterine cancer. But the problem is likely to be much more complex than appears from this suggestion based on the comparative death-rates given above.

#### ILLUSTRATIONS.

(1) In 1919 the cancer death-rate in England and Wales was 964, and in the registration area of the United States 805 per million. It varied from 980 in Massachusetts to 459 in South Carolina. The highest rate recorded for whites was 925, and for coloured persons 822 per million, and the corresponding lowest rates were 476 and 385 respectively.

*Observations.*—With equal degrees of accuracy of certification of causes of death, standardized death-rates, or separate death-rates for different age-periods, will be needed before it can be inferred that the American is lower than the English cancer-rate. It might be argued that both white and coloured persons suffer less from cancer

in the south than in the north; but before this can be maintained, corrections as indicated above are necessary, and inquiry must be made as to relative accuracy and completeness of death certification and registration.

(2) **Phthisis and Cancer.**—It has been argued that if you prevent death in middle life from phthisis, you increase the chance of death later on from cancer.

*Observations.*—This frequent statement, as quoted above, is literally true. Some of those who now escape death from phthisis will eventually die from cancer. This is the inevitable result of continued life into the ages at which cancer claims a large percentage of the total lives. But it does not follow that a lowered phthisis death-rate means an increased cancer death-rate; there is no reason to think that any such connection exists. This is another form of the—

(3) **Fallacy of Substitution of Diseases.**—Malthus is quoted by Mapother as stating:—

“I have not the slightest doubt that if the introduction of the cow-pox should extirpate the smallpox, and yet the number of marriages remain the same, we shall find a very perceptible difference in the increased mortality of some other diseases.”

This quotation illustrates the same error as the statement that reduction of phthisis increases cancer. Reduction in the deaths from any disease implies that the survivors remain and are liable to other diseases. The fallacy is avoided by stating deaths from any given cause at a given age-period per 1,000 living in this age-period.

(4) **Cancer Problems.**—In a recent article it is remarked that it is equally important to ascertain if possible why cancer does not occur or is extremely rare among native Indians in the South American tropics as to ascertain why it is extremely common among other people.

*Observations.*—The evidence as to cancer in native races is scanty. Its age-distribution and the age-distribution of the population in question must be ascertained before the extent to which cancer prevails can be stated with an approach to accuracy.

(5) In a recent appeal by a Dietetic Reform Association, the statement is made that “in Ireland, where it is a national custom to cook potatoes in their skins thus retaining their mineral elements, the death-rate from cancer is very small, and shows no such marked increase as is found in other countries.”

*Observations.*—On the statistical side of this statement, it may be noted that the death-rate from cancer at all ages between 1896 and 1920 increased 54 per cent. in England, 58 per cent. in Ireland, and 68 per cent. in Scotland. In 1920 it was 0·85 per 1,000 in Ireland, 1·17 in England, and 1·19 in Scotland. These crude death-rates require to be standardized or separate death-rates stated for each age-period before accurate comparisons can be made, even if we accept the improbable assumption that certification of causes of death is equally accurate in the three countries. There is no valid statistical basis for the dietetic hypothesis suggested above.

(6) The need for standardization of death-rates is further illustrated by the following quotations from Dr. J. Shaw's *Cancer: Fallacy, Theory and Fact* (1923).

(a) “Cancer is a disease of degeneration, and cancer mortality in Ireland is low because the ‘age-constitution’ is high.” Here

the lowness of the cancer death-rate in Ireland is attributed to the less degree of activity of the processes of degeneration which shorten the span of life and thus induce malignant tumours. This may be a true view; but before accepting it, the arithmetical causes of variable death-rate must, so far as practicable, be eliminated by calculating standardized death-rates and by forming an opinion as to accuracy of certification of causes of death.

(b) The preceding statement is said to be confirmed by statistics of occupational mortality. Thus "the age-constitution of clergymen is higher than that of lawyers' clerks, but their cancer mortality is much lower. Similarly, agriculturists with a high age-constitution have a low cancer mortality," etc. In fact, however, all the occupations included in the official occupational statistics are reduced to equality of age-constitution before comparisons are made; and differences of cancer mortality must be explained otherwise.

(c) In the same volume is included an investigation of proportion between mortality from each particular cancer and total cancer mortality, and it is inferred that inasmuch as the proportion of deaths from cancer in parts of the body in which operation is practised to total deaths from cancer has increased, operative interference has increased the amount of cancer mortality. This is based on the assumption that "advance in registration and diagnosis must diminish the proportion of cancer of accessible cancers." This would, however, only necessarily occur if cancer were due to constitutional conditions, the effects of local poisoning or irritation being equally distributed. It is more likely that special provocative causes of cancer have come into operation in certain parts of the body, as the mamma in women, and the mouth and oesophagus in man. The statement of deaths from a particular cancer in proportion to total cancer offends against the rule laid down in page 368.

The problem as to the *effect of operation on mortality from cancer* of accessible parts, e.g. of the mamma, deserves further inquiry. It is beset with difficulty, and the statistical data to be obtained would require to be safeguarded, so far as practicable, against fallacies arising from (a) varying ages of patients at the time the disease was first recognized; (b) stage of disease at which operative intervention occurred; (c) completeness of operation. It would be necessary to trace the subsequent history of each patient for 5 or 10 years, and if possible until death occurred. Then the supremely great difficulty arises of check observations. What is the cause of cancer of mamma when undisturbed by operation in an adequate series of cases? Incomplete data on any of these points would be valuable as a contribution to full proof of the degree of utility of removal of mammary cancer.

**PART II**  
**METHODS AND MISCELLANEA**

## CHAPTER XLIII

### THE ARITHMETIC OF ELEMENTARY STATISTICS

THE necessity for a detailed statement of the more advanced mathematical methods of statistics in this work on Applied Vital Statistics does not arise in view of the textbooks on General Statistics now available. For more elementary students Professor A. L. Bowley's *Elementary Manual of Statistics* (Macdonald & Evans) is valuable as a general guide, and W. P. and E. M. Elderton's *Primary Statistics* (A. and C. Black) is an elementary introduction to mathematical statistics. W. P. Elderton and R. C. Fippard's small book, *The Construction of Mortality and Sickness Tables* (A. and J. Black), will also be found useful. For the description of higher mathematical methods the student should study *Elements of Statistics*, by Professor A. L. Bowley (P. S. King & Son), *An Introduction to the Theory of Statistics*, by G. Udny Yule, F.R.S. (C. Griffin & Co.), or *A First Course of Statistics*, by D. C. Jones, M.A. (G. Bell & Sons). Professor G. C. Whipple's *Vital Statistics* (J. Wiley & Sons, New York) includes a concise description of mathematical methods.

To one or other of the above works the student is referred for guidance on the advanced statistical methods as applied to biometrical problems; also to contributions in *Biometrika*, and in the *Journal of the Royal Statistical Society*. Reference in this volume is necessarily made to some important conclusions based on these advanced statistical methods, and the validity of some of these conclusions is criticized; but, so far as is practicable, the work maintains its original character as a guide to Applied Vital Statistics by such arithmetical methods as are comprehensible to the average physician or layman who has no advanced mathematical acquirements.

The first essential in statistical investigation is accurate

definition of each unit to be counted. Probably more errors arise at this than at any later stage, heterogeneous data being compiled, regardless of essential differences in age, sex, or some other condition. The error of heterogeneity may arise whether all the observations are counted or a random sample only is taken.

Sampling is of value in some public health inquiries, as in ascertaining height and weight of contrasted social groups. A limited sample may give an approximately good result, if precautions against bias are taken. Assuming that the group to be sampled is not heterogeneous to begin with, sampling may be effected by numbering the whole group, and drawing at random a given percentage of the numbers at given intervals for further examination. In school medical inspection and in various social and medical inquiries the task of ascertaining the complete facts respecting an entire group may be impracticable, and some method of sampling may need to be adopted. It is essential that every member of the group under examination should approximately have an equal chance of being included in the sample. This is usually attempted by random selection. First the group is accurately defined as to age, sex, occupation, area, etc. In a school investigation on a sampling plan, absentees should be included to avoid bias. The results will need to be stated as an average, and the precision of an average increases as the square root of the numbers taken. In a social investigation of poverty in a town, it would be absurd to limit a sampling investigation to a slum area. If statistics have been collected on an erroneous or biased plan, they cannot be made valuable by the use of refined statistical methods.

When in an investigation unexpected conclusions, contrary to our collateral knowledge and judgment, appear to be suggested, the need arises to examine critically the original data.

**Errors of Collection.**—It is seldom that complete accuracy of data can be secured, but—although this assumption needs always to be accepted with caution—it may often be assumed that errors in various directions tend to balance. This remark refers to what may be described as the natural inaccuracy of data; but this inherent possibility of error

and of balancing of errors in arithmetical statements renders it all the more imperative to avoid the classification of data which are essentially incomparable.

For most branches of ordinary public health work, partial statistics should be regarded as open to suspicion. Complete data respecting an area or a class and its subdivisions are desirable, though for special purposes, with precautions to avoid bias, sampled observations may suffice. Bowley's statement that "common sense is the chief requisite and experience the chief teacher" is important both in respect of the collection and the tabulation of data.

Accuracy, including completeness of statement, is necessary on such points as registration of births, deaths, sickness, etc., and in census enumerations of groups or of the entire population. Illustrations of lack of accuracy in the collection of data have been included throughout this volume. One of the most important sources of error in dealing with statistics on a small scale is the personal equation of the observer. In a sparsely populated district a doctor may enter pneumonia as bronchitis or conversely. In school medical inspections personal bias is a frequent cause of error; the inspector finds a larger proportion of the cases in which he is interested than another inspector who is not interested in these cases. This fact diminishes the medical value of tabulated results of medical inspection of scholars.

In compiling statistics of the height and weight of school children, it is desirable to state the age of each child in months as well as years; and if the tables give only the year of age, there must be no confusion between the age last birthday and next birthday, the heading of the table stating which method is adopted.

**Averages.**—The average or arithmetical mean is the most common method of generalized statement of a series of facts. Thus the mean age<sup>1</sup> at death of 8 persons whose deaths were announced in a daily journal on one day was as follows in years:—

$$\frac{1 + 5 + 11 + 22 + 35 + 70 + 75 + 82}{8} = \frac{301}{8} = 37.6 \text{ years,}$$

and of six on the next day:—

$$\frac{6 + 9 + 15 + 28 + 39 + 52}{6} = \frac{149}{6} = 24.8 \text{ years.}$$

The mean age at death for the persons whose deaths were announced in these two days, of course, was not

$$\frac{37.6 + 24.8}{2} = 31.2, \text{ but } \frac{450}{14} = 32.1 \text{ years.}$$

The average or arithmetical mean may give a misleading impression, if the extent of variation of the individual items in the group of observations is not also given. If an average death-rate for a number of towns is given, always ascertain the lowest and the highest death-rate in the experience of these towns. Similarly, if the infant mortality per 1,000 births appears low, we should not be contented until a statement is obtained giving the maximum and minimum infant mortality-rate in each town and in individual wards or other divisions of each town, and the number of deaths on which each of these rates is based.

The statement of maximum and minimum rates, as of infant mortality above, does not fulfil the needs of systematic study. For accurate work there is required a graph or table of the detailed observations, and often the employment of one of the methods of measuring the "scatter" or "dispersion" of the observations described in the following paragraphs.

Further light is thrown on a series of facts by ascertaining the mode and median. The mode is the magnitude of the item which is most common in the entire distribution or group of data. Thus in the measurement of children of the same sex and age the mode is the height which measures the largest number of children.

The median is the magnitude of the middle item in a distribution. Thus if in seven successive years in a given town, 15, 20, 25, 30, 35, 40, 45 cases of typhoid fever were notified, the median is 30 cases. If in a group of school children of homogeneous age and sex, those taller and those less tall than the median be respectively grouped, the middle term of each of these groups is the quartile.

In order that a large group of data may be examined more fully than by a statement of mean or mode or extreme values, it is necessary to group the data according to successive variations in the size of the characteristic under examination, and the grouped data are described as the frequency

distribution of the data. This term is defined by Elderton (p. 5, *Frequency Curves and Correlation*) as follows: "If statistics are arranged so as to show the number of times or frequency with which an event happens in a particular way, then the arrangement is a frequency distribution."

In games of chance, such as the tossing of coins or casting of dice, the distribution of the number of successes, given an adequate number of observations, follows intimately the "normal curve." Thus if a coin is tossed  $n$  times or  $n$  coins are tossed, the distribution of the number of heads in a series of repetitions of the experiment is the successive terms of the binomial  $(\frac{1}{2} + \frac{1}{2})^n$ , which when  $n$  is indefinitely increased becomes in the limit the "normal curve." Generally, if  $p$  = the chance of success, and  $q$  = the chance of failure, so that  $p + q = 1$ ,  $(p + q)^n$  gives the distribution.

The normal curve (Gaussian curve) is the form of distribution which is closely reproduced when the heights of a large number of children of a given age and sex in a given social stratum are measured. A bell-shaped curve results, in which large variations from the mean height occur less frequently than small variations. In all work with frequency curves and "correlation" (to be referred to subsequently) deviations are measured from the mean. Many series of observations form an asymmetrical series, not conforming to the normal curve, and a system of curves has been evolved by Professor Pearson which has been found to represent satisfactorily a large number of the distributions occurring in practice.

The standard deviation ( $\sigma$ ) of a group of data is a measure of the dispersion or "scatter" of the data in the group. It is the square root of the average of the squares of the deviations from the arithmetical average of the group. If the data are grouped, it generally suffices to assume that the data in a group are concentrated at its mid-point, so that the number of cases must be multiplied by the square of the distance of the mid-point of the group from the mean. In this approximation an error is involved, for which see Yule or Bowley's textbooks.

**Probable Errors.**—Inasmuch as all data are finite, and even very limited in ordinary experience, a statement of probable error<sup>1</sup> is necessary. Examination of successive

<sup>1</sup> The term "probable error" is in general use, although Francis Galton

samples of experience will give variations in coefficients, and a statement of the probable error gives some measure of the significance of a determination.

The probable error should be stated along with all statistical coefficients, including the coefficient of correlation described in the next paragraph.

The development of statistical theory has started very largely from the "normal curve" as a basis. This curve, as already indicated, is the form taken by the binominal  $(p + q)^n$ , when  $n$  becomes infinite. In this curve a distance measured on either side of the mean (or of the mode, the curve being symmetrical) of  $.6745 \times \sigma$  where  $\sigma = \sqrt{pqn}$ , comprises half of the total area of the curve, i.e. includes half the number of cases, the distribution of which is represented by the curve. Hence it is equally likely that a given deviation will exceed or that it will fall short of  $.6745 \sqrt{pqn}$ .

For these historical reasons it has become conventional to adopt as a criterion of significance, not the standard deviation, but  $.6745 \times \sigma$ . It is usual to regard a coefficient which is greater than 3 times its probable error as "significant," i.e. as not being within the limits of random sampling. Obviously the use of  $\pm 3 \times$  probable error as a criterion is approximately equivalent to  $\pm 2 \sigma$ . Some writers use  $\pm 3 \sigma$  as a criterion. The matter is one of individual judgment. In the normal curve  $\pm 3 \sigma$  includes 99.7 per cent. of the total area included by the curve, and  $\pm 2 \sigma$  includes 95.4 per cent. of the area, i.e. of the data, assuming that the distribution can be adequately represented by the normal curve, which is perfectly symmetrical about its mean.

It will be noted that what is usually described as the probable error, "p.e.," is in effect a conventional reduction of the standard deviation (s.d.). It is s.d.  $\times$  a constant. The probable error of the mean is given by the formula

$$.6745 \frac{\sigma}{\sqrt{n}}$$

(*Probability, the Foundation of Eugenics*, 1907), writing of the measurement of the relative variability of two normal curves, said: "the quartile is commonly employed as the limit of probability under the almost grotesque name of 'Probable Error.'"

In the following example the method of obtaining the s.d. and p.e. is illustrated :—

District.	Rate of Infant Mortality.	Deviation from Average.	Square of Deviations.
A ..	143	+ 7	49
B ..	143	+ 7	49
C ..	136	0	0
D ..	136	0	0
E ..	136	0	0
F ..	134	- 2	4
G ..	136	0	0
H ..	136	0	0
I ..	136	0	0
J ..	136	0	0
K ..	143	+ 7	49
L ..	143	+ 7	49
M ..	132	- 4	16
N ..	122	-14	196
O ..	138	+ 2	4
P ..	138	+ 2	4
Q ..	138	+ 2	4
R ..	121	-15	225
S ..	138	+ 2	4
	2,585		653

$$\text{Mean} = \frac{2,585}{19} = 136$$

$$\text{Standard deviation} = \sqrt{\frac{653}{19}} = \sqrt{34.37} = 5.9$$

$$\text{Probable error (p.e.) of mean} = .6745 \frac{\sigma}{\sqrt{n}} = .6745 \frac{5.9}{\sqrt{19}}$$

$$\log .6745 = \bar{1}.8290$$

$$\log 5.9 = .7709$$

$$\log 19 = \frac{1.2788}{.6394}$$

$$.5999$$

$$.6394$$

$$\hline 1.9605$$

$$\therefore \text{p.e.} = .9,$$

. Thus, regarding the districts A to S as a representative sample of the whole area under consideration, we may infer approximately that the true value of the mean rate for the whole area lies, as likely as not, between 136 - .9 and 136 + .9.

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Subject to certain conditions to be noted subsequently, if it be assumed that  $p$  = proportion of cases manifesting a given condition, and  $q$  the proportion from which it is absent, so that  $p + q = 1$ , then in a sample of  $n$  cases it may be expected that the proportion of cases having the given characteristics as likely as not will lie at any point between

$$p \pm .6745 \sqrt{\frac{pq}{n}}$$

Dealing with actual numbers this formula becomes

$$[I] \quad pn \pm .6745 \sqrt{npq} \text{ cases.}$$

By means of the above formula prediction can be made. Thus we may predict the limits within which the results of a second series of observations will probably lie, if this sample is taken from the same population as a sufficiently large first sample which gave an observed proportion  $p$ .

By an inverse process it becomes practicable to measure the accuracy of a partial experience. The probable error of  $p$  being  $.6745 \sqrt{\frac{pq}{n}}$ , the true value of  $p$  in the universe of which a sample has been taken may be expected, as likely as not, to lie between

$$p + .6745 \sqrt{\frac{pq}{n}} \text{ and } p - .6745 \sqrt{\frac{pq}{n}}$$

For death-rates per 1,000, the above formula becomes

$$1,000 \times \frac{n}{N} \pm \frac{.6745}{N} \sqrt{mn} \times 1,000$$

where  $N$  = population,  $n$  = deaths, and  $m + n = N$ ,

so that 
$$p = \frac{n}{N}, \quad q = \frac{m}{N}$$

**Example.**—Among a group of men numbering 3,300, aged 45–55, phthisis caused 20 deaths in a given year. What is the death-rate and its probable error?

Here  $n = 20$ ,  $m = 3,330 - 20 = 3,310$ ,  $N = 3,330$

$\begin{array}{r} \log n = 1.30103 \\ \log N = 3.52244 \\ \hline \bar{3}.77859 \end{array}$	$\begin{array}{r} \log n = 1.30103 \\ \log m = 3.51983 \\ \hline 4.82086 \end{array}$
<p>which is the log. of ·006006, the death- rate per unit of population, or 6·01 per 1,000.</p>	$\begin{array}{r} \log N = 3.52244 \\ \hline 2)1.29842 \\ \hline \cdot 64921 \end{array}$

$\begin{array}{r} \log .6745 = \bar{1}.82898 \\ \log N = 3.52244 \\ \hline \bar{4}.30654 \end{array}$	$\begin{array}{r} \bar{4}.30654 \\ \cdot 64921 \\ \hline \bar{4}.95575 \end{array}$
---	---

which is the log. of ·000903,  
the probable error per unit of  
population.

The probable error per  
1,000 = 0·9.

Thus it is as likely as not that the true value of the death-rate lies between 6·91 and 5·11, and that another group of men under the same conditions will have a phthisis death-rate between the same limits.

The formula, of the application of which an example is given above, is based on the assumption that  $(p + q)^n$  can be represented approximately by the normal curve. *This is only so when the total observations (n) are fairly numerous and when the difference between p and q is fairly small. If p is very small, as in the above example (20 deaths), the number of observations must be very large, some thousands, to justify the approximation given by the above formula. It must also be assumed that the events are independent of each other.* Where the formula breaks down owing to paucity of data, recourse must be had to the binomial  $(p + q)^n$  itself.

It is often necessary to ascertain whether the differences between averages derived from similar groups are due to random errors of observation or to real differences in the characteristic under observation. The formula employed is as follows :—

The probable error of the sum or difference of two *independent* variables  $x$  and  $y$

$$= .6745 \sqrt{\sigma_x^2 + \sigma_y^2}.$$

If by this formula an observed difference is shown to be three times greater than the value of the probable error, it may be "significant."

**Example.**—Two groups of patients of equal age and sex distribution, etc., were treated by two methods, B and C, for the same infectious disease during an outbreak common to the two groups, and another group A in the same circumstances was not so treated. The results were as follows :—

	A.	B.	C.
No. of cases ..	1,200	865	1,236
No. dying ..	42	20	10
Fatality per cent.	3.5	2.3	0.81

Is there any significant difference between these percentages, or might they be the result of accidental sampling ?

$$\begin{aligned} \text{Since } \sigma &= \sqrt{\frac{pq}{n}} \\ \sigma_{3.5} &= \sqrt{\frac{3.5 \times 96.5}{1,200}} \text{ per cent.} \\ \sigma_{2.3} &= \sqrt{\frac{2.3 \times 97.7}{865}} \quad " \\ \sigma_{.81} &= \sqrt{\frac{.81 \times 99.19}{1,236}} \quad " \end{aligned}$$

*Taking group A and group B :—*

Difference in fatality = 1.2 per cent., and  
Probable error of the difference

$$\begin{aligned} &= .6745 \sqrt{\frac{3.5 \times 96.5}{1,200} + \frac{2.3 \times 97.7}{865}} \\ &= .6745 \sqrt{\frac{338}{1,200} + \frac{225}{865}} \end{aligned}$$

$$\begin{aligned}
 &= .6745 \sqrt{.281 + .260} \\
 &= .6745 \sqrt{.541} \\
 &= .50 \text{ per cent.}
 \end{aligned}$$

But the difference  $3.5 - 2.3 = 1.2$  is not greater than 3 times .50, and is probably not significant. In other words, so far no evidence of the efficacy of the treatment appears.

Taking group A and group C:—

Difference in fatality = 2.7 per cent.

Probable error of difference

$$\begin{aligned}
 &= .6745 \sqrt{\frac{3.5 \times 96.5}{1,200} + \frac{.81 \times 99.19}{1,236}} \\
 &= .6745 \sqrt{.281 + .065} \\
 &= .6745 \sqrt{.346} = .4 \text{ per cent.}
 \end{aligned}$$

Here 2.7 is greater than  $3 \times .4 = 1.2$  per cent., and the difference may be significant. The comparison between groups A and B fails to show evidence of significant difference as regard results of treatment, and this suggests the possibility that some other unstated and possibly overlooked difference exists between the three groups. To make the above comparisons valid it must be assumed that the deaths are independent of one another, and that the groups from which the above samples are drawn are large.

Formula [I] on page 510 is a statement in a modern form of what is known as *Poisson's formula*, as may be seen by comparing it with the following statement from a former edition of this book:—

Let  $\mu$  = total number of cases recorded,  
 $m$  = number in one group,  
 $n$  = number in the other group,  
 so that  $m + n = \mu$ .

The proportion of each group to the whole will be respectively  $\frac{m}{\mu}$  and  $\frac{n}{\mu}$ . These proportions will vary within

certain limits in succeeding instances, and the extent of variation will be within the proportion represented by

$$\frac{m}{\mu} + 2 \sqrt{\frac{2mn}{\mu^3}}$$

and

$$\frac{n}{\mu} - 2 \sqrt{\frac{2mn}{\mu^3}}$$

It is evident that the larger the value of  $\mu$  (the total number of observations) the less will be the value of  $2 \sqrt{\frac{2mn}{\mu^3}}$ , and the less will be the limits of error in the simple proportion  $\frac{m}{\mu}$ .

Poisson's formula, in effect, takes as a criterion  $2\sqrt{2} = 2.828$  times the standard deviation  $\sqrt{\frac{pq}{n}}$ , whereas in modern practice  $3 \times .6745 \times$  standard deviation is commonly taken, i.e. 2.024, or practically twice the standard deviation.

Poisson's formula thus differs from modern practice in the degree of variation to be regarded as within the "limits of error," the formula taking as its limits a somewhat wider range of variation, viz.  $\frac{2.828}{2.024} = 1.397$  times the variation given by 3 times the probable error, or approximately  $\sqrt{2}$ , as will be seen from the above. Fundamentally the old and the new formulæ are identical.

It must again be emphasized that the formula can only be absolutely trusted in certain ideal conditions, the detailed discussion of which is outside the scope of this book. The results obtained, even from a large number of observations, are, moreover, only an approximation to the truth, although the limits of error are reduced with each increase in the number of observations, given equality of all the conditions involved.

Example.—The following illustration is taken from an article by Mr. de M. Rudolf (*Lancet*, June 10, 1922). It summarizes results of a series of pathological observations by Drs. Eastwood and F. Griffith, showing the proportion

of human tuberculosis of bones and joints due respectively to bovine and to human infection.

Age-period in Years.	Total Number of Cases.	Number of Bovine Infections.	Percentage of Bovine Infections.	Maximum Variation Possible.
0-5 .. ..	47	14	29.79	18.87
5-10 .. ..	108	31	28.71	12.31
10-16 .. ..	62	7	11.29	11.37
16-25 .. ..	15	3	20.0	29.2
Over 25 .. ..	29	—	0.0	0.0
	261	55	—	—

For convenience of the student, the working of this example for one age-group is shown.

At ages 0-5:—

$$\sqrt{\frac{pq}{n}} = \sqrt{\frac{29.79 \times 70.21}{47}} = \sqrt{44.5} = 6.67.$$

The maximum variation according to Poisson's formula is

$$2\sqrt{2} \times \sqrt{\frac{pq}{n}} = 2.828 \times 6.67 = 18.9.$$

Had 3 times the probable error been taken instead, we should have had

$$3 \times .6745 \times \sqrt{\frac{pq}{n}} = 2.024 \times 6.67 = 13.5,$$

and  $1.397 \times 13.5 = 18.9$  obtained by the use of Poisson's formula.

In view of the common use of Poisson's formula in medical statistics, it may be well to show the relation between the two formulæ:—

$$p = \frac{m}{\mu} \quad q = \frac{n}{\mu}$$

$$n \left( \text{in } \sqrt{\frac{pq}{n}} \right) = \mu, \text{ so that } \sqrt{\frac{pq}{n}} = \sqrt{\frac{mn}{\mu^3}}$$

In the following table are shown in parallel columns the

results obtained in the preceding example by applying the two formulæ:—

	Formula $3 \times .6745 \times \sqrt{\frac{pq}{n}}$	Formula $2 \sqrt{\frac{2mn}{\mu^2}}$
At ages 0-5 ..	13.5	18.9
"   6-10 ..	8.8	12.3
"   11-15 ..	8.1	11.4
"   16-25 ..	20.9	29.2

The numbers in the first column can be approximately converted into the corresponding numbers in the second column by multiplying by 1.397.

**Example.**—If out of 1,000 cases of cholera 700 recover, how near is this to the true average of recoveries ?

By Poisson's formula the true average lies between the limits:—

$$\begin{aligned} .7 \pm 2 \sqrt{\frac{2 \times 700 \times 300}{(1,000)^2}} &= 2 \sqrt{\frac{2 \times .7 \times .3}{1,000}} \\ (\cdot 7 \text{ being the rate of recovery per unit}) \\ &= \frac{2}{10} \sqrt{\cdot 042} = \frac{2}{10} \times .2049 = .04098. \end{aligned}$$

(1) Thus in 100,000 cases the range of recoveries is  $70,000 \pm 4,100$ .

(2) If the 70 per cent. of recoveries were based on 10,000 cases, then

$$\begin{aligned} .7 \pm 2 \sqrt{\frac{2 \times .7 \times .3}{10,000}} &= .7 \pm \frac{2}{100} \sqrt{\cdot 42} \\ &= .7 \pm .0130: \end{aligned}$$

Thus in 10,000 cases the range of recoveries is  $7,000 \pm 130$ .

(3) If the 70 per cent. of recoveries were based on 1,000 cases, then

$$.7 \pm 2 \sqrt{\frac{2 \times .7 \times .3}{1,000}} = .7 \pm .0410.$$

Thus in 1,000 cases the range of recoveries is  $700 \pm 410$   
Had our measure of the "limits of error" been taken as

3 times the p.e., the arithmetic would have been identical. Thus in case (1)

$$.7 \pm 3 \times .6745 \sqrt{\frac{.7 \times .3}{1,000}}$$

which differs merely in the constant  $3 \times .6745 = 2.024$ , as compared with  $2\sqrt{2} = 2.828$  in Poisson's formula.

The numbers must be fairly large for the formula to work. 10 is inadequate, 100 barely so. For approximate results probably 1,000 suffices.

**Coefficients of Correlation.**—The measurements so far considered relate to a single group of phenomena, for which it is required to give a concise statement of the average, and of deviations and probable error of this average. In medical and public health research, a frequent need is a measure of the degree of correspondence between two sets of phenomena. This is especially so when an inquiry into causation is undertaken. The general principles of such inquiries are discussed in Chapter XLIV. Here we are concerned with the measures of correlation which are associated with the names of Galton and Pearson. Only the elementary points required for comprehension of the statement of correlation coefficients in other parts of this volume can be given. For further details see the special statistical textbooks.

Professor A. L. Bowley states the generally accepted meaning of correlation as follows:—

“When two quantities are so related that the fluctuations in one are in sympathy with the fluctuations of the other, so that an increase or decrease of one is found in connection with an increase or decrease (or inversely) of the other, and the greater the magnitude of the changes in the one, the greater the magnitude of the changes in the other, the quantities are said to be correlated” (*Elements of Statistics*).

The measures of correlation which have been generally adopted state correlation on a scale of 0 to 1, 1 corresponding to “perfect correlation,” where the relationship is one of complete coincidence or of cause and effect.

The process of obtaining the coefficient of correlation is shown in the instance given on page 519.

The general formula is  $r = \frac{1}{n} \frac{\sum xy}{\sigma_x \sigma_y}$  where  $n$  = number of observations,  $x$  and  $y$  associated deviations from their respective means, and  $\sigma_x$  and  $\sigma_y$  are standard deviations of the distribution of  $x$ 's and  $y$ 's, i.e.

$$\sigma_x = \sqrt{\frac{\sum x^2}{n}} \quad \text{and} \quad \sigma_y = \sqrt{\frac{\sum y^2}{n}}$$

$r$  should never be stated without its probable error (E,

$$= .67449 \times \frac{1-r^2}{\sqrt{n}}$$

or in logarithmic form

$$\log (E_r) = \bar{1} \cdot 82898 + \log (1 - r^2) - \frac{1}{2} \log n.$$

It must be emphasized that the use of  $r$  as a measure of "correlation" is only justified when the "regression is linear," i.e. when the relationship between the two associated variables  $x$  and  $y$  is such that the values of  $y$  (say  $\bar{y}$ ) associated on the average with given values of the other variable,  $x$ , if plotted on a diagram lie on a straight line; or, expressed algebraically, can be represented by the formula  $\bar{y} = mx$ , where  $m$  is a constant, and  $r = \frac{\sigma_y}{\sigma_x}$ .

The relationship between the ages of husbands and wives (Fig. 7, p. 66) furnishes an example of "linear regression." If the average age values ( $\bar{y}$ ) of wives corresponding to groups of husbands aged  $x$  be plotted, it will be found that the values of  $\bar{y}$  lie closely on a straight line. The value of  $r$  as a valid measure of correlation diminishes in proportion to the departure from linearity. For the treatment of non-linear regression the authors cited at the beginning of this chapter may be consulted.

The example on page 519 shows the method of calculating the coefficient of correlation. It is taken from my Third Report to the Local Government Board on Infant Mortality dealing with Infant Mortality in Lancashire (Cd. 7511).

It cannot be said that there is any definite relationship between population of a town *per se* and its rate of infant

County Boroughs.	Popula- tion in Thousands (X).	Rate of Infant Mortality (1913) (Y).	z	y - Y - 140.	z <sup>2</sup> .	y <sup>2</sup> .	xy.	
							+	-
Bury .. ..	59	142	- 49	+ 2	2,401	4	—	98
Blackpool .. ..	61	126	- 47	- 14	2,209	196	658	—
Barrow-in-Furness .. ..	65	117	- 43	- 23	1,849	529	989	—
Southport .. ..	71	91	- 37	- 49	1,369	2,401	1,813	—
Bootle .. ..	72	145	- 36	+ 5	1,296	25	—	180
Warrington .. ..	74	131	- 34	- 9	1,156	81	306	—
Wigan .. ..	90	179	- 18	+ 39	324	1,521	—	702
Rochdale .. ..	93	106	- 15	- 34	225	1,156	610	—
St. Helens .. ..	99	156	- 9	+ 15	81	225	—	135
Burnley .. ..	109	175	+ 1	+ 35	1	1,225	35	—
Preston .. ..	118	159	+ 10	+ 19	100	361	190	—
Blackburn .. ..	134	148	+ 26	+ 8	676	64	208	—
Oldham .. ..	150	140	+ 42	0	1,764	0	—	—
Bolton .. ..	184	142	+ 76	+ 2	5,776	4	152	—
Salford .. ..	234	141	+ 120	+ 1	15,876	1	126	—
	15)1,613	15)2,007			35,103	7,793	4,987	1,115
	108	140					1,115	
							3,872	

$$r = \frac{1}{n} \cdot \frac{\sum xy}{a_x a_y}$$

Here  $\sum xy = 3,872$   
 $n = 15$

$$a_x = \sqrt{\frac{35,103}{15}}$$

$$a_y = \sqrt{\frac{7,793}{15}}$$

$$\log 3,872 = 3.58794$$

$$\frac{4.21853}{1.36941}$$

which is the log of .23410.

Probable error of  $r = .67449$  (say  $\frac{1}{3}$ )  $\times \frac{1 - (.2341)^2}{\sqrt{15}}$

$$= \frac{1}{3} \times \frac{.945}{\sqrt{15}}$$

$$= \frac{1}{3} \times \frac{.945}{3.87} = \frac{1}{3} \times .244 = .163.$$

Hence  $r = .234 \pm .163$ , which is barely significant.

mortality. The same conclusion is obvious on inspection of columns X and Y above.

In utilizing the coefficient of correlation as a measure of possibly causal relation between two series of data, we

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are not relieved from the serious difficulties which these investigations of causation :—

(1) In public health work commonly it is historical series, the comparison of which is desired ; and in such " time series " other important factors besides the two compared may have varied in a manner likely to affect the result. Thus, when the correlation between the quinquennial averages of birth rates and infant death-rates in England for the 13 periods 1851-55 to 1911-15, is ascertained, it is found to be  $\cdot 81 \pm \cdot 07$ . This " significant " correlation is quite consonant with the fall in the rate of infant mortality being independent of the fall in the birth-rate. As seen in Fig. 12, p. 115, steady fall in the birth-rate was unassociated with decline of infant mortality for a long series of years. It is likely that this earlier decline of birth-rate occurred to a greater extent in families of a social condition which would have had relatively low infant mortality had the families been large ; and it is arguable that the influence of a lowered birth-rate (implying longer intervals between births) would be chiefly visible in more recent years in which the lowering of birth-rate has spread to families in less easy social circumstances. Even if this be accepted, the coefficient of correlation ( $\cdot 8$ ) does not teach as much as a study of the curve on page 115. The subject is further discussed in Chapter X.

(2) The coefficient of correlation when obtained sums up the total relationship between the two series A and B. But in doing so, it disguises the variations of each of the series, seasonal, secular, or irregular, which when examined often reveal causal relationships or their absence, otherwise unsuspected. (On this see also p. 542.)

**Example.**—In a recent public health report is given a table showing the " sanitary index " of each of 24 districts in a city. The sanitary index is the marking, on a scale of 1 to 10, of the blocks of houses in each of these districts, according to the collective findings under certain sanitary headings. The marks run from 3·39 to 7·90, the low numbers representing best conditions. Parallel with this column is given the tuberculosis death-rate in each of these districts, which varied from 5·4 to 20·6 per 10,000 persons under 60 years old.

The coefficient of correlation between these two was given as  $.67 \pm .077$ , from which it was inferred that "there is a very decided relation between tuberculosis mortality and the sanitary index of the district." This in itself is a probable result. If the two series are plotted out in curves, the corresponding items of each series being placed parallel, the result is shown in Fig. 81, the two series being stated proportionally, in order that variations may be on an equal scale.

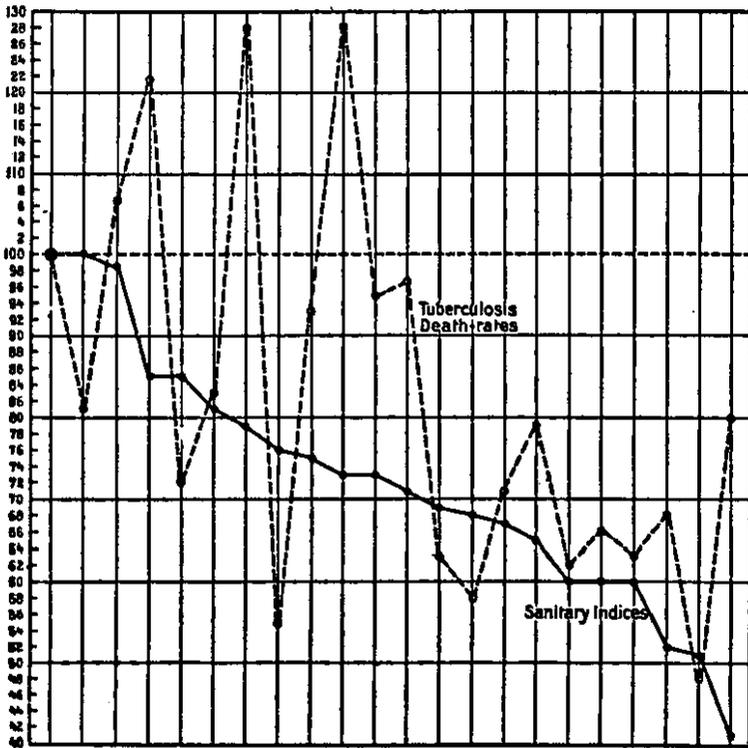


FIG. 81.—Curves of Sanitary Index and of Tuberculosis Death-rate in 24 districts, the first item in each series being stated as 100, and subsequent items in proportion to this.

It may be said generally that the percentage of insanitary houses is highest in the districts with the highest tuberculosis death-rates, and that low tuberculosis death-rates and favourable housing run together; but the exceptions are numerous, and the inevitable conclusion is that the fairly high correlation between the two factors gives a misleading impression of the relation of the two. The curves

irresistibly suggest the inference that either the records are erroneous, or that—the association of tuberculosis with bad housing being almost axiomatic—in certain districts other factors provoking tuberculosis are acting to a much greater extent than conditions which secure an unfavourable sanitary index.

(3) Although the existence of a high degree of correlation between two series of ratios does not necessarily prove a causal relation either of one to the other series or between them and some third series, the coefficient of correlation, when other considerations converge to the conclusion that two sets of phenomena are essentially related, gives a more compact measure of the relationship than can otherwise be secured.

This relationship between series may be misconstrued on mere inspection of the series whether in tabular or graphic form. In this respect a coefficient or correlation serves an analogous purpose to a standardized death-rate at all ages (p. 216). But in both instances there is considerable loss. Departures from parallelism or association between two curves are lost in the coefficient of correlation; and similarly investigation of the death-rate at each successive age-period is impossible from a standardized death-rate alone. The formula for obtaining correlations in short "removes us somewhat from the original data, and it does not relieve us from the necessity of making a close investigation of these observations" (Westergaard in *Quarterly Journal of the American Statistical Association*, September 16, 1921). Coefficients short of unity, suggesting causal relationships between phenomena, imply incomplete isolation of the factors involved. And such coefficients cannot be said to increase greatly our knowledge of the relationship between two rows of ratios or the two curves based on them, though they have the important advantage of obviating the intrusion of the personal factor in the reading of curves or tabular statements.

**Other Correlation Methods.**—The theory of correlation is given in Bowley's and Yule's textbooks of statistics; and Yule's paper on "The Theory of Correlation" (*Journal of the Royal Statistical Society*, December 1897) should be consulted. Those wishing to pursue the study further should consult *Biometrika* for April 1914, page 179, a paper "On the Variate Difference Correlation Method and Curve Fitting," by Professor

W. M. Persons, of Harvard University (*Quarterly Journal of the American Statistical Association*, June 1917), and Mr. Udny Yule's paper on "The Problem of Time Correlation, with Especial Reference to the Variate Difference Correlation Method" (*Journal of the Royal Statistical Society*, July 1921). Mr. Yule's paper emphasises the point already mentioned; "the essential difficulty of the time-correlation problem is the difficulty of isolating for study different components in the total movement of each variable."

A chief difficulty in the use of the more refined methods of advanced statistics is the inadequacy of the material examined. Occasionally also failure to make the arithmetical corrections called for in elementary statistical work destroys the value of conclusions derived from coefficients of correlation. A startling illustration of this is given on page 586.

In the statement as to coefficients of correlation given in the previous pages, only two associated factors have been dealt with, although other factors may be acting or conceived to be acting.

The method of connecting two variables by a *linear* relationship, involving a single constant which depends on  $r$ , may be extended to three or more variables, although the limits imposed by the condition of "linear progression," still require consideration. This is the method of *partial or multiple correlation*.

Taking three variables  $x$ ,  $y$  and  $z$  as an illustration, we assume that the value of  $z$  associated *on the average* with a given pair of values of  $x$  and  $y$  may be represented by the linear relationship  $z = ax + by$ , where  $x$ ,  $y$ , and  $z$  are measured from their respective means.  $a$  and  $b$  can then on certain assumptions be expressed in terms of the ordinary  $r$  described above, based on the various pairs of variables involved. An example of the application of this method will be found in Dr. E. C. Snow's paper on "The Application of the Method of Multiple Correlation to the Estimation of Post-Censal Populations" (*Journal of the Royal Statistical Society*, May 1911).

In the *variate difference method* the differences between successive observations are correlated instead of the actual data, and there is no agreement among experts as to possibilities of usefulness. Professor Persons has stated t

the method "involves the assumption that the taking of multiple differences leads to series of random variates. In practice for short series this assumption is not fulfilled. And Dr. Brownlee has "a very profound suspicion of any deduction based on that method." For further particulars, an article on "Correlation of Time Series," by Professor Warren M. Persons, of Harvard University, should be consulted (*Journal of the American Statistical Association*, June 1293). In this article he states that "the correlation of the second and higher differences—the 'variate difference method'— . . . is based upon assumptions which cannot be retained even in the simplest problems"; and he refers to an article by K. Pearson and E. M. Elderton in *Biometrika* for March 1923 ("On the Variate Difference Method"), "in which the defective character of the variate difference method, as originally proposed, is admitted."

The variate difference method has been employed in investigating the selective effect of infantile and child death-rates in successive years of life, with the result, as stated by Mr. R. A. Fisher,<sup>1</sup> that as high an inverse correlation was found between the death-rates in the fourth and fifth years as between those of the first and second years of life, a very improbable result. It would reasonably be expected that the selective effect of the mortality of the first year would be higher than any selective effect of the much lower mortality of the fourth year. For further remarks on this particular case see page 358.

Professor Bowley (*Elements of Statistics*, ed. 1920, p. 378) concludes that the various methods, including the variate difference method, "need further examination and more experience of their practicability. It appears that the moving average does not give the right importance to extreme terms, while the difference method is too sensitive to the effect of roughness in observations." The need for caution in accepting anomalous conclusions based on these methods has already been emphasized (p. 520).

**General Observations.**—The coefficient of correlation is a useful summary statement for measuring the general trend of two series of data, but it does not remove the possibility that the two series may have no connection, nor does it obviate

<sup>1</sup> Discussion on Yule's paper (ref. p. 106).

the necessity of careful examination of the series in detail. This examination may throw more light on the problem of relation than the coefficient itself.

The value of the coefficient and of other measures of probability has been the subject of destructive criticism. These objections have been stated in a noteworthy manner in Mr. J. M. Keynes' *Treatise on Probability*, 1922, and they are quoted as warranting suspension of judgment when the conclusions drawn from coefficients of correlation run counter to inferences on the same subject based on biological (including medical) considerations. Mr. Keynes expresses "disagreement with the fundamental premises on which Professor K. Pearson's work in probability and statistics seem to rest." He adduces Darwin's argument as to the Origin of Species, consisting of an elaborate combination of induction and analogy superimposed upon a narrow and limited knowledge of statistical frequency as illustrating the fact that the probability of an induction cannot be exactly measured. And yet, in Keynes' words: "many persons seem to believe that in the weaker and much more difficult type of argument, where the association under examination has been in our experience, not invariable, but merely in a certain proportion, we can attribute a definite measure to our future expectations and can claim practical certainty for the results of predictions which lie within relatively narrow limits. Coolly considered, this is a preposterous claim, which would have been universally rejected long ago, if those who made it had not so successfully concealed themselves from the eyes of common sense in a maze of mathematics."

His general conclusion is that, generally speaking, "the business of statistical technique ought to be regarded as strictly limited to preparing the numerical aspects of our material in an intelligible form, so as to be ready for the application of the usual inductive methods."

Statistical workers will do well always to keep in mind the warning conveyed by Keynes in the following words: "There is no more common error than to assume that because prolonged and accurate mathematical calculations have been made, the application of the result to some fact of nature is absolutely certain" (p. 382). Again (p. 384): "To apply these methods to material, unanalysed in respect of the cir-

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cumstances of its origin, and without reference to our general body of knowledge, merely on the basis of arithmetic, and of those of the characteristics of our material with which the methods of descriptive statistics are competent to deal; can only lead to error and to delusion. . . .”

## CHAPTER XLIV

### THE STATISTICAL STUDY OF CAUSATION

VITAL statistics are of practical value as a summarized record of facts, as a method of investigation, as a means of drawing attention to the incidence of controllable diseases, and as a general instrument of enlightenment and impetus to the control of remediable evils.

Information as to cases of typhus or typhoid fever or smallpox enables prompt inquiry into their source and measures for their control to be taken. This action can often be taken even before cases have multiplied to an extent which renders statistical study possible, beyond the stage of surmise or suspicion.

But a chief value of the study of vital statistics consists in the possibility of their furthering our knowledge of causation of measured phenomena; and the extent to which this use of statistics is possible and the inherent limitations of statistical research into causation should be considered. A discussion of this aspect of vital statistics, however sketchy, is needed at this stage.

In an induction, which may be defined for statistical purposes as an inference or generalization from statistical data embodying one or more series of measured observations or experiments, there is always the "inductive leap," the conclusion containing more than the premises.

Ordinary reasoning proceeds by an enumeration of instances, backed commonly by circumstances of comparison or analogy. In analogical reasoning the instances are weighed rather than counted. When we reason by analogy, we conclude that probably, if phenomena agree in ascertained particulars, they will agree in all; in drawing an induction we argue that because in certain instances phenomena behave in a certain way, therefore all instances of the kind will behave so.

Darwin's great induction as to the Origin of Species was based on a necessarily limited number of facts, supported by analogical reasoning, the truth of the induction being confirmed as time went on by further facts. False analogies are common, as are also correlations of events which do not indicate any causal relationship.

When studying the causation of phenomena, it is essential to ensure that each fact has been accurately observed, and that all the facts are homogeneous and may be aggregated. Their order of occurrence is important.

In social and medical investigations it almost always occurs that causes are multiple. A common definition of the cause of an event is that it denotes the circumstances in the absence of which the event would not have happened; but this definition is too limited in outlook, and we may speak of conditions favouring a given event as causal, even though their action is not indispensable for its occurrence. Thus scarlet fever, diphtheria, and rheumatic fever in this country prevail most widely in years of deficient rainfall; but they occur in other years. To eliminate climatic factors in studying the spread of these diseases would exclude an important factor in foretelling prevalence in a given year. In this illustration there is suggested a difference between the causation of a case and of an epidemic of an infectious disease.

Even if the word "cause" be limited to a necessary antecedent of a given result, causation may be multiple. Thus water only boils at 100° C. when the atmospheric pressure is equivalent to 760 mm. of mercury; and tuberculosis only follows infection by tubercle bacilli when the dosage of infection is adequate to overcome the natural or acquired resistance of the recipient—a varying amount. This resistance again embraces a number of factors.

The action of a cause may be prevented or mitigated—

(a) *By counteracting causes* or conditions rendering the specific cause impotent. A spark fails to ignite gunpowder when this is wet. The close association of typhus and relapsing fevers with personal filth and starvation is well known. This may be explained by the circumstance that these conditions imply also pediculosis; but it is not certain that depressed vitality, resulting from dirt and starvation, plays no part. Conversely,

in the absence of pediculosis, and failing the importation of infection, dirtiness or starvation cannot produce either of these fevers. These factors therefore stand in a different category from the specific infection and the specific vector of infection. All the same, action directed against them is needed as well as disinfection and isolation of patients.

(b) *By modifying causes.* When an elm tree is blown down in a storm, the high wind as well as the rotten trunk of the tree shares the responsibility for the event. The causation of rickets is a case in point. Experimentally it can be produced in rats kept in confinement by feeding them on a dietary deficient in certain respects; but under these circumstances rickets may be avoided if the rats have daily access to sunlight. There is nothing incompatible in these results. Rats insufficiently fed and kept in confinement have their metabolism and growth interfered with, the disability being obviated under the influence of sunlight, which enables the system to utilize more fully a given food supply. Sunlight may have a further direct effect. This case resembles a large number in social and medical work, and points to the extreme difficulty of inference from statistical statements.

The difficulty is greater when, as in human experience, observations cannot be checked by carefully devised experiments. One has constantly to be on guard against the tendency noted in Bacon's observation: "men mark when they hit, never mark when they miss."

In studying the causation of a social phenomenon, e.g. divorce or poverty, the logical methods of argument often fail of a definite result, because the same result may have a plurality of causes. An excessive rate of divorce may be due to laxity of moral standards; the rate will also be markedly affected by the character of legislation bearing on divorce; and in comparing one State with another or the same State with itself at different periods, the causes for which divorce is granted must be known. As pointed out by Professor Willcox, a statement of increase of divorce since habitual drunkenness was made an adequate cause for it will carry little weight, unless we know the number of divorce cases in which drunkenness has been the reason for a successful application for divorce.

So also in investigating the poverty of a country at

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different times, it is necessary to remember that the Poor Law organization does not deal with the whole of poverty; and that the official poverty-rate may easily be increased or decreased by changes in administrative methods, as well as by changes in prosperity. Again, indoor or institutional pauperism is largely a measure of the medical needs of the community, and in England is rapidly ceasing to be a fair measure of destitution.

These are arithmetical considerations illustrating the precautions needed in collecting and still more in framing conclusions from statistics. They illustrate, further, the fact that statistical data commonly cannot be subjected to ordinary inductive methods. The phenomena are so complex that a specific cause is undeterminable; the real cause is a combination of forces, some inimical and some helpful to the result under investigation. Bertrand Russell (in an address "On the Notion of Cause," Aristotelian Society, 1912) goes so far as to deny the existence of causes: "the law of causation, like much that passes muster among philosophers, is a relic of a bygone age, surviving because it is erroneously supposed to do no harm." This statement is at least useful as reminding us that in medical studies of causation, when exact experimental evidence is unobtainable, what is practicable is to determine the conditions under which a phenomenon appears.

It is at this point that the theory of probability is utilized. It deals with events in which given antecedents are sometimes followed by a given event and sometimes not, as in the throwing of dice, or the forecasting of weather, or anticipation of the rise and fall in money markets and stocks. The factors involved in the problem are so many and so complex, that the ordinary methods of inductive inquiry fail. Commonly, some of the items concerned are unknown, or it may be surmised that they are absent, and this is perhaps the most common case in statistical investigations. Hence the limitations of statistical inquiry into causation. It can suggest causation and open up channels of valuable confirmatory statistical inquiry, of further observations, or best of all of experiment, but it cannot compete with physical or chemical experimentation in determining a law of origin. It can give the average results applicable to communities, but these are

liable to serious error when applied rigidly to each individual. On this basis the science and art of life insurance has been built. If one were to estimate the expectation of life of any man by sole reference to his age, the estimate, though based on the average experience of the community, would be likely to be wrong. Age is only one factor concerned in the individual estimate; the man's family history, his previous medical history, his occupational and social position, etc., all influence the estimate. But when, as in statistical investigations of groups, we have an imperfect comprehension of causal connection, and are therefore obliged to substitute possible for real causes, the statistical method is indispensable. By multiplying the data, groups can be formed in which the number of theoretically possible causes is outweighed by a more limited number of more important causes, and—assuming the data are truly homogeneous—probable conclusions can be drawn or suggested.

**Predisposing Causes.**—Dr. John Snow, who discovered the specific causation of cholera, in his work on *Cholera* (second edition, p. 110), deprecated the continued classification of causes into predisposing, exciting, and proximate. He pointed out that for certain diseases, e.g. scabies, syphilis, smallpox, measles, this division of causation had been practically abandoned; but that we still continued to appeal to secondary causes in explanation of continued fever, adding, "various conditions are requisite for the production of a disease, as they are for the production of a crop of wheat or turnips, but it is not necessary to dignify these conditions with the name of causes."

At the time he wrote many physicians still regarded specifically polluted water as merely a predisposing cause of cholera.

Tuberculosis is perhaps the chief disease in which it is still necessary to consider auxiliary conditions as well as the tubercle bacillus in determining the origin of this disease in a given patient. But how far these conditions act by increasing dosage of infection, and how far by lowering resistance to infection, is still disputable ground.

We know, for instance, that phthisis is most prevalent in inferior dwellings; but as to whether this excess is due to the fact that these dwellings are occupied by an

intrinsically inferior stock, or is due to the results of overcrowding, or of malnutrition (which again may both favour and be the result of tuberculosis), a varying answer will be given, according to the mental bias of the interpreter. All the above statements contain an element of truth, and only a careful examination of the history of each family concerned holds out hope of ascertaining the relative value of these factors in an individual case.

“**Dynamical Investigation.**”—Carefully compiled and analysed statistics can give useful evidence, but the “dynamical investigation” of each case has its very special value. On this point the words of Clerk Maxwell<sup>1</sup> may be quoted:—

(In) the statistical method of investigating social questions . . . persons are grouped according to some characteristic, and the number of persons forming the group is set down under that characteristic. This is the raw material from which the statist endeavours to deduce general theorems in sociology. Other students of human nature proceed on a different plan. They observe individual men, ascertain their history, analyse their motives, and compare their expectation of what they will do with their actual conduct. This may be called the dynamical method of study as applied to man. However imperfect the dynamical study of man may be in practice, it evidently is the only perfect method in principle, and its shortcomings arise from the limitations of our powers rather than from a faulty method of procedure. If we betake ourselves to the statistical method, we do so, confessing that we are unable to follow the details of each individual case, and expecting that the effects of widespread causes, though very different in each individual, will produce an average result on the whole nation, from a study of which we may estimate the character and propensities of an imaginary being called the Mean Man. . . .

The discussion of statistical matter is within the province of human reason, and valid consequences may be deduced from it by legitimate methods; but there are certain peculiarities in the very form of the results which indicate that they belong to a different department of knowledge from the domain of exact science.

In the study of a single case of tuberculosis instanced above, careful individual inquiry would concern itself *inter alia* with the possibly associated conditions of defective nutrition, exposure to unsatisfactory conditions of work, alcoholic habits, etc., with the duration of the unsatisfactory housing, and with the date of the first onset of symptoms of pulmonary tuberculosis. The inquiry would carefully investigate whether there was a history of prolonged exposure to domestic infection

<sup>1</sup> *The Life of James Clerk Maxwell*, by L. Campbell and Wm. Garnett, 1882, pp. 434-444.

by tuberculosis, and the duration and dates of beginning and end of this, so far as ascertainable; and would attempt to distinguish between possible infection in the present unsatisfactory dwelling and the diminished resistance to infection due to bad housing.

The results of the inquiry would be compared with our experimental knowledge of the causation of tuberculosis by infection and with the exact experimental knowledge of means for annihilating tuberculosis in herds of cattle (concerning which exact statistical information is available); and the inferences drawn as to the relation between housing and tuberculosis would be based on a complete survey of our knowledge of this disease from every viewpoint, and not merely on statistics which in this instance supply in the main only end-products, viz. deaths and housing conditions at the time of death (see p. 308).

Further illustrations both of the value and of the limitations of the value of vital statistics are found in other chapters of this book.

**Science Dependent on Measurement.**—In other chapters the chief statistical methods of measuring the value of homogeneous groups of accurately ascertained facts are discussed. We cannot agree with M. Thiers' statement: "*La statistique est l'art de préciser ce qu'on ignore.*" It is only when measurement becomes possible that science begins. Every measure, it must be remembered, however, is a compound of a fact and of the errors which observers or their instruments of measurement will make. These errors may be constant in character, causing a bias in one direction, and multiplication of data in such a case merely increases the error; or they are variable, which in the long run may equalize errors in two directions. Imperfect measures are better than none. Given accurate all-round knowledge of a subject and an unbiased judgment, even defective statistics can become the source of valuable additions to our knowledge. But there are branches of knowledge—partial knowledge it is agreed—where statistical proof of results of a given line of action is unobtainable, and yet the action in question is undoubtedly good.

The value of the statistical method depends on the existence of equivalent units available for comparison. Thus there is no answer to the schoolboy puzzle—what is the

sum of two apples, three pears and an egg, except that there is no such sum. Or to use an illustration of Professor E. L. Thorndike of Columbia University, if the piety of St Paul = 100, what measure is to be attached to that of John Wesley? Nor can any statistical measure, so far as I can see, be applied in matters exemplified by the following case: The State of Massachusetts in 1908 passed a law which required every city and town with a population of 10,000 or over to vote on the question as to whether playgrounds should be provided and maintained out of public taxes. During the following year, of 42 cities and towns, 40 voted in favour of this proposal by a vote of about 5 to 1. Thus each of these communities will be called upon to provide play-places, with competent leaders for games and plays (L. H. Gulick, *Science*, N.S., vol. xxxi, 1910). The usefulness of these playgrounds is beyond doubt; but how to measure the degree of their value surpasses human ingenuity, in view of the numerous collateral influences, for and against the physical and moral health of the children concerned, which must enter into an analysis of the problem. Medicine and hygiene are beset with similar problems, in which we must seek out and welcome every effort to measure activities and their results; but we must continue our work when these are not forthcoming.

In the administrative work of the medical officer of health, the need for action on low degrees of probability not infrequently arises. Thus, when three or four notifications of diphtheria or scarlet fever are notified in households supplied from a single dairy, it is reasonable, indeed imperative, to institute inquiries respecting this supply, although the basis of suspicion is small; and given two or three lines of evidence converging to throw suspicion on a given supply of milk the health officer may be justified in advising or even in insisting on temporary pasteurization of this supply or its intermission, without waiting for statistical evidence on a larger scale. We are obliged in practical life to decide in each given case according to the balance of probability, in accordance with the following dictum from Bishop Butler's *Analogy* (vol. i, p. 3, Clarendon Press Edition):—

1. In questions of difficulty, or such as are thought so, where more satisfactory evidence cannot be had or is not seen, if the result of

examination be that there appears on the whole any, the lowest presumption on one side and none on the other, or a greater presumption on one side, though in the lowest degree greater, this determines the question even in matters of speculation; and in matters of practice will lay us under an absolute and formal obligation in point of prudence and of interest, to act upon that presumption or low probability, though it is so low as to leave the mind in very great doubt which is the truth.

But the public health necessity indicated above does not relieve us from the obligation of careful epidemiological study of each outbreak of disease and of accurate statistical statement, so far as practicable, as a means to this study.

**Imponderable Elements in assessing Value of Public Health Work.**—In the last section the need of administrative action on an unsatisfactory basis of epidemiological facts has been illustrated. There are more protracted forms of public health work in which also it is impossible, with the imperfect data at present available, completely to assess the value of work done. Work for the prevention of tuberculosis has already been adduced as an instance of special complexity, in which a number of auxiliary factors of evil are concerned, against none of which is the health officer willing to stay his hand. But until we possess more exact differential knowledge, the measurement of relative values must continue to be biased by personal judgment.

So likewise with the measurement of the value to be attached to the medical and hygienic work of health centres and of public health nurses (health visitors) in reducing infant mortality. It is most desirable that means for measuring relative values of various activities should be sought and experimentally applied; but they have not yet been perfected. By comparison of selected areas in different towns the value of sanitation and instruction in reducing infant mortality can be shown, although—inasmuch as with these two factors other factors are also concerned for which accurate information often cannot be tabulated—we may still find it impracticable to measure satisfactorily the value of each single factor.

But meanwhile the public health worker has no hesitation in acting on the belief based on his general experience that for the welfare of children knowledge is more salutary than ignorance, and that domestic cleanliness and skilled care safeguard health, and he continues to press forward work fulfilling these conditions.

## MISCELLANEOUS EXAMPLES BEARING ON THE STUDY OF CAUSATION IN PUBLIC HEALTH.

**I. Evidence as to Control of Scarlet Fever.**—In recent correspondence in a medical journal it is stated that the ordinary methods of control, including removal to hospital, examination of contacts, quarantine of contacts, disinfection, and search for slight and anomalous cases "have been tried in the area of every large sanitary authority in England, and yet scarlet fever is to-day more prevalent than ever it was before."

*Remarks.*—The last statement quoted above is unproved and cannot be proved. The mortality from scarlet fever has greatly declined, owing to increasing mildness of attacks; there is no proof that the number of cases has increased, and some indications point to the opposite conclusion. Next, the sweeping statement that all the methods named above have (presumably simultaneously) been tried in any sanitary area on a scale commensurate with the prevalence of the disease is most unlikely to be correct. There is in this statement grave confusion between quality and quantity of preventive measures. That many cases of scarlet fever are unrecognized, and probably unrecognizable, is highly probable, and further research is needed for new possibilities of prevention. But the advocacy of this does not justify extravagant statements respecting the best measures now available.

**II. Evidence as to Control of Ophthalmia Neonatorum.**—In a report of a M.O.H. it is stated that 56 cases of ophthalmia neonatorum were notified in the year 1920. In only one case did blindness (only partial) result. The practice of instillation by midwives of drops of collosol argentum was introduced in the previous year, and "I have every reason to believe that without such a measure the incidence of ophthalmia neonatorum would have been greater" than the amount it was, viz. 6.5 per 1,000 births, as against 3.5 in the previous year.

*Remarks.*—Much further information is needed to justify the expression of opinion quoted above. The statistics should show for a series of years the number of cases of ophthalmia neonatorum per 1,000 births, (a) in the practice of midwives, (b) in the practice of doctors. Some clue should be given as to the extent to which midwives carried out the instruction as to instillation of a silver salt. Was this done in the 56 cases of ophthalmia neonatorum, and, if so, what is the explanation of the occurrence of these cases?

**III. Cancer and Smoking.**—It is suggested that the habit of smoking conduces to the production of cancer. What evidence is there of this, and how could one proceed to investigate this problem statistically?

*Remarks.*—It may probably be assumed that any effect of smoking will be more likely to be produced in and about the mouth and throat. Cancer of the lip, tongue, mouth, and pharynx in 1919 caused 2,118 deaths of males, and only 280 deaths of females. It would appear, therefore, that some provocative agent of cancer of these parts is much commoner in men than in women. We know that prolonged local irritation may lead to cancer, and there is a *prima facie* case for a possible association of cancer of these parts and smoking. But the association may be accidental: and some other irritating agent, e.g. alcoholic spirits, may be responsible. Further exact data on a large scale are needed, and these at present are unobtainable. If we knew

(in every instance corrected for age and sex) the number of smokers and non-smokers in the general population, and the number of cases of cancer in each group, a nearer approximation to a conclusion would be possible. There is the further difficulty that the habit of smoking is not distributed at random. Smokers are likely to differ from non-smokers in other respects than that of smoking, just as teetotallers may differ in other respects than that of alcoholic habits from non-teetotallers. A number of variables may be handled by modern statistical methods; but for this purpose a large amount of statistical information is essential, which in this instance is unprocurable.

We are driven back, therefore, on observations of coincidence in medical practice, on the analogy of other instances of cancer produced by irritating agents, and on our general pathological knowledge of the subject.

**IV. Typhus Fever.**—Dr. Brownlee ("Periodicity of Infectious Diseases," *Public Health*, March 15th) says: "I think the disappearance of typhus was as much due to natural causes as to sanitary endeavour. . . . The fact that the disease disappeared from the West Highlands and from the West of Scotland at the same time as it died out in England suggests that some change in the organism was at least of as much importance as the application of sanitary measures."

*Remarks.*—This statement deserves more detailed discussion than can be given in this paragraph. The antitheses are between natural causes and sanitary endeavour, and between suggested changes in the organism of typhus and sanitary measures. It is suggested that natural causes have operated by producing changes in the typhus organism. Such changes cannot, I think, be proved for this country. In America an attenuated form of typhus, like an attenuated form of smallpox, does occur. But in this country typhus when it appears generally has a high fatality, and the problem is one of almost complete disappearance rather than of diminished virulence. Diminished virulence in other diseases aids survival of these diseases in the community.

Typhus fever has disappeared from Great Britain coincidentally with the increasing application of measures of hospital isolation of cases, of surveillance of contacts, and of cleansing of premises and persons. Now that it is known that this disease is spread, probably solely, by body lice, the above circumstances, combined with the important historical facts that there has been greatly reduced importation of the disease from Ireland and other countries, where it has been endemic, suffice to explain its disappearance even from the Highlands; and in accordance with the logical law of parsimony of causation, which deprecates unnecessary hypotheses, no further suggestion is needed.

**V. The fall of infant mortality in New Zealand,** as shown in Fig. 82, has been ascribed to various causes, the explanation which has received widest publicity being that it has resulted from the undoubtedly beneficent work of the "Plunkett" nurses. A study of the curve shows, through the oscillations, a trend throughout towards lower mortality. Possibly there was some defect in birth registration prior to 1900, but not since then. The recorded birth-rate has shown relatively little decline throughout; hence the lowered rate of infant mortality cannot be attributed to smaller families. The work of child welfare nurses has doubtless been valuable, but much of the decline occurred before they were generally at work (see notes

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to chart); and general improvement in sanitary and social circumstances and enlightenment, not capable of differentiation statistically, may reasonably be regarded as responsible for the greater part of the reduction in mortality. There is no evidence of altered climatic conditions to account for the smaller peaks of mortality in recent years; and in producing these, and the more rapid reduction in infant mortality, public health nurses and general propaganda in favour of increased infantile care have borne their part. To throw further light on the problem it would be necessary to analyse the

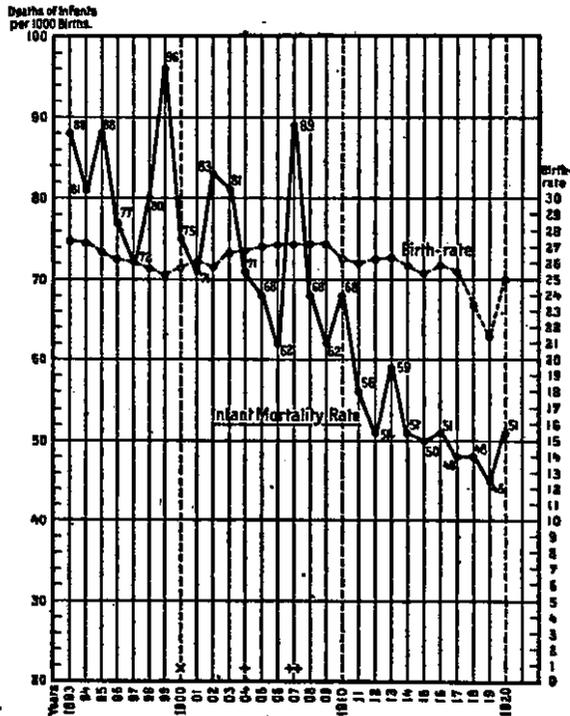


FIG. 82.—Course of Birth-rate and of Rate of Infantile Mortality in New Zealand, 1893-1920.

NOTES.—x A Public Health Department was constituted under the Public Health Act, 1900.

+ The Midwives Act came into force.

++ Regulations gazetted laying down a standard for milk.

The Royal New Zealand Society for the Health of Women and Children began operations, first locally, at Dunedin.

infant mortality for a series of years and for different parts of New Zealand, showing the rate of decline from the chief causes of death, and of deaths in the first and subsequent months after birth.

VI. Correlations of Coincidence.—In a special report on the "Mortality of Cholera in England, 1848-9," published in an early Registrar-General's report, Dr. Wm. Farr stated that "the elevation of

the soil in London has a more constant relation with the mortality from cholera than any other known element," the mortality from cholera being in the inverse ratio of the elevation. He fully recognized the operation of other factors besides elevation, and proposed a rule by means of which one might determine roughly how much of the total effect is due to elevation. Thus in the following table the number

Elevation of District in Feet.	Number of "Terrace" from Bottom.	Cholera Deaths per 10,000 Inhabitants.	Calculated Series.
Under 20 ..	1	102	$\frac{102}{1} = 102$
20-40 .. ..	2	65	$\frac{102}{2} = 51$
40-60 .. ..	3	34	$\frac{102}{3} = 34$
60-80 .. ..	4	27	$\frac{102}{4} = 26$
80-100 .. ..	5	22	$\frac{102}{5} = 20$
100-120 .. ..	6	17	$\frac{102}{6} = 17$
340-360 .. ..	18	7	$\frac{102}{18} = 6$

of deaths which may be ascribed to the factors included under the word "elevation," are obtained by dividing 102 successively by 2, 3, 4, 5, 6. The calculated approximate to the observed results; and Farr linked up this result with his rule as to the relation between density of population and mortality (p. 280). The law, he said, is that "the mortality in towns of some extent and density is inversely as the elevation." Under the conditions then holding good, this rule was valid; it may be that London, then being supplied with water largely from surface wells, wells neighbouring on the river level, had their drinking water more contaminated than that of more elevated districts. The lower-lying parts of London also were more densely populated, with correspondingly greater risks of personal infection. There is, however, as we now know, no constant relationship between elevation of dwellings and prevalence of cholera.

Dr. Snow's classical investigation of water-infection in cholera, based on accurate observation of a small number of cases, proved the essential relation of specifically contaminated water, and not of elevation, to cholera; and in the epidemic of 1854 proof on a large scale of Dr. Snow's induction was forthcoming. About one-fifth of the population of London was supplied with water by two water companies, both of whom derived their supply from the River Thames. In 1849 the point of the river from which each company obtained its supply was very polluted; but in 1854 the Lambeth Company had moved its intake much higher up the river, the Southwark and Vauxhall continuing to be supplied from a lower and more polluted part of the

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river. The relative experience of the two areas in 1854 was as follows :—

Areas Supplied by	Number of Houses.	Number of Persons.	Deaths from Cholera.	Cholera Deaths per 10,000 of Population
The Lambeth Company ..	25,854	166,906	611	37
The Southwark and Vauxhall Company .. .. .	39,726	268,171	3,476	170

Evidently some cause of cholera was acting five times as much in the area of one water company as in that of the other. It became necessary next to compare the experience of 1854 with that of the earlier epidemic in 1849, and it was found that in the area of distribution of the Southwark and Vauxhall Company the cholera death-rate was 118 in 1849 and 130 in 1854; while in the area of distribution of the Lambeth Company the cholera death-rate fell from 125 to 37.

When cholera is prevalent an excess of diarrhoea also appears in the death-returns; and comparing again the two areas at the two periods, it emerged that the diarrhoeal death-rate in the area of distribution of the Lambeth water fell from 29 to 21 per 10,000 of population; in the Southwark area it rose from 27 to 33 per 10,000, when comparing 1847 with 1853-4.

House to house inquiries showed numerous instances in which cholera had unerringly selected houses supplied by the dirtier water, omitting the area of the Lambeth supply. The contemporaneous comparison, the historical comparison, the evidence from experience as to deaths returned as caused by diarrhoea, and most convincing of all the intensive house-to-house observation in streets among the inhabitants of which the two companies were competing to supply, all converged to one conclusion as to the causation of the cholera, and illustrate exceptionally well the need to proceed, whenever practicable, by both contemporaneous and historical comparisons, by using allied diseases in aid, and by intensive observations of a limited number of accurately observed facts. In other words, field observations, i.e. classified instances on a small scale and statistical observations for masses of population must be kept in their right perspective.

**VII. Healthiness of Hospitals.**—In a Dublin hospital it was found that a higher mortality prevailed among patients treated in wards on the ground floor than in those treated on the floors above, and the greater unhealthiness of the ground floor was assumed to be a fact. (Sixth Report of the Medical Officer of the Privy Council, 1863, p. 527).

It was subsequently discovered that this was an amusing instance of *non ceteris paribus*, for the porter of the hospital had been in the habit of placing patients that could not walk on the lower and those that could walk on the upper floor.

**VIII. Relation between Pauperism and Licensed Houses.**—A propagandist society is responsible for the following statement: "There is no evidence to support the statement that when a drink-shop is opened it increases pauperism. On the contrary, we find that

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Canterbury, with 49·14 on-licences per 10,000, has a pauper rate of 16s. 8d. per £ assessable value. On the other hand, East Ham, with only 2·26 on-licences per 10,000, has a pauper rate of 27s. per £1."

This comparison of an industrial community, liable to great unemployment, with a residential city, on the assumption that the only difference between the two is in the number of public-houses, is only exceeded in absurdity by the assumption that ratio of rateable value to pauperism instead of number of paupers per 1,000 of population is the right measure of pauperism.

## CHAPTER XLV

### CORRELATION AS A MEASURE OF FACTORS INFLUENCING LIFE

THE destructive criticism by Mr. Keynes quoted at the end of Chapter XLIII naturally leads to a study of some of the instances in which inferences of great public health importance have been drawn from correlation coefficients. The most important of these have been published from the Galton Laboratory, under Professor K. Pearson's guidance, to whom the mathematical study of statistics is chiefly indebted for its present stage of development.

It is an important advance in science when measurement of facts becomes practicable, and qualitative is replaced by quantitative investigation. Subject to the cautions emphasized in other chapters, quantitative reasoning must, as available data of adequate accuracy accumulate, replace qualitative reasoning; and although doubt is expressed as to some of the conclusions from biometrical data quoted hereafter, the difference of opinion is concerned with the uncertainty as to whether the data are adequate and comparable, and as to whether they embrace the chief factors, which, experience indicates, are involved in the comparisons. In some instances it may be a duty to remain contented with a qualitative judgment until better and more adequate data can be obtained, though this qualitative judgment is as much open to revision and criticism as a quantitative judgment based on defective data, or which has failed to correlate the essential factors. But although this is so, the insistence on obtaining a quantitative besides (and in order to check) a qualitative judgment represents a marked advance in social science, and definite and final judgment depends on accurate and complete statistical knowledge, employed with knowledge and judiciously. It was Francis Galton (1822-1911) who introduced the con-

ception of correlation as a measure of the relative intensity of the factors influencing biological or social progress. Professor K. Pearson has extended Galton's original method and introduced more exact methods of mathematical statement of degrees of correlation. The coefficient of correlation for a given factor is measured on a scale from  $-1$  to  $+1$ ; and much importance attaches to measurements of the correlation between two social or biological phenomena, when these can be successfully isolated.

The difficulty of isolating factors for satisfactory examination by this method is, however, sometimes insuperable. In considering, for instance, the factors influencing the physical and mental fitness of a group of persons, we have to deal with a vast complex of associated conditions and influences, and unless it is possible to pick out the more important of these and relate them to the persons observed, mathematical investigation may give no more than is given by a qualitative inference. But the process of selection of factors necessarily involves some mental bias, a pre-judgment of the issue, and the selection, if made by persons with differing views, may easily vary greatly. The impossibility of eliminating the mentality of the investigator is especially serious when social and mental phenomena are concerned. It is in this preliminary selection that the chief blunders have arisen, though the unsatisfactory character of the data utilized is an almost equal source of error. In this respect the correlation method merely shares the disabilities of other methods of statistical investigation and of qualitative inductions.

**Marital Infection in Tuberculosis.**—(1) Thus Professor Pearson has found that there is only a low coefficient of correlation between the amount of tuberculosis in one partner and the other in married life; and this result is quoted as evidence that infection, as compared with heredity, has a minor influence in causing tuberculosis. Is this conclusion trustworthy? We will assume, contrary to likelihood, that in arriving at such a conclusion not only the age of all the partners exposed to infection, but also the duration of the exposure in married life are known; and that distinction is drawn between instances in which the simple precautions required to avoid personal infection are taken, and others in which the patient is careless. Evidently data fulfilling these

and like conditions of accuracy are difficult to secure. But even if all other possible sources of error are eliminated, the proof that there is little infection from tuberculous husband to wife or wife to husband becomes largely irrelevant to the problem of infection, if it be discovered that in a majority of cases of adult tuberculosis the disease is due to infection acquired or before adolescence, lying latent for some years, but provoked into activity by unfavourable industrial or social circumstance by alcoholism, or by an acute illness, e.g. influenza. The weight of evidence in support of the conclusion that adult tuberculosis originates largely, if not chiefly, in early life has steadily increased; the breakdown in health, when it happens depending sometimes on massive infection in adult life, more often on conditions which lower the resistance to the development of latent disease. The determining conditions may be entirely environmental, or partly the result of intrinsic differences of resistance in members of some families. The frequency of these breakdowns cannot unhesitatingly be accepted as a measure either of the frequency of infection in adult life or of inherent tendency to disease without a more exhaustive analysis than is implied in a study of marital relationships.

**Factors of Intelligence.**—(2) Miss Elderton in an inquiry into the condition of school children in Edinburgh arrived at the following results:—

	Boys.	Girls.
Correlation of intelligence in the children with the number of persons per room . . . . .	.02	.04
Correlation of intelligence in the children with good economic conditions . . . . .	.10	.16
Correlation of intelligence in the children with good physical condition of parents . . . . .	-.04	.06
Correlation of intelligence in the children with good moral condition of parents . . . . .	-.07	.03

Where negative signs are shown, these indicate that the better physical condition and moral condition of parents were associated with somewhat lower intelligence, a result which suggests the probability that some fallacy lurks in the measurements, or some error in classification. The general figure for heredity being taken as .49, the relative influence

of the factors named in the table on intelligence must be regarded as insignificant, if we accept the judgment of the observers and the accuracy of the measurements employed. Intelligence appears to have been measured on the impression of the individual investigator or of the teacher, and even were rigidly organized tests used, mental bias of investigators is a disturbing influence. There is the further preliminary difficulty pointed out by Professor Leonard Hobhouse<sup>1</sup> that in these investigations it is assumed that better economic and social conditions are generally indicative of superiority of stock. Hence the children of parents conforming to these better conditions should show better results, instead of the insignificant correlations of the preceding table. "We seem driven to the conclusion either that this particular method of calculation is misleading, or that the general assumption upon which many of the sociological arguments of eugenicists are based, that the socially more fortunate classes are of the best hereditary strain, is unfounded." We may properly hesitate to accept as conclusive the measures of environment used in this investigation, and regard them, even when obtained with minute care and accuracy, as measuring only a fractional part of the environment affecting intelligence. A somewhat similar investigation by Dr. D. Heron (*Eugenic Laboratory Investigations*, viii) has been critically examined by Mr. Udny Yule (in *School Hygiene*, lxxiii, p. 547), who doubts the validity of the data as to intelligence. These data are defended by Dr. Heron (*Questions of the Day*, No. II), who retains his confidence that no environmental condition produces an effect on the mentality of the child comparable with that of heredity (see also p. 561).

The results of a recent investigation published by the Medical Research Council ("The Relation between Home Conditions and the Intelligence of School Children," by I. Esserlis, D.Sc., and Mrs. Frances Wood, B.Sc., 1923) throw further doubt on the deductions made in the investigation quoted above. Carefully selected schools in London were chosen where the children who were to be reviewed differed widely in economic status, but were under the same teacher. The children in each instance were submitted (a) to the teacher's estimate of intelligence, and (b) to the special

<sup>1</sup> *Social Evolution and Political Theory*, Columbia University Press, 1911.

psychological tests indicated in the report, and the results thus obtained were compared with each other. The teachers were judging intelligence, not knowledge, and their estimates showed little correlation with age, unlike the special intelligence tests, but in general the two sets of tests gave results consistent with each other. The data obtained were tested by "partial correlation." The definite conclusion reached is that the influence of home conditions upon intelligence is a positive one, lying between .3 and .4. "Children from better homes showed, on the whole, more rapid progress than their less fortunate school-fellows; yet the individual differences within the economic groups are so large that the groups themselves enormously overlap," states Mr. Cyril Burt in his prefatory statement; and Dr. Esserlis concludes that although there is not implied "any adjudication of the shares of environmental and inborn factors in producing intelligence" . . . "we are entitled to conclude that progressive improvement in home conditions may be expected to react favourably not only on the health, but also on the intelligence of school children. Another argument . . . is thus provided for further efforts to ameliorate the home conditions of the children who attend elementary schools."

**Infant Mortality.**—(3) Hesitation is needed similarly in accepting the conclusions as to infant mortality in three manufacturing towns (*Eugenics Laboratory Lecture Series, III*). The conclusion is reached that conditions of heredity—"nature value"—have at least 4.5 times the value of the "nurture value," as tested by conditions like overcrowding, dampness, possibility of ventilation. The facts on which the correlations are based are not fully detailed in the above lecture; and the relatively insignificant place given by the correlation method to environmental conditions is so contrary to the experience of medical officers of health, which shows the great improvement securable in an infantile population by the application of personal domestic and municipal hygiene, that one must suspect the validity of the tests used in the investigation or the method employed in isolating them from other factors.

There is force in Professor K. Pearson's contention (p. 50 of above lecture) that our division into categories can only be very general. Thus suitable feeding may depend on many

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factors, and so also may conditions of housing, parental habits and parental health being concerned as well as physical environment. The parental factors again may be "nature factors," or they may be acquired, in part at least, in consequence of adverse physical environment. The importance of such considerations as these appears when the influence of any one environmental factor on health is under investigation.

**Alcoholic Habits.**—(4) A further example of the difficulties besetting accurate measurements in social inquiries is furnished by the results as to the influence of alcoholic drinks in parents on the height, weight, general health and intelligence of their children, derived by Miss Elderton from inquiries in Edinburgh and Manchester. The chief results are given in the following table :—

CORRELATIONS BETWEEN—

		Drink and Weight.	Drink and Height.	Drink and Intelligence.
Edinburgh	Boys .. ..	.05	.04	-.03
	Girls .. ..	.08	.09	.00

		Father.		Mother.	
		Intemperance and Health.	Intemperance and Intelligence.	Intemperance and Health.	Intemperance and Intelligence.
Manchester	Sons .. ..	-.06	-.11	-.07	.01
	Daughters	-.04	-.02	-.03	-.08

The Edinburgh figures in Professor Pearson's words (p. 17 of the above quoted lecture) show "that drink in the parents has no effect on the intelligence of boys or girls, and practically none on the height and weight of boys. In the case of girls there is a slight correlation between drinking of the parents and lower height and weight in the daughters ; but considering that the probable error of these results is about .03, they are only just significant." Evidently a correlation of .09 is very small as compared with a correlation of .49 for heredity.

The Manchester figures are regarded as evidence that

what very slight influence drink has on the general health and intelligence of boys and girls "is in favour of the children of drinking parents, they are healthier and more intelligent." It should be added that the authors of the *First Study of the Influence of Parental Alcoholism, etc.*, from which the above table is derived, accept the possibility of evil resulting from the economical and moral changes due to drunkenness, including distress and poverty, adding (Lecture, Series III, p. 26), "it is, perhaps, a consolation that to the obvious and visible miseries of the children arising from drink, lowered intelligence and physique are not added." I confess it is difficult to think of protracted parental drunkenness not affecting the physique and the mental (including the moral) condition of the children, notwithstanding the apparent absence of correlation between parental drunkenness and health shown above.

The above conclusions have originated a considerable controversial literature, some of which is summarized by Professor Pearson (in *Questions of the Day, etc.*, No. III). To justify the conclusions summarized above it would be necessary to show—

(1) That the group of non-alcoholic parents and children with which comparisons were made differed solely or chiefly in respect of alcoholism.

(2) That the tests of intelligence and physique were satisfactory, and were uniformly applied.

(3) That the alcoholic habits or the non-alcoholic habits were of a duration which would influence the condition of the compared children from intra-uterine life onwards, or short of this that the two groups were comparable in respect of shorter or longer exposure to the differential condition.

The first condition named above is especially important. More than half of the families included in the investigation were receiving some form of charity. Were the alcoholic parents of a superior initial type, who had been reduced to this condition by their habits, while in respect of physique and character the non-alcoholics represented an inferior stock? There appears to have been little information as to whether the parental alcoholism, the influence of which on the offspring was the subject of investigation, occurred before or after the birth of the offspring. It is noteworthy also that the

comparisons made are between "moderate" and immoderate drinkers, the few teetotallers found in the survey being grouped with the moderate drinkers.

Professor Pearson's pamphlet, quoted above, should be read by those wishing to study the difficulties of such a statistical social investigation as this. It is quoted here in order to emphasize the difficulties which statistical investigation of social phenomena on lines like the above has still to conquer.

There will be agreement with "Galton's fundamental principle that before we know the meaning of anything we must measure it," only it is desirable in the interest of accuracy to introduce the word "completely" into this quotation, both as regards meaning and measurement; and we must repeat the *caveat* that when results of measurement are not consonant with collateral knowledge, the measurements must be rigidly inspected as to accuracy and relevance.

Mill's words,<sup>1</sup> on taking into account, not merely the facts revealed in a particular inquiry, but all available evidence, require constantly to be borne in mind.

"The probability of events as calculated from their mere frequency in past experience affords a less secure basis for practical guidance than their probability as deduced from an equally accurate knowledge of the frequency of occurrence of their causes."

He then speaks of men who,

"having made themselves familiar with the difficult formulæ which algebra affords for the estimation of chances under suppositions of a complex character, like better to employ those formulæ in computing what are the probabilities to a person half informed about a case than to look out for means of being better informed. Before applying the doctrine of chances to any scientific purpose, the foundation must be laid for an evaluation of the chances, by possessing ourselves of the utmost attainable amount of positive knowledge."

According to Archdall Reid, the objection to biometrical methods of investigating the relative influence of nature and nurture goes even deeper, especially when mental characteristics are concerned. Pearson's position is that "the relative gain from education depends to a surprising degree on the raw material presented to the educator." Reid emphasizes the fact that "man is mentally an extremely adaptable, malleable, educable, intelligent, and intellectual

<sup>1</sup> Mill's *Logic*. III, xviii. 4.

animal," and that the terms "innate," and "acquired" are misnomers, slow evolution occurring under the stimulus of use. Thus Reid regards it as overwhelmingly probable that the physical inferiority of slum-dwellers, factory hands and the like, will vanish if their surroundings are improved sufficiently, while Pearson assumes that the inferiority is germinal, and therefore beyond cure except by natural selection. We may, however, assume that germinal inferiority and acquired inferiority both occur, while denying that biometrical methods so far have been able completely to differentiate between the two forms of inferiority; and we are bound to adopt in practical life the only justifiable policy of attempting to improve inferiority wherever found.

The views of the two extreme schools of thought quoted above may serve to illustrate the complexity of the statistical factors involved in social investigations, though they do not exhaust possible statements of the problem of inheritance.

The general conclusion must be that great caution is justified, indeed necessitated, in the acceptance of correlations which are not *a priori* probable, and which may embody only a fraction of the factors involved. There are, of course, dangers of no less magnitude in qualitative inferences, which are apt to neglect cases not supporting a given contention; and the general thesis is incontrovertible that accurate measurements and quantitative comparison of homogeneous phenomena represents a great stride forward in science.

## CHAPTER XLVI

### TESTS OF PHYSICAL AND MENTAL EFFICIENCY

A MASS of material bearing on national efficiency is being accumulated in the records of school medical inspections. Its value, however, is necessarily lowered by the varying standards and degree of accuracy of observations in different areas and by differences of method of record and tabulation. A similar remark applies to the weighings of infants and young children in child welfare centres. These weighings have immediate value in stimulating interest and in encouraging efforts to improve health; but for scientific purposes they are largely useless, owing to frequent neglect of elementary precautions as to weighing without apparel, etc. For scientific purposes, mass statistics such as are indicated above have much less value than samples on a smaller scale, chosen and measured under strictly scientific conditions.

Similar objections can be urged against the massed results of physical measurements and proportions of rejections of military recruits, especially statistics collected under war conditions, when accuracy and comparability of observations were commonly not secured.

**Recruiting Statistics.**—For several generations such statistics for Great Britain have been quoted as furnishing evidence that modern civilization produces physical deterioration, regardless of the need for comparison with countries in which there is universal compulsory military service, and without consideration of the variations in the English standards of rejection in accordance with the fluctuations of enlistment coincident with corresponding fluctuations in industrial conditions.

Dr. T. Graham Balfour, F.R.S., in his inaugural address as President of the Statistical Society (November 1888),

gave details as to the supposed deterioration of recruits, which showed that the changes in rejections were caused by the failure to overlook the condition of "other things being equal." Thus in the years 1860-64 inclusive, 32,320 examinations of recruits were made by Army surgeons; and the rejections from all causes were 371.7 per 1,000. During 1882-86, 132,563 men offered themselves for enlistment, of whom 415.6 per 1,000 were rejected. A late Director-General of the Army Medical Department could explain this increase in the rejections in one way only: "The masses, from whom the army recruits are chiefly taken, are of an inferior physique to what they were twenty-five years ago." Dr. Balfour however, instituted independent inquiries, which threw grave doubt on this conclusion, and satisfied him that a large proportion at least of the striking excess of rejections at the later period was due, not to an increase in the disabilities among the recruits examined, but partly to improvements introduced into the returns in 1864, by which they were made much more complete, and partly to changes instituted in 1879 and 1880 in the system of examination. Owing to the varying regulations in force in the Army, it was impossible to arrange the results of the two series of years in a form which complied with the condition of "other things being equal."

Army statistics fail as an index of national health, where recruiting is voluntary, both in this country and in the United States. Thus in 1897 the ratio of American recruits accepted was 70.2 per cent. In 1907 the percentage of white men rejected for the American Army was 9.2; in 1911-15 it was 11.3.

It has, furthermore, to be remembered that a large number of military rejections are for conditions not implying complete inefficiency. Colonel Keefer (*American Journal of Public Health*, 1920, p. 236) draws attention to the threefold test through which American recruits passed during the late European War. Of 3,208,446 registrants who were physically examined during one period, 255,312 were rejected by local boards, 172,000 were refused by camp surgeons, and 40,382 were subsequently discharged by camp surgeons. He adds that more than 88 per cent. of the "rejects" could be classified under the following heads:—

	Per Cent.
Conditions which prevented free mobility ..	26
Defects of special senses .. .. .	15
Cardio-vascular cases .. .. .	13
Nervous and mental abnormalities .. .. .	10
Tuberculosis .. .. .	9.5
Defective physical development .. .. .	8
Hernia .. .. .	6

Much valuable information on this subject is given in Dr. F. C. Hoffman's monograph on *Army Anthropometry*, in which the military experience of many countries is tabulated.

**English Recruiting Statistics in the Great War.**—In an official report (Cmd. 504) is given an elaborate account of the physical examination by medical boards of men of military age. The report, in its somewhat pessimistic summary, makes inadequate allowance for the fact that many of the defects, such as obesity, flat foot, knock-knee, hammer-toe, are not of a kind seriously impeding many walks in civilian life, though other defects show that a considerable proportion of the adult population are inferior in physique and efficiency. The men were classified in four grades, the first comprising men normal in strength and health, the second having some partial disability, the third included men with flat foot, hernia, varicose veins, and men who were unable to undergo full physical exertion, and the fourth grade men entirely unfit for military service. Nearly 2½ million men were examined during the period of these records. Of this total the examinations placed 36 per cent. in Grade I, between 22 and 23 per cent. in Grade II, from 31–32 per cent. in Grade III, and rather over 10 per cent. in Grade IV. It is noted that after entering the Army more men were de-graded than up-graded, a fact which may be held to confirm the original grading.

Some doubt is necessarily entertained as to whether the men examined from October 31, 1917, to November 1, 1918, who were included in this report, are a fair sample of the population of military age, though this question is answered affirmatively in the report. A further doubt arises as to whether the physiological standards adopted were appropriate; and most important of all, we have here massed statistics based on examinations by many medical boards under varying circumstances of leisure or hurry, of adequacy

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or inadequacy. The report may usefully be consulted; but without attempting to discuss results in the limited space here available, I merely record my opinion that the figures do not justify a pessimistic view of English physique. They show the presence of much disease and many defects in a considerable proportion of the adult population; but there is little, if any, reason for thinking that the proportion of these conditions has increased in the last twenty years.

**School Medical Statistics.**—Doubts suggested in the last paragraph as to the validity of generalized statistics of the physique of recruits under war conditions apply in large measure to massed statistics respecting school children. Much more can be said in favour of selected statistics from typical areas, such as are collected in the Annual Report of the Chief Medical Officer of the Board of Education, 1920 (Cmd. 1522). The results of the routine examination in 24 industrial, 24 residential, 24 rural areas and in London, showed the following results for four conditions which I have selected from the official report:—

	Pediculi Capitis.	Malnutrition.	Defective Vision.	Dental Disease.
Industrial areas .. ..	8.2	3.8	14.5	23.9
Residential areas .. ..	5.0	2.3	7.4	14.2
Rural areas .. .. .	7.3	4.3	9.4	23.6
London .. .. .	19.0 <sup>1</sup>	1.1	11.7 <sup>2</sup>	23.4 <sup>2</sup>

<sup>1</sup> Results of nurses' surveys.

<sup>2</sup> Defects noted for treatment.

It is assumed that the age-groups are homogeneous in the table, or that there is an equal proportion of children of different ages in each of the groups. The residential areas, as might be expected, come out favourably in the comparison, but it is unlikely that there are more badly nourished children in them than in London; nor are the variations in the amount of dental disease likely to correspond to fact. Probably London children are quite as clean as others; but in the metropolis there is well organized machinery for detecting pediculosis. The above are grouped areas in which the range of ratios is attenuated by combination; the range in each class would, doubtless, be much greater, if the extreme ratios for the single districts comprised in each area had

been given ; and in some of the classes the percentages cannot be trusted as giving indications of relative prevalence of defects. Such percentages have, however, much administrative importance in individual areas, as indicating work which requires to be done ; and extreme variations in percentages would, furthermore, draw attention to the competence or conscientiousness of the inspecting staff.

Statistics of "malnutrition" are perhaps the most unsatisfactory of all ; just as lacking in guidance as would be statistics of impressions on the part of an inspector of intelligence or poverty in the absence of rigid further tests ; or as are statistics of ascites, headache or dyspepsia, in the absence of a further medical diagnosis. This brings up the question of—

**Height and Weight Standards.**—Many tables of height and weight of children at different ages and for the two sexes have been published. These give *mean* heights and weights, and the mistake commonly made consists in regarding these as the *normal* heights and weights, forgetful of the facts that— (1) a large number of children range considerably on one or other side of the mean, without departing from normality, and (2) that the means are depressed by the inclusion of unhealthy, e.g. flat-footed, rachitic, scoliotic and ill-nourished children, as well as by the inclusion of children retarded in development by various illnesses. The only legitimate standard is one obtained by excluding all those. Dr. Dublin quotes Messrs. Emerson and Manug who recommend a lower limit of 7 per cent. from the average as indicating underweight and of 20 per cent. above the average for overweight. But "these limits make 20 to 40 per cent. of school and pre-school children mal-nourished, and that cannot be right except for highly selected children" (Dublin).

Certain points need to be noted : (1) Stature and weight at a given age vary with race. Welsh children, for instance, are shorter than Scandinavian, and Jewish than German at a given age. (2) A much larger range than is usually given must be allowed in a given fairly homogeneous group, before it is assumed that the condition is abnormal. (3) Not uncommonly there is marked familial difference in the age-distribution of growth. What is called malnutrition may merely be retardation of growth. (4) Evidence of mal-

nutrition, as shown by height and weight, or the proportion between these, must be tested by other evidence of the child's condition, his general appearance, his interest in his work, the condition of his skin and eyes, etc.

Dr. Dreyer in his work on *The Assessment of Physical Fitness* has based his conclusions on the inter-relation between weight, height sitting (stem length), circumference of chest, and vital capacity as tested by the spirometer, and by formulæ gives the value of each of these in terms of each of the others.

**Measurements of Race Differences.**—The extent to which physical differences and differences in vital experience have a racial origin is most debatable. Much of what has been attributed to race is caused by differences in cleanliness and sanitation, in personal habits and in social and economic circumstances. Although we may hesitate to apply to health conditions J. S. Mill's dictum,<sup>1</sup>

Of all vulgar methods of escaping from the consideration of the effect of social and moral influences on the human mind, the most vulgar is that of attributing the diversities of conduct and character to inherent and natural differences,

there is sufficient truth in it to warn the social worker against assuming an erroneously fatalistic attitude.

Now that tests of intelligence have been organized which appear to give fairly concordant results, even the above statement can be partially tested by statistics. It is, however, more than doubtful whether the indefinite reaction we call "intelligence" is the chief criterion of social efficiency, the elusive elements embraced in "character" possessing even greater importance. Thus Professor Wm. McDougall<sup>2</sup> gives the results of tests of white and coloured recruits to the American Army in the Great War, which are reproduced in Fig. 83.

The tests were devised to give no advantage to the better schooled men. Even allowing that education develops intelligence, there are differences between white and coloured in each group, and the curve for the illiterate white and the literate coloured roughly correspond.

<sup>1</sup> Quoted by Buckle from Mill's *Principles of Political Economy*, vol. i, p. 390.

<sup>2</sup> *National Welfare and National Decay*, by Wm. McDougall, F.R.S., 1921.

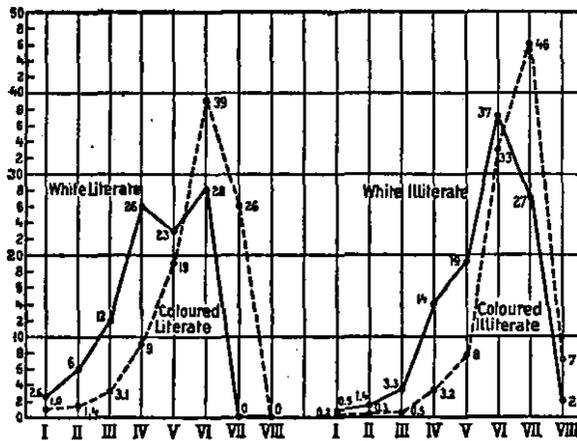


FIG. 83.—The Percentage proportion of Military Recruits in different Classes, according to the Military System of Mental Testing. Four Classes are shown, White and Coloured, Literates and Illiterates, the grading being from left to right in the Order of Decreasing Intelligence.

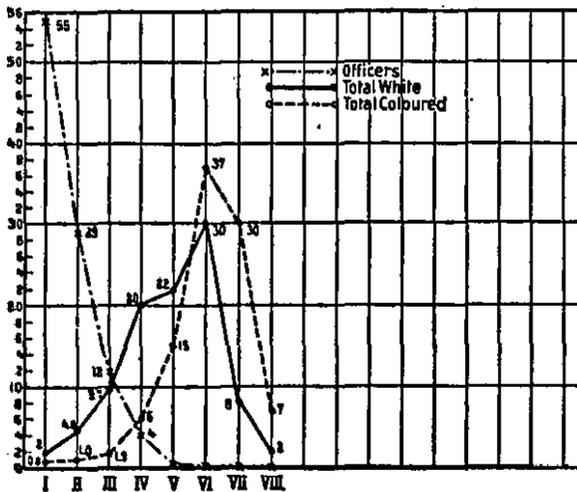


FIG. 84.—Showing the Percentage Proportion of Military Recruits—Total Whites and Total Coloured—and of Officers in the United States Army, graded as in Fig. 83.

**Social Status.**—It is convenient to consider at this point the social distribution of intellectual capacity as shown in the curves in Fig. 84, derived from the same source as Fig. 83.

The remarkable difference between officers and total white soldiers, or even between officers and white literate

soldiers, shown in the curves is greater than between white and coloured soldiers; and the explanation of race, therefore, only holds good for a fractional part of the results. Assuming the accuracy of the observations for all the classes, the conclusions indicated appear to be that *stock* is even more important than *colour* in the determination of intellectual capacity as ascertained by the tests applied, and that education—in the sense of total environment of each class—is an important factor in the results.

Another example, on a somewhat scanty scale, may be quoted from McDougall's book. Miss Arlitt tested 342 children from the primary grades of schools in one district. Of these 191 were of American-born white parents, 80 were born of Italian immigrants, 71 were coloured. All spoke English without difficulty. The Americans were classified in four groups in order of descending social status. The "intelligence quotients" (I.Q.) of these four groups in order of their medians (p. 506) were 125, 118, 107, 92.

The Italians had an I.Q. of 84, the coloured children of 83. It is noted that recent Italian immigrants are probably not a fair sample of the population of Italy. Although the above figures are quoted, I cannot satisfy myself that foreign birth and lack of quickness in responding to tests in an unaccustomed medium did not prejudice results for foreigners as against the American children. One would like to see corresponding tests made respectively by an intelligent negro teacher and an Italian teacher.

**Mental Condition of American Recruits.**—Mental tests of American recruits during the Great War were made on some 1,700,000 drafted men. These may be assumed to have had at least the average intelligence of the entire adult male population of the States, since no evidently feeble-minded were drafted. Seven grades were recognized. A men with very superior intelligence, B "superior," C+ "high average," C "average," C- "low average," D "inferior," D- "very inferior." The "intelligence tests" applied to these men were intended to measure intellectual competence rather than acquired information or education. The results were as follows, as stated in "mental age" of the recruits. By this phrase is meant that the recruit had the same mental capacity as a "normal" child of the same age.

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INTELLIGENCE STATUS OF AMERICAN DRAFTED MEN.

Grade.			Mental Age.	Per Cent. of Total.
A	..	..	18-19 years	4.5
B	..	..	16-17 "	9
C +	..	..	15 "	16.5
C	..	..	13-14 "	25
C -	..	..	12 "	20
D	..	..	11 "	7.5
D -	..	..	10 "	10
				100

The results indicate, to quote Professor Conklin,<sup>1</sup> that "assuming the drafted men are a fair sample of the entire population of approximately 100 millions, nearly one-half of the whole of the population will never develop mental capacity beyond the stage represented by a normal twelve-year-old child." It is not unlikely, however, that the tests were originally planned to exclude a high proportion of the drafted men. A further preliminary *caveat* may be entered as to the "normal" child, who probably is much above the average, if this could be ascertained. A further *caveat* is needed as to the exact meaning of "mental capacity," and as to the extent to which it covers the entirety of non-physical life. It is not the same quality as judgment or wisdom, and it is not the sole factor determining conduct, though it ranks high as a determinant of character. "Mental capacity" as tested is not identical with mental power, which is a function of two variables, native intelligence and the number and quality of the person's experience. This is true of the idiot, the moron, the highly intelligent man, and the genius; but the ability to respond to tests may be lowered either by initial deficiency or owing to undeveloped mental potentialities. Do the tests, or can they, distinguish between these? and if not, should the results of the military intelligence tests be regarded with the dismay with which they have often been quoted?

**Educational Ability.**—For a careful study of methods and results in the study of "the distribution and relations of educational abilities," including a study of the distribution

<sup>1</sup> *The Direction of Human Evolution*, by Professor E. G. Conklin, Princeton University, 1921.

of mental defect in school children, the reader should consult Mr. Cyril Burt's Report to the London County Council, entitled as above (P. S. King & Son, 1917), and more fully in *Mental and Scholastic Tests*, by the same author (1921).

The "Criminal Diathesis."—Dr. Charles Goring's *Statistical Study of the English Convict* (Abridged Edition, 1919, published by H.M. Stationery Office) is a lucid exposition of an intricate and difficult problem, which should be read by statistical students, if only for the light thrown in it on biometrical methods of investigation. The general conclusions of the investigation are that there is no such thing as a physical criminal type, that crime in this country is only to a trifling extent a product of adverse environment, and that the "criminal" is to a large extent a "defective," physically and mentally. Dr. Goring examined the correlations between environment and criminality. Of the circumstances thus examined, inferior school education, low standard on leaving school, irregular employment, alcoholism, size of family, may be enumerated; all these correlations were found to be very small. The conclusion is that "the particular nature of crime committed in this country has very little, if any, relation, apart from the relation of class, to any of the same environmental conditions. . . . Relatively to its origin in the constitution of the malefactor, and especially in his mentally defective constitution, crime is only to a trifling extent (if to any) the product of social inequalities, of adverse environment, or of other circumstances of what may be comprehensively termed the force of circumstances." On the other hand, "the criminal diathesis, revealed by the tendency to be convicted and imprisoned for crime, is inherited at much the same rate as are other physical and mental qualities and pathological conditions in man."

This conclusion, if firmly established, is extremely important. It may be urged that the high correlations (.45 to .6) indicating the degree of restriction of crime to certain stocks may result from moral contagion, and not be due to "inheritance of anti-social proclivities." The fact that there is a high correlation between criminality in wife and husband would support this view; but in the report this is explained on the hypothesis that such marriages are assortative and not truly random; and if this explanation

be accepted, the chief exception to the apparent rule of inheritance disappears.

But doubt still lingers as to the success in separating moral contagion from heredity.

Sir Bryan Donkin (*Journal of Mental Science*, vol. lxxiii, 1917, p. 16) has criticized the above *Study* in an article which should be read after reading the *Study*. He agrees that mental defects are present more frequently in criminals than in the general population, although the relatively small group of mental defectives among criminals needs to be carefully separated from the majority. The main difficulties in accepting Dr. Goring's conclusions are two:—

(1) It appears to be assumed throughout that criminality is a unity, a fallacy similar to that which treats poverty or any other social or anti-social phenomenon thus; for there are in fact "no special qualities, physical or mental, common to all criminals."

(2) Grave doubt must attach to the view that because high correlations exist between heredity and crime, and insignificant correlations between certain environmental circumstances and crime, the existence of a type, the victim of an inborn make-up, is established. The human organism is subject from earliest life onwards to infinitely complex influences or stimuli, and every human being has almost infinite ability to acquire capacities and qualities from these stimuli. It cannot be agreed that the few circumstances of environment enumerated in Dr. Goring's report, which show insignificant correlation with crime, are an adequate measure of these stimuli. That inheritance bears an important share in the production of crime need not be doubted. It bears an important share in the possession of every human capacity; but this does not imply that the criminal is the creature of his inborn capacities or incapacities alone, and the significance of environment in the widest sense cannot be said to have been statistically disproved.

**Delinquency and Feeble-mindedness.**—Dr. Francis L. Dunham (quoted in *Lancet*, December 16, 1922), of Baltimore, Maryland, in a recent address has given important considerations which are relevant to the above remarks on the statistical investigation of criminality. Discussing the commonly accepted belief that a positive correlation exists

between low mental age as measured by the ordinary intelligence tests and moral delinquency, he points out that there is quite a high proportion of dullards in every community, yet "so well does the dull but stable" (i.e. emotionally stable) "person manage himself in our varied civilization, with its constantly increasing public health care, that we tend to forget him as a good citizen, and only recognize him when he is bad. Among several hundred delinquents who have come under Dr. Dunham's observation during the past five years about one-sixth represented a grade of intelligence which in the usual child of corresponding mental age would not assure enough insight, judgment, or co-ordinative capacity to keep out of harm's way and to carry out ordinary hygienic requirements." One-third of the remainder were not so backward, but that with proper vocational guidance they might not have become useful citizens, and the rest of the delinquents were ranged all the way from a mental age of  $13\frac{1}{2}$  years to those with unusual intelligence and a college training. Altogether Dr. Dunham concludes that while "standard statistics in social hygiene tell us that one-third of all prostitutes are feeble-minded," the statement that "the percentage of mental defect among prostitutes is no greater than it is among other commercialized groups is probably nearer the truth. . . . The mere fact that our ingenuous snares catch dullards is no sign that all offenders are stupid enough to be caught."

The important consideration is emotional instability. This is not, as Dr. Dunham shows, necessarily an inborn characteristic, but quite frequently results from suppression or perversion of normal sexual tendencies during a girl's adolescence. Hence the importance that the general public should be brought to a sane comprehension of the physiology and psychology of sex.

**The Handicapping of the First-born.**—Reference may be made here to a critical paper by M. Greenwood and G. Udny Yule "On the Determination of Size of Family and of the Distribution of Characters in Order of Birth from Samples taken through Members of the Sibships" (*Journal of the Royal Statistical Society*, vol. lxxvii). They point out errors of previous investigators, as for instance in the statement that "criminals are the product of the most prolific stocks in the

## TESTS OF PHYSICAL AND MENTAL EFFICIENCY 563

community," and indicate a class of fallacies inherent to methods employed in estimating the relative liability to disease, e.g. tuberculosis or insanity, in successive members of a family. The method used in these biometrical investigations has been a statement of proportion of firstborn who are defective, etc., to those in the sibship of which they are members. Such a method must be regarded as "essentially fallacious," for it would produce the heaviest incidence in the earlier born of any character desirable or not. Such comparisons are liable to error, also, in consequence of the varying size of family in different social classes. Large families being more numerous, they will be unduly weighted in any comparison of the family incidence of tuberculosis, insanity, etc.

This paper has been criticized in a later paper by Professor K. Pearson, "On the Handicapping of the First-born" (*Eugenic Lecture Series*, X, 1914).

Both aspects of the controversy are too detailed for summary here, but the unbiased reader of the two above papers will realize the importance of caution in accepting conclusions as to inheritance, which run counter to collateral knowledge. Incidentally Pearson expresses some disagreement with Goring's statistical treatment of the problem of crime in the elder-born, which had been criticized by Greenwood and Yule.

## CHAPTER XLVII

### REPRESENTATION OF DATA BY TABLES AND GRAPHS

BUT few general rules are needed as to the tabulation of data, technical knowledge of the subject, accuracy of work, and common sense being the chief requirements. A table, as Giffen has said, is really an argument, and it should fulfil the following minimum conditions:—

1. It should be self-explanatory, having a full descriptive heading. The headings of each column and of side lines should be clear and precise. Nothing should be left to be guessed or puzzled out.

2. To avoid the necessity of the last-named possibility, explanatory notes should be given, though when bulky notes are needed the value of the table is diminished.

3. Simplicity should be aimed at, the compression of many terms into a single table being avoided.

4. Economy of figures should be secured, decimals being used only when they are significant.

A dichotomous system of tabulation should be followed when practicable, dual division being followed by similar subdivision of each item, and so on. It is not always convenient or necessary to adopt this plan.

It is assumed that the data on which the table is based have been carefully examined and their trustworthiness assured.

Throughout this volume numerous tables are found, and further examination of these will show some of the chief possibilities of tabulation.

**Tables for Investigation.**—Tabulation gives a manageable summary of a mass of facts, which otherwise would be unserviceable. It is thus informative. It may also be a means of investigation. The following examples illustrate this more important use of tables:—

(a) In epidemiological or social inquiries concerned with measurable homogeneous facts, tables can be made to show the historical sequence of events; and from this sequence it becomes possible to suspect new empirical laws, especially when the sequence is subsequently tested by comparison with other similar tables, or curves based on them. The word "suspect" is used advisedly, for, as Westergaard has said, "the task of the statistician is not so much to find the causality himself as to help others to find it." The revelation of the real significance of relationships between groups of events of medical interest is the task of the natural sciences, including medicine in so far as it is scientific and not merely empirical.

Every epidemiologist who has been engaged in studying a particular disease prizes official reports which give the necessary data *for a long series of years*. The value of such a series increases year by year as it grows in length. If the figures recorded are sickness or death-rates, and not the original numbers, the possibility arises that some of the more ancient rates may have been calculated on an erroneous estimate of population, and this may need to be checked by reference to census populations. It is necessary also in all such investigations to inquire whether the observations have an equal degree of accuracy throughout. Thus in an historical investigation of sickness-rates and death-rates from diphtheria, the introduction of the aid to diagnosis given by bacteriology and the effect of antitoxin on the course of the disease would be disturbing influences.

In a table or curve dealing with an epidemic disease can be seen not only (1) the *irregular fluctuations* of the disease year by year, but also (2) the *cyclical fluctuations* of epidemic and inter-epidemic periods; and (3) if the series is long enough, it may be practicable to distinguish *secular fluctuations*, when a disease shows a persistent decline or increase, behind its cyclical fluctuations.

(b) Tables may also serve to give valuable information as to the seasonal incidence of disease, as in the following table from the yearly statement of infectious diseases in England and Wales, published for the last eleven years in a separate report; for 1921 included in the Annual Report of the Registrar-General. The table is also a good illustration

# 566 THE ELEMENTS OF VITAL STATISTICS

ENGLAND AND WALES, 1921.

*Seasonal Incidence of Certain Infectious Diseases.*

(1921) Week ending—	Scarlet Fever.	Diph- theria.	Enteric Fever.	Cerebro- Spinal Fever.	Polio- myelitis.	Encephalitis Lethargica.
Jan. 8 ..	98	125	69	188	33	248
" 15 ..	88	111	55	125	33	318
" 22 ..	99	129	77	188	33	407
" 29 ..	100	127	53	163	44	471
Feb. 5 ..	92	138	66	225	56	479
" 12 ..	88	117	49	163	22	304
" 19 ..	91	119	70	138	22	229
" 26 ..	92	115	55	88	56	282
March 5 ..	91	112	50	50	56	189
" 12 ..	87	110	58	200	11	157
" 19 ..	86	106	65	113	44	107
" 26 ..	79	89	51	113	22	104
April 2 ..	77	89	74	100	22	111
" 9 ..	74	89	55	138	78	79
" 16 ..	72	87	58	100	22	82
" 23 ..	70	91	59	138	33	71
" 30 ..	79	83	59	88	44	75
May 7 ..	74	85	70	113	—	75
" 14 ..	80	80	57	25	44	54
" 21 ..	69	78	51	150	67	75
" 28 ..	74	73	73	125	33	71
June 4 ..	74	79	57	75	111	86
" 11 ..	69	75	58	100	22	61
" 18 ..	75	72	45	138	56	36
" 25 ..	74	72	63	113	100	57
July 2 ..	74	79	72	100	56	50
" 9 ..	83	83	63	50	78	39
" 16 ..	81	78	73	63	78	46
" 23 ..	80	76	108	75	100	54
" 30 ..	71	75	73	63	100	43
Aug. 6 ..	62	67	131	63	100	39
" 13 ..	57	61	159	113	200	61
" 20 ..	66	61	170	63	278	25
" 27 ..	69	61	191	50	200	25
Sept. 3 ..	79	74	201	88	167	50
" 10 ..	96	79	191	88	300	14
" 17 ..	108	89	182	63	222	64
" 24 ..	112	89	149	25	222	32
Oct. 1 ..	125	98	150	100	211	21
" 8 ..	158	112	127	25	289	29
" 15 ..	150	117	135	50	211	21
" 22 ..	163	134	130	75	167	43
" 29 ..	159	137	136	50	289	25
Nov. 5 ..	162	135	209	100	178	36
" 12 ..	157	135	230	113	133	29
" 19 ..	168	124	182	113	189	36
" 26 ..	164	137	161	63	158	36
Dec. 3 ..	161	130	78	100	111	25
" 10 ..	150	128	96	38	122	50
" 17 ..	148	143	100	138	56	46
" 24 ..	129	130	74	100	56	39
" 31 ..	117	120	59	75	89	50
	100	100	100	100	100	100
Average weekly number of cases notified ..	2,636	1,279	74	8	9	28

NOTE.—The actual average weekly number of cases is shown at the foot of each column. The proportion of the notifications to this average taken as 100 is shown for each week, any seasonal excess of 30 per cent. over the mean for the year being shown by black type.

## REPRESENTATION OF DATA BY TABLES 567

of a percentage method of statement. The weekly cases of each disease are first tabulated, the average weekly number for each is ascertained; this is then taken as 100, and the number for each week is stated proportionally.

The table, it will be noted, has black type for the weeks in which each disease is more than 30 per cent. above the average for the year; and the table thus serves to some extent as a graph of seasonal incidence. Conversely graphs may be made a method of tabulation, if at each point of the group the ratio is stated (see Fig. 85).

(c) Perhaps one of the most useful objects of tabulation is the comparison of sickness and death-rates in different areas. The table serves as a pointer to areas of excessive illness, and directs investigation and administrative efforts in these areas. It is often important to ascertain the relative distribution of various rates of mortality or sickness, as illustrated in the two following examples:—

**Example 1.**—On p. 123 of the Registrar-General's Annual Report for England, 1919, is given a statement of total

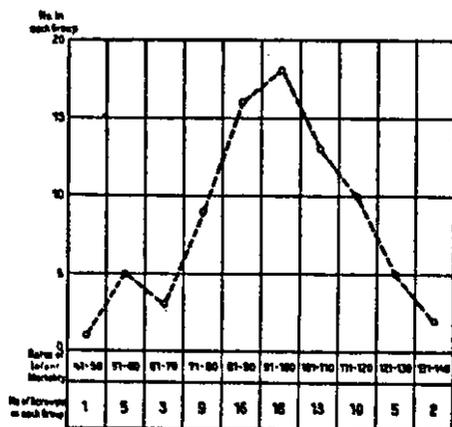


FIG. 85.—Table-diagram of Infant Mortality in 82 County Boroughs.

infant mortality and of mortality under one month per 1,000 births in county boroughs; it is required to ascertain what number of these boroughs have high or low infant mortality.

The distribution of mortality may be shown by the diagram above. Each town may be marked in its respective place by /, the fifth dash being written across the preceding four. The table in this form at once shows the frequency distribution

of the variables, or a curve may be constructed as given in the diagram-table to bring this out more clearly. The original table from which the summary is derived does not convey so vivid an impression as this diagram, which shows that the most frequent infant mortality in 1918 was from 91 to 100, but that 20 out of the 82 boroughs secured an infant mortality below 80, while in 7 it was over 120.

**Example 2.**—What was the distribution of enteric fever sickness in the 82 county boroughs and the 29 metropolitan boroughs of England and Wales in 1920?

For such a comparison rates in terms of population must be available. These are given in the official annual return of infectious diseases, and by the process already described the following tabular result is obtained:—

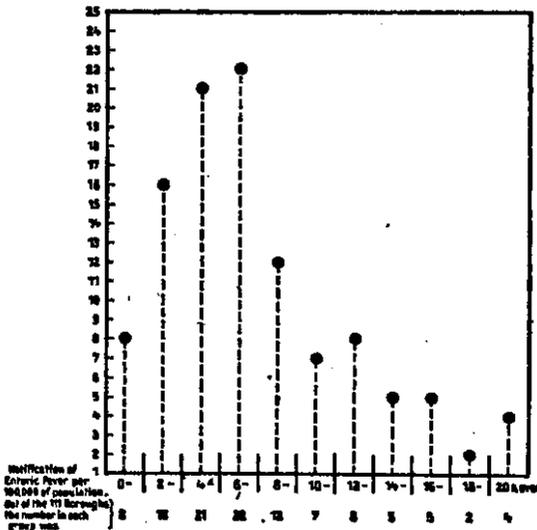


FIG. 86.—Table-diagram of Amount of Enteric Fever in 111 Boroughs.

The diagram gives a good picture of the distribution of enteric fever. The mode or observation which is most frequent is 6-8 in the above series.

Such a statement as this at once suggests lines of investigation and of administrative action. Detailed comparison between individual towns with much and with little enteric fever will give further information; and special inquiry in the towns with excessive enteric fever should lead to practical reform.

## CHAPTER XLVIII

### THE GRAPHIC REPRESENTATION OF STATISTICS

EVEN the clearest tabulation may fail to render easily comprehensible large and complex arrays of figures. Assistance to this end is given if the type of neighbouring columns is varied, or if italic or black type is employed for specially significant items (see p. 34); but graphs are most useful in bringing to view salient characteristics of groups and series, and in enabling each step in the general course of events to be seen easily. If graphs are complex, or otherwise fail to be intelligible, they are useless.

The most useful form of diagram is the rectangular; the horizontal base line is called the *axis of abscissæ*, and the vertical line at right angles to it the *axis of ordinates*, each of these proceeding from a common zero point. In historical diagrams the ordinates may be made to represent years or other intervals of time, and the abscissæ the magnitude of the event of the corresponding year, or this arrangement may be reversed.

As a rule, the whole of the vertical scale should be shown from zero upwards, although sometimes this may leave an inordinately large blank space below the curve. If the diagram is curtailed, its incompleteness should be indicated clearly, as by a jagged line below.

Other forms of graphic representation of statistics are polar diagrams, solids and maps. The two first named of these are seldom used in vital statistics, and they present no advantage over curves and columns, except when it is desired to show diagrammatically the relative share of a number of items in a total result. Even in this instance a tabular statement is better than a segmented circle. This needs to be supplemented by a table. It will be remembered

that the area of any arc of a circle varies with the area of the circumference.

**Maps.**—Maps are used in two ways: (a) Maps showing by *shading* or colouring the varying geographical incidence of the phenomenon in question. The following map taken from an official report to the Local Government Board on Infant Mortality in Lancashire (Cd. 7511) illustrates the value of such a map in directing attention to the areas in which efforts to counteract the evils of environment producing excessive infant mortality are most needed. As a further illustration of the value of maps, and of how they may be made to point out the intimate relationship between industrial life, and excessive toll on child life, I may quote the following remark from my report on "Child Mortality" at ages 0-5 (Cd. 8496), in the same series as the above-named report.

A map of the coal measures of the country would almost serve, though with rather less exactitude than the maps on the preceding pages, as a map of the chief areas in which child mortality is excessive.

The same method may advantageously be adopted in emphasizing the local incidence of excess of infant mortality in certain wards or divisions of a large town.

(b) *Spot maps* are useful in keeping track of the course of an epidemic. A large map of the district is kept in the medical officer of health's office, and each day the street in which a new case or cases of infectious diseases occur is noted by an appropriately coloured flag or pin. For diseases of exceptional rarity, e.g. smallpox or typhus fever, this plan is especially valuable. It may also be useful for enteric fever, scarlet fever, or diphtheria, in suggesting possible local infection of water or milk supply, special relation of cases to a school, etc. But this detailed information should be obtained, as a matter of course, by personal inquiry into the circumstances of each case; and for tracking connection of cases with milk supply or school attendance, a register of cases showing these items in parallel columns is most satisfactory in suggesting possible sources of infection. The publication of spot maps in an annual report, summarizing the experience of a year, requires justification. They may present features of interest, as in smallpox and plague;

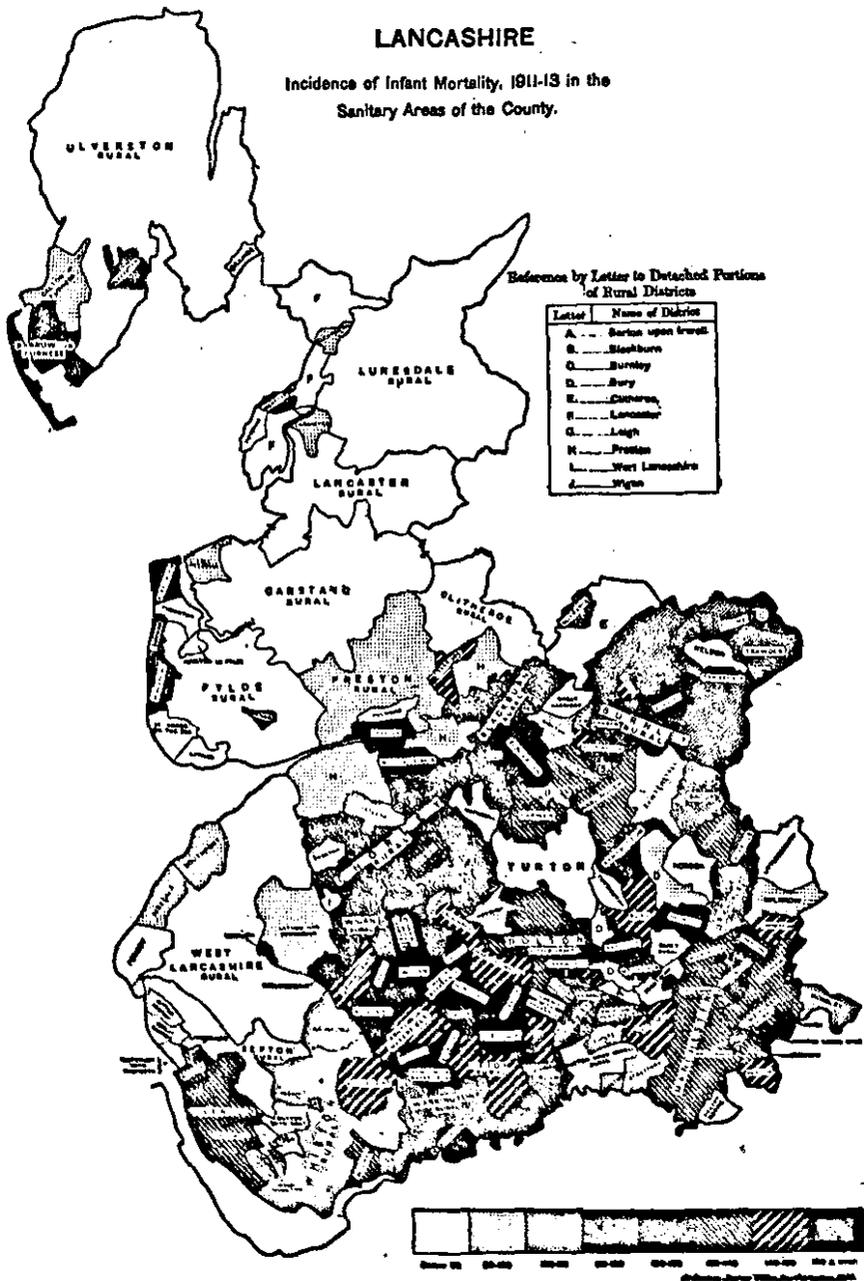


FIG. 87.—Map of Incidence of Infant Mortality in Different Parts of Lancashire (from Cd. 7511, by permission of H.M. Stationery Office).

but in the majority of instances they may be described as maps of relative densities of population, more than of real relative incidence of disease. This is especially true when a spot map of a common infectious disease is made.

This is a convenient point for drawing attention to another office device for quickly ascertaining whether any given infectious disease is prevailing excessively. The method is chiefly useful for very large and populous areas.

**Diagrams of Cumulative Data.**—A record is kept of the weekly incidence of each infectious disease. When the second week's returns are received, the number for each disease is added to the corresponding number for the first week, and so on for the entire year. On the wall is kept a graph of corresponding returns for the past year, possibly also for an average of several years; and as each week's returns are plotted on this graph, the position of a given week in relation to last year's or to average experience is at once apparent.

This information may lead to valuable inquiry in the area in which excess of disease is found. It holds possibilities of unwise inertia if it suggests that when the record shows no departure from the average experience, the work of steady "field investigation" of each case can safely be intermitted.

Cumulative diagrams have other uses, as may be seen from the illustration on page 573 of the age-distribution of the population of England and Wales, 1921 (persons).

By drawing a curve smoothly through the top of each rectangle in A in such a manner that approximately the amount cut off shall equal the amount added by the curve, a fairly accurate estimate of the number of persons in any given year of life is obtained.

A joint Committee of the American Statistical Association, of the American Society of Mechanical Engineers, and of a number of other Societies and official organizations in a preliminary report have made the following, among other recommendations, as to diagrams (*Journal of the American Statistical Association*, December 1915):—

1. The general arrangement of a diagram should proceed from left to right.
2. Where possible, it should represent quantities by linear magnitudes, as areas or volumes are more likely to be misinterpreted.

3. For a curve the vertical scale, whenever practicable, should be so selected that the zero line will appear on the diagram.
4. If the zero line of the diagram will not normally appear on the curve diagram, the zero line should be shown by the use of a horizontal break in the diagram.
5. The zero lines of the scales for a curve should be sharply distinguished from the other co-ordinate lines.
6. For curves having a scale representing percentages, it is usually

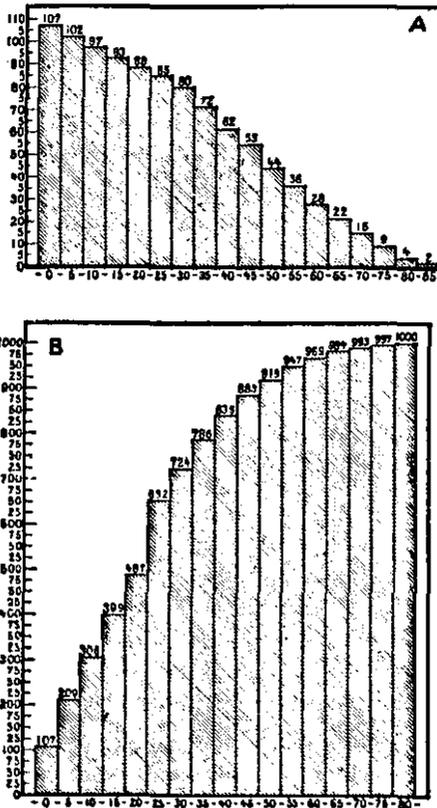


FIG. 88.—A, Age-distribution in 5-Yearly Age Periods of Population of England and Wales, 1921, Both Sexes, Aggregate Number at all Ages = 1,000. B, Ditto; but the Height of the Column at Each 5-Yearly Period shows the Number Living in that and in all Earlier Age-Periods.

desirable to emphasize in some distinctive way the 100 per cent. line or other line used as a basis of comparison.



8. When curves are drawn on logarithmic co-ordinates, the limiting lines of the diagram should each be some power of 10 on the logarithmic scales.

9. It is advisable not to show any more co-ordinate lines than necessary to guide the eye in reading the diagram.

10. The curve lines of a diagram should be sharply distinguished from the ruling.

11. In curves representing a series of observations, it is advisable, whenever possible, to indicate clearly on the diagram all the points representing the separate observations.

14 and 15. It is often desirable to include in the diagram the numerical data represented, . . . or if this is not done, to give the data in tabular form accompanying the diagram.

**Value of the Graphic Method.**—Its most impressive use is as a *method of education*, and it is in this connection that its chief sins are committed. By exaggerating or minimizing the scale on which the incidence of a disease is shown an erroneous impression is easily produced, and this is the usual offence. Most of the errors which might be mentioned under this heading are really errors of statistical method mentioned elsewhere, or errors in reasoning, of which examples are given on pp. 536-541. For educational purposes there are numerous impressive methods of constructing diagrams which scarcely require description.

Graphic representation is a useful *instrument of control*. In a long tabular statement an error of calculation or a misstatement may easily escape notice; in a curve it at once emerges. (See Fig. 1 for an illustration.)

The construction of a curve forms a valuable *means of interpolation*. If, for instance, it be required to ascertain the number of persons in a given population aged 22, the numbers at the census being given only in 5 or 10 yearly periods, parallelograms can be formed showing the number in each of the 5 or 10 yearly groups of population. A curve run through the upper part of each of these parallelograms will allow the approximate number at each year of life to be read off on the vertical scale. This method is employed in the graphic construction of a life-table, as illustrated in Fig. 88a. In this diagram the number living at the age 22 is 11,000. The rule in reading off the points on such a curve is that, for instance, in the quinquennial period 20-25 in the figure the sum of the numbers at each age 21, 22, 23, 24 and 25, shall equal the total, 54,303, living in this quinquennial age-period; furthermore, that the total sweep of the curve from childhood to old age shall be natural and easy, and fit as nearly as possible the course indicated by the parallelograms.

## GRAPHIC REPRESENTATION OF STATISTICS 575

The most important use of curves is as *an instrument of research*. Resemblances and differences, liable to be overlooked in a table, may be discovered in a diagram. In the study of the incidence of any particular disease for a long period curves are invaluable. Hidden periodicities may be revealed by them; and when curves possibly related are plotted out on the same paper, important suggestions as to relations of cause and effect emerge. It is at this point again that some of the chief fallacies emerge. More often than not the supposed causal relationship is non-existent, but the parallelism of curves, or their trend in the same direction, may serve to initiate collateral lines of more exact inquiry. The likelihood that resemblances between curves have a causal relation is increased when changes in the direction of two curves synchronize, or have some other definite and consistent time relationship as to their maxima and minima, directly or inversely. When considering questions of causation, it most often happens that the rate of increase or decrease in each curve has greater importance than its actual change. The use of logarithms supplies us with a universal scale (p. 585). Curves as an instrument of research are further discussed in the next chapter, when considering the relative value of coefficients of correlation and comparisons of curves.

## CHAPTER XLIX

### THE GRAPHIC REPRESENTATION OF STATISTICS—*Continued.*

**Smoothed Curves.**—Smoothed curves are made by taking year by year the average rate for, say, each quinquennial or triennial period, the year under consideration always being the central year of the average. By this means the general trend of events is shown, and any wide historical trend is displayed better than by the zigzags of annual events. When smoothed curves, giving average results, are used, it is advisable in public health investigations also to set out each annual sickness-rate or death-rate, as otherwise important episodes in the history of the disease under inquiry may be

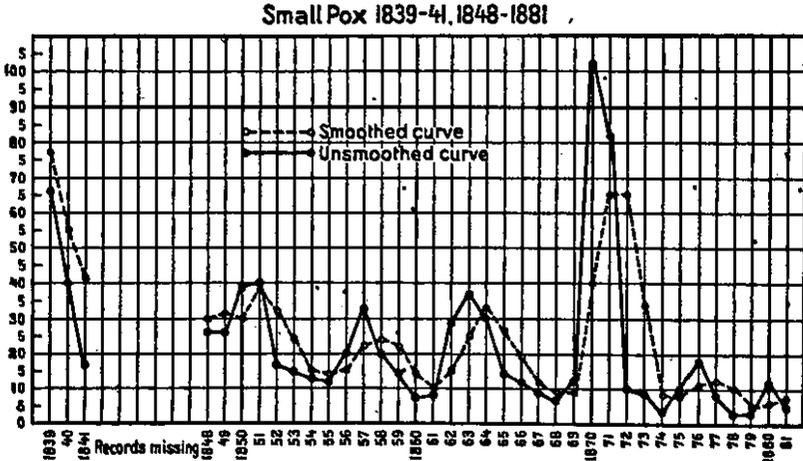


FIG. 89.—England and Wales: Annual Death-rates and Smoothed Death-rates (3 years) from Smallpox, 1848-81.

overlooked. This is particularly the case for epidemic diseases, and for them it is chiefly in studying cyclical changes that smoothed curves are advisable.

The disadvantages of smoothing of epidemic curves may be seen by plotting the death-rate from smallpox in England

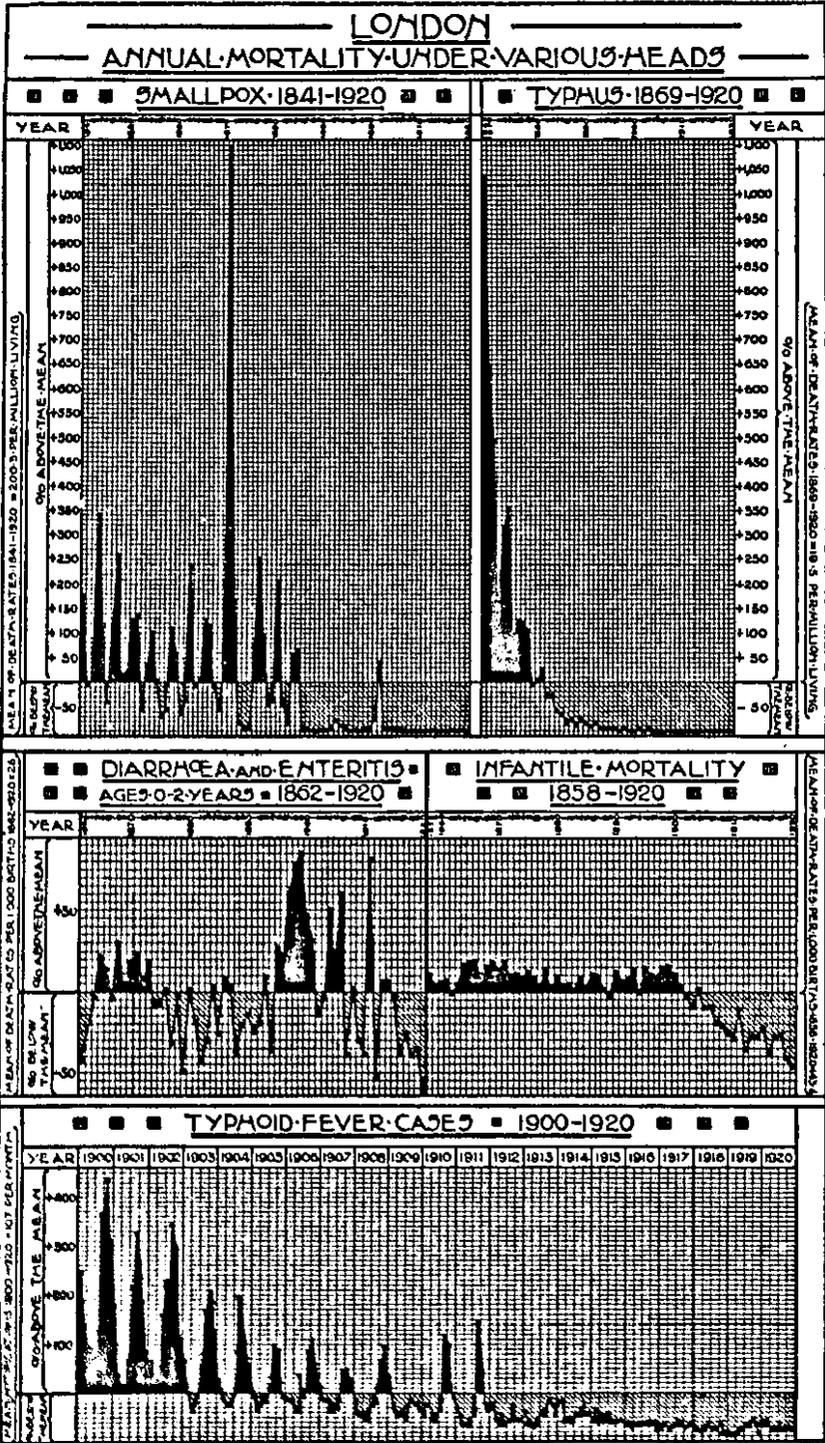


FIG. 90.—London: Annual Mortality Under Various Heads.  
(From Dr. Hamer's Annual Report, 1920.)

and Wales from 1838 to 1881 (Fig. 89), triennial averages being stated year by year. It will be found that for inter-epidemic periods the curves of annual and of triennially smoothed events do not differ greatly; but the triennial average understates the highest point of the 1871 epidemic. Had the curve of annual death-rates gone back to 1837, in which year the smallpox death-rate was 106 per 100,000, it would have been seen that the 1838 epidemic caused a higher death-rate than the epidemic of 1871.<sup>1</sup>

**Relative Mortality Figures.**—These figures reduce rates of very different magnitude to the same scale, and thus make it easy to compare the changes in rates which differ greatly in magnitude. Relative mortality figures are obtained by calculating the average amount or rate for the entire series, and then taking this as 100 and calculating each of the rates in the series as a proportional figure; or by taking the initial or the maximum amount in the series as 100, and calculating the other items in their proportion to this. The first of these two methods is preferable; the second may unduly weight the entire series, if the single rate taken as 100 happens to differ greatly from the other members of the series, and its use is therefore not always advisable when it is proposed to contrast two series of observations similarly treated.

(a) In Fig. 90, taken from Sir William Hamer's Report to the London County Council, 1920, are given several illustrations of the first method. Thus in the smallpox curve the mean death-rate for 1841–1920 being 200·3 per million living, the death-rates for each year in this period are stated as so much per cent. above or below this mean rate taken as = 100. In the lower diagram of this figure a useful modification of this method is employed, which enables the monthly incidence of cases of typhoid fever in London to be shown. For the entire period 1900–20 the mean monthly notifications were 107, and this figure being taken as 100, the notifications for each month in the 21 years are stated in proportion to this.

The same method has been employed for many years by the Registrar-General in showing the seasonal incidence

<sup>1</sup> For London separately this position was reversed.

of various diseases, as in Fig. 91 (also in Figs. 27 and 28). The diagram below gives monthly ratios of disease based on two averages, for 1891-1910 (continuous curve) and for 1841-1910 (dotted curve), showing a maximum of diarrhoea

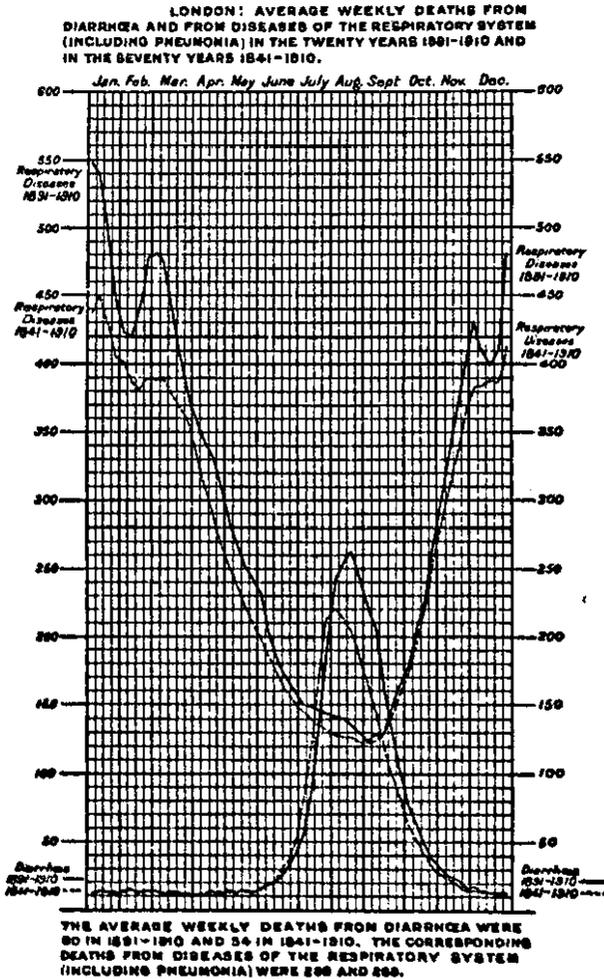


FIG. 91.—London: Average Weekly Deaths from Diarrhoea and from Diseases of the Respiratory System. (From the Registrar-General's Annual Summary.)

in July and August, and a winter excess of respiratory diseases.

(b) It is often convenient to give the amount for the first item in a time series as 100, as in the following figure showing the death-rate from enteric fever for a series of years. In

and Wales from 1838 to 1881 (Fig. 89), triennial averages being stated year by year. It will be found that for inter-epidemic periods the curves of annual and of triennially smoothed events do not differ greatly; but the triennial average understates the highest point of the 1871 epidemic. Had the curve of annual death-rates gone back to 1837, in which year the smallpox death-rate was 106 per 100,000, it would have been seen that the 1838 epidemic caused a higher death-rate than the epidemic of 1871.<sup>1</sup>

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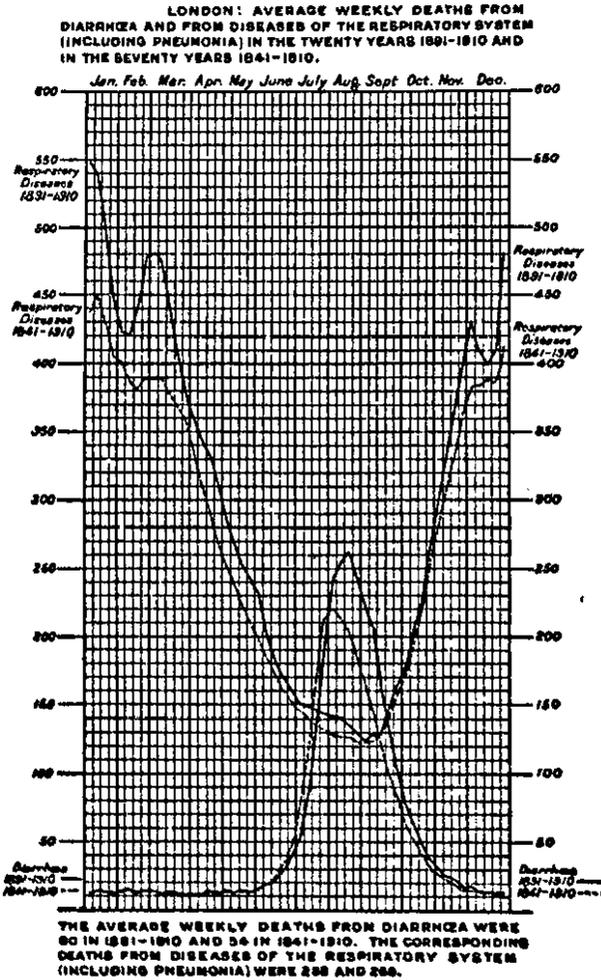


FIG. 91.—London: Average Weekly Deaths from Diarrhoea and from Diseases of the Respiratory System. (From the Registrar-General's Annual Summary.)

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(b) It is often convenient to give the amount for the first item in a time series as 100, as in the following figure showing the death-rate from enteric fever for a series of years. In

this instance the percentage decline for each year can be seen by a glance at the right-hand vertical scale, and the actual death-rate per million of population on the corresponding left-hand vertical scale.

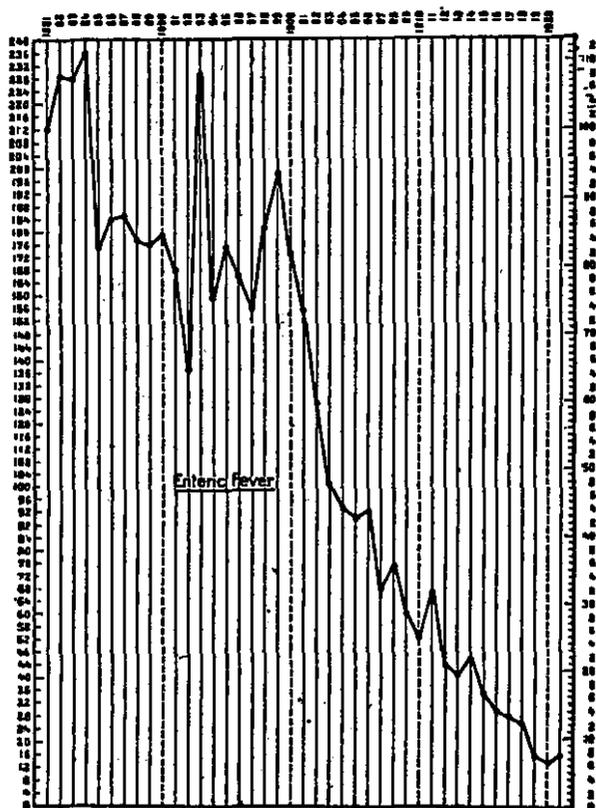


FIG. 92.—England and Wales: Annual Death-rate from Enteric Fever per Million of Population, 1881-1921.

(c) Two series of rates may often be compared with advantage with the total rate of both series, the rate for each period in the total being taken as 100, and the corresponding item in each series stated in proportion to this.

In the diagram (Fig. 93) the infant death-rate per 1,000 births at each of five successive age-periods of the first year of life for the whole of England and Wales is stated as 100, and the corresponding death-rates in county boroughs (representing large towns) and in rural districts are stated proportionally to 100.

In the first month after birth the difference in the risks to infants in town and country is relatively small, but the difference between the two rapidly increases, becoming enormous in the second half of infancy. It must be noted that these differences are average results for large populations, and represent an even greater excess of urban over rural infant mortality for large sections of the total population.

The value of comparisons of two series of death-rates by means of relative mortality figures is well illustrated

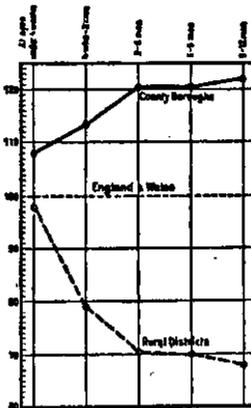


FIG. 93.—England and Wales, 1920: Showing Extent to which Urban Mortality Exceeds and Rural Mortality is Lower than the Death-rate in England and Wales in Different Periods of Infancy.

in the diagram (Fig. 94) reproduced from the late Dr. Russell Wallace's pamphlet on vaccination.

The diagram shows for London a comparison for a long series of years of the annual death-rates from smallpox and from typhus, and from the "chief other zymotic diseases except cholera." These death-rates are all displayed on the same scale, and the misleading character of a diagram thus constructed may be surmised from a comparison of death-rates for 1871 and for 1920.

DEATH-RATE PER MILLION LIVING.

	1871.	1920.
Smallpox .. .. .	1,012	1
Typhus fever .. .. .	121	0
Chief zymotic diseases <sup>1</sup> .. .. .	2,160	510

<sup>1</sup> Measles, whooping cough, scarlet fever, diphtheria, enteric fever.

When differences in the death-rates of 2,160 and 510 for zymotic diseases in the aggregate, and of 1,012 and 1 for smallpox are displayed in curves constructed to the same scale, the strikingly different magnitude of the compared

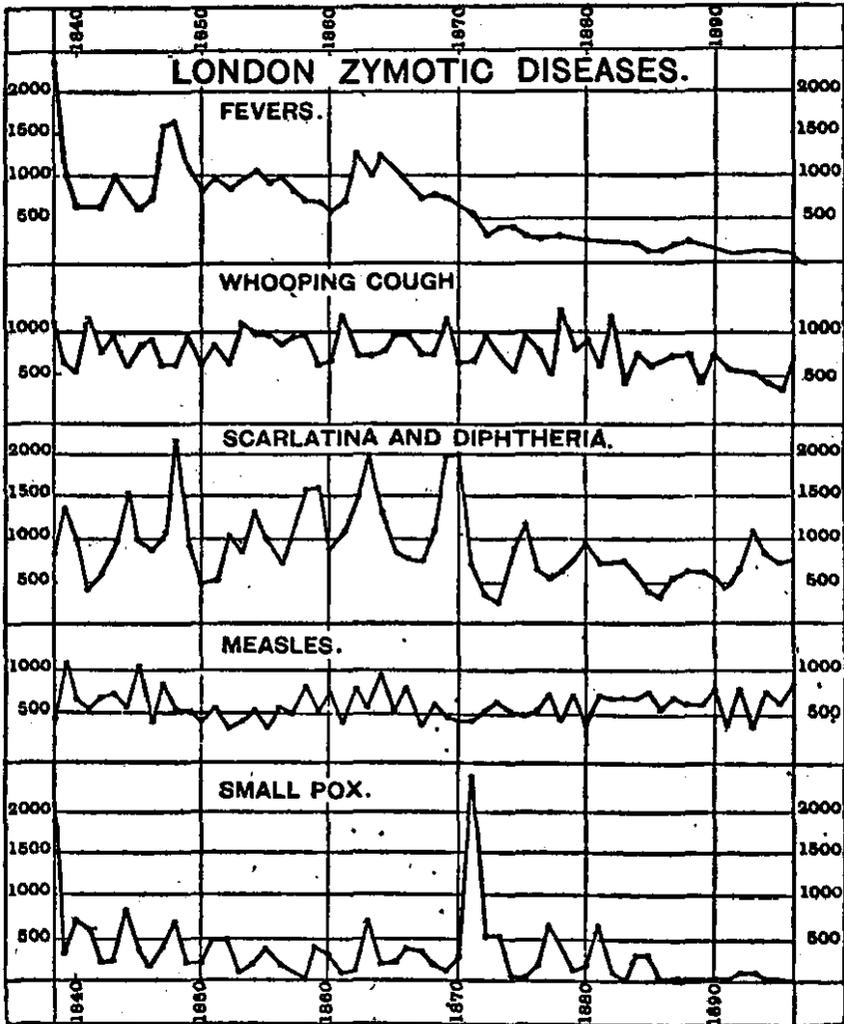


FIG. 94.

diseases and group of diseases and of the changes in their amount is successfully concealed.

Dr. Wallace evidently thought that a diagrammatic curve for a long period showing the experience of each year could not be manipulated, and that the conclusions drawn from

it were indisputable. But on the scale chosen by him, the changes in the smallpox death-rate, except for the pandemic of 1870-72, are barely visible. In actual fact, however, there has been a great decline in mortality from smallpox, as shown in Fig. 95, in which the death-rate at each quinquennial period is stated in proportion to the average death-rate from this disease in the whole period, and the quinquennial average death-rate from zymotic diseases is similarly treated.

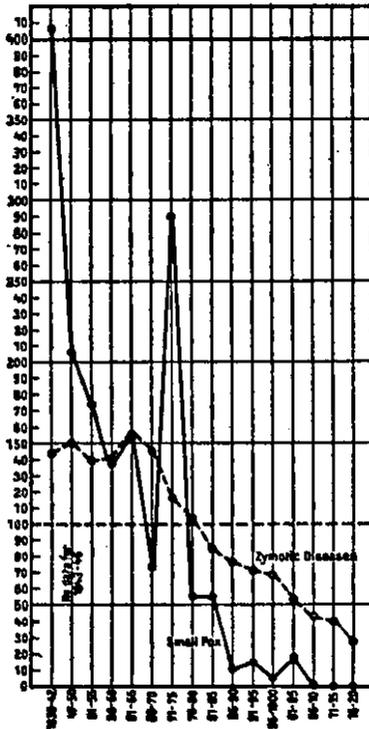


FIG. 95.—England and Wales: Relative Mortality Figures for Smallpox, A (●—●—●), and for the Chief Zymotic Diseases, including Typhus, B (○---○---○), in Quinquennial Periods 1838-42 to 1916-20, the Rates for Each Disease in the Entire Period being given as 100.

nial average death-rate from zymotic diseases is similarly treated.

The lumping together of diseases of such diverse causation as typhus and diphtheria and of measles and enteric fever is to be deprecated, but has been copied in Fig. 95 to bring out the lesson of Dr. Wallace's diagrams. Had scarlet fever, diphtheria, and enteric fever been omitted from B, the residual curve for measles and whooping cough would have shown very little decline.

In comparing the items in two series of relative mortality figures, one is conducting the same operation, as if the original death-rates had been compared. In both plans it is the actual changes from year to year which are displayed, not the rates of change. Thus a curve of the phthisis death-rate showing in 50 years a decline from 2.0 to 1.0 per 1,000 of population runs the same course as a decline from 100 to 50 on a proportional scale. The advantage of the relative figures appears when two or more sets of rates need to be compared in detail, as then each set of rates is reduced to the same scale. To curves plotted on either of these bases, Professor Marshall's remarks (Jubilee Volume of the Royal Statistical Society, 1885) apply: "The defects (of this method) are such that many statisticians seldom use it except for the purpose of popular exposition, and for this purpose, I must confess, it has great dangers." This criticism apparently is made because the ordinary curve displays *differences* and not *rates of difference*.

**Ratio Charts.**—The ordinary curve shows the absolute change, as observation follows observation, but it tells nothing of the *rate of change*. For this reason "ratio charts," so described by Professor Irving Fisher,<sup>1</sup> are preferred when it is desired to show the rate of change in a series of events. The word "ratio" is employed in this paragraph to indicate geometrical as contrasted with arithmetical differences in sequences.

As remarked by Professor Fisher, in the comparison by differences "an inch on the end of one's nose" is exactly as much as an inch added to the height of Washington's Monument; whereas in the ratio comparison it is an addition of about 40 per cent. to the length of one's nose, or as much as 220 feet added to the height of the monument.

Professor Fisher has suggested a simple method of converting an ordinary scale (arithmetical progression) into a "ratio" scale (geometrical progression). Thus if in a diagram the vertical scale proceeds as follows:—

100, 110, 120, 130, 140, 150, 160, 170, 180, 190, 200, etc.,

each item being in arithmetical progress 10 places away from the two neighbouring items, this can be converted

<sup>1</sup> "The Ratio Chart," by Professor I. Fisher (*Quarterly Journal of the American Statistical Association*, June 1917).

into a geometrical scale, showing a 10 per cent. increase between each item in sequence, by substituting the following figures :—

100, 110, 121, 133, 146, 161, 177, 195, etc.

It will be readily seen that each of these numbers beginning with the second is 10 per cent. more than the one preceding it.

If it is desired to avoid the use of logarithms, such a scale may be used; but the more generally useful plan, when it is desired to ascertain the rate of change in an array of figures, is to plot out the logarithms of the rates under examination, using a scale of logarithms on the ordinate curve. By the use of logarithms a universal scale is obtained, which shows equal distances on a curve for equal rates of increase. In epidemiological investigations logarithmic curves are generally preferable.

The logarithmic diagram is thus one *not of quantities, but of rates of change*. No base line should be drawn, which would convey a false impression. A concavity upwards in a logarithmic curve shows slackening, and a convexity shows increase in a rate of change at the period of the change in the curve; and a straight line shows an equal rate of increase or decrease throughout the whole period. A remarkable illustration of error arising from drawing natural instead of logarithmic curves, and deducing inferences which are only legitimate with logarithmic curves, is given on page 586.

If in drawing a diagram of a series of observations the logarithm of each of the series is obtained, and these logarithms are then plotted diagrammatically instead of the original figures, we may dispense with the use of special logarithmic paper.<sup>1</sup> As the appearance of the logarithmic values along the ordinate line may puzzle the uninformed, it is advisable to give the actual rates as well as their logarithms on the scale. The use of specially prepared logarithmic paper obviates the need for a table of logarithms.

The following diagram taken from Professor Fisher's paper on "The Ratio Chart" (*Quarterly Journal of the American Statistical Association*, June 1917), illustrates

<sup>1</sup> Logarithmic paper can be obtained from Messrs. A. & C. Layton, Farringdon Street, E.C.

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well the importance of plotting out "ratios," and not differences. When the actual numbers in the United States at successive censuses are plotted, a much more rapid increase of numbers is shown since 1840, and especially since 1870; when the ratio of increase for each decade is shown, a more rapid increase prior to 1860 is shown; and after that year a fairly uniform rate of increase less than in the earlier years.

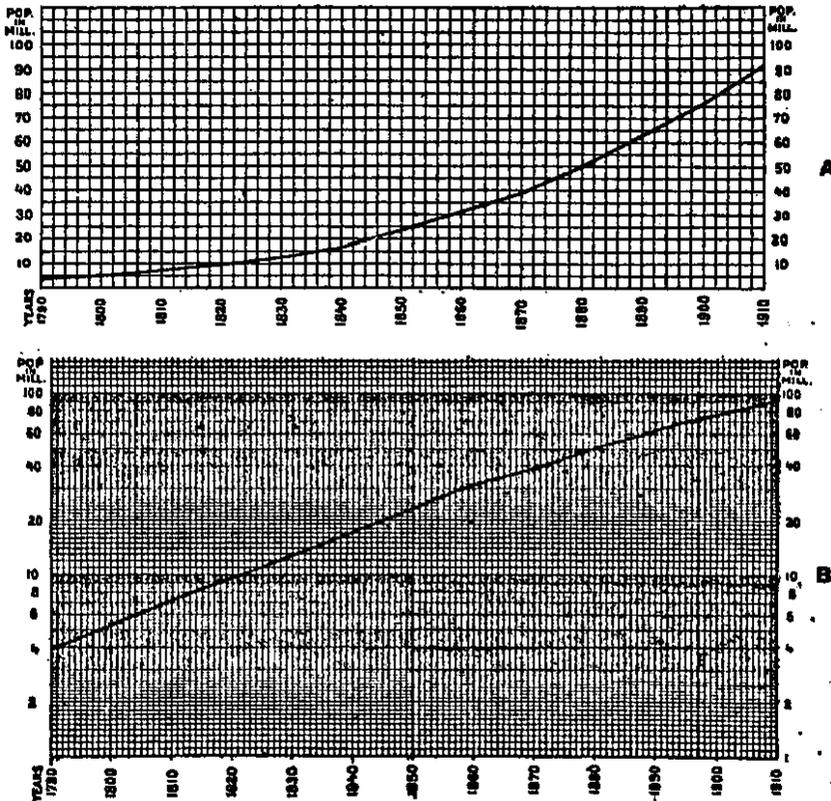
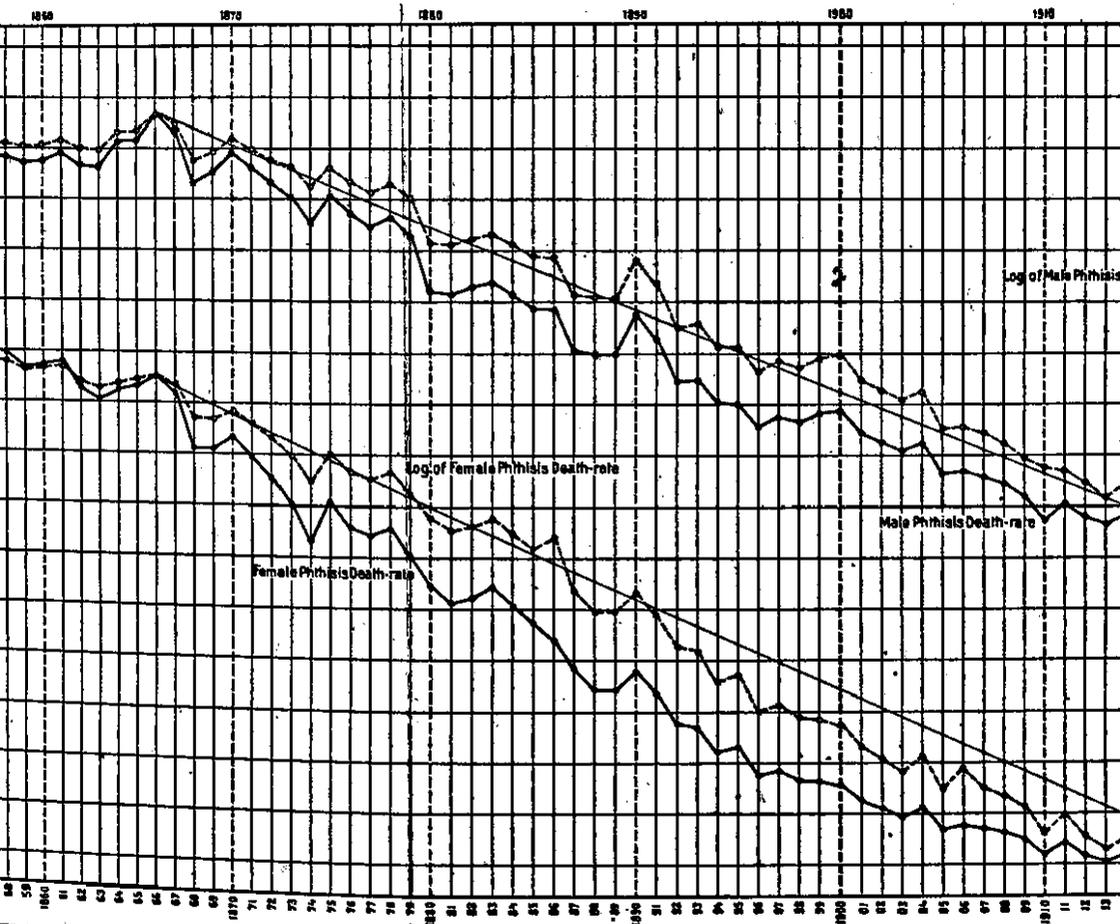


FIG. 96.—Growth of American Population, as Shown by Arithmetical (A) and Geometrical or Logarithmic Curves (B) (after Professor Irving Fisher).

**Confusion between Changes in Arithmetical and in Geometrical Progression illustrated by the Rate of Fall of the Phthisis Death-rate.**—In a pamphlet on *The Fight against Tuberculosis, etc.* (1911), Professor K. Pearson shows curves of the male and female phthisis death-rates in England and Wales from 1847 to 1910, similar to the curves in Fig. 97.

From his curves Professor Pearson infers the existence of



Wales, 1847-1921: A, Male Death-rate from Phthisis. Logarithms of same Death-rates. B, Female Death-rate from Phthisis. Logarithms of same Death-rates.

three periods in the statistical history of phthisis in England. First comes the period prior to 1866, in which little if any decrease of phthisis occurred. The years 1866-94 are regarded as a second period, and from 1894 to 1910 as a third period, and it is stated that a change took place in the death-rate from phthisis, which ceased to fall at the steady rate of the second period, and showed signs of becoming stationary. There was "actually a slackening in the rate of fall."

Regression straight lines were fitted to the curves of facts for these three periods, and the changes of direction of these straight lines in Professor Pearson's diagram support this contention, subject to the unfulfilled condition stated below.

The upper curve of continuous black lines (●—●—●) in Fig. 97 shows the annual death-rate of males from phthisis, and it is on a curve similar to this that Professor Pearson based his conclusion. This conclusion has been reiterated by Professor Pearson in *Biometrika* (vol. xii, 1918-19, p. 374) in a paper entitled "The Check to the Fall in the Phthisis Death-rate since the Discovery of the Tubercle Bacillus and the Adoption of Modern Treatment" in the following words :—

In 1911 I pointed out that from 1865 to about 1895 there was a continuous and rapid fall in the corrected phthisis death-rate, and also in the percentage which the deaths from phthisis were of all deaths. . . . I further indicated that from 1895 onwards there had been a check to this rapid fall, and that the curves seemed to indicate that an actual rise in the phthisis death-rate might in the near future be reasonably anticipated.

He adds :—

If we could trust the accompanying diagrams, the anticipated rise in the phthisis death-rate has already occurred. . . . On the whole it is risky to form a definite judgment, . . . though the general trend indicates that the conclusion previously reached is probable, viz. that the general trend of our graphs (as indicated before the war) [is that] somewhere about 1915 the fall in the phthisis death-rate which had been less rapid since 1895 would cease altogether, and probably be followed by a rise.

Reference should be made in passing to the well-known objection to inferences drawn from the percentage proportion between deaths from phthisis and total deaths and to the curves in the above pamphlet which are based on this

proportion, i.e. between two variables, either of which may possibly vary independently. The utilization of such proportions is inadvisable, except as a *pis aller* of dubious value. The forecast given in the earlier paper mentioned above, and repeated with less certitude in 1918-19, is not supported by the course of events. In Fig. 97 the upper curve (o --- o --- o) shows the logarithms of the male death-rates from phthisis in each year, on a scale which has been carefully adjusted so that the logarithmic curve and the natural curve (that of death-rates) start on the same level in the ordinate scale in 1866, and end on the same level in 1921. Consequently any difference in the course of the two curves represents solely the difference between changes in arithmetical and geometrical progression.

The following point must be borne in mind: *on the logarithmic scale a straight line from the point in the curve for 1866 to the point in the curve for 1921 represents a constant rate of decline; and generally, plotted data which have a constant rate of change produce a straight line, while a change in the direction of the line implies an alteration in the rate of change.* The logarithmic curve approximately follows the straight line course, except during the war years. The lower male curve of actual death-rates which is slightly concave upwards, and which was erroneously regarded as showing a slackened rate of decline, does not show this, but in its present form indicates a fairly constant rate of decline in the male phthisis death-rate since 1866, with some evidence of an increasing rate of decline. The unfulfilled condition mentioned above is that Professor Pearson used natural instead of logarithmic curves, thus confusing between actual differences and rates of difference.

The female logarithmic curve for phthisis shown at B in Fig. 97 shows a maximum rate of decline before 1914, especially rapid from 1890-96, with some decline since then.

Curves for total tuberculosis are not shown in Fig. 97, but the curve for male and to a less extent for female total tuberculosis show that mortality since 1866 has been falling at an ever-increasing rate. For a fuller discussion of these data pages 51-55 of the Annual Review of the Registrar-General for 1921 (New Series, No. 1) should be consulted.

**Dangers of Diagrams with Compressed Scale.**—The

following illustration shows the errors that may arise when curves of death-rates drawn on too small a scale are compared, and at the same time illustrates the value of the logarithmic method.

Dr. Brend (*Health and the State*, p. 111) says:—

A chart of the infant mortality in England, Scotland, and Ireland shows that for many years the tracings have risen and fallen with a high degree of parallelism, indicating that some influence common to the three countries has year by year affected the rates, and this can only be meteorological variations.

Opposite page xxxvii of the Annual Report of the Registrar-General for Ireland, 1914, are given the long period curves referred to. They show that infant mortality in all three countries has followed an apparently similar course, and therefore presumably has been influenced by similar conditions throughout, though not always to a corresponding extent. The period from 1896 onwards can be examined more closely in Fig. 44, p. 348.

This consists of two sets of curves, A and B. In England, although the peaks of excessive mortality coincide with those in Scotland and Ireland, there is a much more rapid fall in the infant death-rate, the extent and rate of which is seen in the logarithmic curve, B, while the actual yearly change is shown in curve A. The rate of infant mortality in 1920 was 45 per cent. lower, in Scotland it was 20 per cent. lower, and in Ireland was 12 per cent. lower than in 1896.

Some factor not influencing Ireland, or influencing England to a larger extent, has operated in England. If meteorological conditions are to be regarded as explaining the approach of the curves towards parallelism in the years prior to 1896, then there is needed a feasible explanation of the special experience of England in the twentieth century, e.g. child welfare work on a large scale, and education of public opinion and practice. There is needed, furthermore, an explanation of the fall in the infant death-rate in Ireland, which since 1899 has been almost continuous, though less in amount than that of England. Meteorological conditions may conceivably have altered since 1899 consistently in a direction favouring decreased mortality from diarrhoea, etc., though no evidence of this is given. Nor is it correct to assume that only meteorological changes have

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occurred. Thus a great change in the prevalence of tuberculosis or syphilis would materially change the rate of infant mortality. It is likely that Ireland has benefited, though to a less extent, than England and Scotland, from increased care of child life.

## CHAPTER L

### OFFICIAL REPORTS. SANITARY INDICES

THE data on which systematic vital statistics are based are— (1) population, enumerated at each periodical census and estimated for periods intermediate between censuses; and (2) the registration of the chief events of life, birth, marriage, sickness, death. The first source of information is periodic and the second continuous in operation.

**Registration Reports.**—The office of Registrar-General of England and Wales was created in 1836, and civil registration began as the result of an Act of Parliament on July 1, 1837. The first of the series of annual reports of the Registrar-General was published in 1839, and to this first report Dr. W. Farr, who acted first as "Compiler of Abstracts" in the newly created General Register Office, contributed the first of that long series of letters, addressed to the Registrar-General, on the causes of death in England, with which our knowledge of the vital statistics of this country is largely wrapped up.

**Sources of Statistical Information.**—To the student of vital statistics these annual reports are invaluable, and the history of the subject and of its development is, in large measure, embodied in their pages. The Decennial Supplements for 1851-60 and 1861-70 contain some of Farr's best work. The Decennial Supplement for 1871-80 was written by Dr. W. Ogle, and comprised besides new life-tables a valuable study of occupational mortality. The next two supplements for 1881-90 and 1891-1900 were written by Dr. John Tatham, and the growth of life-table methods and of occupational mortality statistics is evidenced in these two important reports, which also deal more fully than their predecessors with the chief causes of death. The Decennial Supplement for 1901-10 has been contributed by Dr. T. H. C.

Stevenson, and it is the most complete and most valuable of the series. It is described as Part III, Registration Summary Tables 1901-10 of the Supplement to the Seventy-fifth Annual Report of the Registrar-General, England and Wales, and it is the best guide for the student in search of a complete study of the incidence of each of the chief diseases. Part I of the same Decennial Supplement has been prepared by Mr. George King, F.I.A., and contains an invaluable series of national life-tables with a full description of their method of preparation. Part II by Dr. E. C. Snow gives a number of life-tables prepared by an abbreviated method.

Each week the Registrar-Generals of England, Scotland, and Ireland publish a weekly return of births and deaths, and certain causes of death in 105 great towns. The English return gives fuller weekly particulars for London, and the births and deaths, also deaths from the chief epidemic diseases in a number of foreign cities, and a statement of the number and nature of notified infectious diseases in each sanitary area of England and Wales. This return was formerly published separately by the Local Government Board, and the publication in one return of mortality and sickness returns is a useful improvement, assuming equal promptitude in publication. The Ministry of Health has published separately the yearly return of "Incidence of Notifiable Infectious Diseases in Each Sanitary District in England and Wales," which was begun in 1911. With each year of continuance, the series is becoming of increasing epidemiological value. For 1921 this return appears in the Annual Report of the Registrar-General, and loses much in value by the delay involved in this method of publication.

The Quarterly Return of the Registrar-General summarizes the weekly returns, giving also death-rates and case-rates for the chief infectious diseases, some international statistics, etc. In this return the chief vital statistics of 155 smaller English towns, as well as of the 105 great towns, are given.

**American Returns.**—The Federal Government of the United States issue an annual report of "Mortality Statistics," of which the report for 1920 is the twenty-first in the series. It is issued from the Bureau of the Census, in the Department

of Commerce, of which Mr. S. L. Rogers is the Director, and Dr. Wm. H. Davis, the chief statistician for vital statistics. These reports are rapidly increasing in completeness and in value, and show that the difficulties in securing registration of deaths are being rapidly overcome.

From the same Bureau a valuable report on United States Life-Tables for 1890, 1901, 1910 and 1901-10 has recently been issued (1921), which gives not only life-tables for the registration states and various parts of these, but also for life insurance companies and for foreign countries. The explanatory text prefixed to the report forms a guide to the construction of life-tables.

The same Bureau publishes annual "Birth Statistics for the Birth Registration Area of the United States," of which the report for 1920 is the sixth in series. The birth registration area is smaller than the death registration area, and returns are incomplete in some states. This report also deals with infant mortality rates, the reason given for publishing these in the Birth Statistics volume being that the Annual Mortality Report is already a large volume, and that it has been thought best to give in the report on Birth Statistics infant mortality tables for the birth registration area. Other tables showing deaths under one year of age for the larger death registration area will be found in the Annual Mortality Statistics.

By the American Permanent Census Act, approved March 6, 1902, the collection of both birth and death statistics was approved, so far as concerns such communities as in the opinion of the Director of the Census possessed records of sufficient accuracy.

The Public Health Reports issued weekly by the United States Public Health Service contain special articles on public health subjects, and much statistical information as to disease in various American states and cities and in foreign countries.

It is impracticable to summarize sources of statistical information in other countries; but National Year Books for each country indicate the more important material available, and give references to special publications on vital statistics, etc.

**Information as to Social Conditions.**—The student of

vital statistics is not concerned solely with the vital statistics of the community in which he lives. He needs to know much more both locally and nationally, if he is to utilize fully the vital statistics already in his possession.

**Local Reports.**—Local reports by medical officers of health for counties and for nearly every sanitary area in this country are published annually, which supplement and extend the information given in national reports. The same applies to a varying extent to reports for American states, cities, etc.

Vital statistics are concerned with other aspects of communal life besides births, deaths, and sickness, and the social student and the health officer should be familiar with the chief sources of statistics throwing light on his work.

The various volumes of the Census Reports for this country give important information, not only on age and married condition of the population in the chief areas (p. 57), but also regarding occupations (pp. 311), housing conditions (pp. 302 and 385), birthplaces of the population of each country (p. 49), etc.

The Poor Law reports, local and central, show the amount of destitution which receives official relief, a subject of moment to the medical officer of health. He needs equally to be familiar with the statistics of various forms of charitable relief, and particularly with the extent and variety, as well as the quality, of the hospital treatment available in his area.

The statistics of convictions for drunkenness, of the distribution of public-houses (saloons) in his area, have an important bearing on infant and child mortality.

Information as to the distribution of industries, the number employed and the conditions of work, and accurate detailed information as to housing conditions, are necessary to an accurate knowledge of local health conditions.

The price and quality of foods, and especially of milk, and many other items lending themselves to statistical statement, have important bearings on vital statistics. It is assumed that through the school medical service the medical officer of health has accurate information as to all schools and scholars.

The above partial list may serve to indicate the need of the wider social outlook which the study of vital statistics

should take; and many Government departments issue reports suitable for the table of the medical officer of health. Among these may be enumerated the Registrar-General's annual and other returns, the reports of the Ministry of Health and of the Board of Education, and of their Medical Departments, the Annual Report of the Factory Department of the Home Office, and the Licensing and Criminal Statistics of the same Department, reports of the Ministry of Pensions and of the Ministry of Agriculture.

**Measures of Public Health Work.**—The tabular information given in various parts of this volume indicates the information which should be comprised in a report on the vital statistics of a town or county. It is convenient here to add an appreciation of the various tests of public health which are commonly employed. Attention may be drawn to the discussion of the difficulty in measuring the value of certain parts of public health work in statistical terms (p. 535). Of the death-rates which can be ascertained the following should, whenever practicable, be given :—

1. Death-rate per 1,000 of population at all ages
 

{	male ..	}
{	female ..	}
2. Death-rate standardized for age and sex distribution.
3. For larger areas, death-rate
 

{	male ..	}
{	female ..	}

 per 1,000 living at each age-group (as on p. 202).
4. A comparison of 1 and 2, and if possible of 3 for a series of years.
5. A statement for the current year and for a series of years of the death-rate under 1 year of age per 1,000 births.
6. A similar statement for the first week and for the first month after birth.
7. A statement of the death-rate per 1,000 births from diarrhoea and enteritis of children under 2 years of age.
8. A statement of the number of deaths from septic and from other diseases and accidents associated with child-bearing per 1,000 births, if possible for a series of years.
9. A statement of the death-rate from tuberculosis
 

{	All Forms ..	}
{	Phtlisis ..	}

 for a series of years.

## 10. A statement of the death-rate from—

Typhoid fever,  
 Diphtheria,  
 Scarlet fever,  
 Measles,  
 Whooping cough,

and of any other prevalent infectious disease, e.g.

Malaria,  
 Cerebro-spinal fever.

The value of each of these is increased when the rates for a series of years can be given.

The above list is not exhaustive, and it may easily be extended.

Of the statistical mortality indices giving the best tests of the stage of social and sanitary civilization which a community has reached, 5, 6, 7, 8, 9, and 10 (especially typhoid fever) are the most valuable.

**Sanitary Indices.**—Various attempts have been made to combine some of the above rates into a common figure which can be a true criterion of the health conditions of a community. An illustration of one of these is given on page 521. Another sanitary index employed in one State is the rate per 1,000 of population of deaths caused by the diseases numbered 1-15 in the abridged international classification of causes of death, exclusive of influenza and inclusive of deaths under one year. It thus gives a conglomerate measure of the deaths due to the acute infectious diseases, to tuberculosis, and to infant mortality. Of the pitfalls attaching to the "zymotic death-rate," there is a discussion on page 583. The addition of the further items above increases the confusion. Accurate knowledge can only be attained by analysis of diseases, not by their composition, and there can be no short cut to the satisfactory relegation of a community to its due place in the sanitary hierarchy.

**Death-rates as End Products.**—The relative value of morbidity and mortality statistics is discussed on page 123, and it must be confessed that under present conditions deaths as a rule give more reliable statistical information than cases of sickness. But in adjudging the value of sanitary work

importance must be attached to the statistical statement of the amount and variety of various public health and associated activities, even though the influence of these activities on the death-rate cannot be immediately determined. Thus—

(1) A statement of the amount and character of hospital provision for various diseases including insanity,

(2) A statement of the number of cases treated at various treatment centres, and

(3) A statement of the extent of activity of inspectors, health visitors, tuberculosis nurses, etc., and other allied tests form important indices of the distance which a given community has emerged from sanitary barbarism, even if the death-rate of this community is higher than that of others in which these activities are less advanced. A death-rate (general or specific) must be measured, or at least viewed when it cannot be measured, in the light of the weight of the existent adverse factors, as well as of the work done to counteract these factors.

**Aids to Calculation.**—It is assumed throughout that the student is familiar with the use of tables of logarithms. For the majority of the calculations required in medical statistical work, Crellé's Multiplication Tables, or the Direct Calculator of M. B. Cotsworth (York, 21s. net; at present out of print), are more expeditious than logarithmic tables, and simply invaluable for every-day work. Fuller's Slide Rule is also useful, but in my experience is not so convenient as Crellé's or Cotsworth's Tables.

For particulars as to the use of the various arithmometers the manufacturers' catalogues and textbooks on statistics may be consulted.

## CHAPTER LI

### STATISTICAL FALLACIES

**THEORETICALLY**, a separate chapter for consideration of statistical errors is almost as unnecessary as would be a chapter devoted to the consideration of grammatical errors at the end of a treatise on grammar. In both instances the rest of the treatise should make such a special chapter redundant. There is practical convenience, however, especially for the medical student, in summarizing some of the more important statistical errors; and the opportunity is taken, furthermore, to detail some instances which have not arisen in the preceding chapters.

Quetelet's four chief rules are always worthy to be held in remembrance, as their observance would render statistical errors relatively rare:—

(1) Never have preconceived ideas as to what the figures are to prove.

(2) Never reject a number that seems contrary to what you might expect, merely because it departs a good deal from the apparent average.

(3) Be careful to weigh and record *all* the possible causes of an event, and do not attribute to one what is really the result of the combination of several.

(4) Never compare data which are not fully comparable.

**Errors Already Exposed.**—The indispensability of accurate records of the population concerned, and of the vital events, birth, marriage, sickness and death, affecting the given population, have been urged repeatedly in previous pages. The necessity for confining comparisons to populations of equivalent age and of the same sex has been emphasized. Wrong methods of presentment of facts have been pointed out in each chapter; and the possibility that cyclical changes, or the lack of knowledge of all factors concerned, or other conditions, may render compared facts

in reality incomparable or unmeasurable, has been repeatedly indicated.

Reference may be made to the errors implied in the ratios between two variables (p. 340), in comparing incomparable items (p. 504), in drawing inferences from insufficient data (pp. 496 and 606) in variable age and sex distribution of population, e.g. in cancer and phthisis mortality (pp. 218 and 335), in giving average rates (p. 390), etc.

**Sources of Error.**—A chief cause of error is lack of attention to the definition, meaning, and limitation of each item which is under consideration. Perhaps this is the most common source of *fallacies of observation*. Another source of such errors is the non-realization that some elements in the problem, e.g. of health, poverty, or crime, may not, in our present stage of knowledge, be able to be measured numerically. Often a part is mistaken for the whole, or a part is given an extravagant value, and this is perhaps the chief source of error in measuring the relative importance of environment and heredity in human development. The statistical measures adopted may give nothing beyond a fractional measure of the environment whose influence is being assessed. Often, again, the mental bias of the observer gives disproportionate magnitude to one factor, and this happens especially in medical observations, in which experimental check observations may be impracticable. Errors from paucity of data are illustrated on p. 606.

**Errors of Inference** have been considered in Chapter XLIV, and illustrations occur in other chapters and in the appendix to this chapter.

The succeeding paragraphs consist of notes of some errors which have not yet been fully considered.

**Errors as to Average Strength.**—The sickness and mortality statistics in the Army and Navy are calculated on what is known as the *average strength* or *mean force*. When many changes of troops occur, it is often difficult to ascertain the mean strength, and erroneous calculations are consequently not uncommon. An example, quoted by the late Dr. Parkes from a paper by Dr. Balfour, affords an instance in which an unhealthy station in India (Masulipatam) was credited with a more favourable rate of mortality than its real rate. The Madras Medical Board stated that the death-

rate among all the European regiments in the Presidency, from January 1813 to December 1819, was 56·9 per 1,000; while that of the regiments, at Masulipatam from 1813 to 1832 inclusive was 51·0 per 1,000; and they inferred that the rate of mortality having been somewhat lower than throughout the rest of the Presidency for such a period, there was reason for concluding that the station could not be considered under ordinary circumstances as unhealthy. In arriving at the preceding death-rate for Masulipatam, however, the fact had been lost sight of that in several of the years between 1813 and 1832 the regiments were quartered at Masulipatam during part of the year only. Under such circumstances, in calculating the annual death-rate, only such a proportion of the mean annual strength should be taken as corresponded with the period during which the regiment was stationed there. If it was stationed there six months, the calculation should be based on half the strength; if nine months, on three-fourths of it, and so on.

When the necessary correction was made in the instance cited, the annual death-rate from 1813 to 1832 was found to average 63·94 per 1,000, instead of 51·00 as previously stated.

The error we have just described is similar to the assumption that, in a town with a population of 100,000 persons, and in which 3,000 deaths occurred during nine months, the annual death-rate is 30 per 1,000. The population should, of course, be reduced by one-fourth; and the annual death-rate, on the assumption that the same rate of mortality continues during the remaining three months of the year, is 40 per 1,000.

**Fallacies of Hospital Statistics.**—Much of the misapprehension which prevailed for some years concerning hospital mortality was due to a lack of appreciation of similar considerations. The subject is discussed in the Sixth Report of Sir John Simon to the Privy Council for 1863, which was founded on an investigation made by Dr. Bristowe and Mr. Holmes into the sanitary conditions of, and results obtained in, various large hospitals.

To begin with, the word "healthy," as applied to a hospital, evidently cannot denote that its inmates shall be persons in health; nor that its inmates shall not have a high

death-rate, for this is involved in the condition of the inmates. A "healthy" hospital is one "which does not *by any fault of its own* (whether *inherent fault*, as of site or construction; or *fault of keeping*, as dirtiness or overcrowding) aggravate ever so little the sickness, nor oppose ever so little the recovery of persons who are properly its inmates."

Death is unquestionably the most serious form in which lack of success in treatment is evidenced. It is essential, however, if hospital death-rates are to possess the slightest value, that they should be calculated on *given magnitudes of illness*. The comparison of the death-rate in a fever hospital with that in an orthopædic hospital would obviously be absurd. Unless due regard be had, therefore, to the uncertain import of the word "patient," death-rates are worthless as evidence of success or failure in hospital treatment. Hospitals differ enormously from one another in regard to the quality and magnitude of the cases received in them for treatment. Large urban hospitals receive patients at any time and of the gravest character, and "wage an ever precarious contest against the least conquerable forms of disease"; while in country hospitals admission often is by subscriber's letter, and there may be comparatively infrequent change of patients and a minimum of severe cases. Hence the hospitals with high death-rates have no reason to be ashamed, nor the hospitals with low death-rates to congratulate themselves on these grounds.

The census on April 8, 1861, showed how many special inmates were contained in each of the hospitals of England, while the death-returns of the year 1861 showed how many deaths occurred during the year in the same hospitals. From these materials the Registrar-General in his Twenty-fourth Annual Report compiled an annual death-rate per 100 occupied beds, which may be called a *bed death-rate*. Such bed death-rates are misleading.

(a) In the first place, they were calculated on the hospital population of a single day—that of the census, which may have been much above or below the average—and not on the average daily sick population.

(b) Each bed in a hospital usually receives during the year a succession of patients. All that a bed death-rate means is that there occurs in every occupied bed in a hospital

a certain number of deaths per annum. A bed death-rate of 100 per cent. per annum means that on an average one death occurs during the year in every occupied bed of the hospital.

(c) These objections, however, are trifling when compared with the objections already stated against death-rates for all causes in the aggregate as measures of hospital healthiness.

Thus the Nottingham hospital had a bed death-rate under 41, while that of Manchester was over 130; at Swansea the death-rate was only 10, while at Bath it was 102, per 100 occupied beds.

These results are quite untrustworthy. Assuming that the mortality in urban hospitals was twice as great as in rural hospitals, then we might form any one of three conclusions: "either (1) that the urban hospitals change their sick population twice as often as the rural hospitals, and that other conditions are equal; or (2) that in the urban hospitals the mean gravity of cases received for treatment is twice as great as in the rural hospitals, and that other conditions are equal; or (3) that in the urban hospitals the success of treatment of given magnitudes of disease is half as great as in the rural hospitals, and that other conditions are equal." In all probability the two first of these suppositions express the truth.

If general death-rates are employed at all in regard to hospitals, the true principle on which to calculate them is on the basis of the aggregate annual number of cases treated to a termination. This may be called the *patient death-rate*, as distinguished from the bed death-rate. There is no necessary connection between the range shown by bed death-rates in the preceding statistical comparison and the range of patient death-rates in the same institutions. Whether the two ranges would correspond depends on whether *the average time of staying in hospital* is the same in the hospitals compared. But as a matter of fact the staying-time varies greatly in different hospitals, being usually shorter in larger hospitals, and shorter in hospitals where the proportion of acute cases is high. If the mean stay of patients in hospitals is known, *bed death-rates* may at once be converted into *patient death-rates*, or *vice versâ*.

It follows from the preceding considerations that com-

parisons of hospital statistics, if they are to serve any useful purpose, must be in considerable detail. Not only should cases of like nature be compared, but, inasmuch as the mortality from many diseases varies with age, the age-constitution of the patients of the institutions under comparison should be noted. Thus a typhus patient aged 55 is 10 times as likely to die as a typhus patient aged 15.

The success of the major amputations again varies greatly according to the age of patients, and according to whether operation is required as the result of injury or disease; and in regard to all statistics dealing with the results of treatment it is desirable that the age and special circumstances of the individual cases should be fully stated.

**Errors from the Composition of Ratios.**—As a general rule, it is dangerous to combine or compound rates. This error is so commonly fallen into that the following illustrations of the resulting mistakes cannot be considered superfluous:—

Thus the population of—

A was 125,091, and its death-rate	20·00
B „ 14,450 „ „ „	13·70
	33·70

Incorrectly obtained mean death-rate of the two = 16·85

The true method is as follows:—

A population, 125,091; deaths, 2,503	
B „ 14,450; „ 199	
	2,702
	139,541

Therefore  $\frac{2,702 \times 1,000}{139,541} = 19·59$ , is the true death-rate of

A and B together.

In the first calculation equal weight was erroneously given to the healthiness of A and of B, although B had only one-eighth of the entire population.

A further amusing instance is furnished by a correspondence in *The Times* during September 1888. X wrote to *The Times* newspaper, and on the assumption that the death-rate in the British Army at home and abroad in 1885 was 11·12

per 1,000, and the death-rate of troops at home 6.68, argued gravely that the death-rate of troops abroad was therefore 4.44 per 1,000! *Y* wrote to correct this statement, and pointed out that if *X*'s method were correct, then it would be equally true that if the death-rate of the English and Irish in the United Kingdom was 21 per 1,000 and that of the Irish 20 per 1,000, the mortality of the English was only 1 per 1,000; or if the death-rate of the Irish was over 21, then the English live for ever! *Y* then proceeded to maintain that the true mortality of the troops abroad was 15.56 per 1,000, without mentioning, as *Z* pointed out in a subsequent letter, that this was only correct when the troops at home and abroad were equal in number; on which *Y* replied that "rates per 1,000 are quite irrespective of numbers at home and abroad"—a conclusion which is true for rates regarded separately, but flagrantly false when applied to their composition.

The general problem is as follows: Having given the death-rate of the component parts of a population, to find what is the death-rate for the whole.

Let  $a + b$  = total number of population (or body of men, as in the preceding example), where  $a$  and  $b$  represent the population of each part.

Also let  $x$  = death-rate per unit of the portion  $a$ ,  
and  $y$  = " " " " "  $b$ ,

where  $x$  differs from  $y$ .

Then the number of deaths in  $a = a \times x = ax$ .

Also " " " "  $b = b \times y = by$ .

Therefore the total number of deaths in  $(a + b) = ax + by$ .  
Hence, dividing by the total population, we obtain—

$$\frac{ax + by}{a + b} = \text{death-rate per unit for the whole.}$$

If the two parts of the population are equal, i.e. if  $a = b$ ,

$$\text{the death-rate for the whole} = \frac{ax + ay}{a + a} = \frac{a(x + y)}{2a} = \frac{x + y}{2},$$

which is the mean of the two rates  $x$  and  $y$ .

Hence, when the parts of which a population is composed are equal, the death-rate of the whole is the mean of the death-rates of the components parts.

But if  $a$  be twice as great as  $b$ , i.e. if  $a = 2b$ , then the formula  $\frac{ax + by}{a + b}$  may be written  $\frac{2bx + by}{2b + b} = \frac{b(2x + y)}{3b} = \frac{2x + y}{3}$ , where evidently the death-rate for the whole is not the mean of the death-rates for the two parts.

From this it is evident that when the death-rates of the component parts of a population are given, the death-rate of the whole population will depend on the relative proportion existing between its component parts; and any variation in these proportions will cause a corresponding variation in the total death-rate. In order, therefore, to ascertain the total death-rates from the death-rates of the parts, we must either know the actual population of each component part or their relative proportions.

Reverting once more to the formula already given, viz.,  $\frac{ax + by}{a + b}$  = death-rate per unit of the population ( $a + b$ ), it is evident that, where the total death-rate is given and the death-rate of one component part of the population, this same formula will enable us to find the death-rate of the remaining portion.

Thus, taking the example already quoted from *The Times* newspaper,

The death-rate of the army at home and abroad in 1885 = 11.12 per 1,000.

The death-rate of the army at home = 6.68 per 1,000.

To find the death-rate of the army abroad:—from the Director-General's returns, we find the strength of the total army in 1885 = 198,064; of the army at home = 91,579; of the army abroad = 105,748.

$$\text{By the formula } \frac{ax + by}{a + b} = 11.12 = \frac{91,579 \times 6.68 + 105,748 \times y}{198,064}$$

From which we obtain the result that  $y = 15$  nearly.

Similarly, having given the death-rate of the army in the United Kingdom in 1887 to be 5.3 per 1,000, of the army abroad 14.0, to find the death-rate of the total army, the strength of the army in the United Kingdom being 106,767, and of the army abroad 102,807.

Death-rate of the whole army

$$\begin{aligned} &= \frac{ax + by}{a + b} = \frac{106,767 \times 5.3 + 102,807 \times 14.0}{106,767 + 102,807} \\ &= 9.6. \end{aligned}$$

The use of the death-rate per 1,000 instead of per unit in these calculations does not alter the result, as it affects both numerator and denominator equally.

### ILLUSTRATIONS.

**Lack of Definition of Terms.**—A letter in the *Spectator* of April 1, 1922, quotes figures showing that in 59 cities in the United States, with a combined population of 20,000,000, there were during the year 1920 109,768 arrests for drunkenness, and then contrasts these figures with the fact that in England and Wales in the same year, with a population of 37,000,000, the convictions for drunkenness numbered 95,763. It is added: "It would appear that the United States under prohibition are not nearly so sober as England and Wales without it."

Are these figures comparable? Can any valid deduction be made from them?

**Observations.**—It will be noted that "arrests for drunkenness" are compared with "convictions for drunkenness," which may not

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be strictly comparable, and we have no information as to the relative police stringency of action in the two countries. Evidently no valuable conclusion can be drawn from these data. More detailed and exact statements are required, and especially it is desirable that the number of "arrests" and "convictions" for drunkenness should be ascertained for a series of years in each country, including years before the prohibition law was enacted.

The following miscellaneous examples are added in illustration of common mistakes needing to be avoided.

**Two Variables.**—In a local municipal discussion, a councillor observed that whereas before the war the cost of education, as compared with the national expenditure, was 15 per cent., it had now declined to 9 per cent. Instead of spending less we ought to spend more.

*Observations.*—This is the old fallacy of a proportion between two variables. Although the expenditure on education is now, a smaller proportion of the total expenditure than formerly, its amount may at the same time have increased, either absolutely or in terms of the population. Each of the items, (a) educational, (b) other public expenditure, should be given for a series of years if argument is to be based on a satisfactory statement.

**Inadequate Data.**—An extreme instance of a conclusion, widely advertised, which is based on inadequate data, insufficiently analysed, is the following extract from the Annual Report of a Medical Officer of Health: "240 babies under one year old were fed on X, and only 1 died. This gives an infantile mortality rate of 4 per 1,000. . . . Amongst the remainder (about 160) 37 died, which yields an infantile mortality rate of 232 per 1,000."

*Observations.*—No conclusion is justified from the above figures, though the above very limited experience might have been instructive, had the age in weeks or months of all the infants been stated, as also the duration of each method of feeding in the experience of each infant. The social status of the contrasted infants should also be defined.



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**STRICTLY CONFIDENTIAL**

NAME and SURNAME :—	RELATIONSHIP to Head of Household.	
<p>of every person who is alive at midnight on the night of Sunday, 24th April, 1921, and who, whether as member of the family or as visitor, boarder or servant in the household or establishment :—</p> <p>(1) passes that night in the dwelling of the household or establishment, or</p> <p>(2) arrives and is received into the household or establishment on the morning of Monday, 25th April, not having already been enumerated elsewhere.</p> <p><i>No one else must be included.</i></p> <p>(For order of entering names see Examples on back hereof.)</p>	<p>State whether "Head," or "Wife," "Mother," "Son," "Daughter," "Step-son," or other Relative, "Visitor," "Boarder," or "Servant,"</p> <p>(See Instruction No. 1.)</p>	<p>ad F o " " (Se</p>
(a)	(b)	
1		Ye.
2		
3		
4		
5		
6		
7		
8		
9		
10		

To be filled up by the Enumerator.			
Males.	Females.	Persons.	Rooms

## APPENDIX B

### RULES FOR ALLOCATION OF DEATHS

RULES IN USE IN THE GENERAL REGISTER OFFICE,  
ENGLAND, FOR SELECTION OF ONE FROM TWO OR  
MORE JOINTLY STATED CAUSES OF DEATH.

*(From Manual of the International List of causes of death as adapted  
for use in England and Wales, 1912, H.M. Stationary Office.)*

1. In cases where the effect of any two rules appears to be at variance, the first stated is to be followed, unless the second refers explicitly to an exception to be made in the application of the first.

2. In cases of the separate statement as joint causes of death of two diseases the names of which are components of a single compound pathological term, the death is generally to be classed as indicated in the Manual, for the compound term, e.g. Gastritis, Enteritis, treat as Gastro-enteritis.

*N.B.*—This does not apply to Bronchitis, Pneumonia.

3. The general order of preference is as follows:—

1. VIOLENCE.
2. GENERAL DISEASES.
3. LOCAL DISEASES.
4. ILL-DEFINED CAUSES OF DEATH (Nos. 187-189).  
(For Nos. 150-154 see Rule 8.)

#### VIOLENCE.

4. Where any forms of violence and disease are jointly stated as causes of death, the violence is to be preferred except in the following instances:—

- (a) Deaths from any definite disease stated to have been accelerated by accident are to be classed to the disease.
- (b) Deaths during or resultant from operation or the administration of an anæsthetic are to be classed to the disease or injury for which the operation was performed.
- (c) Deaths from pneumonia or other lung diseases consequent upon accidental immersion are to be classed to the disease.
- (d) Deaths from injuries received during an epileptic or apoplectic fit are to be classed to epilepsy or apoplexy, as the case may be.
- (e) Deaths from tetanus, erysipelas, pyæmia, septicæmia, blood-poisoning, etc., following accident are to be classed to the disease if the injury was slight, such as "scratch" or "abrasion"; but if the injury was apparently severe enough to kill by itself (e.g. by vehicle, machinery, etc.), the death is to be classed to violence.
- (f) Deaths from cancer and accident in conjunction are to be classed to cancer.

## GENERAL DISEASES.

5. Any general disease, except—

- (a) Membranous laryngitis (9 B.) and croup (9 C.), which for this purpose are regarded as local diseases, and
- (b) Undefined anæmia and chlorosis (in 54), "other tumours" (46), and chronic rheumatism (48 A.) which for this purpose rank below all except the ill-defined causes of death,

is to be preferred to any local disease except aneurism (81 A.), strangulated hernia and acute intestinal obstruction (in 109), and puerperal fever, phlebitis, and diseases of the breast (137, 139 A., and 141), which for this purpose are included with the general diseases in Group I below.

6. The general diseases are divided into four groups in order of their importance for the purpose of selection. Any disease in Group I is to be selected in preference to any other not in Group I; any in Group II is to be preferred to any other not in Groups I and II, and so on. If two or more of the diseases in any group are stated together, the disease of longest duration, or that first mentioned in the Certificate should as a rule be chosen. (See Rule 10.)

*Group I.*

- 5. Smallpox.
- 12. Asiatic cholera.
- 21. Glanders.
- 22. Anthrax (Splenic fever).
- 23. Rabies.
- 24. Tetanus.
- 39-45. Cancer (all forms).
- 57-59. Chronic lead and other chronic poisonings.
- 81 A. Aneurism.
- In 109. Strangulated hernia and acute intestinal obstruction.
- 137. Puerperal fever.
- 139 A. Puerperal phlegmasia alba dolens and phlebitis.
- 141. Puerperal diseases of the breast.

And other epidemic diseases of exceptional interest, such as Mediterranean fever (3 B.), Plague (15), Yellow fever (16), Leprosy (17), Beriberi (27), etc.

*Group II.*

- 1. Enteric fever.
- 2. Typhus.
- 3 A. Relapsing fever.
- 4. Malaria.
- 6. Measles.
- 7. Scarlet fever.
- 8. Whooping cough.
- 9 A. Diphtheria.
- 14. Dysentery.

*Group III.*

- 10. Influenza.
- 25. Mycoses.
- 28-35. Tuberculosis (all forms).<sup>1</sup>

<sup>1</sup> Deaths from tubercle of two or more organs should be assigned to No. 28 or No. 29 if the lungs are involved; otherwise to 35. (See notes to Nos. 28 and 35, pp. 5 and 8 of the Manual.)

- 37-38. Venereal diseases.
- 47. Rheumatic fever.
- 52. Addison's disease.

*Group IV.*

- 18. Erysipelas.
- 19 A. Mumps.
- 19 B. German measles.
- 19 C. Varicella.
- 20 (A. B. Pyæmia and Septicæmia.<sup>1</sup>
- 36. Ricketts, softening of bones.
- 48 B. Osteo-arthritis.
- 48 C. Gout.
- 49. Scurvy.
- 50. Diabetes.
- 51. Exophthalmic goitre.
- 53. Leucocythæmia, Lymphadenoma.
- In 54. Pernicious anæmia.
- 55. Other general diseases.

7. If one of the diseases mentioned is an immediate and frequent complication of another, the primary disease should be preferred to its complication.

8. The conditions comprised under headings 150-154 are to be dealt with as follows, notwithstanding anything to the contrary implied in any preceding rule:—

(a) Congenital defects (150), premature birth (151 A.), icterus neonatorum (151 C.), and sclerema and œdema neonatorum (151 D.)—

*Under 3 months*—these conditions are to be preferred to any disease except syphilis and the diseases in Groups I and II.

*Over 3 months*—any definite disease not presumably the consequence of a congenital defect is to be preferred to these conditions.

Premature birth (151 A.) is to be preferred to congenital defects (150) and "other diseases peculiar to early infancy" (152), when occurring together on the same Certificate.

(b) "Other diseases peculiar to early infancy" (152) are to receive the same preference as congenital defects under 3 months of age.

(c) Atrophy, debility and marasmus of infants (151 B.), want of breast milk (151 E.), and senile decay (154 B.), are to be treated as ill-defined causes of death.

(d) Lack of care (153) is to be treated for this purpose as a form of violence.

(e) Senile dementia (154 A.) is to be treated in the same manner as other forms of insanity (see Rule 9).

LOCAL DISEASES.

9. The following are to be selected in preference to any other local diseases appearing in the same Certificate, except aneurism (81 A.), strangulated hernia, and acute intestinal obstruction (in 109), and puerperal fever, phlebitis, and diseases of the breast (137, 139 A. and 141).

<sup>1</sup> Pyæmia and septicæmia are subject to Rule 7, but in cases where the application of this rule causes a local disease to be preferred to either of them, the local disease acquires Group IV precedence

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<i>Column A.</i>	<i>Column B.</i>
61 A. Cerebro-spinal fever.	62. Locomotor ataxy.
61 B. Posterior basal meningitis	63. Other diseases of spinal cord.
78 B. Infective endocarditis	67. General paralysis of insane.
92 A. Lobar pneumonia.	68. Other forms of mental alienation.
104 & 105 A. Infective enteritis.	69. Epilepsy.
106, 107, 112, 121, and other headings according to part affected.	74 A. Idiocy, Imbecility.
}	74. C. Cerebral tumour.
	154 A. Senile dementia.
108. Appendicitis.	
143. Carbuncle, Boil.	
144 A. Phlegmon.	

A disease in Column A is to be preferred to any disease in Column B, when occurring upon the same Certificate. (See also Rules 6 and 10.)

10. Where two or more local diseases, neither of which is included in the preceding list, are certified together, that of longest duration should be preferred; if duration is not recorded, any disease of a chronic nature should be preferred to a disease not so characterized; if neither disease can be assumed to be chronic, the first mentioned on a *medical* certificate should be selected. Exceptions to this rule are as follows:—

- (a) Any definite disease of the heart (77–80 and 85 A.), or kidney (119–122) is to be preferred to any disease of the respiratory system (86–98).
- (b) "Congestion" of any organ, convulsions (70 and 71), "hemorrhage" (85 C.), laryngismus stridulus (87 A.), thrush (99 B.), and dyspepsia (in 103 B. and 104 and 105 E.) rank below all except the ill-defined causes of death. Alcoholism, however stated, takes the same rank, in view of the treatment of organic disease attributed to it (see pp. x and xiv of Manual).
- (c) Arterial sclerosis (81 B.), heart diseases (77–80 and 85 A.), cirrhosis of the liver (113), and Bright's disease (120 A.) are to be preferred to apoplexy (64 A.), cerebral hæmorrhage (64 E.), hemiplegia (66 A.), and cerebral embolism and thrombosis (82 A.), which on the other hand are to be preferred to bronchitis (89 and 90 B.).
- (d) Cirrhosis of the liver with neuritis is to be taken as alcoholic cirrhosis of liver (113 B.).
- (e) In the case of deaths occurring in lunatic asylums, nervous diseases other than those mentioned under (b) and (c) are to be preferred to other local diseases, except those receiving special preference under rules 6 and 9.

**NOTE.**—The foregoing rules have been framed primarily for the selection of one from two jointly stated causes of death. Where three or more causes are jointly stated it may occasionally be found that the effect of different rules is conflicting. In these cases, which are infrequent, the coder must rely upon his own judgment for guidance as to the rule to be followed.

RULES ISSUED BY THE INTERNATIONAL COMMISSION  
IN 1903 FOR THE SELECTION OF ONE FROM TWO  
JOINTLY STATED CAUSES OF DEATH.\*

*N.B.*—Not in use in the General Register Office for England and Wales.

1. If one of the two diseases is an *immediate and frequent* complication of the other, the death should be classified under the head of the primary disease. Examples :—

*Infantile diarrhœa* and *convulsions*, classify as *infantile diarrhœa*.

*Measles* and *broncho-pneumonia*, classify as *measles*.

*Scarlet fever* and *diphtheria*, classify as *scarlet fever*.

*Scarlet fever* and *nephritis*, classify as *scarlet fever*.

2. If the preceding rule is not applicable, the following should be used : If one of the diseases is *surely fatal*<sup>1</sup> and the other is of less gravity, the former should be selected as the cause of death. Examples :—

*Cancer* and *broncho-pneumonia*, classify as *cancer*.

*Pulmonary tuberculosis* and *puerperal septicœmia*, classify as *tuberculosis*.

*Icterus gravis* and *pericarditis*, classify as *icterus gravis*.

3. If neither of the above rules is applicable, then the following : If one of the diseases is *epidemic* and the other is not, choose the epidemic disease. Examples :—

*Typhoid fever* and *saturnism*, classify as *typhoid fever*.

*Measles* and *biliary calculi*, classify as *measles*.

4. If none of the three preceding rules is applicable, the following may be used : If one of the diseases is *much more frequently fatal* than the other, then it should be selected as the cause of death. Examples :—

*Rheumatism (without metastasis)* and *salpingitis*, classify as *salpingitis*.

*Pericarditis* and *appendicitis*, classify as *pericarditis*.

5. If none of the four preceding rules applies, then the following : If one of the diseases is of *rapid development* and the other is of slow development, the disease of rapid development should be taken. Examples :—

*Diabetes* and *icterus gravis*, classify as *icterus gravis*.

*Cirrhosis* and *angina pectoris*, classify as *angina pectoris*.

*Pleurisy* and *senile debility*, classify as *pleurisy*.

6. If none of the above five rules applies, then the diagnosis should be selected that best characterises the case. Examples :—

*Saturnism* and *peritonitis*, classify as *saturnism*.

Precise diagnosis should be given the preference over vague and indeterminate terms, such as "hæmorrhage," "encephalitis," etc. Arbitrary decisions should be avoided as much as possible by the use of the preceding rules. None of them is absolute, but all are subject to exceptions, which may vary according to local usages. In practice the first rule, which is the most logical of all, is the one of most frequent application. The others have been formulated only to prepare for all cases and to treat them with system and uniformity.

<sup>1</sup> Apart from all treatment. This provision is necessary to assure stability in the application of the rules. Otherwise a therapeutic discovery, for example that of the anti-diphtheritic serum, would modify the tables and injure the comparability of the statistics.

## APPENDIX C

### NOSOLOGIC NOMENCLATURE

#### NOMENCLATURE OF DISEASES AND CAUSES OF DEATH AGREED UPON BY THE INTERNATIONAL COMMISSION, PARIS, OCTOBER 14, 1920.

GENERAL OBSERVATIONS.—The statistics of diseases and causes of death should be given by ages in as detailed a manner as possible, and should show at least the following groups :—

- From 0 to 1 year.
- From 1 to 19 years.
- From 20 to 39 years.
- From 40 to 59 years.
- From 60 years and over.

It seems *desirable* to divide, if possible, the second age group as follows : From 1 to 4 years, from 5 to 14 years, from 15 to 19 years. The distinction by sex for each group is equally desirable.

It is *indispensable* to publish the population by age (and by sex, if the mortality data are so given), conforming to the age-groups adopted for the statistics of causes of death.

#### DETAILED NOMENCLATURE.

*(The titles given in italics relate to morbidity statistics only.)*

##### I. EPIDEMIC, ENDEMIC, AND INFECTIOUS DISEASES.

1. Enteric fever :
  - (a) Typhoid fever.
  - (b) Paratyphoid fevers.
2. Typhus.
3. Relapsing fever ("Spirillum obermeieri").
4. Mediterranean fever ("Melito-coccosis").
5. Malarial fever or cachexia :
  - (a) Malarial fever.
  - (b) Malarial cachexia.
6. Smallpox.
7. Measles.
8. Scarlet fever.
9. Whooping cough.
10. Diphtheria.
11. Influenza :
  - (a) With pulmonary complications specified.
  - (b) Without pulmonary complications specified.
12. Miliary fever.
13. *Mumps*.
14. Asiatic cholera.

15. Cholera nostras (choleric form enteritis).
  16. Dysentery :
    - (a) Amœbic.
    - (b) Bacillary.
    - (c) Due to other causes or of unspecified origin.
  17. Plague :
    - (a) Bubonic.
    - (b) Pneumonic.
    - (c) Septicæmic.
    - (d) Not otherwise defined.
  18. Yellow fever.
  19. Spirochaetosis ictero-hæmorrhagica.
  20. Leprosy.
  21. Erysipelas.
  22. Acute poliomyelitis.
  23. Encephalitis lethargica.
  24. Meningococcal meningitis.
  25. Other epidemic diseases.
  26. Glanders.
  27. Anthrax.
  28. Rabies.
  29. Tetanus.
  30. Mycoses.
  31. Tuberculosis of the respiratory system.
  32. Tuberculosis of the meninges and central nervous system generally.
  33. Tuberculosis of the intestines and peritoneum.
  34. Tuberculosis of the vertebral column.
  35. Tuberculosis of the joints.
  36. Tuberculosis of other organs :
    - (a) Tuberculosis of the skin and subcutaneous cellular tissue.
    - (b) Tuberculosis of the bones (vertebral column excepted).
    - (c) Tuberculosis of the lymphatic system (mesenteric and retroperitoneal glands excepted).
    - (d) Tuberculosis of the genito-urinary system.
    - (e) Tuberculosis of organs other than the above.
  37. Disseminated tuberculosis :
    - (a) Acute.
    - (b) Chronic.
  38. Syphilis :
    - (a) *Primary*.
    - (b) *Secondary*.
    - (c) *Tertiary*.
    - (d) *Hereditary*.
    - (e) *Stage not indicated*.
  39. Soft chancre.
  - 40A. Gonococcal infection (ophthalmia excepted).
  - 40B. Gonorrhœal or purulent ophthalmia.
  41. Purulent infection, septicæmia.
  42. Other infectious diseases.
- II. GENERAL DISEASES NOT INCLUDED ABOVE.
43. Malignant tumours of the buccal cavity.
  44. Malignant tumours of the stomach and liver.

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45. Malignant tumours of the peritoneum, intestines and rectum.
46. Malignant tumours of the female genital organs.
47. Malignant tumours of the breast.
48. Malignant tumours of the skin.
49. Malignant tumours of other or unspecified organs.
50. Benign tumours, and tumours not returned as malignant  
(tumours of the female genital organs excepted).
51. Rheumatic fever.
52. Chronic rheumatism, osteo-arthritis, gout.
53. Scurvy.
54. Pellagra.
55. Beriberi.
56. Rickets.
57. Diabetes.
58. Anæmia, chlorosis :
  - (a) Pernicious anæmia.
  - (b) Other anæmias and chlorosis.
59. Diseases of the pituitary gland.
60. Diseases of the thyroid gland :
  - (a) Exophthalmic goitre.
  - (b) Other diseases of the thyroid gland.
61. Diseases of the parathyroid glands.
62. Diseases of the thymus.
63. Diseases of the adrenals.
64. Diseases of the spleen.
65. Leukæmia, lymphadenoma.
  - (a) Leukæmia.
  - (b) Lymphadenoma (Hodgkin's disease).
66. Alcoholism (acute or chronic).
67. Chronic poisoning by mineral substances.
68. Chronic poisoning by organic substances.
69. Other general diseases.

### III. DISEASES OF THE NERVOUS SYSTEM AND SENSE ORGANS.

70. Encephalitis.
71. Meningitis.
72. Tabes dorsalis (locomotor ataxy).
73. Other diseases of the spinal cord.
74. Cerebral hæmorrhage, apoplexy :
  - (a) Cerebral hæmorrhage.
  - (b) Cerebral thrombosis and embolism.
75. Paralysis of unstated origin.
  - (a) Hemiplegia.
  - (b) Other forms of paralysis.
76. General paralysis of the insane.
77. Other forms of mental alienation.
78. Epilepsy.
79. Convulsions (non-puerperal ; 5 years and over).
80. Infantile convulsions (under 5 years of age).
81. Chorea.
- 82A. *Hysteria and neuralgia.*
- 82B. Neuritis.
83. Cerebral softening.
84. Other diseases of the nervous system.

85. Diseases of the eye and annexa :  
 (a) *Diseases of the organs of the eye.*  
 (b) *Follicular conjunctivitis.*  
 (c) *Trachoma.*  
 (d) *Tumours of the eye.*  
 (e) *Other diseases of the eye and annexa.*

86. Diseases of the ear and of the mastoid sinus.

#### IV. DISEASES OF THE CIRCULATORY SYSTEM.

87. Pericarditis.  
 88. Acute endocarditis and myocarditis.  
 89. Angina pectoris.  
 90. Other diseases of the heart.  
 91. Diseases of the arteries :  
 (a) Aneurism.  
 (b) Arterial sclerosis.  
 (c) Other diseases of the arteries.  
 92. Embolism and thrombosis (not cerebral).  
 93. Diseases of the veins (varices, hæmorrhoids, phlebitis, etc.).  
 94. Diseases of the lymphatic system (lymphangitis, etc.).  
 95. Hæmorrhage without determined cause.  
 96. Other diseases of the circulatory system.

#### V. DISEASES OF THE RESPIRATORY SYSTEM.

97. Diseases of the nasal fossæ and of their annexa.  
 98. Diseases of the larynx.  
 99. Bronchitis :  
 (a) Acute.  
 (b) Chronic.  
 (c) Not otherwise defined under 5 years of age.  
 (d) Not otherwise defined over 5 years of age.  
 100. Broncho-pneumonia (including capillary bronchitis).  
 101. Pneumonia :  
 (a) Lobar.  
 (b) Not otherwise defined.  
 102. Pleurisy.  
 103. Congestion and hæmorrhage infarct of the lung.  
 104. Gangrene of the lung.  
 105. Asthma.  
 106. Pulmonary emphysema.  
 107. Other diseases of the respiratory system (tuberculosis excepted):  
 (a) Chronic interstitial pneumonia, including occupational diseases of the lung.  
 (b) Diseases of the mediastinum.  
 (c) Diseases not included under (a) or (b).

#### VI. DISEASES OF THE DIGESTIVE SYSTEM.

- 108A. *Diseases of the teeth and gums.*  
 108B. Other diseases of the buccal cavity and its annexa.  
 109. Diseases of the pharynx and tonsils (including adenoid vegetations).  
 110. Diseases of the œsophagus.  
 111. Ulcer of the stomach or duodenum:  
 (a) Ulcer of the stomach.  
 (b) Ulcer of the duodenum.

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112. Other diseases of the stomach (cancer excepted).
113. Diarrhoea and enteritis (under 2 years of age).
114. Diarrhoea and enteritis (over 2 years of age).
115. Ankylostomiasis.
116. Diseases due to other intestinal parasites :
  - (a) Cestodes (hydatids of the liver excepted).
  - (b) Trematodes.
  - (c) Nematodes (other than ankylostoma).
  - (d) Coccidia.
  - (e) Other parasites.
  - (f) Undefined parasites.
117. Appendicitis and typhlitis.
118. Hernia, intestinal obstruction :
  - (a) Hernia.
  - (b) Intestinal obstruction.
- 119A. *Diseases of the anus and stercoral fistula.*
- 119B. Other diseases of the intestine.
120. Acute yellow atrophy of the liver.
121. Hydatid tumour of the liver.
122. Cirrhosis of the liver :
  - (a) Returned as alcoholic.
  - (b) Not returned as alcoholic.
123. Biliary calculi.
124. Other diseases of the liver.
125. Diseases of the pancreas.
126. Peritonitis of unstated origin.
127. Other diseases of the digestive system (cancer and tuberculosis excepted).

### VII. NON-VENEREAL DISEASES OF THE GENITO-URINARY SYSTEM AND ITS ANNEXA.

128. Acute nephritis (including unspecified under 10 years of age).
129. Chronic nephritis (including unspecified over 10 years of age).
130. Chyluria.
131. Other diseases of the kidneys and their annexa (diseases of the kidneys in pregnancy excluded).
132. Calculi of the urinary passages.
133. Diseases of the bladder.
134. Diseases of the urethra, urinary abscess, etc. :
  - (a) Stricture of the urethra.
  - (b) Other diseases.
135. Diseases of the prostate.
136. Non-veneraeal diseases of the male genital organs.
137. Cysts and other benign tumours of the ovary.
138. Salpingitis and pelvic abscess.
139. Benign tumours of the uterus.
140. Non-puerperal uterine hæmorrhage.
- 141A. *Metritis.*
- 141B. Other diseases of the female genital organs.
142. Non-puerperal diseases of the breast (cancer excepted).

### VIII. THE PUERPERAL STATE.

- 143A. *Normal childbirth.*
- 143B. Accidents of pregnancy :

- (a) Abortion.
- (b) Ectopic gestation.
- (c) Other accidents.

- 144. Puerperal hæmorrhage.
- 145. Other accidents of childbirth.
- 146. Puerperal sepsis.
- 147. Phlegmasia alba dolens ; puerperal embolism or sudden death in the puerperium.
- 148. Puerperal albuminuria and convulsions.
- 149. Childbirth (without other explanation).
- 150. Puerperal diseases of the breast.

**IX. DISEASES OF THE SKIN AND CELLULAR TISSUE.**

- 151. Gangrene.
- 152. Furuncle.
- 153. Phlegmon, acute abscess.
- 154A. *Trichophytosis*.
- 154B. *Scabies*.
- 154c. Other diseases of the skin and its annexa.

**X. DISEASES OF THE BONES AND ORGANS OF LOCOMOTION.**

- 155. Diseases of the bones (tuberculosis and rickets excepted).
- 156. Diseases of the joints (tuberculosis and rheumatism excepted).
- 157. Amputation.
- 158. Other diseases of the organs of locomotion.

**XI. MALFORMATIONS.**

- 159. Congenital malformations (still-births excepted).

**XII. DISEASES OF EARLY INFANCY.**

- 160A. *Nurslings discharged from hospital without disease*.
- 160B. Congenital debility, icterus and scleroma.
- 161. Premature birth ; injury at birth.
- 162. Other diseases peculiar to early infancy.
- 163. Lack of care.

**XIII. OLD AGE.**

- 164. Senility.

**XIV. EXTERNAL CAUSES.**

- 165. Suicide by solid or liquid poisons.
- 166. Suicide by corrosive substances.
- 167. Suicide by poisonous gas.
- 168. Suicide by hanging or strangulation.
- 169. Suicide by drowning.
- 170. Suicide by firearms.
- 171. Suicide by cutting or piercing instruments.
- 172. Suicide by jumping from high places.
- 173. Suicide by crushing.
- 174. Other suicides.
- 175. Poisoning by food.
- 176. Poisoning by venomous animals.
- 177. Other acute accidental poisonings.
- 178. Conflagration.
- 179. Burns (conflagration excepted).

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180. Accidental mechanical suffocation.
181. Accidental absorption of irrespirable or poisonous gas.
182. Accidental drowning.
183. Accidental injury by firearms (war casualties excepted).
184. Accidental injury by cutting or piercing instruments.
185. Accidental injury by fall.
186. Accidental injury in mines and quarries.
187. Accidental injury by machinery.
188. Accidental injury by other forms of crushing (vehicles, railways, landslides, etc.).
189. Injury by animals (poisoning excepted).
190. Wounds of war.
191. Execution of civilians by belligerent armies.
- 192A. *Fatigue*.
- 192B. Hunger or thirst.
193. Excessive cold.
194. Excessive heat.
195. Lightning.
196. Electricity (lightning excepted).
197. Homicide by firearms.
198. Homicide by cutting or piercing instruments.
199. Homicide by other means.
200. Infanticide (murder of infants less than one year of age).
- 201A. *Dislocations*.
- 201B. *Sprains*.
- 201C. Fracture (cause not specified).
202. Other external violence.
203. Violent deaths of unknown causation.

### XV. ILL-DEFINED DISEASES.

204. Sudden death.
- 205A. Cause of death unstated or ill-defined.
- 205B. *No disease; simulation*.
206. Diseases omitted as having caused less than 10 deaths.

NOTE.—When less than 10 deaths are attributed to a disease the data may be given simply in a footnote. The total number of deaths from causes omitted for this reason must then be given under No. 206.

The International Commission charged with the third decennial revision of the Nosologic Nomenclatures was convoked by the French Ministry of Foreign Affairs upon the recommendations of the League of Red Cross Societies to meet at Paris, October 11, 1920. The above nomenclature was agreed to by the delegates of forty-two nations, and the articles of agreement were signed October 14, 1920. The official report with detailed index and the minutes of the meeting is not yet issued (June 1923).

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