

DEPARTMENT OF ECONOMICS AND STATISTICS

UNITED PROVINCES



VITAL STATISTICS

IN

UNITED PROVINCES

(A CRITICAL ANALYSIS OF FORTY YEARS DATA)

BY

A. R. SEN, M. Sc., F.S.S. (LONDON)

ASSISTANT STATISTICIAN

Department of Economics and Statistics,

United Provinces Government

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INTRODUCTION

THE only vital statistics, collected in the United Provinces so far consist of the registered figures of births, deaths and a few of the important infectious diseases. The unreliability of the figures of births and deaths reported, has been stressed from time to time by various schools of experts on health in India. Both the Royal Commission on Agriculture and the Royal Commission on Labour in India drew pointed attention to the defects in Indian vital statistics and laid considerable emphasis for effecting their early improvement.

2. In the rural areas of the United Provinces which constitute roughly 88 per cent. of the total population of the Province reporting of events is mostly unsatisfactory. The reporting of events of births and deaths in these areas is not obligatory on house-holders and our reporter is the illiterate and ill-paid Village Chowkidar, one of whose many duties is to report at the Thana births and deaths from various diseases occurring in his charge twice a month on fixed dates. Thus overburdened with other duties he naturally seems to regard the duties in connection with registration of vital statistics as of relatively smaller importance. The fact that registration of births and deaths is not compulsory in the rural areas, coupled with the fact that our chowkidar is illiterate and ill-paid, with many other responsibilities to discharge, leads to serious errors of omission and commission in the number of births and deaths reported. In this connection it may be worth while to recall that the Population Data Committee in their report in 1945 have calculated the range of under-estimation of birth-rate at 40-50 per cent. for one of the areas in India where better facilities for registration are available and in the case of death rate the estimated range is even higher, viz., 35-55 per cent.

3. It would thus be seen that in the absence of certification of the registered cause of death by a medical man, the Village Chowkidar being ignorant of the signs and symptoms of these diseases often fails to report the recorded cause of deaths correctly, in the case of almost all communicable diseases excepting cholera, plague and small-pox. This is firstly because the common villager is generally familiar with the signs and symptoms of the diseases cholera, small-pox and plague more so when they occur in epidemic form and secondly because of the standing orders of the Director of Medical and Health Services, United Provinces, that Village Chowkidars shall report in their respective Thanas primary outbreaks of cholera, plague and small-pox immediately after their occurrence with details of the number of persons attacked or dead, whether such persons were local residents or visitors. Subsequent deaths from these diseases are, however, to be reported by the Chowkidar on his usual fortnightly attendance at the station. Failure to comply with the orders and instances of delay in the submission of the reports are to be brought to the notice of the officer concerned for disciplinary action. Thus immediate reporting of events by the chowkidars

reduces by far the possibility of errors of omission which he is likely to commit otherwise, by trying to remember events (being generally unable to record such events on account of his illiteracy) of deaths and births during a fortnight till his fortnightly report of such events at the Thana on scheduled dates.

4. It is mainly for the comparative reliability of the statistical reports of the epidemic diseases, cholera, small-pox and plague which form an important part of the vital statistics of the United Provinces, that these alone have been selected for the purpose of study. Although the individual figures would naturally be subject to certain percentage errors, the recorded figures are likely to give a fairly clear indication of the trend of events.

5. One of the main objects of the statistical examination of the mortality data in respects of the diseases has been to enable us to find out whether on the whole mortality from a particular disease has a declining or a rising trend, whether the disease under examination exhibits any marked seasonal periodicity and locate as far as possible for such a disease, the districts of high mortality in the Province and finally suggest wherever possible means for eradicating them. It is obvious that answers to these questions would provide the field-worker in the Public Health Department with a powerful weapon to combat these diseases, particularly in the districts of high mortality. Attempt has been made in the following pages to answer these problems by subjecting the data over a period of 40 years, 1906—45, to statistical analysis (details in special cases explained in the appendix) and in this due consideration has been made of the changes in the methods of calculation of death rates after 1941. In fact calculations after 1941 have been made on the same lines as before that date to maintain uniformity. My thanks in this connexion are due to Dr. A.C. Banerjee (Director of Medical and Health Services, United Provinces) and his staff for kindly placing at my disposal all the annual reports of the Department of Public Health during the period under investigation. I am indebted to Mr. Kunwar Kishen (Statistician to Director of Agriculture, United Provinces) for his valuable suggestions on certain aspects of the problem and also to Dr. Chandra Sekhar (Statistician, Health and Hygiene Institute, Calcutta) with whom I discussed epidemic investigations in general, when he last visited Lucknow.

RESULTS OF ANALYSIS

(a) Percentage Mortality

In table I is presented the deaths during any year for each of the three diseases cholera, small-pox and plague, for the Province expressed as percentage of total deaths from all causes during the year for the years 1906—45. In column 6 of the table is shown the sum total of the percentage mortality due to the three diseases for the years 1906—45. A glance at the table would show that the percentage mortality from cholera was highest during 1921 (which was the year of highest mortality on record for the Province during the period under examination), viz., 8·34 per cent. of the total deaths from all causes for the Province and lowest during subsequent year, viz., 0·20 during 1922. In the case of small-pox the range was 0·05 per cent.—2·39 per cent. the highest percentage figure being attained during 1908, which was perhaps the most fatal year of mortality for the Province. For plague the range of variation was sufficiently wide, viz., 0·36 per cent.—15·88 per cent. the highest figure of 15·88 per cent. of the total deaths from all causes being attained during the year 1907 which was an acute epidemic year for the Province. The total percentage mortality from the three diseases was as high as 21·42 per cent. during 1911, i.e., about one-fifth of the total mortality from all causes and as low as 2·06 during 1942, i.e., 1/50 of the total mortality. The mean percentage mortalities over the period for the three diseases cholera, small-pox and plague were respectively 2·97, 0·69 and 3·76 per cent. the total for the three diseases being 7·42 per cent. or roughly 1/14 of the mortality from all causes.

TABLE I—Annual mortality from cholera, small-pox and plague expressed as percentage of total mortality from all causes in United Provinces during 1906—45.

Serial no.	Years		Cholera	Small-pox	Plague	Total of columns 3, 4, 5
1	2		3	4	5	6
1	1906	.. ..	8·04	0·72	3·74	12·50
2	1907	.. ..	1·08	1·08	15·88	18·04
3	1908	.. ..	3·32	2·39	0·91	6·62
4	1909	.. ..	1·23	0·32	2·14	3·69
5	1910	.. ..	5·56	0·05	8·56	14·17
6	1911	.. ..	5·58	0·07	15·77	21·42

Serial no.	Years		Cholera	Smallpox	Plague	Total of columns 3, 4, 5
1	2		3	4	5	6
7	1912	.. ..	1·34	0·23	8·19	9·76
8	1913	.. ..	3·70	0·49	6·60	10·79
9	1914	.. ..	2·06	1·14	6·63	9·83
10	1915	.. ..	6·42	0·17	4·13	10·72
11	1916	.. ..	2·41	0·10	3·56	6·07
12	1917	.. ..	1·21	0·11	7·28	8·60
13	1918	.. ..	5·11	0·07	4·53	7·71
14	1919	.. ..	4·17	0·55	0·89	5·61
15	1920	.. ..	0·40	0·35	1·42	2·17
16	1921	.. ..	8·34	0·08	1·34	9·76
17	1922	.. ..	0·20	0·04	2·04	2·28
18	1923	.. ..	0·26	0·09	6·97	7·32
19	1924	.. ..	5·23	0·21	4·38	9·82
20	1925	.. ..	0·69	0·85	4·36	5·90
21	1926	.. ..	0·52	1·04	5·02	6·58
22	1927	.. ..	2·74	0·75	1·51	5·00
23	1928	.. ..	4·10	0·29	7·37	11·76
24	1929	.. ..	4·62	1·07	3·42	9·11
25	1930	.. ..	4·96	0·88	0·88	6·72
26	1931	.. ..	2·37	0·26	2·37	5·00
27	1932	.. ..	0·90	0·27	1·98	3·15
28	1933	.. ..	0·21	1·07	1·07	2·35
29	1934	.. ..	2·47	1·16	3·66	7·29
30	1935	.. ..	0·85	2·18	1·90	4·93
31	1936	.. ..	0·62	1·33	06·6	2·61
32	1937	.. ..	0·61	0·23	2·34	3·28
33	1938	.. ..	5·65	0·35	1·08	7·08
34	1939	.. ..	2·47	0·91	1·65	5·33
35	1940	.. ..	2·48	1·52	1·10	5·10
36	1941	.. ..	4·93	1·24	0·36	6·53

Serial no.	Years		Cholera	Smallpox	Plague	Total of columns 3, 4, 5
1	2		3	4	5	6
37	1942	.. ..	0·76	0·43	0·87	2·06
38	1943	.. ..	2·34	0·52	0·68	3·54
39	1944	.. ..	3·74	0·96	1·44	6·14
40	1945	.. ..	7·07	2·01	1·27	10·35
	Mean	.. ..	2·97	0·69	3·76	7·42

2. It may be interesting to observe that the total percentage mortality from the three diseases shows a somewhat declining tendency with years. The percentage mortality figures have been plotted in graph 1, and A, B, and C represent respectively the percentage mortality curves for cholera, small-pox and plague. The curves A_1 , B_1 and C_1 represent respectively their general tendencies (as obtained by moving averages). It would appear from the graph C_1 that percentage mortality from plague, has a visibly declining tendency showing thereby that the share of plague in total mortality continued to decline with years. In the case of cholera the curve A_1 represents the declining tendency which, is, however, not so marked as that in the case of plague. It would be noticeable, however, from the curve A_1 , that the declining trend was visible till 1931 and thereafter the curve ceased to have any tendency whatever, either for decline or for rise. In other words the share of cholera in total mortality continued to decline till 1931 and thereafter remained more or less unchanged. In the case of small-pox the curve of general tendency B_1 indicates that the share of small-pox in total mortality remained more or less constant over the period under examination.

(b) Secular Trend

In columns 3, 4 and 5 of table II, are set out the annual death rates (deaths per thousand population per year) from the three diseases and in column 6 of the table are shown the death rates from all causes for the Province for the years 1906—45.

2. It would appear from the table that mortality from cholera was highest during 1921, i. e., 3·30 per thousand population and lowest during 1933, i. e., 0·04 per thousand population. As has also been seen before, the year 1921 figured as the year of highest percentage mortality from cholera for the Province during the period under examination. In the case of small-pox, the year 1908 recorded the highest mortality, viz. of 1·26 per thousand population, the lowest figure of 0·01 per thousand or 10 per million being attained during 1922. For plague, the mortality ranged between 0·07 and 7·09 per thousand the lowest and highest figures being attained during the years 1941 and 1911 respectively, the year 1911 being an epidemic year of highest mortality for the Province. The total mortality from all causes was highest during 1918, viz., 82·37 per thousand, partly because the year 1918 was year of high mortality both for cholera and plague and mainly because of the large number of deaths due to influenza epidemic which pushed up the figures of mortality from fevers to 68·72 per thousand. The mortality rates in table 2 are presented in graph. The curves A, B and C represent respectively the mortality rates from cholera, small-pox and plague and the straight lines A_1 , B_1 and C_1 , their general tendencies as obtained by fitting regression lines (see Appendix). It would appear from the trend of the straight line A_1 that mortality rate from cholera has on the whole a visibly declining tendency with years, the rate of decline (as would be seen from the equation to the straight line $y = -0\cdot02962x + 1\cdot55651$ fitted) being 0·02962 per thousand per year or roughly 30 per million per year. In the case of smallpox, the straight line B_1 representing the general trend shows no such tendency for decline or rise (the line $y = -0\cdot00135x + 0\cdot22424$ being almost parallel to the axis of x). In other words the number of deaths per year for the Province seems to remain more or less unchanged throughout the entire period under examination. As regards plague, it would be seen from the graph that the line of general tendency C_1 (equation to the line is $y = -0\cdot08306x + 2\cdot98723$) shows a marked decreasing trend with years, i. e. to say mortality from plague shows a real decrease during the period 1906—45 under examination, the rate of decrease being approximately 0·083, per thousand per year or roughly 83 per million per year. An examination of the distribution of mortality rates from plague for the years 1906—45 for all the districts of the Province (as given in the annual reports issued by the Director of Medical and Health Services) shows that during recent years except for the districts of Banaras and Gorakhpur Divisions, the rest of the Province has almost been free from plague mortality. In the case of cholera also, it is noticeable that mortality is not so pronounced during recent years as it used to be in the beginning of the period under examination although the decline is not so marked as in the

case of plague. Thus although mortality rates from small-pox remained unaltered during the period, those from plague and cholera show a real fall which may be due to the improved facilities afforded by the Public Health Department to combat the epidemic diseases in the province.

TABLE II—*Annual mortality rate per 1,000 population from cholera, smallpox and plague in U. P. during 1906—45*

Serial no.	Years		Cholera	Smallpox	Plague	Mortality from all causes
1	2		3	4	5	6
1	1906	.. ..	3.14	0.28	1.46	39.07
2	1907	.. ..	0.47	0.47	6.00	43.46
3	1908	.. ..	1.75	1.26	0.48	52.73
4	1909	.. ..	0.46	0.12	0.80	37.34
5	1910	.. ..	2.15	0.02	3.31	38.67
6	1911	.. ..	2.51	0.03	7.09	44.95
7	1912	.. ..	0.40	0.07	2.45	29.91
8	1913	.. ..	1.29	0.17	2.30	34.84
9	1914	.. ..	0.69	0.38	2.22	33.46
10	1915	.. ..	1.93	0.05	1.24	30.04
11	1916	.. ..	0.71	0.03	1.05	29.50
12	1917	.. ..	0.46	0.04	2.76	37.91
13	1918	.. ..	2.56	0.06	3.73	82.37
14	1919	.. ..	1.74	0.23	0.37	41.69
15	1920	.. ..	0.15	0.13	0.53	37.23
16	1921	.. ..	3.30	0.03	0.53	39.57
17	1922	.. ..	0.05	0.01	0.51	25.01
18	1923	.. ..	0.06	0.02	1.63	23.37
19	1924	.. ..	1.48	0.06	1.24	28.29
20	1925	.. ..	0.17	0.21	1.08	24.78
21	1926	.. ..	0.13	0.26	1.26	25.10
22	1927	.. ..	0.62	0.17	0.34	23.59
23	1928	.. ..	0.99	0.07	1.78	24.15
24	1929	.. ..	1.12	0.26	0.83	24.26

Serial no.	Years		Cholera	Smallpox	Plague	Mortality from all causes
1	2		3	4	5	6
25	1930	.. ..	1.35	0.24	0.24	27.20
26	1931	.. ..	0.64	0.07	0.64	26.97
27	1932	.. ..	0.20	0.06	0.44	22.23
28	1933	.. ..	0.04	0.20	0.20	18.69
29	1934	.. ..	0.66	0.31	0.98	26.75
30	1935	.. ..	0.21	0.54	0.54	24.78
31	1936	.. ..	0.14	0.30	0.15	22.61
32	1937	.. ..	0.13	0.07	0.50	21.38
33	1938	.. ..	1.46	0.09	0.28	25.82
34	1939	.. ..	0.57	0.21	0.45	23.09
35	1940	.. ..	0.54	0.33	0.24	21.78
36	1941	.. ..	0.95	0.24	0.07	19.28
37	1942	.. ..	0.14	0.08	0.16	18.78
38	1943	.. ..	0.47	0.11	0.14	19.76
39	1944	.. ..	0.73	0.18	0.28	19.49
40	1945	.. ..	1.41	0.40	0.25	19.94
	Mean	.. ..	0.95	0.20	1.28	30.2

(c) Seasonal Distribution

It has frequently been observed in everyday life that mortality from a particular epidemic is high during a particular time of the year and that other periods of the year are characterised by low mortality and sometimes by its complete absence. We now proceed to study this seasonal behaviour in respect of the three diseases, cholera, small-pox and plague.

2. With this object in view the number of deaths in the Province for each of the three diseases during any month of a year have been expressed as percentage of the total deaths during the year. In other words for purposes of comparison assuming that the total deaths for the Province during any year remained 100, we have worked out the monthly deaths for the year in respect of each of the diseases. We now proceed to study the seasonal characters in respect of the diseases.

3. Cholera—In table III are presented the monthly deaths from cholera during any year expressed as percentage of the total deaths during the year for the Province for the years 1906—45. The first two months in order of maximum percentage mortality during any year have been *underlined* it would appear from an examination of the maxima that mortality from cholera is most pronounced during the 6 months of the year, viz., May to October. The average seasonal indices* for the Province have next been calculated and presented in graph III. The height of the bar against each month indicates the relative importance of that cause of mortality. The horizontal line corresponding to a seasonal index of 100 represents the level of average mortality from cholera. The bars whose heights exceed this level represent cases of mortality higher than the average. It would be noticeable from the graph that the months May to October are characterised by high cholera mortality, mortality during the remaining six months November to April, being below normal (=100). It would further be seen that the highest index of 174 is attained during the month of August. It is interesting to observe that mortality is most pronounced during the four months June to September, which roughly coincide with the rainy season in the Province and this seems to indicate that the rainy months are generally the months of high mortality. It may be useful to extend the study to individual districts and particularly study this fact in respect of the districts of high mortality.

*Analysis of Time Series—Statistical Methods, by F. C. Mills.

TABLE III—Monthly deaths from cholera in U.P. expressed as percentage of total deaths from cholera during the year for the years 1906—45

Years	Months											
	January	February	March	April	May	June	July	August	September	October	November	December
1906	0·55	1·85	1·35	12·32	<u>21·10</u>	<u>16·69</u>	4·89	6·07	12·37	13·41	7·13	2·27
1907	3·20	3·99	3·55	5·22	2·81	6·40	7·50	6·50	<u>16·49</u>	<u>25·46</u>	13·86	5·02
1908	7·90	7·80	12·04	<u>19·40</u>	<u>20·79</u>	15·54	9·56	3·67	1·34	0·42	0·67	0·87
1909	0·19	0·05	0·62	4·93	<u>10·80</u>	15·94	12·08	16·67	<u>16·68</u>	<u>16·73</u>	4·68	0·63
1910	0·02	0·03	0·12	1·56	<u>10·74</u>	16·03	<u>30·51</u>	<u>17·33</u>	8·19	10·61	4·24	0·62
1911	0·08	0·07	0·11	1·23	2·94	<u>16·80</u>	<u>44·25</u>	13·81	4·18	7·28	7·70	1·49
1912	1·38	0·90	2·43	<u>18·65</u>	<u>25·64</u>	13·70	1·96	7·94	13·59	9·95	3·18	0·59
1913	0·07	0·08	0·42	8·76	<u>27·32</u>	<u>24·90</u>	16·82	12·71	5·85	1·85	1·03	0·19
1914	0·80	0·82	1·42	7·11	8·48	13·26	6·03	9·35	<u>16·56</u>	<u>14·50</u>	13·11	8·56
1915	0·05	0·05	0·47	2·10	5·58	9·85	4·42	6·74	8·38	<u>29·41</u>	<u>21·90</u>	11·05
1916	0·87	0·10	6·68	8·98	<u>17·26</u>	8·93	10·47	<u>17·29</u>	13·79	15·85	5·44	0·34
1917	0·16	0·17	0·58	2·85	<u>1·79</u>	5·38	3·51	6·99	16·28	<u>29·58</u>	<u>27·15</u>	5·56
1918	0·23	0·08	0·38	3·09	13·06	<u>31·17</u>	<u>22·61</u>	12·22	3·53	4·18	7·00	2·36
1919	0·07	0·04	0·08	8·34	<u>19·62</u>	<u>26·12</u>	12·07	13·02	11·83	6·88	1·31	0·62

1920	..	..	1' 58	1' 35	1' 47	2' 53	3' 44	3' 39	3' 65	16' 53	36' 90	18' 63	8' 85	1' 68
1921	..	..	0' 02	0' 03	0' 33	3' 38	8' 59	8' 37	11' 93	35' 99	18' 43	9' 48	2' 29	1' 16
1922	..	..	8' 07	0' 39	4' 68	24' 75	20' 00	16' 65	7' 77	8' 63	5' 24	2' 96	0' 47	0' 39
1923	..	..	0' 12	0' 15	0' 93	2' 05	3' 13	5' 52	7' 18	18' 99	41' 05	17' 64	3' 20	0' 04
1924	..	..	0' 00	0' 20	7' 53	39' 30	18' 55	11' 70	4' 06	8' 29	8' 01	1' 64	0' 53	0' 19
1925	..	..	0' 46	1' 02	0' 65	2' 60	4' 09	3' 63	4' 27	16' 52	21' 88	10' 22	28' 22	6' 44
1926	..	..	0' 78	0' 92	5' 01	11' 90	11' 21	14' 11	14' 63	15' 13	11' 66	10' 33	3' 75	0' 57
1927	..	..	0' 04	0' 08	0' 42	6' 57	26' 72	32' 96	17' 90	8' 36	4' 24	1' 82	0' 52	0' 37
1928	..	..	0' 08	0' 08	1' 36	11' 47	17' 44	20' 74	12' 35	9' 75	6' 28	8' 78	8' 15	3' 52
1929	..	..	0' 29	0' 15	0' 49	6' 88	15' 51	15' 56	16' 04	16' 11	13' 23	8' 53	4' 77	2' 44
1930	..	..	0' 20	0' 71	1' 49	14' 83	18' 90	18' 39	9' 80	11' 54	14' 11	7' 14	2' 22	0' 67
1931	..	..	0' 08	0' 10	0' 39	2' 11	5' 82	13' 94	16' 83	30' 09	16' 00	10' 13	3' 70	0' 81
1932	..	..	0' 40	0' 17	1' 36	2' 79	3' 91	7' 22	11' 90	19' 75	33' 32	15' 12	3' 28	0' 78
1933	..	..	0' 03	0' 52	6' 37	55' 29	18' 49	6' 27	5' 01	3' 97	0' 89	1' 72	0' 84	0' 00
1934	..	..	0' 01	0' 02	0' 10	0' 28	3' 26	12' 83	20' 56	21' 88	16' 09	16' 93	5' 24	2' 80
1935	..	..	1' 39	1' 40	6' 19	18' 13	13' 36	17' 55	10' 54	13' 42	13' 92	3' 55	0' 47	0' 08
1936	..	..	0' 18	0' 36	1' 30	5' 36	17' 75	23' 28	13' 25	12' 10	10' 23	7' 12	6' 29	2' 78
1937	..	..	0' 16	0' 87	0' 46	3' 66	2' 89	6' 34	3' 50	15' 23	10' 01	19' 21	24' 03	13' 64
1938	..	..	0' 18	0' 08	0' 41	2' 92	19' 97	29' 76	16' 97	10' 25	5' 74	6' 65	4' 90	2' 17
1939	..	..	0' 16	0' 20	0' 43	3' 10	4' 18	10' 89	23' 25	25' 44	16' 86	9' 95	3' 94	1' 15
1940	..	..	0' 20	0' 06	0' 30	2' 55	4' 08	10' 94	17' 36	21' 75	23' 91	13' 91	3' 32	0' 93

		Months											
		January	February	March	April	May	June	July	August	September	October	November	December
Years													
1941	.. ..	0·25	0·08	0·73	10·66	<u>21·79</u>	21·51	<u>24·25</u>	12·90	4·18	1·57	1·44	0·64
1942	.. ..	1·66	0·33	1·74	2·69	1·92	1·97	5·04	21·73	<u>21·95</u>	<u>24·42</u>	11·58	4·97
1943	.. ..	0·14	0·37	0·26	0·89	1·51	4·63	9·53	13·41	<u>19·47</u>	<u>29·85</u>	13·49	6·45
1944	.. ..	0·67	0·28	0·32	0·64	3·25	8·29	8·91	<u>25·60</u>	<u>21·82</u>	14·79	9·13	6·30
1945	.. ..	0·48	0·28	0·33	2·30	<u>23·02</u>	<u>27·54</u>	<u>14·34</u>	16·03	8·88	3·64	1·31	1·85

4. **Small-pox**—In table IV is presented the percentage monthly mortality from small-pox for the Province for the years 1906 to 1945. Here again the two months with the highest monthly mortality in order, during any year have been italicised. It would appear from an examination of such months that mortality from small-pox is generally acute during the three months, April, May and June of the year. Except for the month of December during the year 1918 which figured rather unusually in being the month of highest mortality it would appear that the months April, May and June are generally the months of pronounced mortality during the period under investigation. It would also be noticeable that the seasonal periodicity is more regular in this case than in the case of cholera. The seasonal indices as given in graph IV would seem to confirm the conclusions arrived at above. It would appear from this graph that mortality from small-pox remained above normal (the horizontal line representing the line of average mortality index=100) during the five months—March, April, May, June and July, mortality during the remaining seven months being below normal. It would also appear that the 3 months April, May and June are months of acute mortality and that mortality is most pronounced during the month of May, the index being as high as 216.

TABLE IV—Monthly deaths from small-pox in U.P. expressed as percentage of total deaths from small-pox during the year for the years 1906—45

Months		Years											
		January	February	March	April	May	June	July	August	September	October	November	December
1906	.. ..	5·48	6·86	10·29	13·55	<u>19·44</u>	<u>16·33</u>	11·13	5·30	2·86	1·42	1·94	5·34
1907	.. ..	3·54	4·06	6·88	12·29	<u>15·36</u>	<u>16·05</u>	13·57	6·77	2·62	1·98	4·34	12·54
1908	.. ..	7·90	7·80	12·04	<u>19·40</u>	<u>920·7</u>	15·54	9·56	3·67	1·34	0·42	0·67	0·87
1909	.. ..	8·24	10·46	17·22	<u>21·28</u>	<u>18·71</u>	11·73	6·53	2·67	0·91	0·66	0·63	0·96
1910	.. ..	7·67	4·35	6·99	13·17	<u>11·34</u>	<u>14·57</u>	<u>14·20</u>	9·28	3·09	3·09	4·12	8·13
1911	.. ..	4·53	5·88	11·09	<u>15·55</u>	<u>16·50</u>	14·47	14·74	6·90	1·89	1·15	3·18	4·12
1912	.. ..	2·29	2·10	7·03	14·77	<u>15·32</u>	<u>18·85</u>	12·90	5·48	1·87	1·23	4·74	13·42
1913	.. ..	6·71	9·45	11·29	<u>14·60</u>	<u>15·38</u>	11·77	7·81	2·76	1·51	1·67	4·34	12·71
1914	.. ..	7·35	11·93	15·61	<u>20·06</u>	<u>20·21</u>	13·24	7·26	2·19	0·77	0·22	0·46	0·70
1915	.. ..	8·07	10·68	15·36	<u>17·53</u>	<u>19·70</u>	12·20	6·47	3·60	2·39	1·74	0·65	1·61
1916	.. ..	2·71	5·15	8·32	13·86	<u>15·12</u>	<u>20·97</u>	13·33	7·66	4·03	1·65	1·39	5·81
1917	.. ..	6·91	6·91	13·58	<u>18·30</u>	<u>18·44</u>	16·06	8·06	4·48	1·64	1·39	1·84	2·39
1918	.. ..	1·82	3·13	6·12	8·91	<u>13·93</u>	8·56	5·16	2·89	2·65	1·07	6·43	39·33
1919	.. ..	9·41	7·73	9·86	16·12	<u>20·77</u>	<u>17·73</u>	9·09	4·18	1·61	0·65	0·89	1·96

1920	..	..	5' 26	6' 97	11' 32	<u>16' 35</u>	16' 02	<u>17' 33</u>	12' 06	7' 73	2' 91	1' 75	1' 10	1' 20
1921	..	..	12' 16	9' 17	13' 27	<u>15' 78</u>	14' 18	<u>14' 94</u>	8' 90	5' 55	1' 81	2' 43	1' 11	0' 90
1922	..	..	7' 07	7' 44	9' 09	<u>16' 91</u>	<u>15' 27</u>	13' 22	12' 81	4' 96	2' 89	0' 83	4' 55	4' 96
1923	..	..	1' 20	2' 14	5' 62	11' 91	<u>15' 39</u>	<u>34' 02</u>	13' 52	4' 69	1' 87	2' 28	2' 14	5' 22
1924	..	..	1' 84	3' 60	5' 21	10' 94	14' 39	<u>24' 45</u>	<u>15' 38</u>	6' 09	2' 57	2' 17	3' 67	9' 69
1925	..	..	2' 91	4' 40	9' 92	<u>19' 85</u>	<u>23' 66</u>	16' 78	8' 75	3' 18	1' 66	1' 30	1' 50	6' 09
1926	..	..	7' 64	7' 85	13' 34	14' 52	<u>18' 72</u>	<u>15' 51</u>	9' 50	4' 62	2' 23	0' 98	1' 37	3' 72
1927	..	..	6' 70	9' 94	11' 90	14' 33	<u>15' 75</u>	<u>15' 09</u>	13' 26	6' 04	2' 81	1' 29	1' 04	1' 85
1928	..	..	5' 88	6' 54	9' 26	14' 91	<u>20' 12</u>	<u>18' 36</u>	10' 32	3' 19	1' 46	0' 83	2' 52	6' 61
1929	..	..	3' 92	5' 54	10' 14	<u>20' 55</u>	<u>21' 30</u>	12' 75	6' 87	2' 60	1' 21	0' 78	2' 10	12' 24
1930	..	..	13' 59	9' 12	10' 37	<u>19' 87</u>	<u>16' 62</u>	12' 95	9' 01	3' 45	1' 62	0' 87	1' 19	2' 34
1931	..	..	10' 52	9' 18	11' 24	<u>17' 58</u>	<u>16' 63</u>	14' 01	9' 09	5' 96	2' 41	0' 91	0' 83	1' 64
1932	..	..	4' 86	6' 51	10' 40	13' 21	<u>16' 80</u>	<u>20' 28</u>	11' 23	6' 30	1' 73	1' 01	2' 12	6' 55
1933	..	..	4' 29	6' 08	10' 27	<u>18' 15</u>	<u>23' 03</u>	16' 40	7' 49	3' 00	1' 15	0' 92	2' 11	6' 24
1934	..	..	5' 28	6' 54	10' 49	13' 35	<u>17' 30</u>	15' 94	9' 63	4' 83	1' 80	1' 29	3' 91	9' 64
1935	..	..	6' 21	7' 21	9' 88	<u>18' 79</u>	<u>20' 23</u>	15' 77	8' 44	4' 77	1' 98	1' 00	1' 80	3' 83
1936	..	..	9' 38	11' 36	13' 65	<u>18' 07</u>	<u>20' 75</u>	13' 11	6' 86	3' 04	0' 97	0' 50	0' 60	1' 75
1937	..	..	10' 09	9' 09	10' 78	13' 97	<u>15' 67</u>	<u>15' 31</u>	7' 84	4' 06	2' 06	1' 88	3' 94	5' 41
1938	..	..	8' 59	6' 71	11' 56	<u>15' 60</u>	<u>20' 44</u>	12' 49	5' 85	2' 74	1' 20	0' 70	3' 08	11' 04
1939	..	..	7' 10	7' 41	10' 57	14' 64	<u>20' 15</u>	<u>15' 33</u>	6' 93	3' 73	1' 50	1' 31	1' 75	9' 58
1940	..	..	8' 30	8' 60	7' 87	13' 56	<u>19' 51</u>	<u>16' 60</u>	10' 24	4' 65	2' 31	1' 02	2' 07	5' 2

Years	Months		January	February	March	April	May	June	July	August	September	October	November	December
	1941	6' 91	6' 23	10' 66	<u>20' 31</u>	<u>18' 95</u>	13' 50	9' 35	5' 49	2' 84	1' 15	1' 72	2' 80
1942	10' 63	10' 00	9' 51	14' 31	<u>19' 19</u>	<u>17' 19</u>	6' 90	3' 48	2' 30	1' 67	1' 25	3' 48
1943	5' 04	4' 74	9' 36	<u>15' 17</u>	<u>17' 44</u>	14' 74	11' 17	6' 33	3' 04	2' 09	2' 38	8' 50
1944	8' 35	9' 86	12' 00	11' 79	<u>14' 35</u>	<u>13' 89</u>	10' 64	4' 94	2' 47	1' 14	2' 55	8' 02
1945	5' 02	5' 68	11' 05	17' 51	<u>22' 18</u>	<u>17' 68</u>	11' 23	4' 60	2' 07	0' 93	0' 63	1' 42

5. **Plague**—In table V is presented the percentage monthly mortality from plague for the Provinces. The two months in a year with the highest percentage mortality in order have again been italicised. It would appear from the table that mortality from plague is generally high during the three months—February, March and April, mortality being most pronounced during the month of March in almost all the years. It would appear from seasonal indices presented in graph V that mortality from plague is generally pronounced during the first four months of the year, the seasonal indices during these months being above the normal, viz., 100. The highest index of 349 which is more than thrice the normal is attained during the month of March which seems to confirm the conclusion arrived at previously from a study of the mortality percentages during each year as presented in Table V.

TABLE V—Monthly deaths from plague in U.P. expressed as percentage of total deaths from plague during the year for the years 1906—45

Years	Months		January	February	March	April	May	June	July	August	September	October	November	December
	1906	6.30	13.12	<u>23.96</u>	<u>23.88</u>	6.24	0.30	0.21	0.09	1.27	2.24	5.80	15.69
1907	6.45	11.15	<u>26.53</u>	<u>33.34</u>	18.83	2.24	0.11	0.09	0.19	0.21	0.26	0.60
1908	11.09	<u>22.50</u>	<u>34.52</u>	22.04	3.96	0.39	0.24	0.17	0.41	0.35	0.01	2.52
1900	3.48	5.52	11.42	7.03	6.13	0.79	1.65	4.56	4.39	4.67	<u>13.29</u>	<u>37.07</u>
1910	17.16	<u>20.97</u>	<u>27.00</u>	13.65	3.68	0.24	0.13	2.57	0.40	0.90	4.41	10.89
1911	13.91	15.62	<u>31.20</u>	<u>26.71</u>	7.90	0.29	0.09	0.03	0.08	0.39	1.13	2.65
1912	15.53	25.21	<u>30.37</u>	<u>17.72</u>	3.38	0.32	0.05	0.17	0.44	0.70	1.81	4.80
1913	7.39	<u>12.97</u>	<u>28.97</u>	<u>27.12</u>	5.19	1.44	1.33	1.17	0.71	0.98	3.32	9.41
1914	16.08	<u>20.79</u>	<u>32.52</u>	19.05	5.55	0.60	0.05	0.11	0.16	0.27	1.25	3.57
1915	8.41	16.49	<u>30.56</u>	<u>28.57</u>	6.45	0.23	0.05	0.11	0.33	0.58	1.92	6.30
1916	13.46	18.18	<u>31.40</u>	11.50	1.98	0.11	0.21	0.77	0.74	1.08	8.97	11.60
1917	8.69	<u>16.46</u>	<u>23.64</u>	<u>17.33</u>	6.62	1.50	0.52	1.01	0.72	1.49	5.04	16.98
1918	23.21	<u>26.06</u>	<u>27.92</u>	16.72	4.57	0.46	0.31	0.05	0.05	0.10	0.25	0.30
1919	6.26	19.68	<u>36.48</u>	<u>23.18</u>	4.92	0.46	0.08	0.43	0.37	0.28	1.62	6.24

1920	..	..	11.23	18.01	<u>31.31</u>	<u>22.79</u>	4.22	0.63	0.10	0.78	1.02	0.00	1.80	7.21
1921	..	..	15.54	<u>21.96</u>	<u>39.47</u>	14.77	1.60	0.10	0.02	0.10	0.23	0.26	1.46	4.49
1922	..	..	11.03	19.87	<u>27.10</u>	10.86	2.19	0.48	0.24	0.64	0.56	0.85	4.81	<u>21.37</u>
1923	..	..	13.47	<u>23.00</u>	<u>35.29</u>	18.64	3.17	0.48	0.05	0.13	0.23	0.72	1.44	3.38
1924	..	..	8.78	16.29	<u>26.17</u>	<u>25.78</u>	0.96	2.02	0.40	0.13	0.36	1.02	2.52	6.57
1925	..	..	13.57	18.12	<u>29.97</u>	<u>22.81</u>	6.58	0.68	0.29	0.56	0.35	0.52	1.60	4.95
1926	..	..	8.99	16.16	<u>26.20</u>	<u>25.82</u>	15.45	2.91	0.54	0.22	0.12	0.36	1.01	2.22
1927	..	..	12.02	17.19	<u>26.09</u>	<u>18.39</u>	5.48	0.58	0.23	0.19	0.61	0.82	3.87	14.53
1928	..	..	6.69	15.93	<u>32.19</u>	<u>30.04</u>	9.10	0.83	0.29	0.38	0.12	0.17	0.94	3.32
1929	..	..	15.07	<u>27.12</u>	<u>34.63</u>	17.30	3.33	0.27	0.08	0.05	0.09	0.12	0.66	1.38
1930	..	..	8.79	14.26	<u>27.43</u>	<u>24.30</u>	8.37	1.10	0.23	0.45	0.30	0.94	3.55	10.28
1931	..	..	8.74	12.93	<u>34.24</u>	<u>32.64</u>	7.94	1.53	0.25	0.18	0.12	0.13	0.13	1.17
1932	..	..	14.53	<u>24.01</u>	<u>30.50</u>	20.53	6.63	1.31	0.18	0.05	0.09	0.21	0.59	1.37
1933	..	..	5.60	11.65	<u>17.70</u>	16.75	12.29	2.17	0.46	0.60	0.56	1.79	6.16	<u>24.27</u>
1934	..	..	13.15	19.00	<u>29.54</u>	<u>26.04</u>	7.24	1.03	0.13	0.33	0.28	0.42	0.96	2.88
1935	..	..	9.25	14.86	<u>23.26</u>	<u>27.92</u>	16.69	3.21	0.43	0.23	0.38	0.58	1.15	2.04
1936	..	..	8.06	12.57	<u>21.21</u>	18.86	6.21	1.89	0.66	1.21	1.89	1.82	6.18	<u>19.44</u>
1937	..	..	8.98	14.48	<u>29.71</u>	<u>28.12</u>	10.40	1.49	0.57	0.67	0.62	0.42	1.46	2.80
1938	..	..	15.03	14.16	<u>25.45</u>	<u>24.03</u>	6.30	1.03	1.06	1.91	1.29	0.87	1.94	6.93
1939	..	..	9.40	16.78	<u>32.72</u>	<u>24.53</u>	7.36	1.00	0.16	0.54	0.84	1.02	1.40	4.25
1940	..	..	14.35	18.23	<u>29.37</u>	<u>24.30</u>	8.24	2.38	0.56	0.08	0.14	0.25	0.56	1.51

Years	Months		January	February	March	April	May	June	July	August	September	October	November	December
	1941	12·37	19·83	31·94	17·03	3·20	1·02	0·72	0·64	0·57	0·99	2·50	9·19
1942	8·86	15·87	31·36	25·98	9·77	1·13	2·11	0·01	0·23	0·47	0·99	3·22
1943	11·43	10·41	27·15	22·95	9·97	2·37	1·06	0·94	1·06	0·98	1·40	3·65
1944	4·28	8·43	24·19	30·79	15·70	2·19	0·84	0·37	0·62	1·09	3·70	7·71
1945	13·21	10·72	29·74	21·93	8·67	2·22	0·97	0·27	0·26	0·46	1·31	4·24

6. The seasonal indices for three diseases are assembled in table VI. It is clear that our seasonal indices, being based on the mortality data for the Province as a whole, have their own practical limitations in that they would give roughly, on a broad basis, an idea of the seasonal distribution for the province as a whole. As it is known that such seasonal distributions differ from district to district it may be useful if detailed study be made by calculating on exactly similar lines seasonal indices separately for each district, at least for the districts of high mortality.

TABLE VI—*Adjusted values of seasonal indices of mortality (normal =100) from cholera, smallpox and plague for the United Provinces based on data over the period 1906—45*

Month	Disease		
	Cholera	Smallpox	Plague
January	10	78	134
February	8	85	210
March	20	127	349
April	100	190	264
May	141	216	90
June	174	102	14
July	151	118	5
August	176	53	0
September	169	25	7
October	140	16	9
November	81	26	29
December	30	71	83

(d) Zones of High, Normal and Low Mortality

Before we proceed to classify the districts of the Province into the three main zones of high, normal and low mortality in respect of each of the diseases the statistical technique utilized in this connection may be briefly explained as under.

2. The mean mortality rates for each of the districts in respect of a disease have been first worked out by dividing the sum total of the mortality rates (deaths per thousand of population) for the districts over the 40 years 1906—45 under examination by 40. We next proceed to measure the variation in mortality from year to year over the 40 years for a district by subtracting from the sum of the squares of the mortality rates for the 40 years for the district the square of the sum total of the mortality over the period divided by the number of years

which in this case is 40. The figure so obtained is next divided by the number of years minus one (in this case 39) and the square root of the figures thus obtained known in statistical language as Standard deviation represents our index of variation for each district in respect of a disease. We next obtain a normal range of the mean mortality rates for each of the districts in respect of a disease (see appendix) based on the mortality rates over the 40 years for all the districts such that a district with its mean mortality less than the upper limit and higher than the lower limit of the range may for all practical purposes be called a district of normal mean mortality. A district with a mean mortality higher than the upper limit of the range may be called a district of high mean mortality : conversely a district with mean mortality lower than the lower limit of the range may be termed a district of low mean mortality. Border districts with mean mortality rates equal to the upper or lower limit of the range of normal mortality may for all practical purposes be called districts of normal mean mortality. This has been illustrated in respect of each of the diseases by means of dot-diagrams.

3. In the dot-diagram the mean mortality rates for the districts in respect of each of the diseases, are represented by blue dots and measured along the vertical scale (y -axis) the districts being represented horizontally on the x -axis. The blue horizontal lines enclose a space of normal mean mortality for the districts for a disease, such that a district with its corresponding blue dot falling within the enclosed space represents a district of normal mean mortality. The blue dots lying outside the boundary lines and above the upper line represent districts with high mean mortality and those lying below the lower boundary line represent districts of low mean mortality. Districts for which the corresponding blue dots lie on the border of the boundary lines may be called border districts and as said above have been included amongst districts of normal mean mortality.

4. The procedure for classifying the districts in respect of standard deviation is exactly similar to that adopted for mean mortality. A range has likewise been obtained in respect of a district for standard deviation (method explained in appendix) which may be considered as normal range of variation for all the districts for the disease. On similar reasoning a district with a standard deviation higher than the upper value of the range may be called a district of high variation, a district with standard deviation lower than the upper value of the range and higher than the lower value of the range may be called a district of normal variation and finally a district with a standard deviation lower than the lower limit of the range may be called on the whole a district of low variation. This has similarly been represented graphically by red dots in the dot-diagram for mean mortality and also separately in respect of each of the diseases. Here again standard deviations for the districts are shown by red dots and measured on the same vertical scale. The red horizontal lines likewise enclosed

a space of normal variation. A district for which the corresponding red dot lies within the space enclosed by the red lines represents a district of normal variation. If, however, the red dot lies outside and above the upper horizontal red line the corresponding district will be one of high variation and conversely a district with its red dot lying below the lower value of the range, i.e. below the lower line represents a district of low variation.

5. We thus have finally from statistical considerations the following main divisions of districts of mean mortality;

- (1) high mortality districts ;
- (2) average mortality districts ;
- (3) low mortality districts ;

with the following classifications of districts in respect of variation within each such main division of districts ;

- (1) high variation districts ;
- (2) normal variation districts ;
- (3) low variation districts ;

with ultimately nine combination of divisions of districts.

6. We next study in respect of each of the diseases special features, if any, of the districts lying within each such group from a consideration of the number of the years of high and low mortality over the period (data available in the annual reports of the department of Public Health, United Provinces). Remembering that an epidemic area is characterised by occasional and distinct sudden peaks the infection being probably brought in from outside we should generally expect a district with high mean mortality (sometimes normal mean mortality) and high variation an epidemic district. If, however, in a district with high mean mortality the variation be low it would generally follow that high mortality was more or less a regular feature in the district leading to low variation from year to year. Such a district where annual mortality generally remains high may be termed epidemic the disease being more or less localised.

7. **Cholera**—In dot-diagram 1 is presented the mean mortality by blue dots, in dot-diagram 2 the standard deviation by red dots and in dot-diagram 3 both the mean mortality and standard deviation by blue and red dots respectively for each district of the Province. It would appear from dot-diagram I and from what explained above that the following are the districts of high average and low mean mortality :

(i) *High mean mortality districts*—Pilibhit, Hamirpur, Banda, Mirzapur, Jaunpur, Ghazipur, Ballia, Gorakhpur, Basti, Azamgarh, Garhwal, Sitapur, Kheri, Faizabad, Gonda, Bahraich, Sultanpur, Pratapgarh :

(ii) *Average or normal-mean mortality districts*.—Barcilly, Shahjahanpur, Allahabad, Jhansi, Jalaun, Banaras, Naini Tal, Almora, Lucknow, Rae Bareli, Hardoi and Bara Banki.

(iii) *Low-mean mortality districts*.—Dehra Dun, Saharanpur, Muzaffarnagar, Meerut, Bulandshahr, Aligarh, Mathura, Agra, Mainpuri, Etah, Bijnor, Budaun, Moradabad, Etawah, Farrukhabad, Kanpur, Fatehpur and Unnac.

8. We now proceed to sub-divide the districts within each group into districts of high, normal and low variation with the help of dot-diagrams 2 and 3 and on the basis of the method explained above—

(i) *High mean mortality districts* :—

(a) Districts of high variation:—Pilibhit, Banda, Jaunpur, Garhwal, Sitapur, Kheri, Gonda, Bahraich, Sultanpur, and Pratapgarh.

(b) Districts of normal variation:—Hamirpur, Mirzapur, Ghazipur, Ballia, Gorakhpur, Basti, Azamgarh and Faizabad.

(c) Districts of low variation.—Nil.

(ii) *Average or normal mean mortality districts* :

(a) Districts of high variation—Jhansi, Almora and Bara Banki.

(b) Districts of normal variation—Bareilly, Shahjahanpur, Jalaun, Naini Tal and Rae Bareli.

(c) Districts of low variation :—Allahabad, Benares, Lucknow and Hardoi.

(iii) *Low-mean mortality districts* :—

(a) Districts of high variation :—Unnao.

(b) Districts of normal variation :—Budaun.

(c) Districts of low variation :—Dehra Dun, Saharanpur, Muzaffarnagar, Meerut, Bulandshahr, Aligarh, Mathura, Agra, Mainpuri, Etah, Bijnor, Moradabad, Farrukhabad, Etawah, Kanpur and Fatehpur.

9. It would be seen that on the statistical basis, of mean mortality and standard deviation, the districts Pilibhit, Banda, Jaunpur, Garhwal, Sitapur, Kheri, Gonda, Bahraich, Sultanpur and Pratapgarh with high mean mortality and high variation may be called epidemic districts as defined above, there being technically no epidemic districts (i.e. districts with high mean mortality and low variation) from cholera in the Province. We next proceed to study special features, if any, during any year from an examination of the distribution of annual mortality rates (over the period 1906—45) of high and low mortality for the districts within each sub-group arrived at above from statistical considerations.

10. In the Pilibhit district mortality was high (being above normal) during eight years and normal during four years, the years of high mortality being more frequent during the beginning of the period 1906—45. The remaining 28 years of the period witnessed low and sometimes no mortality. Of the 8 years of high mortality the six years were 1906, 1908, 1911, 1915, 1921 and 1929 which were

also epidemic years for the province as a whole. Banda witnessed 13 years of high mortality and 4 years of normal mortality. The years of pronounced mortality were 1906, 1910, 1924 and 1938. In the Jaunpur district there were 9 years of high mortality and 8 years of normal mortality, the year in which mortality was last high being 1945. In both the districts of Garhwal and Sitapur there were 10 years of high mortality there being 7 and 4 years of normal mortality respectively. In the district of Garhwal mortality was last high during 1927 there being a noticeable decline thereafter and from this view point although the district on the whole behaved as a district of high mortality the low mortality rates since 1928 seem to indicate the behaviour of the district as a normal area during recent years. Kheri had 11 years of high mortality the years being more or less uniformly spaced over the period. The eastern districts of Bahraich and Sultanpur witnessed each 15 years of high mortality and 4 years of normal mortality, mortality being most pronounced during the first half of the period. Gonda and Pratapgarh had respectively 17 and 16 years of high mortality there being only one year of normal mortality at Gonda and 3 years of normal mortality at Pratapgarh. In as much as epidemic years are characterised by occasional and district peaks the eastern districts of Gonda, Bahraich, Sultanpur and Pratapgarh behaved as epidemic districts.

11. Coming to the districts of high mortality with normal variation we notice that of the eight districts in this group high mortality is more frequent in the districts of Mirzapur, Ballia, Gorakhpur, Basti and Faizabad, mortality in the Mirzapur district being high during 16 years and normal during 8 years. There were 17 years of high mortality and 6 years of normal mortality in Ballia district : in Basti mortality was high during 19 years and normal during two years. Gorakhpur district, however, witnessed 20 years of high mortality and 5 years of normal mortality. In Faizabad district, mortality was high during 16 years and normal during 5 years. It would thus be seen that all the four districts Ballia, Gorakhpur, Basti and Faizabad are conspicuous by years of high mortality, the districts of Gorakhpur, Ballia and Basti behaving as acute epidemic districts. The districts of Mirzapur and Faizabad resemble the districts of Gorakhpur, Ballia, and Basti in as much as mortality in these districts remained above normal for a large number of years. Hamirpur and Ghazipur witnessed each 12 and 11 years of high mortality respectively, mortality remaining normal in these districts for 6 and 12 years respectively.

12. Amongst the districts of average mortality with high variation the number of years of high mortality is maximum in the Bara Banki district being 12 years and considering the distribution of the annual mortality rates it can be classed as an epidemic district. Although average mortality in Almora is normal, examination of the individual rate of mortality reveal that mortality in this district remained sub-normal after 1927 except during 1938 when it became high. Jhansi witnessed 8 years of high mortality and 5 years of normal mortality.

13. Consider now the average mortality districts with normal variation. Rae Bareli witnessed 14 years of high mortality and 5 years of normal mortality. In the districts of Jalaun and Naini Tal there were 7 years of high mortality, the latter district showing a definite decline after 1921 the year 1938 being the only exception of high mortality thereafter. There is nothing special to report about other districts in the group.

14. Amongst the average mortality districts with low variation, Banaras witnessed 14 years of high mortality, the mortality years being more or less uniformly distributed over the period and in this respect seemed to behave as an epidemic district. Allahabad witnessed 10 years of high mortality and 7 years of normal mortality. Although Lucknow has been classed as an average mortality district, mortality in the district showed a definite decline after 1918 the year 1939 being the only year of high mortality after that date. Hardoi witnessed 6 years of high mortality and 7 years of normal mortality.

15. Coming finally to the low mortality districts, Unnao witnessed 5 years of high mortality, the last year of high mortality being 1924. There were only 3 years of high mortality in Budaun district, mortality in this district being last high during the epidemic year 1921. In the western districts of Saharanpur, Meerut, Mathura, Agra and Etah there was not a single year of high mortality, and only one year of normal mortality in the first 3 districts. The districts of Muzaffarnagar, Mainpuri and Farrukhabad witnessed each a year of high mortality there being only one year of normal mortality in the Muzaffarnagar district, no year of normal mortality in the Mainpuri district, and 4 years of normal mortality in the Farrukhabad district. There were only 2 years of high mortality in the districts of Dehra Dun, Bulandshahr, Aligarh and Etawah. Bijnor, Moradabad and Fatehpur each witnessed 5 years of high mortality. Mortality rates in the Bijnor and Moradabad districts were last high during the epidemic year 1921, there being no year of high mortality thereafter. Mortality was last high at Fatehpur during 1942. There were only 3 years of high mortality at Kanpur, mortality being last high during 1919.

16. **Small-pox.**—The mean mortality and the standard deviation for each district have been presented separately in dot-diagrams 4 and 5 respectively and in dot-diagram 6 both the mean mortality and standard deviations have been presented together. Here again the blue dots represents mean mortality rates and red dots standard deviations for the districts. We now classify as under the districts of high, normal and low mean mortality as would appear from the dot-diagram 4:

(i) *High mean mortality districts.*—Bijnor, Budaun, Moradabad, Allahabad, Mirzapur, Jaunpur, Ghazipur, Gorakhpur, Azamgarh, Rae Bareli, Sultanpur, and Pratapgarh.

(ii) *Average or normal mean mortality districts.*—Saharanpur, Meerut, Bulandshahr, Aligarh, Mathura, Agra, Mainpuri, Etah,

Bareilly, Pilibhit, Farrukhabad, Etawah, Kanpur, Jhansi, Jalaun, Banaras, Ballia, Basti, Almora, Lucknow, Hardoi, Faizabad and Gonda.

(iii) *Low-mean mortality districts*.—Dehra Dun, Muzaffarnagar, Shahjahanpur, Fatehpur, Hamirpur, Banda, Naini Tal, Garhwal, Unnao, Sitapur, Kheri, Bahraich, and Bara Banki.

17. We next proceed to sub-divide the districts within each group into districts of high, normal and low variation with the help of dot-diagrams 5 and 6 and on lines similar to that followed in case of cholera:

(i) *High mean mortality districts* :

(a) Districts of high variation.—Bijnor, Moradabad, Allahabad Ghazipur, Gorakhpur, Azamgarh, Rae Bareilly, Sultanpur and Pratapgarh.

(b) Districts of normal variation—Budaun, Mirzapur, and Jaunpur.

(c) Districts of low variation.—Nil.

(ii) *Average mortality districts* :

(a) Districts of high variation—Hardoi and Gonda.

(b) Districts of normal variation—Pilibhit, Jhansi, Jalaun, Basti, and Faizabad.

(c) Districts of low variation—Saharanpur, Meerut Bulandshahr, Aligarh, Mathura, Agra, Mainpuri, Etah, Bareilly, Farrukhabad, Etawah, Kanpur, Banaras, Ballia, Almora and Lucknow.

(iii) *Low mortality districts* :

(a) Districts of high variation—Nil.

(b) Districts of normal variation—Nil.

(c) Districts of low variation—Dehra Dun, Muzaffarnagar, Shahjahanpur, Fatehpur, Hamirpur, Banda, Naini Tal, Garhwal, Unnao, Sitapur, Kheri, Bahraich and Bara Banki.

18. We now study for the districts within each group the frequency of the years of high and low mortality during the period under examination besides mean mortality and variation in deciding a district of high mortality.

19. Of the high mortality districts with high variation the number of years of high mortality is maximum in the Ghazipur district, there being 22 years of high mortality and 8 years of normal mortality. In as much as high mortality was almost a regular feature every year during the latter half of the period under examination, Ghazipur behaved as an acute endemic district during this period. Azamgarh ranks second, there being 20 years of high mortality and 7 years of normal mortality, the high mortality years being mostly concentrated towards the end of the period. There were 12 years of high mortality and 5 years of normal mortality in each of the district of Bijnor and Moradabad, the years of high mortality being more or or less uniformly distributed over the period.

20. In the Gorakhpur district there were 12 years of high mortality and 10 years of normal mortality, the years of high mortality being more concentrated towards the latter half of the period. In the Allahabad district mortality is almost uniformly spaced over the period, there being 9 years of high mortality and 15 years of normal mortality. In the Rae Bareli and Sultanpur districts, mortality was most pronounced during the 3 years 1906—08 of the period under examination, mortality during 1908 being as high as 3 and 5 per thousand of population respectively, the year 1908 being the most acute epidemic year for the province as a whole. Although mean mortality rates in these districts are high, it would be seen that except for the first 3 years of the period under examination which has considerably pushed up the general average, the remaining years are practically conspicuous by the absence of mortality in the Rae Bareli district and by normal mortality in the Sultanpur district. It would be seen from the dot-diagram that the Pratapgarh district has a high mean mortality and a very high variation. A study of the individual figures reveal that there are only 4 years of high mortality and 7 years of normal mortality in the district and that mortality was most pronounced during the years 1907 and 1908 respectively, mortality rate during the latter year reaching as high as 5.79 per thousand, which was the highest rate attained amongst the districts of the Province. Except, therefore, for the years of high mortality in the beginning of the period, the district of Pratapgarh behaved as a low mortality district.

21. Amongst the districts of high mortality with normal variation, there are 12 years of high mortality and 7 years of normal mortality in the Budaun district. In the Mirzapur and Jaunpur districts of the Banaras division, there are 11 and 12 years of high mortality, 9 and 14 years of average mortality respectively. The individual figures further reveal that the years of high mortality are mostly concentrated in the latter part of the period under examination.

22. Amongst the average mortality districts, the eastern districts of Hardoi and Gonda have high variation as would appear from dot-diagram 4, there being 6 and 4 years of high mortality respectively in these districts. The years of high mortality in the districts also include the 3 epidemic years 1906—08. It would thus be seen that excluding the high epidemic years in the beginning of the period under examination the districts during the remaining period behaved as low mortality districts.

23. It would further appear from dot-diagram 4 that amongst the average mortality districts the districts of Pilibhit, Jhansi, Jalaun, Basti and Faizabad lie within the normal range of variation. Of these the Jhansi and Faizabad districts have 11 and 12 years of high mortality and 4 and 5 years respectively of normal mortality. In as much as the years of high mortality are almost uniformly distributed over the period, the districts of Jhansi and Faizabad behave as epidemic districts although mean mortality rates in these district are normal.

24. There were 6 years of high mortality in the Pilibhit district and 4 years of high mortality in the Jalaun district, the districts behaving more or less as pandemic areas, the years of high mortality being widely spaced over the period under study. In the case of the Pilibhit district, the years of significantly high mortality coincided with the epidemic years for the Province, viz., 1908, 1930 and 1945 and those for the Jalaun district the years of high mortality were 1906, 1930 and 1945.

25. Of the 9 years of high mortality in the Basti district two years coincided with the epidemic years 1907 and 1908 for the Province, the remaining years of high mortality being mostly concentrated in the last decade 1936—45.

26. Amongst the average mortality districts with low variation, years of high mortality are more frequent in the Banaras and Ballia districts, there being 14 years of high mortality in these districts. There were 5 years of high mortality and 8 years of normal mortality in the Saharanpur district. An examination of the annual mortality rates reveals that the years of high mortality are mostly concentrated in the latter half of the period under examination. In the Aligarh and Lucknow districts there were 11 years of high mortality and 6 years of normal mortality. Farrukhabad and Etawah districts each had 8 years of high mortality, the years 1926, 1930, 1935 and 1945 being high mortality years for both the districts. The districts of Meerut and Bulandshahr witnessed each 8 years of high mortality, the years 1925, 1929, 1930, 1935, 1939 and 1944 being years of high mortality districts, there being no high mortality years prior to 1925. It would appear from above that there is a cyclical tendency of high mortality with a cycle of 4 or 5 years in these districts and working on this basis the future occurrence of high mortality may be during 1948 or 1949. Agra witnessed 10 years of high mortality. Mainpuri and Etah each 7 years of high mortality. There were 5 years of high mortality and 8 years of normal mortality in the Bareilly district. In the Mathura and Kanpur districts there were 4 years of high mortality. There were 6 years of high mortality and 4 years of normal mortality in the Almora district.

27. Amongst the low mortality districts with low variation mortality at Garhwal was throughout low, there being not a single year of high mortality in the district. Mortality at Unnao was high only during 1914, and low during remaining period. Sitapur witnessed high mortality during 1940, normal mortality during 5 years, the remaining period being years of low mortality. There were two years of high mortality in the Bahraich district and 9 years of average mortality. Dehra Dun, Hamirpur, Banda and Bara Bank witnessed each 3 years of high mortality. In the Bara Banki district, the years 1908, 1914 and 1945 were years of high mortality, and the years 1906 and 1907 were years of normal mortality, the remaining period being characterised by low mortality. There were 4 years of high mortality each in the Muzaffarnagar and Kheri districts. Although Naini Tal had 6

years of high mortality, mortality during the remaining period was consistently low there being only 2 years of average mortality. Shah-jahanpur and Fatehpur witnessed each 5 years of high mortality the remaining period being conspicuous by low mortality.

28. **Plague.**—As usual the mean mortality rates for the districts have been shown by blue dots in dot-diagram 7, the standard deviation by red dots in dot-diagram 8 and in dot-diagram 9 both these have been presented together. The districts of high, normal and low mortality as obtained from dot-diagram 7 are classified as under;

(i) *High mortality districts.*—Saharanpur, Muzaffarnagar, Meerut, Jaunpur, Ghazipur, Ballia, Azamgarh and Unnao.

(ii) *Normal mortality districts.*—Bulandshahr, Aligarh, Mathura, Agra, Mainpuri, Etah, Bareilly, Bijnor, Budaun, Moradabad, Pilibhit, Farrukhabad, Etawah, Kanpur, Fatehpur, Allahabad, Banaras, Mirzapur, Gorakhpur, Basti, Lucknow, Rae Bareli, Sitapur, Hardoi, Faizabad, Sultanpur and Bara Banki.

(iii) *Low mortality districts.*—Dehra Dun, Shahjahanpur, Jhansi, Jalaun, Mainpuri, Banda, Naini Tal, Almora, Garhwal, Kheri, Gonda, Bahraich and Pratapgarh.

29. The districts within each group are now further divided into districts of high, normal and low variation, with the help of dot-diagrams 8 and 9, the division being exactly on the lines discussed under cholera and small-pox :

(i) *High mortality districts :*

(a) Districts of high variation.—Saharanpur, Muzaffarnagar Meerut, Ghazipur, Ballia and Azamgarh.

(b) Districts of normal variation—Jaunpur, Unnao.

(c) Districts of low variation—Nil.

(ii) *Normal mortality districts :*

(a) Districts of high variation—Nil.

(b) Districts of normal variation—Bulandshahr, Mathura, Bijnor, Budaun, Moradabad, Kanpur, Lucknow and Bara Banki.

(c) Districts of low variation—Aligarh, Agra, Mainpuri, Etah, Bareilly, Farrukhabad, Etawah, Fatehpur, Allahabad, Banaras, Mirzapur, Gorakhpur, Basti, Rae Bareli, Sitapur, Hardoi, Faizabad and Sultanpur.

(iii) *Low mortality districts :*

(a) Districts of high variation—Nil.

(b) Districts of normal variation—Nil.

(c) Districts of low variation—Dehra Dun, Shahjahanpur, Jhansi, Jalaun, Hamirpur, Banda, Naini Tal, Almora, Garhwal, Kheri, Gonda, Bahraich and Pratapgarh.

30. We now proceed to study details about the districts within each group. In the high mortality districts with high variation Ghazipur and Ballia witnessed each 23 years of high mortality, there being 25 years of high mortality in the district of Azamgarh. A study of the individual years of mortality would further show that during the period 1906—31, the districts of Ghazipur, Ballia and Azamgarh behaved as endemic areas in as much as high mortality was a regular feature in these districts during the period. Mortality thereafter declined and became less frequent. There were 10 years of high mortality and 13 years of normal mortality in the Saharanpur District, 13 years of high mortality and 8 years of normal mortality in the Muzaffarnagar District. Although mean mortality in the district of Meerut was high, there were only 10 years of high mortality, being last high during 1926.

31. Amongst the high mortality districts of normal variation there were 16 years of high mortality in the Jaunpur District and 15 years of high mortality in the Unnao District. It is interesting to note that mortality in Unnao was last high during 1926 and there was practically no mortality after 1929. Although mean mortality in Unnao District was high, the general situation is satisfactory in as much there was practically no mortality after 1929.

32. In the average mortality districts of normal variation, mortality was last high at Bulandshahr and Mathura during 1926, the period 1906—26 being mostly years of high mortality. In the districts of Bijnor, Budaun and Moradabad, the last epidemic occurred during 1934 followed by practically the absence of mortality thereafter. In the district of Kanpur there were 10 years of high mortality, 9 years of normal mortality, mortality being last high during 1924, followed by a steep decline in mortality. Amongst the normal mortality districts of Lucknow and Bara Banki, there were 8 and 10 years of high mortality respectively in these districts, mortality being last high in the Lucknow District during 1918 and in the Bara Banki District during 1928.

33. Coming to normal mortality districts of low variation we notice that there were 5 years of high mortality in the Aligarh District, the last epidemic worthy of record being during 1925. Except for another 5 years during which mortality remained normal, mortality during the remaining period remained below normal and mostly negligible. In the Agra District there were 4 years of high mortality, the year 1926 being last year of occurrence of the epidemic. During the rest of the period mortality was mostly negligible and in this respect the district behaved as a low mortality district although mean mortality over the period under examination remained normal. In the Mainpuri District, mortality remained high during the year 1910, 1911 and 1918. Except for another 6 years during which mortality remained normal, mortality during the rest of the period was almost negligible. In district Etah, mortality during 4 years crossed the upper boundary of the normal range for mortality, the year 1934 being the last epidemic year for the district. During another 6 years

mortality remained normal, mortality during the rest of the period remaining below normal, although, on the whole, the district behaved as a normal district. In the Bareilly and Filibhit Districts there were only 3 years of high mortality, mortality being mostly negligible after 1928, which was the last year of high mortality for the district. In the Farrukhabad, Etawah and Allahabad Districts, the last epidemic year was 1918, there being practically no mortality thereafter. There were 6 years of high mortality in the Farrukhabad and Fatehpur Districts and 5 and 7 years of high mortality respectively in the districts of Etawah and Allahabad. Banaras witnessed 6 years of high mortality and 16 years of normal mortality. There were only 4 years of high mortality in the Mirzapur District, mortality being last high during 1918. The eastern districts of Gorakhpur and Basti witnessed each 14 and 10 years of high mortality, mortality during the remaining period being mostly normal. In as much as these are districts of normal mean mortality with occasional sudden peaks of high mortality, the districts of Gorakhpur and Basti may be regarded as important epidemic areas. In the eastern districts of Rae Bareilly, Sitapur, Hardoi and Sultanpur mortality was last high during the epidemic year of 1918. There were 7 years of high mortality at Rae Bareilly and 6 years of high mortality at Hardoi. There were only 3 and 4 years of high mortality in the Sitapur and Sultanpur Districts but on the whole the districts behaved as areas of normal mortality.

34. Amongst the low mortality districts, mortality at Almorah and Garhwal remained consistently below normal throughout the period under examination, there being practically no mortality in these districts, except for a few years of low mortality. Mortality at Hamirpur was normal only during 1924, there being practically no mortality during the rest of the period. Banda resembled Hamirpur, the only year of pronounced mortality in the district being 1923. At Dehra Dun, the years 1911 and 1912 were years of normal mortality, the remaining years being almost free from mortality. There is nothing special to report about other districts in this group.

CONCLUSION

Attempt has been made in this chapter to summarise in brief the salient points discussed in the foregoing chapters and suggest wherever practicable means for fighting the diseases in the epidemic districts.

2. It may be mentioned here that nothing has been said in the foregoing pages regarding cyclical tendencies in these diseases, as investigation has shown that there was no such marked cyclical tendency for the province during the period under investigation in respect of the diseases. It has already been seen in the case of plague that during recent years, there was practically no mortality in the province except in the districts of the Banaras and Gorakhpur Divisions. This has evidently disturbed the cyclical tendency of mortality pattern in the province. It may, however, be useful to study the cyclical behaviour in respect of the districts of high mortality in the Gorakhpur and Banaras Divisions.

3. Although no marked cyclical tendency is visible in the case of small-pox, it has been roughly estimated from a study of the peaks of annual mortality that there is an average five-yearly periodicity in the provincial mortality rates, the last epidemic year being 1945. Working on this basis it may be fore casted that the year 1950 may in all probability be an epidemic year for the province. A somewhat detailed study revealed that the years 1950-51 are the probable years of future epidemic for the Province.

4. As regards cholera there was uniformly a 3-year epidemic cycle till 1930 and thereafter the pattern seems to have changed. The years 1930, 1938 and 1945 were high epidemic years for the province. Although the three years of high epidemic are not sufficient to forecast the advent of an epidemic, it may be roughly said within the limitations of the data that the future epidemic is likely to occur during the period 1952-53. We now proceed to deal with the diseases separately.

5. **Cholera**—It would be seen from the foregoing chapter that mortality from cholera for the Province showed a real decline with years, mortality being generally acute during the first 20 years of the period 1906—45. The decline in provincial mortality appears to be due to the drive of the Public Health Department during recent years for improved sanitation and better medical facilities in the districts of the Province. The disease took a heavy toll of life in the Province during the two years 1906 and 1921 when the provincial mortality rates reached as high a figure as 3.14 and 3.30 per thousand of population respectively. The epidemic wave during these years touched even the districts of Bijnor, Moradabad and Shahjahanpur which remained practically immune from mortality during the rest of the period. The western districts of Dehra Dun, Saharanpur, Muzaffarnagar, Meerut, Bulandshahr, Aligarh, Mathura,

Agra, Mainpuri and Etah behaved as low mortality districts and from this point of view, these districts may be regarded as safe areas.

6. It would appear from the results of the analysis that mortality from cholera is frequent and most pronounced in the eastern districts of Gorakhpur, Basti, Faizabad, Gonda, Bahraich, Sul'ampur and Pratapgarh, the centrally situated districts of the Province behaving more or less as normal mortality districts. To sum up, the western districts are areas of low mortality, the centrally situated districts are areas of normal mortality, and the eastern and the far eastern districts are areas of high mortality.

7. It appears from what has been discussed in the foregoing pages that the districts of Mirzapur, Ballia, Gorakhpur, Basti and Faizabad behave more or less as acute epidemic centres in as much as these are districts of high mean mortality and normal variation. The district of Gonda with high mean mortality and high variation behaved as an acute epidemic district and the annual mortality rates for the district revealed that in a majority of the years, mortality was highly pronounced in the district. It would be seen that the districts of high mortality are generally economically backward and suffer mostly from poor sanitation. It is suggested that measures to combat the disease should be permanently enforced in these acute epidemic areas of the Province, measures including provision for protected water supply, suitable disposal of nightsoil, rubbish and proper control over food and drink on the lines recommended by the Bhor Committee. Immunisation of the people by anti-cholera inoculation for controlling the spread of the disease during specific outbreaks should, of course, be a temporary measure in the direction.

8. It would appear from dot-diagram 1 that Faizabad, which is a pilgrim centre, is a district of high mean mortality. It was also seen that although the pilgrim centre of Banaras behaved as an average mortality district, individual figures revealed that mortality is a regular feature in the district. It may be useful to mention in this connection that it has been observed from a study of the course of the epidemic in United Provinces that the most important cause of the 1938 epidemic in the Province was dissemination of infection following a large festival held at Hardwar during March 1938. It is suggested that special precautions should be taken in controlling the spread of the disease in such pilgrim centres and as recommended by the Bhor Committee, there should be complete inoculation of persons against cholera before they are permitted to enter the centres on festive occasions.

9. It has also been noticed that the rainy months of June, July, August and September are generally the months of pronounced mortality for the Province, the provincial seasonal index reaching a peak level of 176 during the month of August. The fact that the highly humid and moist districts of the east are acute epidemic districts coupled with the fact that mortality from cholera is more pronounced during the rainy season, seem to indicate that the meteorological factors humidity and rainfall have a tendency to increase the mortality from cholera in the province. It would thus seem

useful to take up a detailed study of the effect of such climatic factors as humidity, rainfall and temperature on mortality in the districts of high mortality and work out details of the seasonal indices in respect of such districts on the lines obtained for the province.

10. **Small-pox.**—A glance at the provincial mortality rates presented in table II would reveal that mortality rates did not on the whole show any variation from year to year (as would be seen from the equation of the regression line) and that mortality during the period was highest during 1908, when the provincial mortality rate reached a peak level of 1.26 per thousand.

11. It was noticed that mortality from small-pox remained mostly high in the districts of Gorakhpur and Banaras divisions in the western districts of Bijnor, Budaun, Moradabad and partly in the eastern districts of the Faizabad Division. An examination of the district mortality rates for the individual districts would reveal a disquieting feature in the situation that high mortality was almost a regular feature during recent years in the districts of the Banaras and the Gorakhpur Divisions, mean mortality being highest in the Ghazipur District, viz. 583 per million per year approximately. Although mean mortality rates in the districts of Bijnor, Budaun, Moradabad, Sultanpur and Pratapgarh are high as would appear from the dot-diagram the annual mortality rates as discussed in the preceding chapter would seem to show that the situation in these districts is not so serious particularly in the eastern districts of Sultanpur and Pratapgarh where the high epidemic years were during the beginning of the period, viz., 1906—08 which pushed up the mean mortality rates above normal. It is surprising to find that the western districts of the Meerut and Agra Divisions remained practically immune from the violent outbreak during 1908 of cholera epidemic which took a heavy toll of deaths throughout the Province.

12. Small-pox is perhaps the most easily controllable among the infectious diseases, if vaccination be performed at regular intervals. It may not be out of place to mention in this connection that the introduction of an Health Organisation in 1922 introducing primary vaccination in the province of Madras led to a fall in average mortality for all ages from 0.77 per thousand during 1917—21 to 0.46 per thousand during 1922—26 and this was followed by a gradual lowering in mortality thereafter, the average mortality rate during 1937—41 being as low as 0.06 per thousand after the introduction of compulsory revaccination in 1932. It is indeed surprising that compulsory vaccination has not yet been enforced in a single rural circle of the United Provinces although the Province has distinct areas of high mortality.

13. It is suggested that primary vaccination be made compulsory throughout the Province and immediate steps taken to make primary vaccination compulsory in the highly epidemic districts of Ghazipur, Azamgarh, Bijnor, Budaun, Moradabad, Gorakhpur, Allahabad, Banaras, Mirzapur and Jaunpur. Attempt should also be made to introduce compulsory revaccination in these districts.

14. It would be seen that various factors including poor housing conditions leading to overcrowding, pressure of population and above all the general economic backwardness of the eastern districts have contributed towards making these districts areas of high mortality. Allahabad and Banaras are pilgrim centres and this fact has to a considerable degree been responsible for the high mortality in these districts.

15. The seasonal indices presented in Table VI would seem to indicate that mortality for the Province is most pronounced during the months of April, May and June. The indices being based on the province as a whole are, of course, bound to suffer from practical limitations in that these do not give any information of mortality in individual districts. It will be useful, however, if seasonal indices be obtained for at least the districts of high mortality. It is suggested that provision for vaccination with potent vaccine lymph be made during the hot weather April, May and June (when the quality is likely to deteriorate with exposure to heat in districts where mortality is most pronounced in the Province. In this connection it may be recalled that the Bhor Committee recommended that possibility of providing for cold storage to maintain the potency of the lymph at its original strength, should be investigated for districts with pronounced mortality.

16. **Plague.**—It is gratifying to note from the results of the analysis that mortality from plague showed a significant decline during the period 1906—45 the rate of decline being 83 per million per year. A study of the district-wise mortality rates from the annual reports of the Public Health Department would further show that during recent years there was practically no mortality from plague in the Province except in the districts of the Gorakhpur and Banaras Divisions.

17. It has been observed that mortality from plague is generally acute during the 3 months February, March and April of the year, mortality being most pronounced during March. It is suggested that during these months when the outbreak of plague is imminent or has actually taken place, temporary measures like preventive inoculation, rat destruction, short period clearing of houses particularly during the months of December and January which are generally the months preceding the plague season and provision of adequate treatment for patients are salutary measures in the direction.

18. It has been noticed from a study of the mean mortality rates as given in dot-diagram 7 that mean mortality from plague has been high in the Saharanpur, Meerut, Muzaffarnagar, Jaunpur, and Unnao districts and unusually high in the Ghazipur, Ballia and Azamgarh districts, the latter districts behaving more or less as endemic foci for the Province. It is known that the eastern districts of Ghazipur, Ballia and Azamgarh are economically backward and the sanitary conditions in these districts are far from satisfactory. Besides the moderately damp climate in these districts seems to favour the spread of the disease in these areas. Above all, the human dwellings in these districts might be haunting houses for rats which are the primary reservoir of infection from which the disease easily spreads to man.

The poor hygienic sense of the people (particularly in the eastern districts of the Province) who generally throw garbage in public places which encourages the breeding of rats may be another cause of high mortality in these districts.

19. It is suggested that as an important measure in the direction, may be taken the systematic destruction of rats in residential areas particularly in the endemic districts of the Province. It may be worthwhile to recall in this connection the recommendations of the Bhor Committee, viz.:

(a) construction of rat-proof dwellings and rat-proof grain stores and railway godowns;

(b) control over the location of certain trades and industries which attract rats; and

(c) an improvement of the general sanitary condition of towns and villages and finally publicity work inculcating in the citizens and villagers the need for hygienic sense as an adequate measure to keep down the rat population.

20. It is worthy to note that among the district of low mortality are the hilly districts of Naini Tal, Almora and Garhwal, all the four districts of the Jhansi Division, Dehra Dun and Shahjahanpur. The plausible reason for the comparative immunity of Naini Tal, Almora and Garhwal seems to be mainly the vigilance and control exercised by the Municipal authorities in taking preventive measures against the possible outbreak of the disease in these districts and partly because the public in these districts have comparatively a better hygienic sense. The same vigilance on the part of the authorities and better hygienic sense in the people may be responsible for the low mortality prevailing in the districts of the Jhansi Division which are mostly important military stations and consequently public health authorities in these centres are required to take special precautions.

21. It has thus been seen that in the districts where there are better medical facilities and where the sanitary services are also improved, the virulence of the disease is greatly mitigated. The control on the admission of the diseased persons particularly amongst the military keeps the hilly districts comparatively free from the disease. It may be recalled in this connection that plague is one of the most serious diseases known to humanity which, if it breaks out in an epidemic form, results in tremendous loss of life. The Black Death of the 14th century took a toll of 25 million lives in Europe alone which constituted three quarter of its population. In England the last epidemic of the disease caused untold havoc and loss of life. Dr. John Drew in his book entitled "Man, Microbe and Malady" has asserted that the relative freedom of England from plague since the last epidemic is the result of (a) better living conditions especially as regards housing, (b) improved sanitation and personal communal hygiene, (c) the provision of a nutritional health service and (d) the unceasing vigilance on the part of the authorities in England and their rigid control over all ships coming to England from known plague ports

abroad. He further observes, " We have the animal reservoir in abundance in this country and we do not possess any natural immunity against plague. We have to thank our island position and the conscientious work of the members of our medical and sanitary services at our sea and air ports that the disease does not gain entrance to our land."

22. It would be seen from Dr. Drew's observations quoted above that it is possible to render a district immune from plague if housing and sanitary conditions are sufficiently improved and rigid vigilance is exercised by the Public Health Department in regard to the entrance of persons coming from known plague areas to the districts. Of course, it would be unreasonable to expect that the housing and sanitary conditions, in the districts of our Province would improve to the extent these have done in England but it is certain that considerable mitigation of the disease could be brought about, if the Public Health authorities in the Province are provided with better facilities and the sanitary conditions in the districts are improved. The statistical evidence goes to show that amongst the average mortality districts, mortality in almost all the districts (excepting the districts of the Gorakhpur and Banaras Divisions), has been practically insignificant during recent years, although in previous years it was often average and sometimes high, and this may be due to the recent improvement in medical facilities and better sanitation in the districts.

23. Attempt has been made to present the statistical data in this bulletin in a popular form, it being mainly intended for the layman. It has thus not been possible to make full use of advanced statistical methods which have been avoided as far as practicable partly because the object is to make the subject matter interesting and mainly because the application of such methods to the crude data available is likely to lead to erroneous conclusions. The statistical methods wherever used have been separately explained in the appendix. Besides, limitations of time and space made me confine only to certain important aspects of the problem. It is hoped, however, that the results arrived at will be helpful to workers in the field to study the problem in details and extend the analysis in most cases to individual districts.

APPENDIX

RESULTS OF ANALYSIS

Secular Trend

The equations to the regression lines A_1 , B_1 , and C_1 , showing the general tendencies of cholera, small-pox and plague are respectively :

$$\text{Cholera } Y = -0.02962x + 1.55651 \dots \dots \dots (1)$$

$$\text{Small-pox } Y = -0.00135x + 0.22424 \dots \dots \dots (2)$$

$$\text{Plague } Y = -0.08306x + 2.98723 \dots \dots \dots (3)$$

We now proceed to test the significance of each of regression coefficients.

Cholera.—Sampling error of the regression coefficient 0.02962 is 0.01108 so that $t = 2.6733$.

5 per cent. value of t for 30 degrees of freedom is 2.042

“ “ “ 40 “ “ “ 2.021

Therefore the value of $t = 2.6733$ for 38 degrees of freedom is significant at 5 per cent. For our practical purposes this means that the difference of the regression coefficient 0.02962 from zero is real.

Small-pox.—Sampling error of the regression coefficient 0.00135 is 0.003015 and $t = 0.4488$. 5 per cent. values of t for 30 and 40 degrees of freedom are respectively 2.042 and 2.021. Therefore $t = 0.4488$ against 38 degrees of freedom is not at all significant and for our purposes the regression coefficient 0.00135 may be taken to be equivalent to zero and the line reduces to $Y = 0.22424$ which is a line parallel to the x -axis.

Plague.—Sampling error of the regression coefficient 0.08306 is 0.01778 so that $t = 4.6715$ which is significant at 0.1 per cent.

0.1 per cent. value of t for 30 d. f. is 3.646 and for 40 d. f. is 3.551.

For further details see art. 26, Statistical methods for Research Workers.

Zones of high, normal and low mortality.

Consider the mortality data for p districts over q years. Denoting the mortality in the i th district for the j th year by X_{ij} .

We have $x_{ij} = m + d_i + y_j + e_{ij}$.

Where m is the general mean, d_i the district effect for the i th district, y_j the yearly effect for the j th year and e_{ij} the sampling error for the i th district in the j th year other than that due to district and yearly effect.

It can be easily shown that—

$$V(\bar{x}_{..}) = \frac{D}{p} + \frac{Y}{q} + \frac{\sigma^2}{pq}$$

where $\bar{x}_{..}$ is the estimate of the general mean and

$$E(d_i^2) = D$$

$$E(y_j^2) = Y$$

$$E(e_{ij}^2) = \sigma^2$$

E denoting expectation.

If now, V_1, V_2, V_3 , be the mean squares due to districts, years and error as obtained from analysis of variance it easily follows that

$$V(\bar{x}_{..}) = \frac{V_1 + V_2 - V_3}{pq}$$

$$\text{and S. E. of } \bar{x}_{..} = \sqrt{\frac{V_1 + V_2 - V_3}{pq}}$$

Considering $\bar{x}_{..}$ as the mean of the p district means each district mean being obtained as an average of the mortality rates for the districts over the q years. We have the critical difference for $\bar{x}_{..} = \text{S. E.}(\bar{x}_{..}) \times t_{p-1}$ where t_{p-1} is the 5 per cent. value of t for $p-1$ degrees of freedom and hence fiducial range for $\bar{x}_{..}$ finally is

$$\bar{x}_{..} \pm \frac{\sqrt{V_1 + V_2 - V_3}}{pq} \times t_{p-1}$$

and this may be taken as the normal range of mean mortality.

The fiducial range for

Cholera is 0.8835 ± 0.3021 or 1.18 and 0.58 roughly ;

Small-pox is 0.1797 ± 0.0664 or 0.25 and 0.11 roughly ;

Plague is 1.1431 ± 0.6006 or 0.54 and 1.74 roughly.

We next obtain the normal range of standard deviation for the districts. If $S_1^2, S_2^2, \dots, S_p^2$ be the estimates of variances for the p districts over the q years we have, if S^2 denotes the average variance over the p districts,

$$S^2 = \frac{\sum_{i=1}^p S_i^2}{p} = \frac{S_1^2 + S_2^2 + \dots + S_p^2}{p}$$

Now for normal parent estimate of

$V(S) = \frac{s^2}{2n}$ (see page 210, The Advanced Theory of Statistics, Vol. I by Kendall).

Here $n = q-1$

and $V(s) = \frac{S^2}{2(q-1)}$

S. E. (S) $3/4 = \sqrt{V(s)} = \frac{\sqrt{S^2}}{2(q-1)}$

Fiducial range of S is $S \pm \sqrt{\frac{S^2}{2(q-1)}} \times t_{q-1}$

where t_{q-1} is the 5 per cent. value of t for $q-1$ d. f.

which may be taken as the normal range for standard deviation.

In our present case for :

Cholera : $q=39.$

$S^2=2.703143.$

$V(s) = \frac{S^2}{2(q-1)} = 0.0346594.$

Fiducial or normal range for S.

is $1.6441 \pm 0.3767.$

or 1.27 and 2.02 roughly.

Small-pox $S^2=0.13906875.$

Fiducial range for S is 0.3729 ± 0.0854 or 0.4583 and 0.2875.

Plague $S^2=7.805531.$

Fiducial range for S

is 2.794 ± 0.6401 or 3.4341 and 2.1539.

**LIST OF PUBLICATIONS OF THE ECONOMICS AND STATISTICS
DEPARTMENT, UNITED PROVINCES**

**I.—PUBLICATIONS OF THE BUREAU OF STATISTICS AND
ECONOMICS RESEARCH (1931—38)**

- *Bulletin no. 1. Agricultural prices in the United Provinces by Raj Bahadur Gupta, M.A., P.H.D. (1937), Rs.2.
- * „ „ 2. The Foods of a Hindu Village of Northern India, by Charlotte V. Wiser, P.H.D., M.SC., (1937), price Rs.2-8-0.
- * „ „ 3. Wages and Labour conditions in Kanpur, by S. P. Saxena, M.A., B.COM. (1938), price Rs.3-8-0.
- * „ „ 4. Prices of Cereals in the United Provinces, How they are determined at various stages by J. K. Pande, M.A. (1938), price Re.1.
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INTELLIGENCE (1938—42)**

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- „ „ 2. The United Provinces Wheat in 1938-39 and Days to come, by J. K. Pande, M.A. (1939).
- „ „ 3. A Study of the Import and Export Trade of the U. P. during the year 1938-39 (1939).
- „ „ 4. Report on Housing Conditions of Mill workers in Cawnpore (1936).

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Monograph: Our Food : Lucknow City, by Professor S. K. Rudra, M.A. (CANTAB.) (1944), price Re. 1-0-0.

Bulletin no. 1. Report on an Enquiry into Labour Conditions in the Brassware Industry of Moradabad, by R. D. Pant (1945), price Re. 0-12-0.

„ „ *2. Crop Estimation in the U. P. by J. K. Pande, M.A. (1945), price Re.0-12-0.

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„ „ 4. Rationing of Foodgrains in the U. P. during World War II, by Prof. S. K. Rudra, M.A. (CANTAB.) (1946), price Re. 0-6-0.

- Bulletin no. 5. Rural Wages in the U. P. by S. C. Chaturvedi, M.A., (1947), price Rs.2-4-0.
- „ „ 6. Sanukt Prant Ke Dehaton men Majoori (Hindi) by S.C. Chaturvedi, M.A.
- „ „ 7. Development of Agricultural Marketing in U. P. and need for its Reorganisation, by R. C. Pande, M.A., LL.B. (1947). price Re. 0-4-0.
- „ „ 8. Some Facts about our Life and Living (1947), price Re. 0-5-0.
- „ „ 9. Vital Statistics in U. P., by A. R. Sen, M.Sc., F.S.S., (Lond.) (1948).
- „ „ 10. A Handbook of Statistical Information (1947), price Re. 0-3-0.
- „ „ 11. Industrial Relations and Trade Disputes in U. P. by J. Singh, M.A. (in Press).
Hindi Version price Re. 0-5-0.

NOTE—All publications of the Department of Economics and Statistics including the monthly Bulletin of Statistics, can be had from the Superintendent, Printing and Stationery, United Provinces, Allahabad, on payment.

PLAGUE

SHOWING DISTRICTS OF HIGH, NORMAL AND LOW MEAN MORTALITY AND VARIATION FROM PLAGUE FOR THE U.P. BASED ON DATA FOR 1906-45

• MEAN MORTALITY
 • STD. DEVIATION
 ENCLOSE SPACE OF NORMAL RANGE OF
 M. - MEAN MORTALITY
 N. - STD. DEVIATION

MEAN MORTALITY

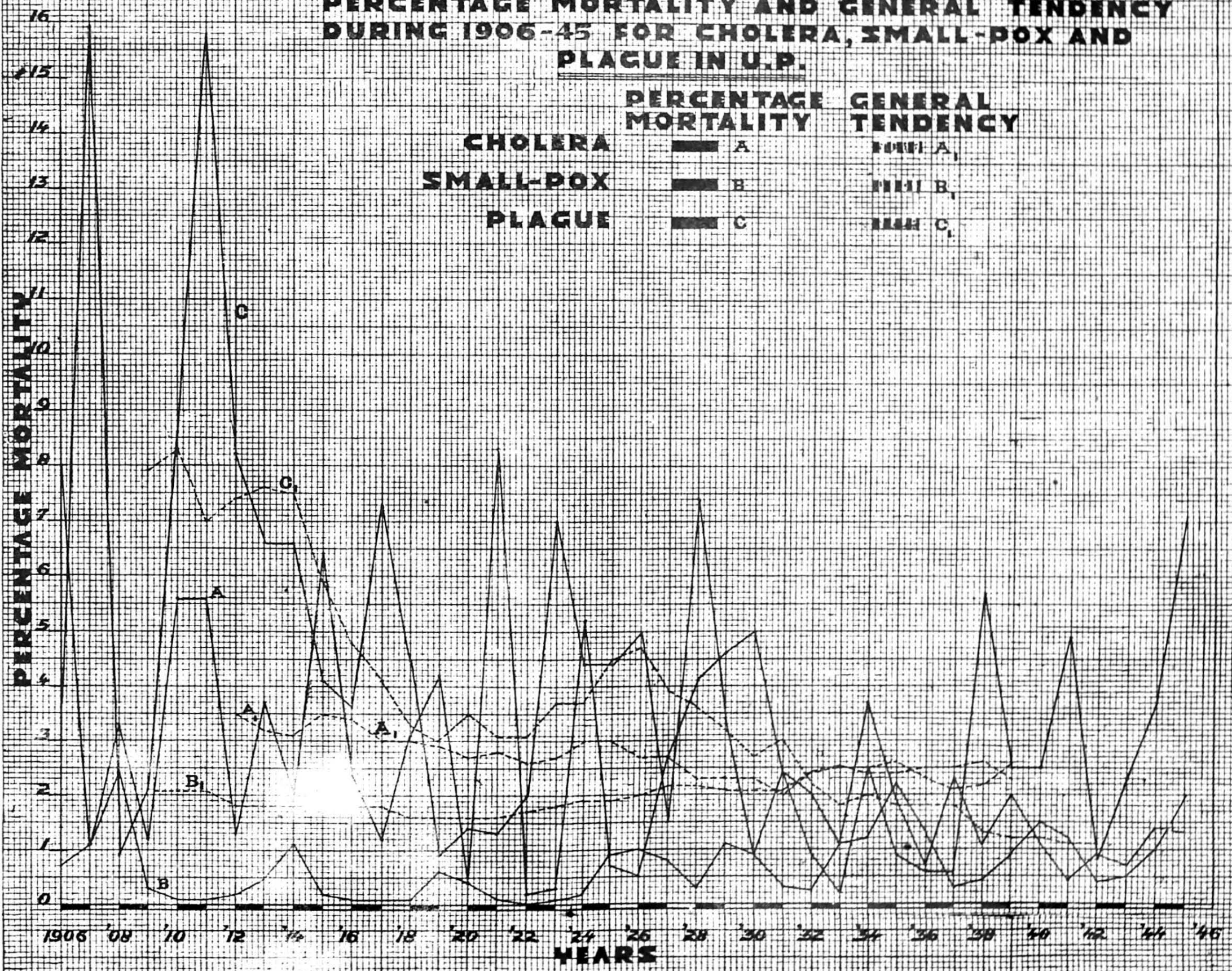
STD. DEVIATION

ZONE OF NORMAL VARIATION

ZONE OF NORMAL MEAN MORTALITY

DEHRADUN	BAHARANPUR	MUZAFFARPUR	MADRAS	BHANDSALAH	ALIGARH	MUTTIA	AGRA	MAINPURI	ALPH	BAREILLY	BALNOR	BUDAUN	MORADABAD	SHAHJAHANPUR	PILIBUT	FARRUKHABAD	HATAWAH	GAWNPORE	FATEHPUR	HHANSI	ALLAHABAD	JALAIN	HATHRPUR	BANDA	BENARES	NIRZAPUR	JAINPUR	GHAZIPUR	BALLIA	GORAKHPUR	BASTI	AZAMGARH	NAINITAI	AINORA	GARHWAL	LUCKNOW	UNAO	KASHMIRI	SURPUR	UNEDOI	NHERI	FYZABAD	GONDA	BAHRAICH	SHEIKANPUR	PARLIAGARH	BABABANKI
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PERCENTAGE MORTALITY AND GENERAL TENDENCY DURING 1906-45 FOR CHOLERA, SMALL-POX AND PLAGUE IN U.P.



SHOWING MORTALITY RATE AND GENERAL TENDENCY FOR CHOLERA, SMALL-POX AND
PLAGUE IN U.P. BASED ON DATA DURING 1906-45

MORTALITY RATE (DEATHS PER THOUSAND POPULATION)

CHOLERA ——— A

SMALL-POX ——— B

PLAGUE ——— C

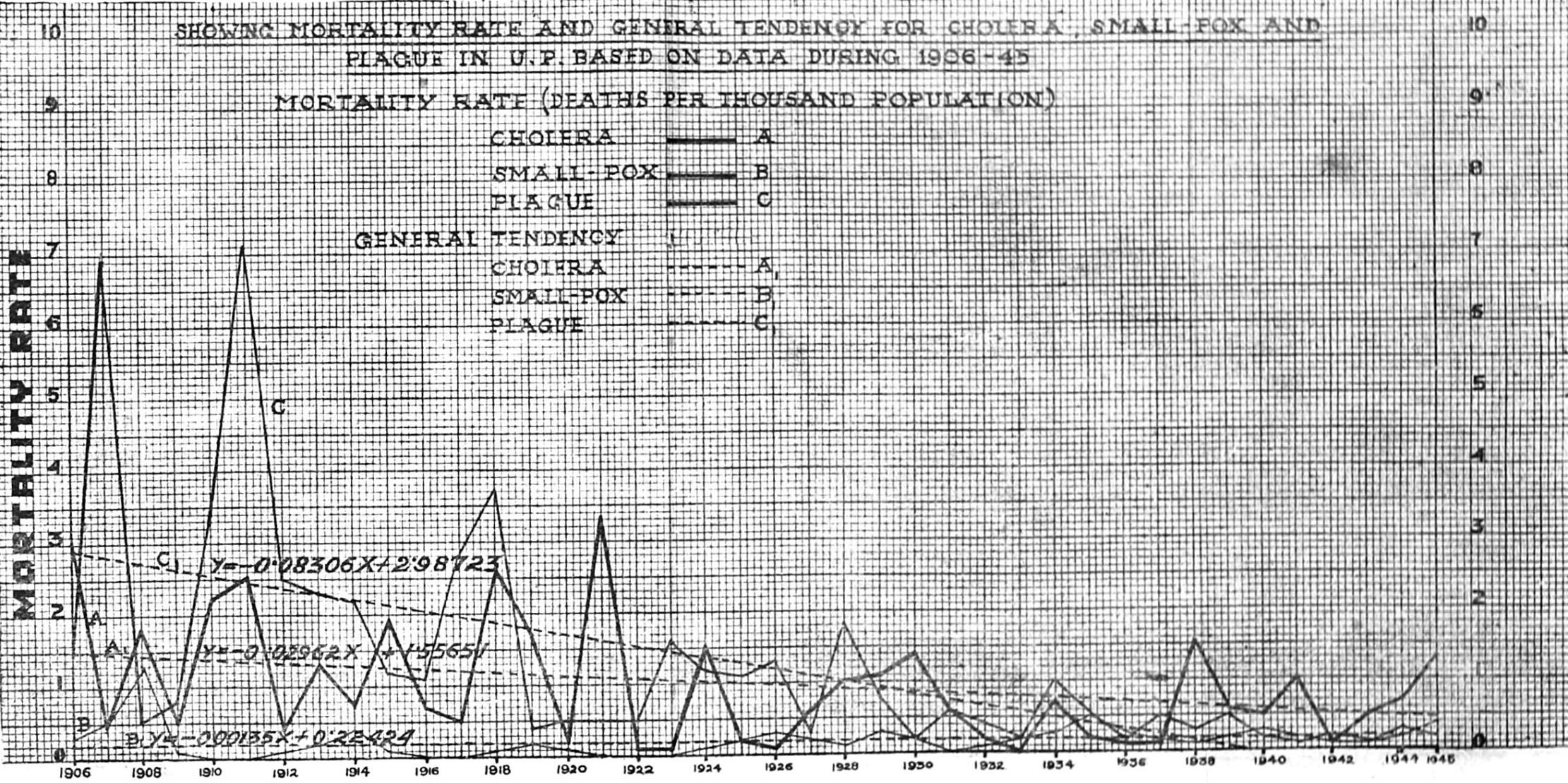
GENERAL TENDENCY

CHOLERA - - - - - A

SMALL-POX - - - - - B

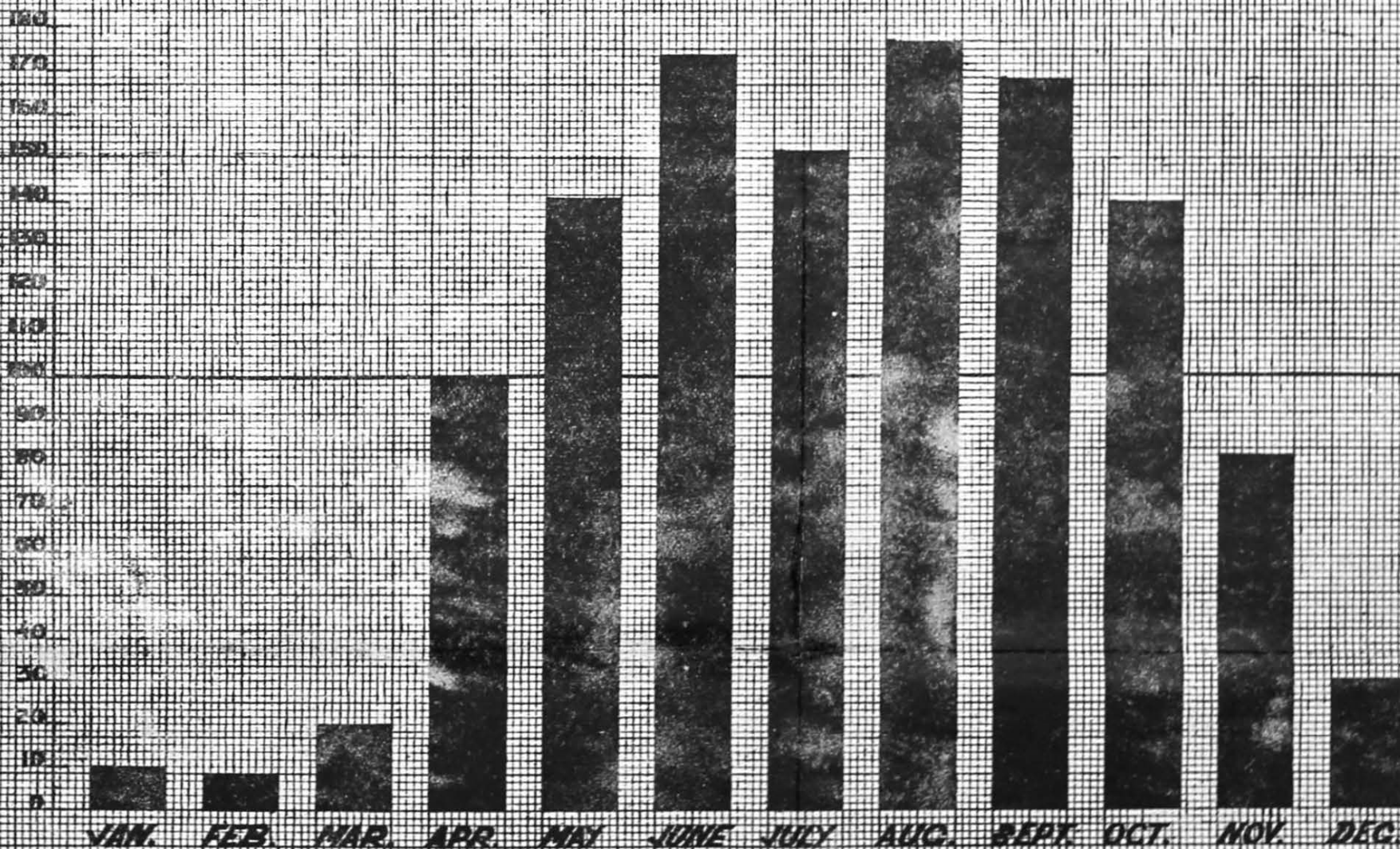
PLAGUE - - - - - C

MORTALITY RATE



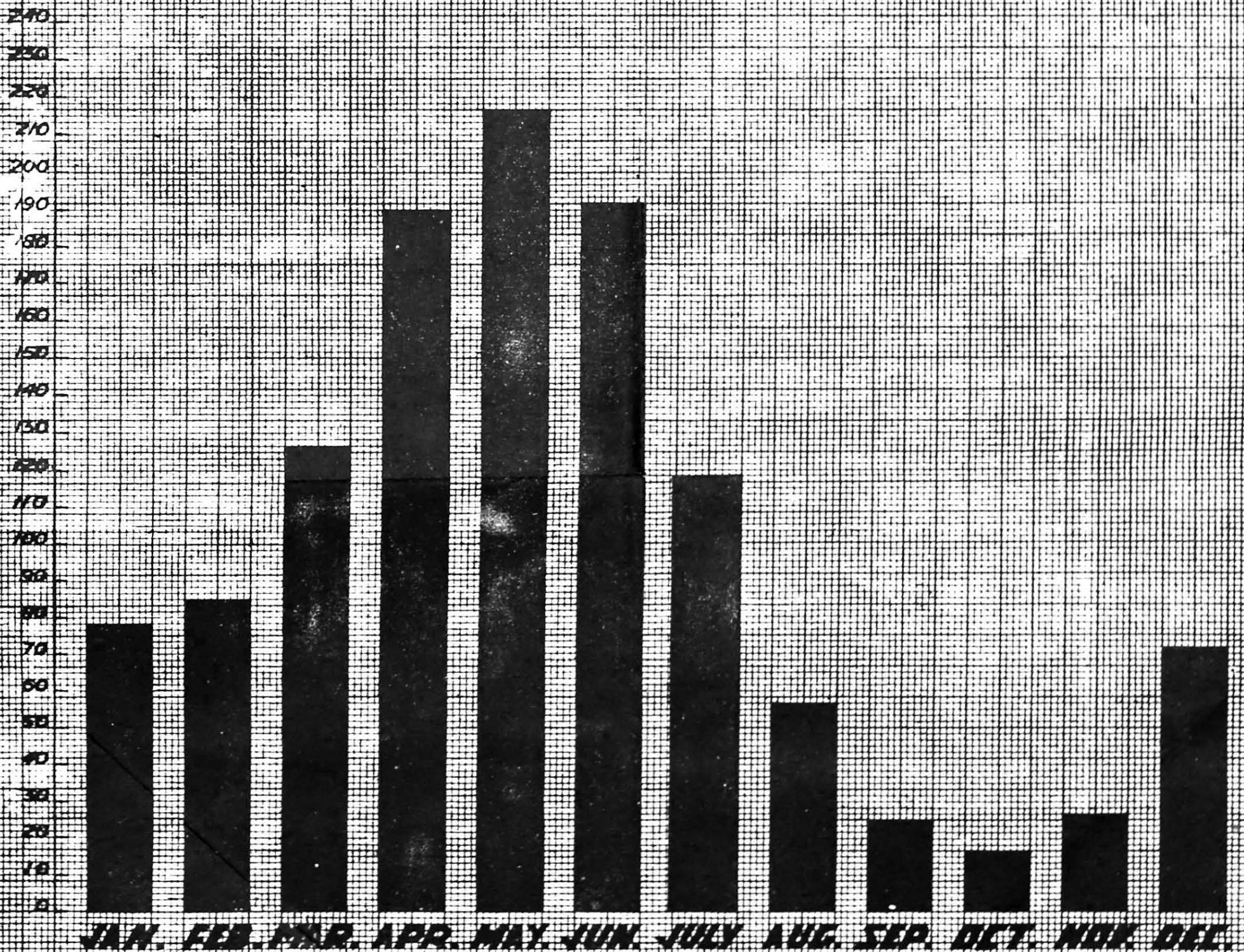
SEASONAL INDICES OF MORTALITY FROM CHOLERA IN U. S.

BASED ON DATA OVER THE PERIOD 1906-49
NORMAL=100



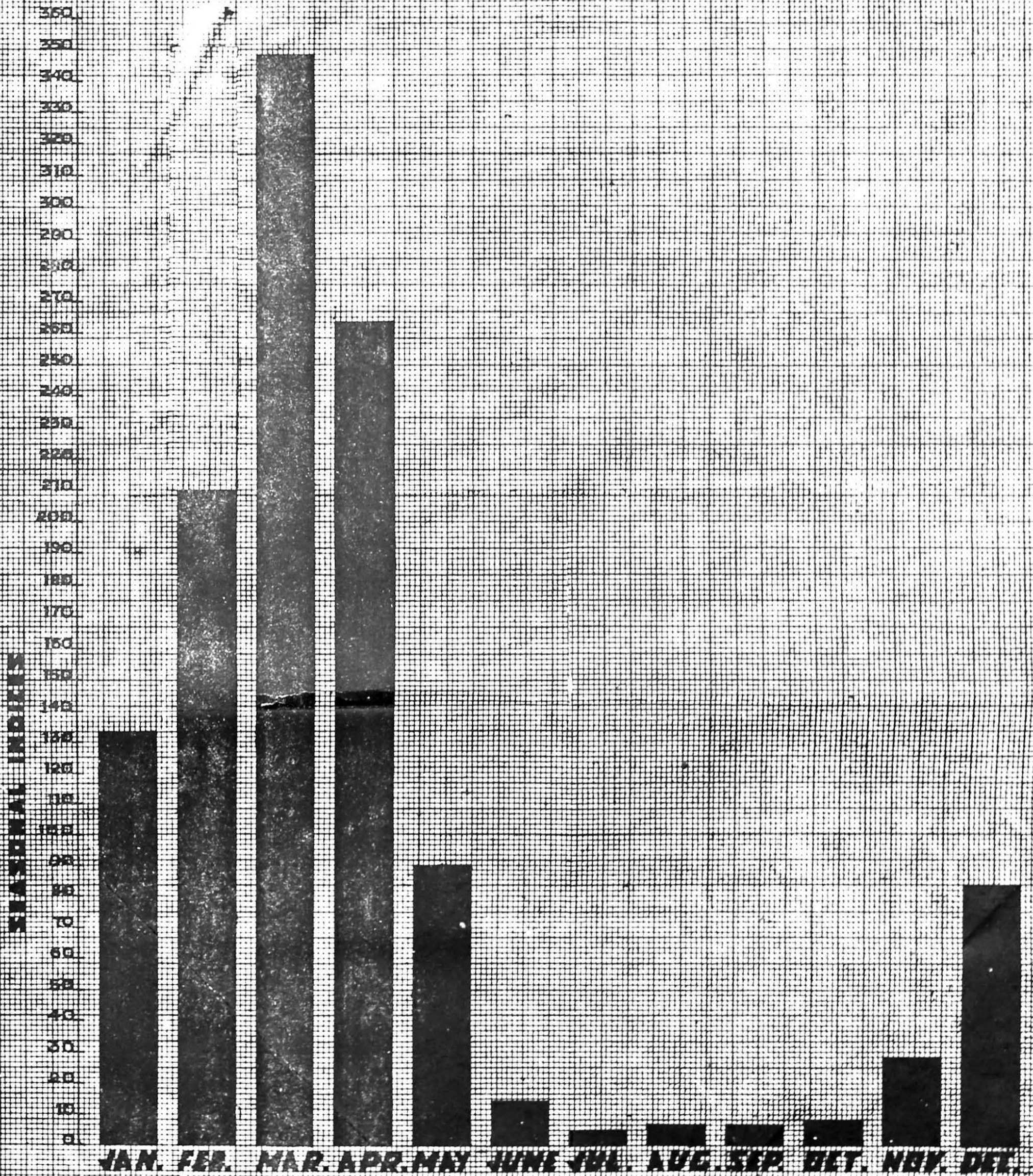
SEASONAL INDICES OF MORTALITY FROM SMALL-POX IN U.S.

BASED ON DATA OVER THE PERIOD 1906-45
NORMAL = 100



SHOWING SEASONAL INDICES OF MORTALITY FROM PLAGUE IN U.S.

BASED ON DATA OVER THE PERIOD 1946-48
NORMAL = 100



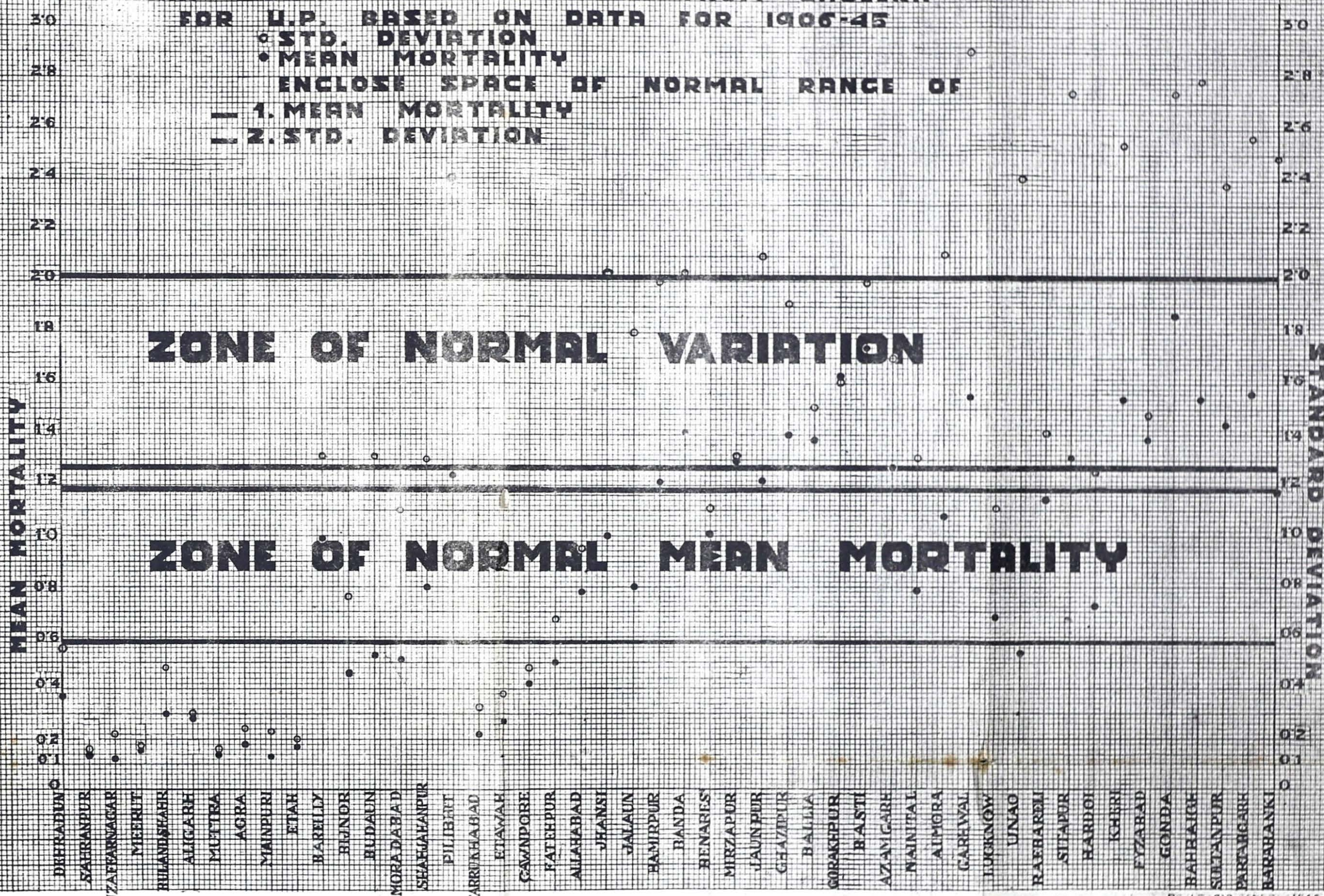
CHOLERA

SHOWING DISTRICTS OF HIGH, NORMAL & LOW,
MEAN MORTALITY & VARIATION FROM CHOLERA
FOR U.P. BASED ON DATA FOR 1906-45

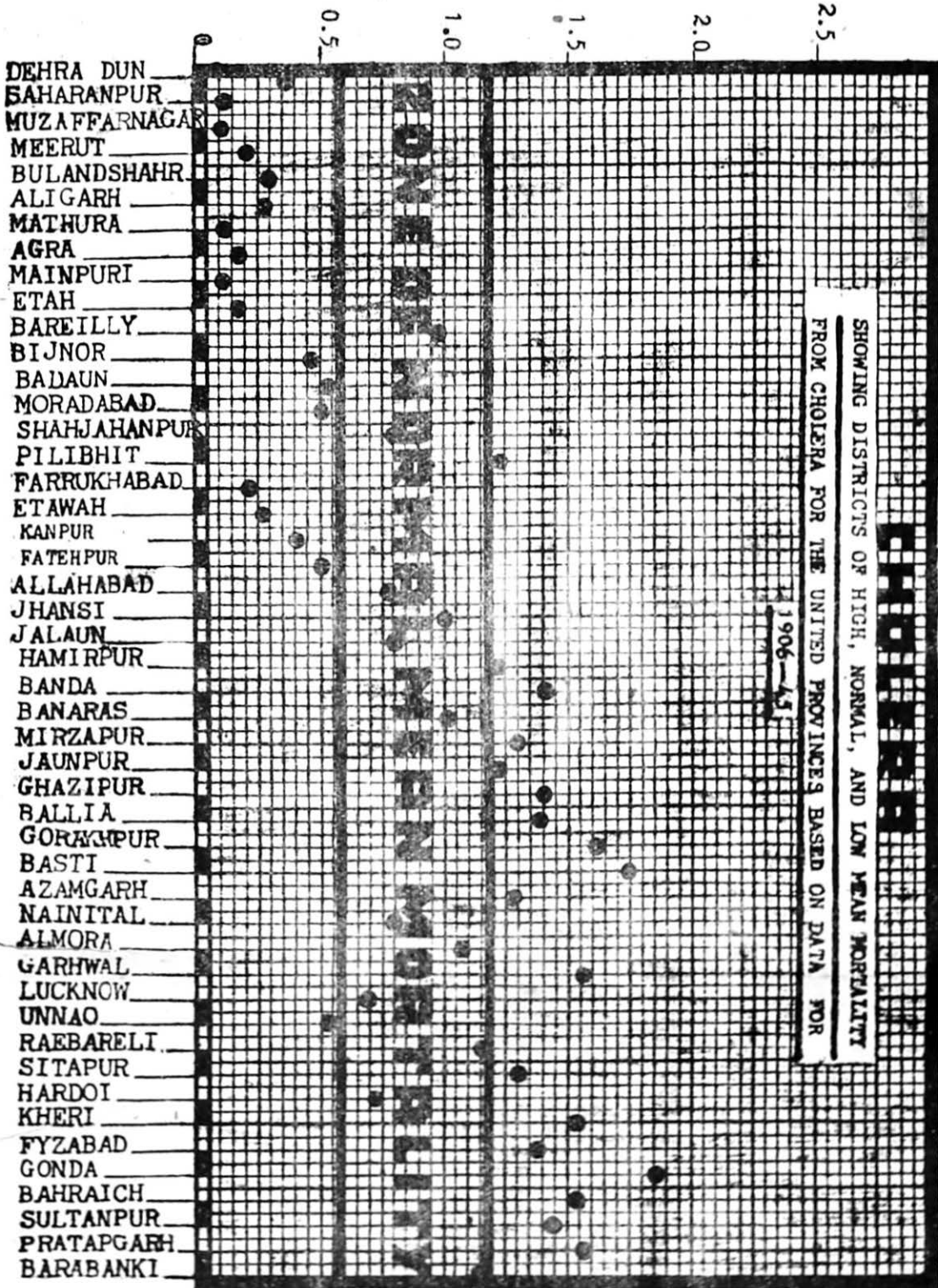
○ STD. DEVIATION
● MEAN MORTALITY

ENCLOSE SPACE OF NORMAL RANGE OF

— 1. MEAN MORTALITY
— 2. STD. DEVIATION



mean mortality



CHOLERA

SHOWING DISTRICTS OF HIGH, NORMAL, AND LOW MEAN MORTALITY FROM CHOLERA FOR THE UNITED PROVINCES BASED ON DATA FOR 1906-1907

Standard deviation

3.0

2.0

1.0

0.5

0

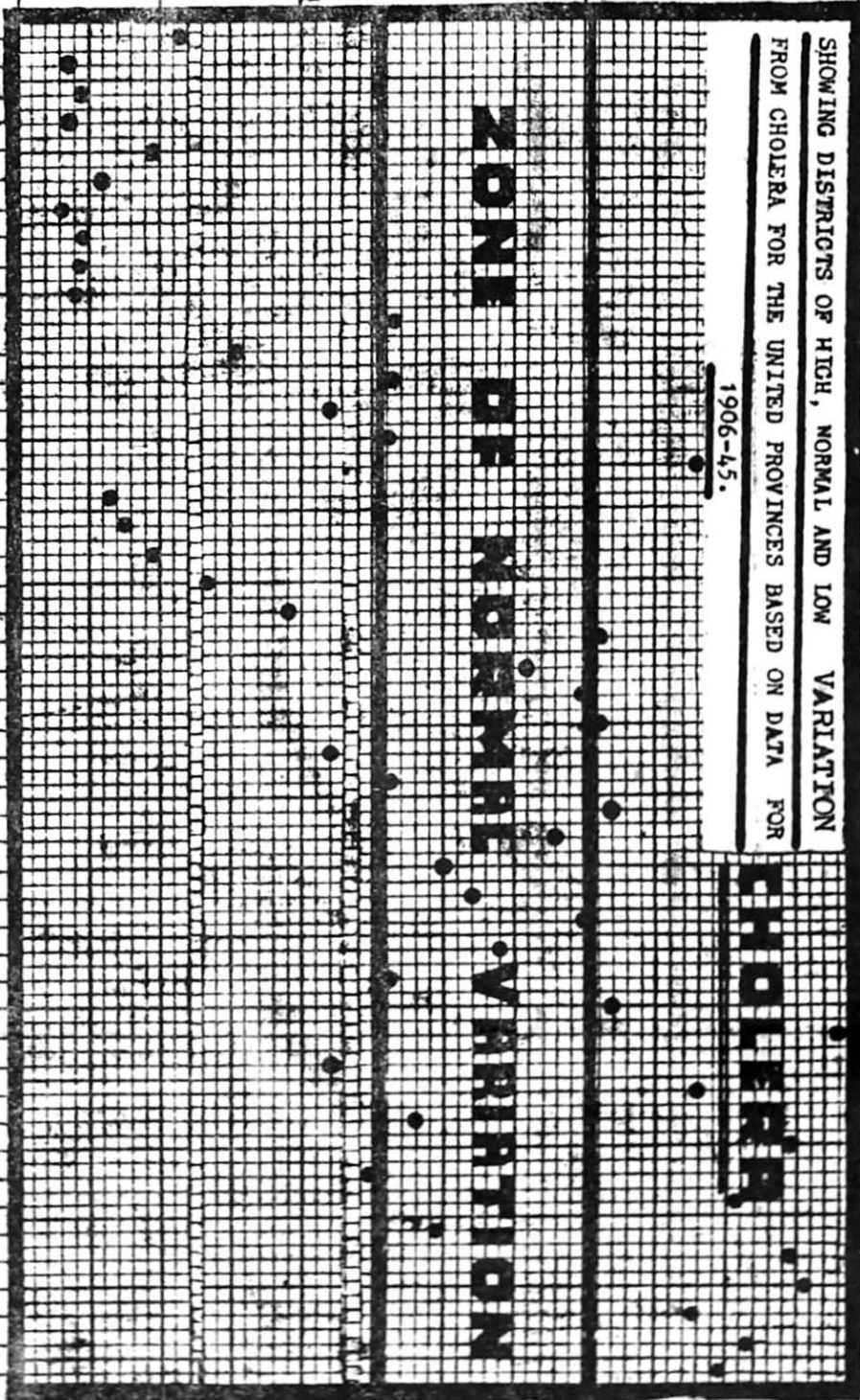
SHOWING DISTRICTS OF HIGH, NORMAL AND LOW VARIATION
FROM CHOLERA FOR THE UNITED PROVINCES BASED ON DATA FOR
1906-45.

1906-45.

ZONE OF NORMAL VARIATION

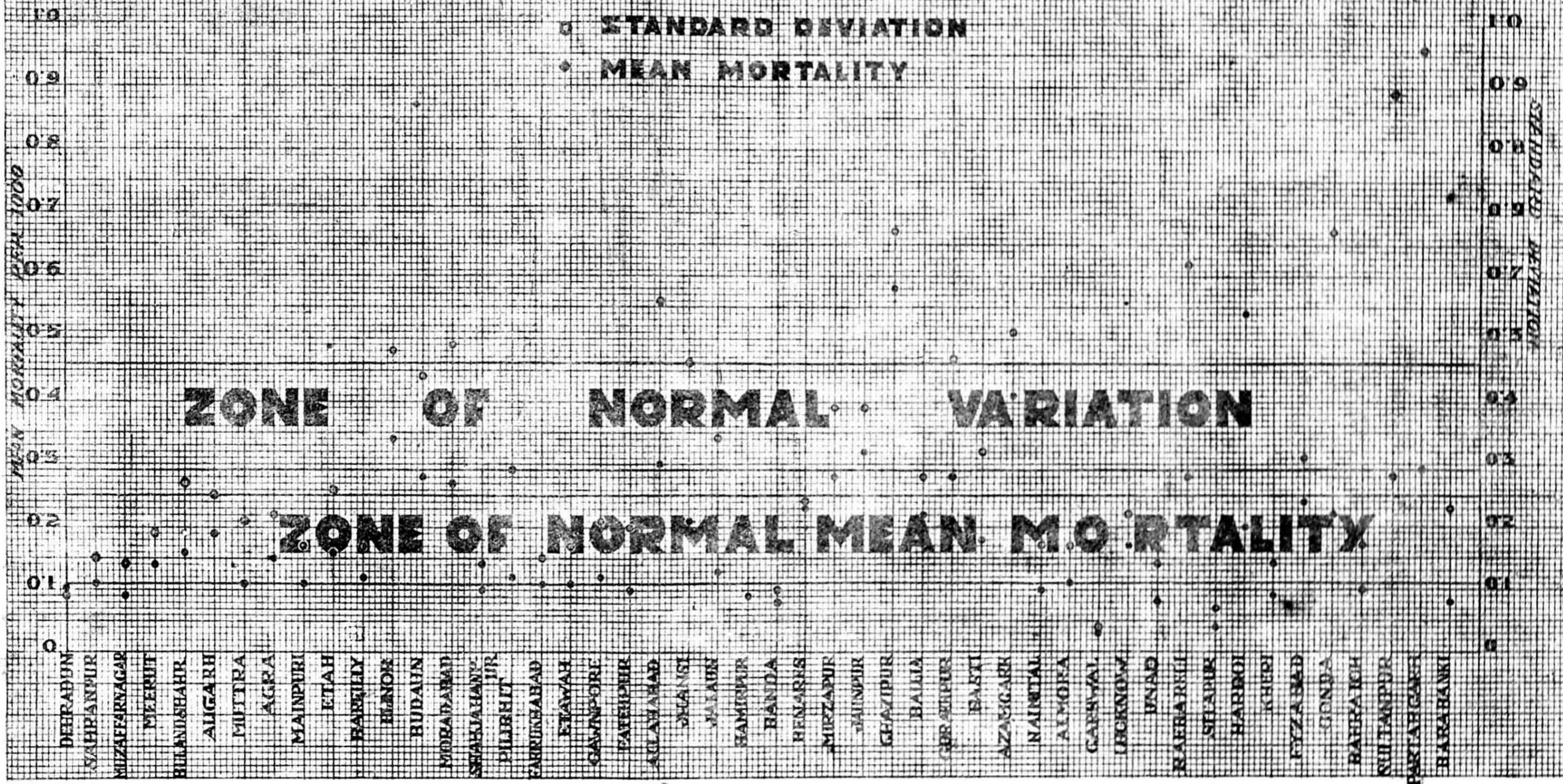
CHOLERA

- Behradun
- Sahranpur
- Muzaffarnagar
- Meerut
- Bulandshahr
- Aligarh
- Mathura
- Agra
- Mainpuri
- Etah
- Bareilly
- Bijnor
- Budaun
- Moradabad
- Shahjahanpur
- Pilibhit
- Farrukhabad
- Etawah
- KANPUR
- FATEHPUR
- Allahabad
- Jhansi
- Jalaun
- Hamirpur
- Banda
- Banaras
- Mirzapur
- Jaunpur
- Ghazipur
- Ballia
- Gorakhpur
- Basti
- Azamgarh
- Nainital
- Almora
- Garhwal
- Lucknow
- Unao
- Raebareli
- Sitapur
- Hardoi
- Kheri
- Fyzabad
- Gonda
- Bahraich
- Sultanpur
- Partagarh
- Barabanki



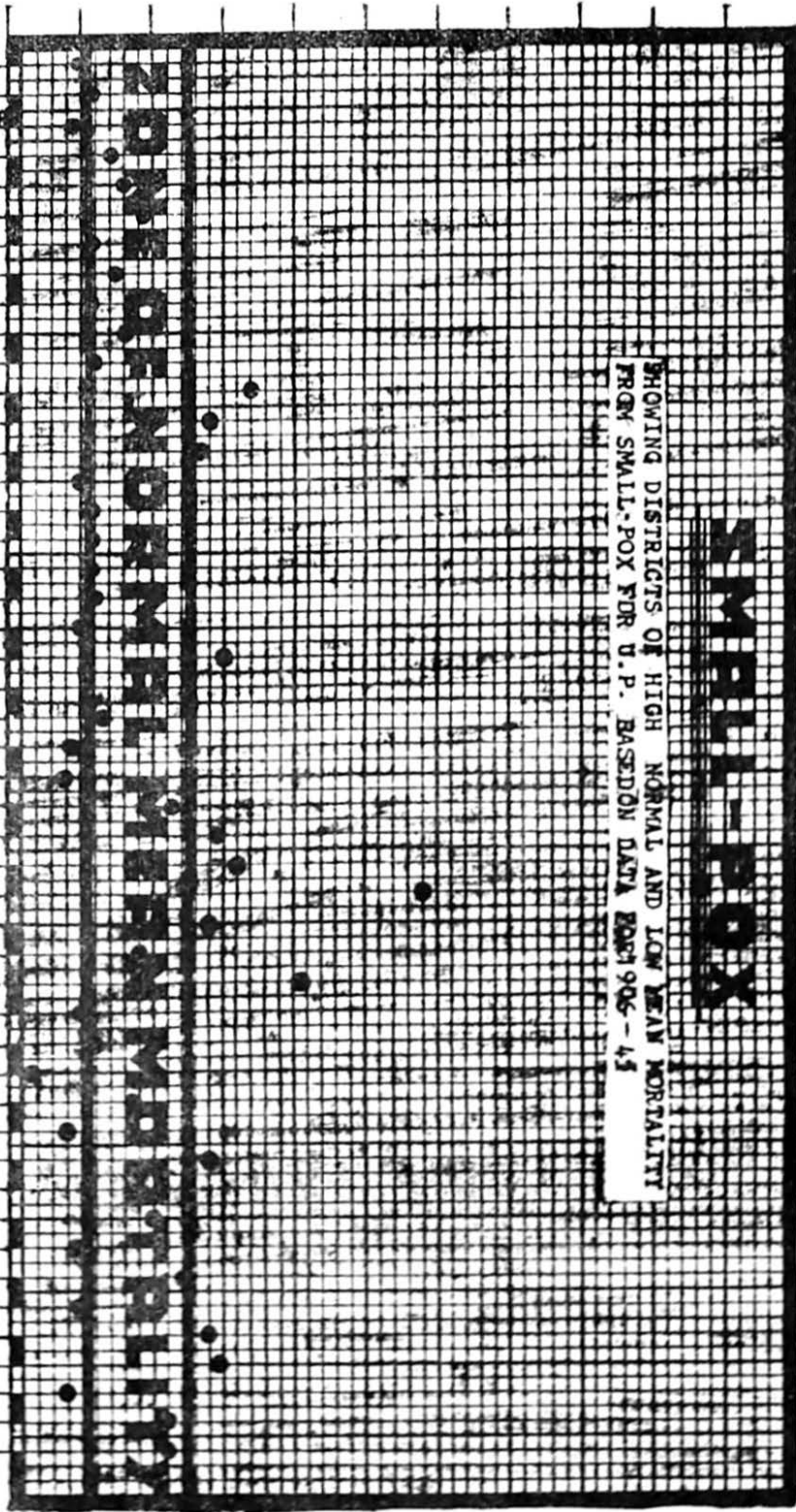
SMALL-POX

SHOWING DISTRICTS OF HIGH, NORMAL AND LOW MEAN MORTALITY AND VARIATION FROM SMALL-POX FOR U.P. BASED ON DATA FOR 1906-45



DEHRA DUN
 SAHRANPUR
 MUZAFFARNAGAR
 MEERUT
 BULANDSHAHR
 ALIGARH
 MATHURA
 AGRA
 MAINPURI
 ETAH
 BAREILLY
 BIJNOR
 BUDAUN
 MORADABAD
 SHAHJAHANPUR
 PILIBHIT
 FARRUKHABAD
 ETAWAH
 KANPUR
 FATEHPUR
 ALLAHABAD
 JHANSI
 JALAU
 HAMIRPUR
 BANDA
 BENARES
 MIRZAPUR
 JAUNPUR
 GHAZIPUR
 GORAKHPUR
 BASTI
 AZAMGARH
 MAINITAL
 ALMORA
 GARHWAL
 LUCKNOW
 UNAO
 RAE BARELI
 SITAPUR
 HARDOI
 KHERI
 FYZABAD
 BAHRACH
 SULTANPUR
 PARTABGARH
 BARABANKI
 BALLIA
 GONDA

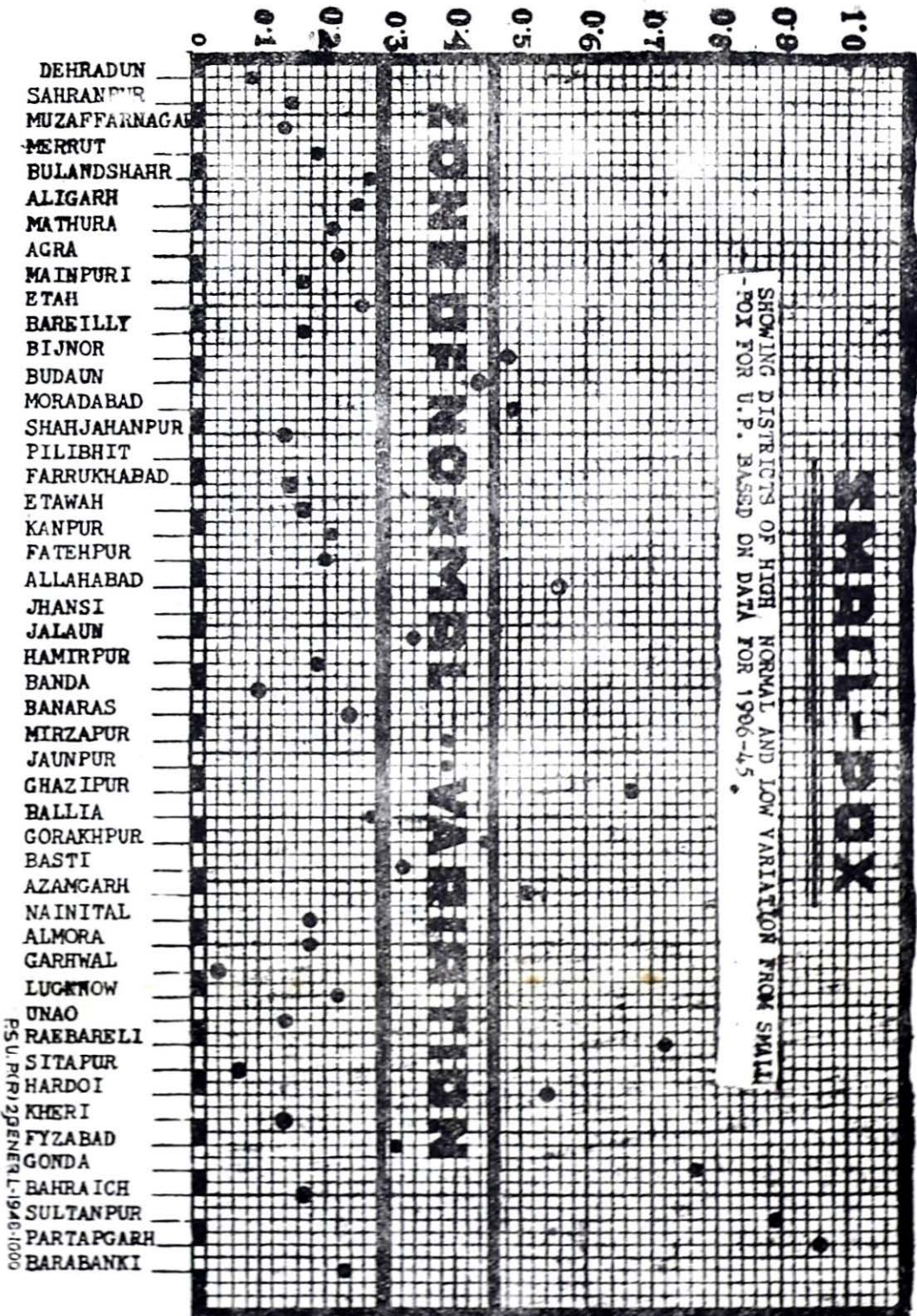
0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0



SHOWING DISTRICTS OF HIGH NORMAL AND LOW YEAR MORTALITY
 FROM SMALL-POX FOR U. P. BASED ON DATA FROM 1906-45

SMALL-POX

STD. DEVIATION



SHOWING DISTRICTS OF HIGH NORMAL AND LOW VARIATION FROM SMALL
 - FOR U.P. BASED ON DATA FOR 1906-45.

SMALL

PS U.P.(R) 2/GENERAL-1946-1000

SAHRANPUR
 MUZAFFARNAGAR
 MEERUT
 BULANDSHAHAR
 ALIGARH
 MATHURA
 AGRA
 MAINPURI
 ETAH
 BAREILLY
 BUNOR
 BUDAUN
 MORADABAD
 SHAHJAHANPUR
 PILIBHIT
 FARRUKNABAD
 ETAWAH
 KANPUR
 FATEHPUR
 ALLAHABAD
 JHANSI
 JALAUN
 HAMIRPUR
 BANDA
 BANARAS
 MIRZAPUR
 JAUNPUR
 GHAZIPUR
 BALLIA
 GORAKHPUR
 BASTI
 AZAMGARH
 NAINITAL
 ALMORA
 GARHWAL
 LUCKNOW
 UNAO
 RAEBARELI
 SITAPUR
 HARDOI
 KHERI
 FYZABAD
 GONDA
 BAHRAICH
 SULTANPUR
 PARTAPGARH
 BARABANKI

ZONE OF NORMAL MEAN MONTHLY

Plumage's estimate of high, normal and low mean monthly
 from August to 11 P. toward via Delta for 1905-1910

PLUMAGE