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THE INDUSTRIAL "CONTROL CHART" APPLIED TO THE STUDY OF EPIDEMICS

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Epidemiologists and health officers have always made use of statistical methods and it is routine with them to graph the incidence of disease as a simple and effective method for discovering and showing changes in this incidence. However, the ordinary graph of incidence against time contains no criterion on which to base a judgment as to when the incidence first rises above what may be considered a normal level. This is especially to be desired for those diseases characterized by a fairly constant, long-continued, low incidence which only occasionally flares up to epidemic proportions. This paper describes such a criterion.

In recent years there has been developed a powerful new statistical tool known as the "control chart" which industry has welcomed and is putting to new uses almost daily. This has proved to be an important aid to industrial management in maintaining constant quality of product because of the fact that it early shows up any tendency to produce an undue proportion of defective articles or of articles falling outside of acceptable limits, whether in length, weight, or any other measurable property. Somewhat different procedures are followed in the treatment of data dealing with defective articles as compared with those arising from measurements, but the final results are similar. When properly applied to suitable data the chart provides a continuous, day by day, up-to-the-minute graphic analysis so that any significant deviation from normal, satisfactory operation becomes immediately apparent, while, at the same time, unimportant deviations are clearly designated as such.

The health officer, striving to see ahead as he extends his daily or weekly graph of the incidence of a transmissible disease may well adopt such an industrial tool. The control chart has previously been applied to another biological problem (*7*), and this led to consideration

of the possibility that the method might have an important application in the analysis of epidemiological data. A study was made of the records of acute anterior poliomyelitis in California, and this study appears to show clearly that the method may become of use in more ways than one to the health officer and epidemiologist. The study was started shortly before the epidemic of 1943 and, on the basis of control chart evidence, the existence of the epidemic was shown several weeks before it was otherwise apparent.

Details as to the principles and methods of this kind of analysis are given in the literature (*1*) (*2*) (*3*), and it must suffice here to state briefly the fundamental characteristics of such charts and, to show how those used in this study were prepared.

The source of data is the report of incidence contained in the Weekly Bulletin of the State Department of Health (now published under the title "California's Health") for the years 1929 to 1943 inclusive. The data are given in table 1. The first week for each year is the first week ending in the new year and may, therefore, in the extreme cases, include the days December 26 to January 1, or the days January 1 to January 7, inclusive. This is sufficiently accurate for the immediate purpose and is convenient because of the way in which cases are reported in the Bulletin.

The control charts are made by plotting points on ordinary coordinate paper with time as the horizontal scale (the X-axis) and the number of new cases reported each week as the vertical scale (the Y-axis). Two horizontal lines above the X-axis distinguish this control chart from the usual graph of the health officer. One of these lines, designated by the symbol $\overline{X}$ ("bar X" or "X bar") corresponds to the mean number of the new cases reported each week for selected periods unmarked by epidemics and therefore is regarded as normal for the purposes of this study. The second line, designated by the symbol U. C. L., is known as the upper control limit and represents a calculated value such that the odds against its occurrence by chance during a nonepidemic period are approximately 200 to 1. (See figs. 1 and 2.)

The selection of "nonepidemic" periods was made primarily on a subjective basis but most epidemics of poliomyelitis are so well marked that there could be little disagreement as to which were and which were not epidemic periods. The first selection was of the three consecutive years, 1931 to 1933, during which nothing remotely resembling an epidemic occurred (fig. 1). Later, other similar but shorter periods were added and the first 10 weeks of 1931 were eliminated because it seemed probable that these had been affected by the obvious epidemic of 1930. In general a period was not considered to be nonepidemic if there was any doubt as to its proper designation. The bias, if any, is conservative and it is believed that the application

TABLE 1.—*Weekly incidence of acute anterior poliomyelitis (number of reported cases) in California, 1929 to 1943, inclusive*

Week	1929	1930	1931	1932	1933	1934	1935	1936	1937	1938	1939	1940	1941	1942	1943
1	1	2	14	5	3	2	16	7	4	5	0	9	3	2	2
2	3	3	8	3	1	8	15	6	3	2	3	14	1	1	10
3	1	3	11	3	2	4	14	1	7	3	1	7	1	4	7
4	3	2	7	1	3	4	10	2	2	1	0	11	3	1	1
5	1	7	8	1	1	3	12	1	2	3	0	9	1	3	10
6	4	0	9	3	1	10	10	2	2	4	2	2	3	1	3
7	3	1	6	2	1	3	13	9	0	3	2	3	3	4	5
8	2	0	6	3	0	5	10	1	1	3	0	3	3	4	8
9	2	2	4	3	0	5	11	4	0	1	2	4	2	2	3
10	0	3	12	5	2	2	12	1	3	2	1	1	2	2	2
11	3	4	3	7	1	6	9	4	1	1	1	3	1	2	7
12	8	2	2	3	3	7	5	5	0	6	0	3	2	3	2
13	0	3	2	0	2	3	6	4	0	0	0	3	1	6	1
14	1	4	3	4	3	7	5	1	3	2	0	4	1	0	5
15	0	3	4	0	3	8	7	4	4	1	3	2	0	0	5
16	1	0	5	3	3	10	2	4	4	2	0	2	1	2	5
17	1	3	6	4	0	11	4	3	2	0	4	4	4	1	5
18	1	6	4	2	1	14	3	1	4	0	4	2	3	1	8
19	3	13	0	2	1	21	7	4	5	1	2	5	3	2	12
20	5	15	4	4	4	37	3	6	3	0	3	4	3	0	14
21	3	13	2	2	2	96	6	4	2	3	5	9	5	1	13
22	3	18	3	1	0	160	3	5	5	3	18	9	7	3	13
23	3	32	10	3	2	284	9	3	6	2	5	14	5	1	35
24	4	46	6	1	1	281	20	2	4	2	15	11	6	1	27
25	5	52	7	2	5	345	32	6	7	1	14	15	8	2	56
26	5	80	3	5	4	299	33	7	9	2	17	34	7	2	62
27	4	92	6	4	3	277	31	8	8	2	17	16	2	3	74
28	5	97	6	3	3	218	29	8	11	4	46	29	8	4	105
29	4	96	3	2	5	158	36	7	19	2	52	16	1	7	101
30	4	88	5	4	4	119	22	13	22	9	45	18	9	3	121
31	2	76	4	6	5	87	26	16	38	6	58	18	8	3	149
32	3	60	8	4	3	110	31	8	36	1	49	14	7	3	122
33	7	51	4	5	1	80	43	8	38	6	58	23	6	6	100
34	11	60	4	6	3	73	34	15	36	11	49	16	16	9	168
35	7	62	6	2	2	72	26	12	47	7	61	13	7	12	147
36	4	49	9	12	3	55	23	26	40	4	45	21	8	23	130
37	8	62	11	4	4	72	22	15	38	5	51	12	8	11	112
38	6	68	9	3	4	56	29	17	46	3	40	9	10	13	148
39	6	76	10	3	5	43	26	20	41	2	58	16	10	4	120
40	1	70	6	5	4	52	30	18	32	8	47	10	6	17	108
41	5	76	8	5	4	42	26	10	17	1	31	10	9	10	76
42	5	85	8	3	8	38	20	15	31	3	34	10	6	16	75
43	0	70	6	4	5	30	20	8	19	2	35	8	4	19	88
44	2	60	4	4	4	17	11	4	18	0	21	9	4	24	69
45	3	46	3	5	5	31	8	11	26	2	23	2	6	8	63
46	3	44	5	6	4	22	12	9	14	0	27	2	2	16	76
47	3	27	5	2	4	23	17	9	12	2	25	7	4	23	60
48	3	28	3	1	4	25	4	9	13	0	16	3	9	14	28
49	3	13	8	3	7	21	6	7	10	2	20	5	2	19	29
50	1	14	3	2	6	14	7	13	2	4	7	3	7	13	18
51	1	19	3	3	1	9	10	6	5	1	8	1	3	7	18
52	2	13	1	2	3	28	5	3	0	1	3	2	1	13	9
53	------	------	------	0	------	------	------	------	------	0	------	------	------	------	11

of the standards based on these selected periods to the entire series of data shows that the standards are reasonable.

The upper control limit is commonly determined by adding to the mean, or $\bar{X}$ value, a sum equal to three times the standard deviation of the individual items as they occurred over a period of normal operation. When thus determined the odds against the chance occurrence of a value at this level, or above it, are approximately 740 to 1—assuming, of course, that the distribution is actually of the type com-

monly called the normal distribution. These odds are higher than is considered desirable in the application of the control chart to epidemiological study. Furthermore, these data do not conform to the normal distribution but do form a close approximation to what is known as a Poisson distribution. (See below and reference (*6*), paragraph 10.46.) Therefore, odds of 200 to 1 were selected as a standard and the U. C. L. value corresponding to these odds has been determined from the convenient graph given by Working (reference (*5*), plate 3, probability limit 0.995). Calculated in the usual manner the $\overline{X}$ value for nonepidemic periods comes out at the level of four new cases per week and the upper control limit (U. C. L.) is determined as 10 per week.

As typically applied in industry a "lower control limit" is also needed but it has no significance in such a case as the one under consideration in which the interest is, for the present at least, entirely in determining significant deviations from normal in the direction of increased incidence.

The assumption that the data under consideration actually represent an acceptable approximation to a Poisson distribution has been tested by the "chi-square test of goodness of fit" (reference (*4*), p. 77 ff.), and it has been shown that for periods unaffected by epidemics in either the first or the second 20 weeks of any one year the assumption is justified. Furthermore, if all of the data are combined for nonepidemic periods falling within the second 20 weeks of the years studied, the resulting frequency distribution forms an exceedingly good approximation to a Poisson except for the fact that there are a few more weeks showing exceptionally high incidence than are called for in a true Poisson. For all practical purposes, it is believed that the assumption that the data are essentially Poisson distributions is justified and that interpretations will not be materially distorted.

The theory is, of course, that so long as the points remain below the upper control limit a "constant cause system" is operating and that nothing unusual or untoward has occurred, the observed, slight variations being due to chance. When points fall above that limit it may be assumed fairly that some new cause is operating. In industry this is taken to mean that the process is "out of control" and that a "basis for action" exists at the moment of this early warning.

It is especially to be noted that it is essential to the control chart method that the standards, $\overline{X}$ and U. C. L., be based on a distribution of data that shows the characteristics of a random sample. The mean and the upper control limit are used as a basis for differentiating between random variations and those due to "assignable causes" and it is obvious that, unless these standards themselves are based on random sampling, the fundamental principle of the control chart method is violated. Only when the standards are derived from essentially

random sampling can one interpret points falling beyond the control limits as "out of control." The normal, the Poisson, and the binomial are the best known ideal distributions and it is a reasonable requirement that data used to determine standards should conform approximately to one or another of these three types (reference (*6*), ch. 10).

If, now, table 1 is examined it will be seen that the standards of this study conform to this principle. In the entire 15 years, during periods that are clearly not affected by oncoming or receding epidemics, there were very few individual weeks in which the reported incidence was above the upper control limit of 10, and in each instance the incidence was above the U. C. L. for the one week only; it dropped the following week to within the normal levels. In every case in which the incidence rose above the U. C. L. and remained there for two or more successive weeks the rise proved to be the beginning of an epidemic—either one of major proportions or what is considered to be a minor epidemic. Therefore, it may be concluded that, if the incidence of poliomyelitis in California rises above 10 per week and remains above this level for two successive weeks, an epidemic exists; and that any available measures should be taken to prevent the further spread of the disease. Undoubtedly, any marked increase in incidence would be noted by the epidemiologist even without the aid of the control chart, but the chart distinguishes immediately the significant from the nonsignificant variations in incidence.

It is well known that poliomyelitis epidemics in the United States usually develop during the summer and fall and this is clearly shown to have been true in California. Only in 1934 and 1943 was the epidemic clearly established before the twentieth week. In addition, the data show a slight but significant tendency for the incidence during nonepidemic periods to be higher during the summer and fall than during the winter and spring. This is true even in years that are entirely free from epidemic occurrence. These facts are pertinent to a consideration of the periods that have been selected as normal and from which have been calculated the mean and the upper control limit.

Preliminary examination of the data showed that the lowest level of what may be called normal incidence prevailed during the first 20 weeks of the year (up to approximately the end of May); that a somewhat higher incidence prevailed for the next 20 weeks (up to about the end of September); and that the last 12 weeks of the year were marked by a generally falling incidence, returning to the lower level of the first 20 weeks. Therefore the mean incidence was determined for the first 20 weeks and for the second 20 weeks separately for those periods that appeared to be normal and unaffected by either past or approaching epidemics. Periods, none of which were of less than 8 weeks' duration, were used as normal. During the 15 years of the record there was a total of 213 weeks that were considered normal and

that fell within the first 20 weeks of the year; and for these the mean incidence was 2.31 cases per week. Within the second 20 weeks of the year there were only 80 weeks during the years of record that were considered normal, because of the fact that there were so few extended periods during this part of the year that were unaffected by epidemics and could be considered as normal. The mean incidence for these 80 weeks was 3.98 cases per week. When these two means (2.31 and 3.98) are compared by applying the usual test for the significance of the difference of two means (reference (*4*), p. 103 ff.) it is seen that the chance of a difference as great or greater than the one observed being due purely to the "errors of random sampling" is extremely small.

Because so many of the epidemics first show up during the second 20 weeks of the year, and because this is the more conservative procedure, the mean for the second 20 [weeks] (approximated fairly by by 4) has been used as the standard. The line of the mean, $\overline{X}$, is therefore drawn at this level above the X-axis. Since the data are of a type that justifies the assumption that the distribution approxi-

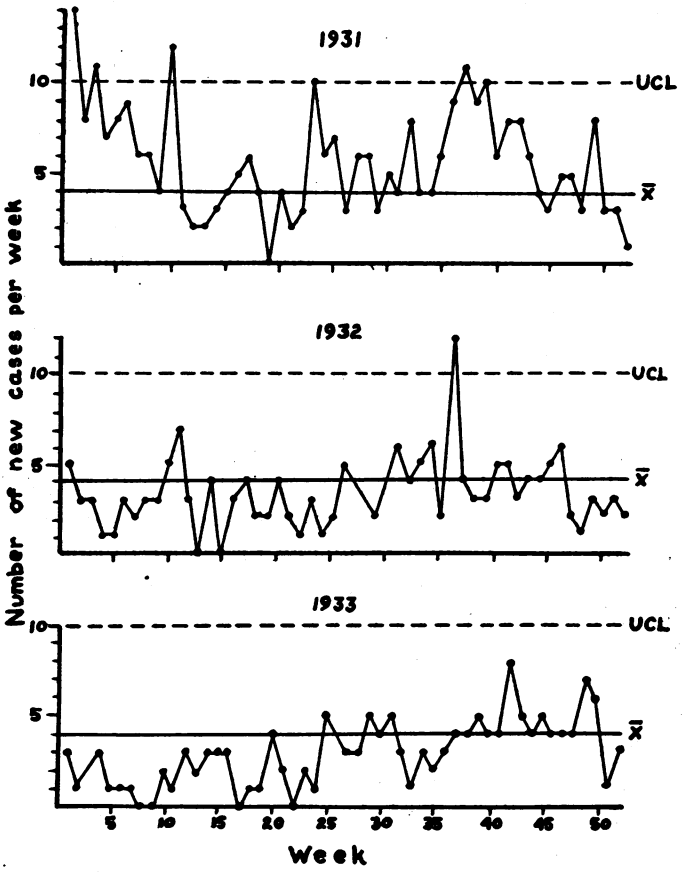

FIGURE 1.

mates a Poisson series, the upper control limit has been determined from figure 4 in reference (*1*), page 20. For a mean of 4 this sets the U. C. L. at 10, with, as has been said, odds of about 200 to 1 against this value being exceeded by chance.

Figure 1 presents such a control chart applied to the 3 years, 1931 to 1933, that were originally selected as the standard, nonepidemic period. The upper panel of figure 2 presents the control chart on the same scale as in figure 1 for the early months of 1943 but this scale is too large to show conveniently the incidence during the epidemic that characterized 1943 after the eighteenth week. The data for the entire year are therefore given with a reduced scale in the lower panel.

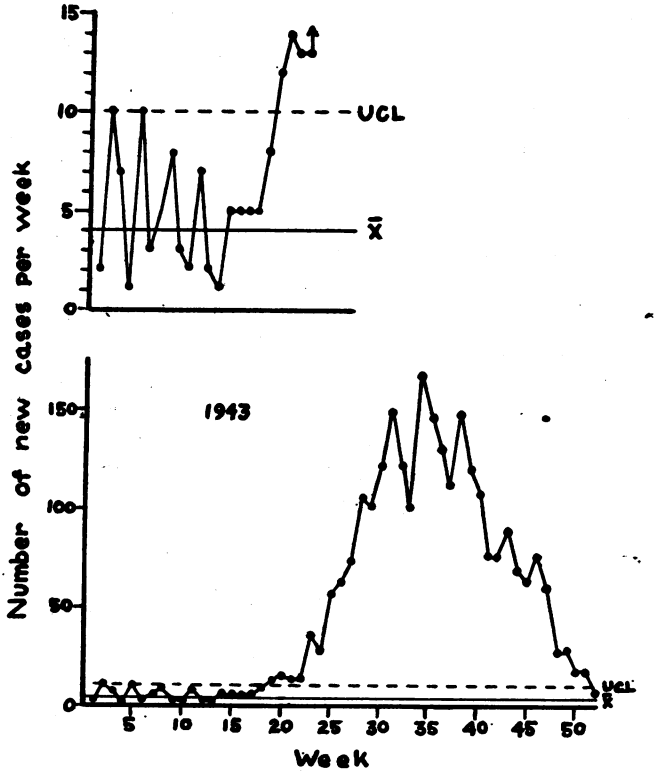

FIGURE 2.

The way in which an epidemic is forecast by the control chart is illustrated in figure 2. Immediately preceding the epidemic there were 4 weeks in which the incidence ranged from 12 to 14 cases—not high enough to cause apprehension as seen on the ordinary graph yet clearly above the safety zone as shown on the control chart. Following this the incidence jumped to 35 in the next week and from then on the epidemic continued until nearly the end of the year. The authors noted these earliest evidences of an epidemic but had

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just begun the study and were doubtful of the significance of the observation.

A refinement of the simple technique described above is possible and may be important when there are marked seasonal fluctuations in incidence of a disease. Instead of using a simple arithmetic mean as the standard, a cyclic curve of trend may be fitted to the data and this curve used as the standard of comparison. This fitting may be done by several methods such as the moving average or the sine-cosine curve. (See Croxton and Cowden (*9*) for these methods.) This fitted curve gives, in effect, the average number of new cases for each week, taking into consideration the seasonal variation. This curve may be used as the $\overline{X}$ line. From the calculated values of the curve and figure 4 in reference (*1*), probability=0.995, the upper control limit for each week can be determined just as when the simple mean is used.

To illustrate this a sine-cosine curve has been fitted to the data and for 1942 and the first 23 weeks of 1943 (fig. 3). The equation of the $\overline{X}$ line is:

$$\overline{X}=3.613-1.622 \sin (6.923\ W)^\circ-0.795 \cos (6.923\ W)^\circ$$

in which, as before, $\overline{X}$ is the line of trend of weekly incidence and W is the number of the week. In this case there is little if any difference in interpretation of the significance of variations whether taken from the arithmetic mean or the line of trend.

Another refinement that may be required is to remove the effect of a long-time (secular) trend such as might come from an increase in population. This may be done by standard methods but it is beyond the scope of this paper to go into this. Schilling (*8*) has made excellent use of both of these refinements.

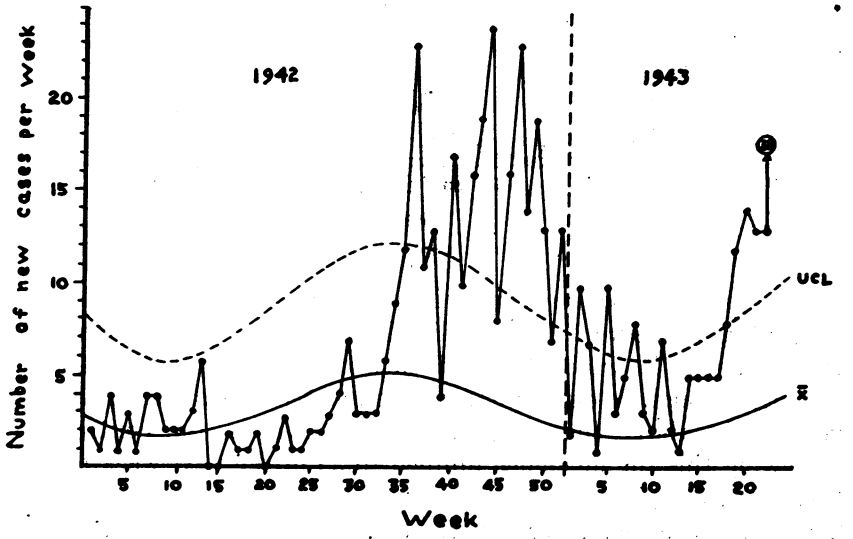

FIGURE 3.

In both figures 2 and 3 it will be noted that the incidence was continually above the mean ($\overline{X}$) during 5 weeks preceding the week in which the incidence rose above the upper control limit. Such patterns, while not conclusive, may well be cause to suspect that an epidemic is in the making and, on this basis, preliminary steps might be justified that would provide better control if an epidemic does develop. As applied in industry, patterns of this sort, even though they stay within the control limits, are interpreted as indicating that all is not well and action is taken in order to prevent the process from going clearly "out of control." When present they strengthen materially the interpretation that points falling above the upper control limit are significant of an unfavorable change in the process. It appears, in short, that, as applied to epidemic diseases, advance information is to be found between the $\overline{X}$ and the U. C. L. lines that can provide a warning to the health officer and a lead to the epidemiologist—information pointing toward the existence of the epidemic condition even before the incidence has risen to the level of the upper control limit. This feature alone would seem amply to justify the use of the control chart principles in maintaining a graphic record of the incidence of diseases subject to epidemic spread.

"Minor epidemics" were identified as periods of several weeks' duration during which the incidence is distinctly higher than during those periods that were considered normal, but that neither last as long nor show the still higher incidence of the typical epidemic. It is not implied that there is any sharp line of distinction between these minor epidemics and typical epidemics, but both are characterized by the fact that the general level of incidence remains for weeks or months above the upper control limit established for nonepidemic periods.

The significance of these minor epidemics is not known but it is believed that they would be worthy of careful investigation because of the light they might throw on the factors involved in the development of the more typical epidemics. It might be found that these minor epidemics are local affairs that, for some reason, do not spread generally throughout any considerable portion of the population of the State. On the other hand, it might be found that they represent only a general, widespread high incidence that does not attain epidemic proportions even in restricted localities. The epidemiological implications would be quite different if one or the other of these two possibilities were affirmed. If the increased incidence is due to localized but intensive epidemics, it would indicate the existence of conditions inhibiting the spread of the disease from one locality to another. But if these minor epidemics represent a general higher level of incidence, it would point toward the existence of general, widespread factors that, perhaps, affect the susceptibility of a con-

siderable part of the population, the virulence of the virus, or the means of transmission.

Other features of the natural history of poliomyelitis epidemics are also indicated by these charts. The fact that there is a distinct difference in the normal level of incidence during the second 20 weeks of the year as compared with the first 20 weeks of the year has already been noted. There is some indication of different normal, nonepidemic levels in different years. Some preliminary work also has been done that indicates that there is a difference in the course of epidemics in the southern as compared with the northern parts of California, with the line drawn at the point where the Tehachepi Range divides the State into two fairly well-marked geographic and ecologic sections. A more detailed study of these and other characteristics of the incidence of poliomyelitis in California by means of the control chart would seem to offer possibilities of discovering facts regarding the ecological factors affecting the spread of the disease and of providing a basis for action that might effect a better control.

The following quotation from the recent book, Virus as Organism, by F. M. Burnet (reference (*10*), p. 68) is pertinent to this thought: "But, whatever increase in knowledge and understanding the future may bring, the study of poliomyelitis will still demand an ecological approach. Infantile paralysis is a changing disease that has not yet reached a standardized expression, and its manifestations may continue to change in this second half-century of its existence as an epidemic disease. Only some dynamic interpretation based on the changing requirements for survivial of a virus whose environment is being altered by its host species' changing social habits can give an adequate comprehension of the phenomena. Such an ecological approach will have the additional merit of opening up new lines of fruitful investigation which we may hope will eventually allow an adequate formulation of the history and the natural history of poliomyelitis."

The results of this graphical analysis show, it is believed, that the industrial control chart may prove to be of general usefulness in many kinds of epidemiological work. When actually applied to epidemiological problems, it may be expected that various refinements in presentation and interpretation will be made that will increase this usefulness. As applied especially to acute anterior poliomyelitis, there is reason to hope that a more detailed statistical analysis of incidence will serve to throw further light on the causes of the epidemics as such. If the method is useful, as it is believed to be, in the study of such a disease as poliomyelitis, which has rather more than its share of unknowns, one may anticipate that it will be found useful in other like studies in the field of public health and epidemiology and even, perhaps, in the analysis of vital statistics in still wider fields.

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AN EVALUATION OF THREE PLAGUE VACCINES AGAINST INFECTION IN GUINEA PIGS INDUCED BY NATURAL AND ARTIFICIAL METHODS [1]

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The protective value of many prophylactic injections against communicable diseases of man must be estimated from the reactions obtained by their application to animals which are not the natural subjects of the respective diseases, and in which the pathogenesis of the artificially induced infection is not closely comparable to that of the disease acquired by man through natural channels.

Bubonic plague is a disease of rodents and its pathogenesis in these animals and in man is so similar when it is acquired by the bites of infected fleas that an attempt to appraise the protective value of vaccines against the infection acquired by guinea pigs through natural, as well as through artificial methods, should contribute evidence of their probable value in protecting man.

The guinea pig was selected as the test animal because it is very susceptible to infection with plague, and usually dies when infected. Furthermore, fleas which are vectors will feed on it with avidity, and the animal lends itself to easy manipulation under the precautions which are desirable. The rat flea (*Xenopsylla cheopis*) was used as

[1] From Headquarters, Plague Laboratory, Plague Suppressive Measures, San Francisco, Calif. This paper was scheduled for publication in Public Health Reports in the issue of June 11, 1943. Because of the subject matter the paper was withheld from publication at that time.

the experimental vector because of its broad geographical distribution and the general acceptance of its capacity as a natural vector.

The vaccine preparations tested were made of *Pasteurella pestis* cultures which were killed by treatment with phenol or formalin The phenolized suspensions were precipitated with ethyl alcohol or with both alcohol and alum. The choice of these preparations resulted from a number of experiments with both white mice and guinea pigs as test animals. Results obtained in these previous experiences indicated that vaccines prepared from cultures of *P. pestis* which were incubated at temperatures lower than 37° C. did not afford as good protection as those in which the organism was grown at 37° C. or higher. A temperature of 39° C. was chosen for incubation because of the development of the larger envelope about the organisms grown on blood agar at this temperature, and because of their close morphological resemblance to the organisms grown in animals at 39° C. to 40° C. The interval of 21 or more days between the first dose of the vaccine and the infecting dose seemed necessary to obtain protection, and the divided dose of vaccine appeared to produce slightly better results. Alcohol precipitation was selected because of favorable reports on its use in the preparation of typhoid and tularemia antigens. The details of preparation and the dosage administered are appended.

Groups of 10 guinea pigs of about 300 gm. weight, obtained from a producer, were given the respective vaccines subcutaneously and 3 weeks later were subjected from time to time during a period of a month to the bites of infected fleas; or were given on the twentieth or twenty-first day, a quantity of *P. pestis* a thousandfold larger than that given control animals which were untreated. The specificity of the protection was compared with that afforded by United States Army typhoid vaccine. The details of the tests and results are recorded in the protocols appended.

The fleas were infected by feeding on a guinea pig with an advanced stage of septicemia which had been induced by the inoculation of a strain of *P. pestis* which was heterologous to that used in the vaccines. Each flea was preserved and fed separately and each was used in the tests when it was believed likely to transmit the infection. Those more likely to transmit the infection have usually developed an obstruction or "block" of the proventriculus occasioned by the growth of a colony of the bacteria in it. Such fleas can be recognized by their restless behavior when applied to the skin for feeding, and by their failure to engorge. They seldom live more than a few days after they have become blocked, and in an effort to be assured that opportunity for transmission had been provided, it was necessary to test a large number of those which were probably infected.

Fleas which killed any of the animals with plague by biting were classified as "vectors." Those which did not kill by biting, but which were found to be infected by producing the disease in a mouse when triturated in saline and injected subcutaneously were classified as "infected." However, the tests which were accepted as satisfactory were those in which a proved vector was used, except in one instance in which the results were well defined, but the flea died before being placed on a control animal. Hence, there were animals among those receiving vaccine injections which developed clinical plague and recovered but which were not included in the statistical evaluation of the protection.

The clinical criteria of successful transmission has been determined by several years of experience with flea transmission. Both vectors and infected fleas produced such clinical evidence of having produced plague by biting. This evidence consists of a red puncture point which is surrounded promptly or within 15 to 30 minutes by a red areola of from 3 to 5 mm. in diameter. The appearance of the red areola or spot is followed within 24 to 72 hours by the development of a red papule at the site, and the subsequent enlargement of contiguous lymph nodes with accompanying fever. Among nonimmune guinea pigs these developments are followed in nearly all instances by septicemia and death within the next 2 weeks. Neither the red spot, papule, nor adenopathy have developed after the bites of noninfected fleas under experimental conditions.

The tests were completed by a pathological and bacteriological examination of each animal at necropsy. Those which recovered or did not develop clinical plague were killed 20 or more days after their exposure to the flea bites, or were injected with a suspension of the virulent culture which was homologous with that used to infect the fleas. All fleas which had not proved themselves vectors were examined to determine whether they were infected.

The protection afforded the animals which received the vaccine injections, and were exposed to the bites of vectors, or to both vectors and infected fleas is summarized in table 1.

TABLE 1

Preparation used	Number animals tested	Clinical plague	Death with plague
Alcohol-precipitated vaccine	8	8	0
Alcohol-alum-precipitated vaccine	5	4	0
Commercial vaccine	8	7	3
Typhoid vaccine	8	7	6
Untreated	15	13	11

The evolution of the lesions produced in the immunized animals which recovered was remarkably similar to that which occurs in human cases which recover. The infiltration and edema of the papule

gradually disappear within a few days, and the site is marked by a hairless scar often surmounted by a small scale. The course of the lymphadenopathy may be a gradual resolution of the edema and infiltration about the node and the slow progressive diminution of its size to that which is nearly normal; it remains definitely hard. On section, the center of these small hard nodes is sometimes colliquated. In some cases the acute inflammation of the affected node may subside, but the node remains large and becomes larger and soft. Later, a fistula may form in the skin and the abscessed node drain. During the acute phases of the infecton the animals become thin, lose the tone in their muscles, and occasionally lose much of their hair; recovery of their general health is rather slow.

Among the nonimmunized animals, the site of the papule is prone to ulcerate if death does not occur within a few days. If the course of the disease is slow, the buboes remain large and infiltrated, but seldom become soft or ulcerated, and the animal becomes much weaker and thinner before death.

A second series of guinea pigs, consisting of 5 groups of 10 animals each, was given, respectively, a divided dose of alcohol-precipitated, alcohol-alum-precipitated, and commercial plague vaccine, typhoid vaccine, and a single dose of alcohol-alum-precipitated vaccine. A control group of 12 animals received no treatment. All the animals were inoculated subcutaneously 3 weeks later with large doses of a suspension of a heterologous strain of virulent *P. pestis*. The test animals, including those receiving typhoid vaccine, were given doses a thousandfold larger than the doses given to untreated controls. The results obtained among this series are indicated in table 2.

TABLE 2

Preparation used	Animals tested	Death with plague
Alcohol-precipitated (vaccine)	10	2
Alcohol-alum-precipitated (vaccine) (divided dose)	10	4
Alcohol-alum-precipitated (vaccine) (single dose)	10	3
Commercial plague vaccine	10	6
Typhoid vaccine	10	9
Controls (no treatment)	12	9

A pathological and bacteriological examination was made at necropsy of each animal which died, or which survived and was killed 3 weeks after inoculation.

The two series of tests indicate that plague vaccines prepared by either of the methods adopted will afford much protection to guinea pigs against plague which is acquired through natural or artificial methods, and that the protection induced is specific insofar as the comparision was made with that which may be conferred by typhoid vaccine. Each series shows that a better protection is afforded by a phenolized and alcohol-precipitated suspension of a North American

ground squirrel strain of *P. pestis* than by a formalinized suspension of an East Indian strain (Commercial). There is no evidence in these tests that the additional precipitate obtained by alcohol and alum increased the protective value of the vaccine.

Impressions gained in the conduct of these and other experiences suggest that an interval of 25 or more days between the final protective injection and the infecting dose may result in an even greater degree of protection. Also, it appears that doses of a relatively large number of the bacteria are necessary, and that the degree of protection bears some relation to the size of the dose, although it is not proportionate.

The protection developed in guinea pigs against natural infections of plague by the use of specific vaccines suggests that similar preparations may be efficacious in man.

Details of Preparation of Plague Vaccines

Alcohol Precipitate

A. Strain B 3035 of *P. pestis* isolated from ground squirrel, Wyoming, July 1940, and maintained on 5-percent blood hormone agar slants at approximately 5° C. Immediately previous to use, the strain was passed through a guinea pig and recovered from the heart blood. The seed cultures were sown on 5-percent blood tryptose beef-heart agar and incubated at 39° C. for 40 hours. The growth was harvested in 5-percent phenolized normal saline and allowed to stand at 5° C. for 20 hours. The number of organisms per cubic millimeter was estimated by turbidity standards, checked against freshly prepared barium sulfate standards, the specified content of typhoid vaccine of recent manufacture by the United States Army, and by Wright's counting method.

B. Two volumes of 95-percent alcohol were added to the phenolized saline suspension and held overnight at 5° C. This was centrifuged until a clear supernatant was obtained, the supernatant discarded, the sediment washed in saline solution, centrifuged, and resuspended in saline and merthiolate (1–7,500) to make the original volume of the phenolized saline suspension.

This constituted the alcohol-precipitated vaccine.

Alcohol-and-Alum Precipitate

A. The same as for alcohol precipitate.

B. Two volumes of 95-percent alcohol were added to the phenolized saline suspension and held overnight at 5° C. Two and seven-tenths cubic centimeters of 10-percent sodium bicarbonate and 25 cc. of 4-percent potassium alum per 100 cc. of volume were added and the mixture allowed to stand at 5° C. for 5 hours. The supernatant was removed by centrifugation and the sediment resuspended in saline and held at 5° C. for 40 hours, centrifuged, and the suspension diluted

to the original volume of the phenolized saline suspension with saline and merthiolate (1–7,500).

This constituted the alcohol- and alum-precipitated vaccine.

Tests for sterility were made on the phenolized saline suspension and on the finished precipitated products.

Commercial

Indian Rat Strain No. 337 *(Hooper Research Laboratories, California).*—The strain stock should be kept in 5-percent blood (rabbit or guinea pig) agar slants, in sealed tubes at a temperature of 5° to 8° C. and their pathogenicity should be tested immediately previous to use in the manufacture of large stocks of the vaccine.

Seed cultures are grown in hormone or hormone-sulfite broth [2] for from 48 to 72 hours at 27° to 30° C. The broth cultures of individual strains are used to seed hormone or hormone-sulfite agar in Blake bottles. The bottles are incubated for 48 hours at 30° C. and during the period of incubation are tilted from time to time to accomplish uniformity in the spread of the surface growth. At the end of the period of incubation, the surface growth is washed down with a 0.25 percent neutral formalin in buffered saline. The suspension so prepared is allowed to stand at room temperature from 6 to 12 hours before further manipulation is attempted. Usually it is then found to be sterile, but check tests should be made by planting 1-cc. volumes in each of several hormone broth tubes which should be incubated for from 48 to 72 hours at 30° C. In the meantime the suspension is pipetted off and, if necessary, strained through a cotton gauze filter to remove small particles of agar. A count is then made by the direct count technique, or by other methods of equivalent validity. The removal of the formalin can be facilitated by the use of a vacuum pump and by placing the flasks of suspensions in a water bath at 37° C. The standard strength of two thousand million organisms per cubic centimeter should be obtained by suitable dilution with an approved disinfectant of proper strength in buffered saline solution (0.5 percent phenol in buffered saline). If more than one strain is used in the production of the vaccine, the final product should contain equal portions of the respective stock suspensions.

United States Army Typhoid Vaccine

Stock of current manufacture.

Challenge strain

W496, isolated from ground squirrel, Washington, May 1940. The inoculum was prepared by incubating each of five transfer cultures in blood broth for 24 hours at 30° C. A guinea pig was inoculated with one-thousandth of a loop of the final culture,

[2] Meyer, K. F., and Batchelder, A.; Selective mediums in the diagnosis of rodent plague. J. Infec. Dis. 39: 370-385 (Nov. 1926).

and upon the death of the animal the organism was recovered by plating the heart blood on blood agar. Checks of identity and purity of the cultures were made with differential media.

PROTOCOL No. 1.—*The protection of guinea pigs treated with vaccines prepared from* Pasteurella pestis *against bites of infected fleas*

[P=plague; D=death; S=survival; No P=plague not found]

Vaccine preparation	Vaccine: Guinea pig No.	Vaccine: Amount in billions	Vaccine: Treatment dosage: Date injected	Vaccine: Treatment dosage: Amount in billions	Vaccine: Date injected	Challenge: Flea bites: Vector	Challenge: Flea bites: Infected	Results: Clinical	Results: Deaths, survivals	Results: Necropsy	Remarks
			1945		*1945*						
Alcohol precipitate.	11	1.5	Feb. 9	1.5	Feb. 15	0	1	P	S	No P	Accepted without control.
	12	1.5	Feb. 9	1.5	Feb. 15	2	2	P	S	No P	Killed 30th day.
	13	1.5	Feb. 9	1.5	Feb. 15	3	7	P	S	No P	Killed 20th day.
	14	1.5	Feb. 9	1.5	Feb. 15	1	0	P	S	No P	Killed 30th day.
	15	1.5	Feb. 9	1.5	Feb. 15	1	0	P	S	No P	Died 22d day.
	16	1.5	Feb. 9	1.5	Feb. 15	----	1	No P	S	No P	No test (no control).
	17	1.5	Feb. 9	1.5	Feb. 15	1	0	P	S	No P	Killed 40th day.
	18	1.5	Feb. 9	1.5	Feb. 15	1	2	P	S	No P	Died 7th day.
	19	1.5	Feb. 9	1.5	Feb. 15	5	4	P	S	No P	Killed 20th day.
	20	1.5	Feb. 9	1.5	Feb. 15	0	1	No P	S	No P	No test (no control).
Alcohol-and-alum precipitate.	[1] 41	1.5	Feb. 9	1.5	Feb. 15	0	5	P	S	[1]No P	No test (no control).
	42	1.5	Feb. 9	1.5	Feb. 15	1	0	P	----	No P	Death 5th day.
	43	1.5	Feb. 9	1.5	Feb. 15	0	0	----	----	No P	No test.
	[1] 44	1.5	Feb. 9	1.5	Feb. 15	0	2	P	S	[1]No P	No test (no control).
	45	1.5	Feb. 9	1.5	Feb. 15	1	0	P	S	No P	Killed 30th day.
	46	1.5	Feb. 9	1.5	Feb. 15	0	4	No P	S	No P	No test (no control).
	47	1.5	Feb. 9	1.5	Feb. 15	2	3	P	S	No P	Killed 21st day.
	48	1.5	Feb. 9	1.5	Feb. 15	1	0	P	S	No P	Killed 30th day.
	[2] 49	1.5	Feb. 9	1.5	Feb. 15	1	3	No P	S	(2)	Injected.
	50	1.5	Feb. 9	1.5	Feb. 15	0	5	P	S	No P	No test (no control).
Commercial----	81	1.5	Feb. 9	1.5	Feb. 15	0	2	No P	S	No P	No test (no control).
	82	1.5	Feb. 9	1.5	Feb. 15	2	1	P	S	No P	Killed 26th day.
	83	1.5	Feb. 9	1.5	Feb. 15	1	1	P	S	No P	Killed 21st day.
	84	1.5	Feb. 9	1.5	Feb. 15	2	1	P	D	P	
	[3] 85	1.5	Feb. 9	1.5	Feb. 15	2	3	No P	S	[3]No P	Injected.
	86	1.5	Feb. 9	1.5	Feb. 15	1	1	P	S	No P	Killed 32d day.
	87	1.5	Feb. 9	1.5	Feb. 15	1	1	P	D	P	
	88	1.5	Feb. 9	1.5	Feb. 15	2	0	P	S	No P	Killed 45th day.
	89	1.5	Feb. 9	1.5	Feb. 15	2	0	P	D	P	
	90	1.5	Feb. 9	1.5	Feb. 15	0	0	----	----	----	No test.
Typhoid----	101	1.5	Feb. 9	1.5	Feb. 15	1	0	P	D	P	
	[4] 102	1.5	Feb. 9	1.5	Feb. 15	0	4	P	S	[4]No P	No test (no control).
	103	1.5	Feb. 9	1.5	Feb. 15	1	1	P	S	No P	Killed 21st day.
	[5] 104	1.5	Feb. 9	1.5	Feb. 15	0	0	----	----	(5)	No test.
	105	1.5	Feb. 9	1.5	Feb. 15	1	0	P	D	P	
	[6] 106	1.5	Feb. 9	1.5	Feb. 15	1	3	No P	S	[6]No P	Injected.
	107	1.5	Feb. 9	1.5	Feb. 15	1	1	P	D	P	
	108	1.5	Feb. 9	1.5	Feb. 15	1	0	P	D	P	
	109	1.5	Feb. 9	1.5	Feb. 15	3	3	P	D	P	
	110	1.5	Feb. 9	1.5	Feb. 15	1	1	P	D	P	

[1] Recovered from clinical plague, and was injected with virulent culture: Survived, necropsy, no plague.
[2] Did not develop clinical plague and was injected with virulent culture: Sick, necropsy, plague.
[3] Did not develop clinical plague and was injected with virulent culture: Survived, necropsy, no plague.
[4] Recovered from clinical plague and was injected with virulent culture: Survived, necropsy, no plague.
[5] Did not develop clinical plague and was injected with virulent culture: Death, necropsy, plague.
[6] Did not develop clinical plague and was injected with virulent culture: Survived, necropsy, no plague.

PROTOCOL NO. 1.—*The protection of guinea pigs treated with vaccines prepared from* Pasteurella pestis *against bites of infected fleas*—Continued

Vaccine preparation	Vaccine: Guinea pig No.	Vaccine: Amount in billions	Vaccine: Treatment dosage: Date injected	Vaccine: Treatment dosage: Amount in billions	Vaccine: Date injected	Challenge: Flea bites: Vector	Challenge: Flea bites: Infected	Results: Clinical	Results: Deaths, survivals	Results: Necropsy	Remarks
			1943		*1943*						
Control, no treatment.	61					1	1	P	D	P	
	62					1	0	P	D	P	
	63					1	0	P	D	P	
	64					1	0	P	S	No P	Buboes for 50 days.
	65					1	0	P	D	P	
	66					0	1	P	S	No P	No test (No vector).
	67					1	0	P	D	P	
	68					1	0	P	S	No P	Killed 25th day.
	69					1	1	P	D	P	
	70					1	0	P	D	P	
	[7] 113					1	2	No P	S	(7)	Injected.
	114					1	0	P	D	P	
	115					1	0	P	D	P	
	116					1	1	P	D	P	
	[8] 117					1	2	No P	S	(8)	Injected.
	118					1	0	P	D	P	

[7] Did not develop clinical plague and was injected with virulent culture: Death, necropsy, plague.
[8] Did not develop clinical plague and was injected with virulent culture: Sick, necropsy, plague.

PROTOCOL NO. 2.—*The protection of guinea pigs treated with vaccines prepared from ground squirrel and Indian rat strains of* Pasteurella pestis *against injections of a heterologous virulent ground squirrel strain*

Preparation	Vaccine: Number of guinea pigs treated	Vaccine: Treatment dosage: Amount in billions	Vaccine: Treatment dosage: Date injected	Vaccine: Treatment dosage: Amount in billions	Vaccine: Treatment dosage: Date injected	Challenge: Dosage: Amount in thousands	Challenge: Dosage: Date injected	Deaths, plague	Survivals, no plague	Remarks
			1943		*1943*		*1943*			
Alcohol precipitate	10	1.5	Feb. 9	1.5	Feb. 15	2,200	Mar. 2	2	8	Survivals killed after 23 days.
Alcohol-and-alum precipitate.	10	1.5	Feb. 9	1.5	Feb. 15	2,200	Mar. 2	4	6	Survivals killed after 23 days.
	10	3.0	Feb. 9			2,200	Mar. 2	3	[1] 7	
Commercial	9	1.5	Feb. 9	1.5	Feb. 15	2,200	Mar. 2	5	4	Survivals killed after 23 days.
	1	1.5	Feb. 9	1.5	Feb. 15	1,700	Mar. 6	1	0	
Typhoid	7	1.5	Feb. 9	1.5	Feb. 15	2,200	Mar. 2	7	0	Survivals killed after 23 days.
	3	1.5	Feb. 9	1.5	Feb. 15	1,700	Mar. 6	2	1	
No treatment	10					2.2	Mar. 2	7	3	Survivals killed after 23 days.
	2					1.7	Mar. 6	2	0	

[1] One death on 21st day, but no findings of plague.

PREVALENCE OF DISEASE

No health department, State or local, can effectively prevent or control disease without knowledge of when, where, and under what conditions cases are occurring

UNITED STATES

REPORTS FROM STATES FOR WEEK ENDED SEPTEMBER 28, 1946

Summary

Decreased incidence of poliomyelitis was recorded during the week in all sections of the country except the New England, Middle Atlantic, and South Atlantic areas. Increases occurred, however, in certain States in all sections except the Mountain area. The total for the week is 1,296, as compared with 1,427 last week, 774 and 976 for the corresponding weeks, respectively, of 1945 and 1944, and a 5-year median of 679. Of 35 States reporting 5 or more cases and showing changes, 18 reported an increase (557 to 681), while a decline (764 to 551) occurred in the other 17 States. The 10 States showing increases and reporting more than 11 cases are as follows (last week's figures in parentheses): Massachusetts 28 (16), New York 117 (90), Pennsylvania 19 (14), Ohio 52 (46), Indiana 27 (22), Wisconsin 95 (94), Missouri 90 (72), Nebraska 34 (33), Arkansas 25 (13), California 129 (124). The total for the year to date (39 weeks) is 18,498, as compared with 9,657 and 14,546, respectively, for the corresponding periods of 1945 and 1944, and a 5-year median of 9,309.

A total of 313 cases of diphtheria was reported, as compared with 295 last week, 532 for the corresponding week last year, and a 5-year median of 444. The cumulative total is 11,436, as compared with 10,749 for the same period last year and a 5-year median of 9,374. As compared with the corresponding period last year, an aggregate increase occurred in the New England, Middle Atlantic, North Central, and Mountain areas (3,784 to 5,384), while a decrease (6,965 to 6,052) was recorded in the South Atlantic, South Central, and Pacific areas.

A total of 991 cases of influenza was reported for the current week, as compared with 1,115 for the corresponding week last year and a 5-year median of 905.

Deaths recorded for the week in 93 large cities of the United States totaled 8,186, as compared with 8,246 last week, 8,378 and 7,993, respectively, for the corresponding weeks of 1945 and 1944, and a 3-year (1943–45) average of 8,289. The total for the year to date is 354,019, as compared with 349,926 for the same period last year.

Telegraphic morbidity reports from State health officers for the week ended Sept. 28, 1946, and comparison with corresponding week of 1945 and 5-year median

In these tables a zero indicates a definite report, while leaders imply that, although none was reported, cases may have occurred.

Division and State	Diphtheria			Influenza			Measles			Meningitis, meningococcus		
	Week ended—		Median 1941–45	Week ended—		Median 1941–45	Week ended—		Median 1941–45	Week ended—		Median 1941–45
	Sept. 28, 1946	Sept. 29, 1945		Sept. 28, 1946	Sept. 29, 1945		Sept. 28, 1946	Sept. 29, 1945		Sept. 28, 1946	Sept. 29, 1945	
NEW ENGLAND												
Maine	0	0	0				13			0	0	1
New Hampshire	0	0	0	1			3			0	0	0
Vermont	1	1	0	1			33	2	3	0	0	0
Massachusetts	24	7	3				71	37	40	1	2	3
Rhode Island	2	0	0		14		3	1	3	1	0	0
Connecticut	0	0	2	1			9	2	6	2	2	2
MIDDLE ATLANTIC												
New York	18	14	9	[1] 4	(1)	[1] 1	46	12	42	5	12	12
New Jersey	3	2	2	2	3	3	12	12	25	2	1	3
Pennsylvania	16	9	9			1	69	53	51	5	10	10
EAST NORTH CENTRAL												
Ohio	16	22	8	1	5	5	14	4	22	5	4	4
Indiana	6	8	8	2	10	10	4	3	3	1	5	1
Illinois	13	3	7	1	1	2	15	33	18	5	5	5
Michigan [2]	4	26	5	3			15	38	38	1	3	3
Wisconsin	15	0	1	18	14	14	22	22	40	2	4	2
WEST NORTH CENTRAL												
Minnesota	4	6	6			1	2	4	4	0	1	0
Iowa	3	2	6				6		2	1	2	0
Missouri	3	8	8	2			2	1	3	0	10	2
North Dakota	1	0	1	4	1	1			4	0	0	0
South Dakota	2	3	4				1	1	1	0	0	0
Nebraska	2	1	1	3			2	1	4	1	0	0
Kansas	2	10	4	4		1	2	7	7	1	0	0
SOUTH ATLANTIC												
Delaware	0	0	0						2	0	0	0
Maryland [2]	6	17	4			2	9	1	7	0	2	2
District of Columbia	0	0	0				4		1	0	0	0
Virginia	27	13	16	161	148	72	12	7	7	4	6	3
West Virginia	2	6	6						2	3	0	1
North Carolina	12	82	69				8	6	6	1	1	1
South Carolina	1	20	25	30	166	171	3	8	15	0	0	2
Georgia	10	24	25	2	3	20	7	4	4	0	2	1
Florida	11	1	6	5	4	4	1		1	2	3	1
EAST SOUTH CENTRAL												
Kentucky	26	22	12			2		5	2	2	3	1
Tennessee	6	54	23	4	14	7	1	9	6	0	4	1
Alabama	11	25	29	28	15	15	5	8	7	2	2	0
Mississippi [2]	10	21	11							1	0	0
WEST SOUTH CENTRAL												
Arkansas	8	16	15		10	23	2	3	3	1	2	0
Louisiana	3	13	6		26	5	5	1	1	0	1	1
Oklahoma	1	4	5	17	17	17	4		2	0	0	0
Texas	15	46	46	624	625	451	39	34	17	3	5	2
MOUNTAIN												
Montana	0	1	1	3	2	2	3	63	14	1	0	0
Idaho	0	0	0	6	3		4	37	6	0	0	0
Wyoming	0	0	0	1		1			1	0	0	0
Colorado	2	6	6	32	14	16	5	2	8	1	1	1
New Mexico	1	3	3	2	5	1	7	2	2	0	0	0
Arizona	2	1	1	22	12	31	3		3	1	0	0
Utah [2]	0	2	0	1			2	4	3	1	0	0
Nevada	0	0	0							0	0	0
PACIFIC												
Washington	5	6	6			1	5	65	16	0	1	3
Oregon	2	1	1	1		4	11	10	22	2	0	2
California	17	26	19	5	3	14	43	110	92	6	7	7
Total	313	532	444	991	1,115	905	527	612	647	64	101	101
39 weeks	11,436	10,749	9,374	195,844	76,184	85,825	642,181	104,737	542,892	4,799	6,679	6,679

[1] New York City only.

[2] Period ended earlier than Saturday.

Telegraphic morbidity reports from State health officers for the week ended Sept. 28, 1946, and comparison with corresponding week of 1945 and 5-year median—Con.

Division and State	Poliomyelitis			Scarlet fever			Smallpox			Typhoid and paratyphoid fever [2]		
	Week ended—		Median 1941–45	Week ended—		Median 1941–45	Week ended—		Median 1941–45	Week ended—		Median 1941–45
	Sept. 28, 1946	Sept. 29, 1945		Sept. 28, 1946	Sept. 29, 1945		Sept. 28, 1946	Sept. 29, 1945		Sept. 28, 1946	Sept. 29, 1945	
NEW ENGLAND												
Maine	2	2	2	22	12	12	0	0	0	0	0	0
New Hampshire	10	2	0	5	4	2	0	0	0	0	0	0
Vermont	7	2	1	0	2	2	0	0	0	0	0	1
Massachusetts	28	39	22	30	63	68	0	0	0	9	3	7
Rhode Island	13	3	1	3	1	3	0	0	0	0	1	0
Connecticut	5	11	11	10	16	13	0	0	0	0	2	2
MIDDLE ATLANTIC												
New York	117	108	108	89	99	99	0	0	0	8	11	12
New Jersey	10	47	29	23	22	30	0	0	0	6	3	2
Pennsylvania	19	52	52	54	93	80	0	0	0	8	9	13
EAST NORTH CENTRAL												
Ohio	52	36	36	93	99	99	0	0	0	6	10	9
Indiana	27	8	8	26	23	25	0	0	0	2	2	2
Illinois	131	71	37	41	68	76	0	1	0	5	2	4
Michigan [3]	60	19	19	43	61	59	0	0	0	3	16	4
Wisconsin	95	56	12	30	36	52	0	0	0	0	0	1
WEST NORTH CENTRAL												
Minnesota	96	26	16	15	30	28	0	1	0	1	0	0
Iowa	31	23	9	17	19	26	0	0	0	0	0	0
Missouri	90	12	12	18	35	32	1	0	0	4	3	5
North Dakota	25	0	1	0	5	3	0	0	0	0	1	0
South Dakota	6	7	1	1	3	5	0	0	0	0	0	0
Nebraska	34	6	8	10	5	12	0	0	0	0	2	0
Kansas	66	8	8	11	44	44	0	0	0	1	0	1
SOUTH ATLANTIC												
Delaware	6	1	2	4	4	3	0	0	0	0	2	1
Maryland [3]	5	12	12	13	29	23	0	0	0	2	1	5
District of Columbia	2	8	3	4	9	9	0	0	0	1	0	1
Virginia	3	11	8	27	70	41	0	0	0	1	17	8
West Virginia	1	5	4	26	63	58	0	0	0	1	1	4
North Carolina	11	7	8	33	55	55	0	0	0	1	4	3
South Carolina	1	2	3	1	13	13	0	0	0	2	3	6
Georgia	3	1	2	10	16	21	0	0	0	3	4	4
Florida	7	12	4	6	2	5	0	0	0	3	1	4
EAST SOUTH CENTRAL												
Kentucky	4	3	6	26	34	34	0	0	0	2	3	5
Tennessee	5	12	7	27	42	43	0	0	0	3	6	6
Alabama	4	8	4	11	16	23	0	0	0	2	6	6
Mississippi [3]	11	4	3	16	8	8	0	0	0	0	4	4
WEST SOUTH CENTRAL												
Arkansas	25	3	1	6	18	4	0	2	0	4	5	5
Louisiana	5	1	2	1	16	6	0	0	0	1	2	4
Oklahoma	12	6	2	3	4	10	0	0	0	1	3	3
Texas	28	36	7	18	85	32	0	0	0	14	12	13
MOUNTAIN												
Montana	9	10	3	2	7	8	0	0	0	1	1	1
Idaho	2	2	0	10	7	7	0	0	0	2	2	2
Wyoming	7	2	1	3	1	1	0	0	0	0	0	0
Colorado	41	4	4	6	8	11	0	0	0	1	0	1
New Mexico	8	0	0	0	6	3	0	0	0	3	6	6
Arizona	2	1	1	8	4	4	0	0	0	1	1	1
Utah [3]	10	15	3	2	11	11	0	0	0	1	0	0
Nevada	0	0	0	3	0	0	0	0	0	0	0	0
PACIFIC												
Washington	27	13	8	17	22	22	0	0	0	0	0	2
Oregon	4	5	5	11	9	9	0	0	0	1	0	1
California	129	52	18	77	109	96	0	0	0	7	0	6
Total	1,296	774	679	912	1,408	1,385	1	4	3	111	149	168
39 weeks	[4]18,496	9,657	9,309	90,904	140,782	104,359	293	283	630	3,225	3,820	4,352

[2] Period ended earlier than Saturday.

[3] Including paratyphoid fever reported separately, as follows: Massachusetts (salmonella infection) 8; New York 1; Ohio 1; Illinois 2; Virginia 1; Florida 1; Arkansas 1; Oklahoma 1; Texas 3; Montana 1; New Mexico 1; Utah 1; California 4.

[4] Delayed reports: Arkansas, week ended August 3, 1 case (included in cumulative total only).

Telegraphic morbidity reports from State health officers for the week ended Sept. 28, 1946, and comparison with corresponding week of 1945 and 5-year median—Con.

Division and State	Whooping cough			Week ended Sept. 28, 1946							
	Week ended—		Median 1941–45	Dysentery			Encephalitis, infectious	Rocky Mt. spotted fever	Tularemia	Typhus fever, endemic	Undulant fever
	Sept. 28, 1946	Sept. 29, 1945		Amebic	Bacillary	Unspecified					
NEW ENGLAND											
Maine	21	57	35								2
New Hampshire	4	6	2								
Vermont	13	11	11								1
Massachusetts	110	114	109		3					*1	
Rhode Island	30	20	26								
Connecticut	20	22	27				1				3
MIDDLE ATLANTIC											
New York	132	316	316	4	17					1	2
New Jersey	128	156	133			2					
Pennsylvania	115	142	142							1	1
EAST NORTH CENTRAL											
Ohio	96	107	129	60		1					5
Indiana	20	13	19				8	4			4
Illinois	102	82	145	8				2			9
Michigan [2]	161	88	191		2						1
Wisconsin	211	69	187								9
WEST NORTH CENTRAL											
Minnesota	12	11	37	2							2
Iowa	27	1	21	1							
Missouri	19	24	23			1			1		1
North Dakota	2	5	13								
South Dakota		5	5								2
Nebraska	1	4	7								
Kansas	7	8	28								2
SOUTH ATLANTIC											
Delaware	3	4	3								
Maryland [2]	27	52	52			1					1
District of Columbia	3	13	9								
Virginia	44	41	41			32		2			3
West Virginia	11	12	10								1
North Carolina	38	54	103					3	1	2	
South Carolina	3	43	43							2	
Georgia	1	3	10	1	3			3		12	2
Florida	11	1	3			1			2	23	6
EAST SOUTH CENTRAL											
Kentucky	20	52	33			1					
Tennessee	22	14	20						4	1	
Alabama	4	11	14				1			7	1
Mississippi [2]									4	1	4
WEST SOUTH CENTRAL											
Arkansas	9	15	20	1					6	2	
Louisiana		2	5	2						1	3
Oklahoma		5	3								
Texas	135	124	123	11	194	13	1			29	8
MOUNTAIN											
Montana		5	10						2		
Idaho	7	10	2			2					
Wyoming	5	3	6								
Colorado	15	27	27	4	1						2
New Mexico	5	7	7		5	11	1			1	
Arizona	3	3	3			36					
Utah [2]	14	11	21								
Nevada							1				
PACIFIC											
Washington	35	16	18								
Oregon	7	6	19			9					
California	75	155	155	3	3		4			4	3
Total	1,728	1,950	2,333	97	228	110	17	14	20	88	78
Same week, 1945	1,950			49	461	392	28	17	13	166	86
Average, 1943–45	1,986			42	470	273	20	[3] 4	11	[3] 130	
39 weeks: 1946	75,875			2,196	12,591	5,180	497	529	717	2,676	3,832
1945	97,536			1,432	20,071	8,734	483	437	589	3,674	3,607
Average, 1943–45	106,253		[3] 139,386	1,456	16,696	7,284	515	[3] 434	564	[3] 3,076	

[2] Period ended earlier than Saturday.
[3] 5-year median, 1941–45.

Anthrax: New York 1 case.
Leprosy: New York 1 case; Texas 1 case.
*Boston 1 case, presumably murine, not yet proved.

WEEKLY REPORTS FROM CITIES

City reports for week ended Sept. 21, 1946

This table lists the reports from 86 cities of more than 10,000 population distributed throughout the United States, and represents a cross section of the current urban incidence of the diseases included in the table.

Division, State, and City	Diphtheria cases	Encephalitis, infectious, cases	Influenza		Measles cases	Meningitis, meningococcus, cases	Pneumonia deaths	Poliomyelitis cases	Scarlet fever cases	Smallpox cases	Typhoid and paratyphoid fever cases	Whooping cough cases
			Cases	Deaths								
NEW ENGLAND												
Maine:												
Portland	0	0	------	0	-------	0	2	0	0	0	0	3
New Hampshire:												
Concord	0	0	------	0	-------	0	0	1	1	0	0	------
Vermont:												
Barre	0	0	------	0	-------	0	0	0	0	0	0	------
Massachusetts:												
Boston	1	0	------	0	5	1	7	6	5	0	0	36
Fall River	0	0	------	1	-------	0	0	0	1	0	0	3
Springfield	0	0	------	0	1	0	0	0	0	0	0	14
Worcester	0	0	------	0	-------	0	4	8	0	0	0	18
Rhode Island:												
Providence	0	0	------	0	1	0	2	0	1	0	0	18
Connecticut:												
Bridgeport	0	0	------	0	1	0	0	1	0	0	0	------
Hartford	0	0	------	0	-------	0	0	1	0	0	0	2
New Haven	0	0	------	0	1	0	1	0	1	0	0	4
MIDDLE ATLANTIC												
New York:												
Buffalo	2	0	------	0	-------	0	2	0	5	0	0	8
New York	12	1	2	1	13	2	50	42	28	0	4	38
Rochester	0	0	------	0	-------	0	0	0	2	0	0	1
Syracuse	0	0	------	0	-------	0	2	1	2	0	1	8
New Jersey:												
Camden	0	0	------	0	1	0	0	0	0	0	0	3
Newark	0	0	------	0	1	1	2	0	1	0	0	12
Trenton	0	0	1	0	-------	0	1	0	1	0	0	2
Pennsylvania:												
Philadelphia	0	0	1	0	2	1	12	5	7	0	2	33
Pittsburgh	0	0	------	0	11	0	9	1	4	0	0	16
Reading	0	0	------	0	-------	1	1	0	1	0	0	1
EAST NORTH CENTRAL												
Ohio:												
Cincinnati	3	0	------	------	-------	0	6	7	7	0	0	3
Cleveland	0	0	------	0	3	0	4	23	10	0	0	11
Columbus	0	1	------	0	-------	0	2	0	5	0	0	5
Indiana:												
Fort Wayne	0	1	------	0	-------	0	0	0	0	0	0	1
Indianapolis	1	1	------	0	-------	4	5	12	3	0	0	5
South Bend	0	0	------	0	1	0	0	1	0	0	0	------
Terre Haute	0	0	------	0	1	0	0	2	0	0	0	------
Illinois:												
Chicago	0	0	------	0	6	2	14	62	17	0	0	77
Michigan:												
Detroit	1	1	1	0	3	1	3	19	13	0	0	89
Flint	0	0	------	0	-------	0	2	0	0	0	0	2
Grand Rapids	0	0	------	0	-------	0	0	10	1	0	0	3
Wisconsin:												
Kenosha	1	0	------	0	-------	0	0	6	0	0	0	4
Milwaukee	0	0	------	0	1	0	5	11	5	0	0	120
Racine	0	0	------	0	1	0	0	3	2	0	0	------
Superior	1	0	------	0	1	0	0	3	1	0	0	------
WEST NORTH CENTRAL												
Minnesota:												
Duluth	0	0	------	0	1	0	1	13	0	0	0	2
Minneapolis	0	0	------	0	-------	0	1	21	5	0	0	------
St. Paul	0	0	------	0	-------	0	2	7	1	0	0	6
Missouri:												
Kansas City	2	0	------	0	-------	0	5	9	0	0	0	2
St. Joseph	0	0	------	0	-------	0	0	1	0	0	0	5
St. Louis	1	0	1	0	1	1	6	34	2	0	0	5

City reports for week ended Sept. 21, 1946—Continued

Division, State, and City	Diphtheria cases	Encephalitis, infectious, cases	Influenza		Measles cases	Meningitis, meningococcus, cases	Pneumonia deaths	Poliomyelitis cases	Scarlet fever cases	Smallpox cases	Typhoid and paratyphoid fever cases	Whooping cough cases
			Cases	Deaths								
WEST NORTH CENTRAL—continued												
Nebraska:												
Omaha	0	0	------	0	-------	0	1	18	1	0	0	------
Kansas:												
Topeka	0	0	------	1	-------	0	0	1	0	0	0	3
Wichita	0	0	------	0	-------	0	2	3	1	0	0	------
SOUTH ATLANTIC												
Delaware:												
Wilmington	0	0	------	0	-------	0	0	1	1	0	0	------
Maryland:												
Baltimore	5	0	2	1	2	1	6	2	4	0	0	32
Cumberland	0	0	------	0	-------	0	0	0	0	0	0	------
Frederick	0	0	------	0	-------	0	0	0	0	0	0	------
District of Columbia:												
Washington	0	0	------	0	4	0	7	2	2	0	0	7
Virginia:												
Lynchburg	1	0	------	0	1	0	0	0	3	0	0	1
Richmond	0	0	21	0	2	1	1	0	7	0	0	1
Roanoke	3	0	------	0	-------	0	0	0	0	0	0	------
West Virginia:												
Wheeling	0	0	------	0	-------	0	0	0	1	0	0	1
North Carolina:												
Raleigh	0	0	------	0	-------	0	1	0	0	0	0	6
Wilmington	0	0	------	0	-------	0	1	0	1	0	0	1
Winston-Salem	0	0	------	0	-------	0	1	1	5	0	0	2
South Carolina:												
Charleston	2	0	1	0	-------	0	3	0	0	0	0	------
Georgia:												
Atlanta	0	0	------	0	-------	0	1	0	1	0	0	------
Brunswick	0	0	------	0	-------	0	0	0	0	0	0	------
Savannah	0	0	------	0	1	0	1	0	0	0	0	------
Florida:												
Tampa	1	0	------	0	-------	0	1	1	2	0	0	------
EAST SOUTH CENTRAL												
Tennessee:												
Memphis	3	0	------	0	1	0	8	1	1	0	0	2
Nashville	0	0	------	0	-------	1	7	0	1	0	0	------
Alabama:												
Birmingham	0	0	2	0	3	0	0	1	0	0	0	------
Mobile	1	0	4	2	-------	1	2	0	0	0	0	2
WEST SOUTH CENTRAL												
Arkansas:												
Little Rock	0	0	------	0	-------	0	0	1	0	0	0	------
Louisiana:												
New Orleans	*4	0	*4	0	*6	*3	*9	2	1	0	*4	*5
Shreveport	0	0	------	0	-------	0	4	0	0	0	0	------
Texas:												
Dallas	1	0	------	0	-------	0	3	2	6	0	0	9
Galveston	0	0	------	0	-------	0	0	0	0	0	0	------
Houston	1	0	------	0	-------	0	2	5	3	0	0	------
San Antonio	0	0	------	0	-------	0	2	1	0	0	0	------
MOUNTAIN												
Montana:												
Billings	0	0	------	0	-------	0	1	0	0	0	0	------
Great Falls	0	0	------	0	1	0	0	3	0	0	0	1
Helena	0	0	------	0	-------	0	0	1	0	0	0	------
Missoula	0	0	------	0	-------	0	0	0	0	0	0	------
Idaho:												
Boise	0	0	------	0	-------	0	0	0	0	0	0	1
Colorado:												
Denver	3	0	------	0	1	1	2	7	2	0	0	13
Utah:												
Salt Lake City	0	0	------	0	2	0	0	4	4	0	0	1

*Including monthly reports from Charity Hospital. Figures not used in computing rates.

City reports for week ended Sept. 21, 1946—Continued

Division, State, and city	Diphtheria cases	Encephalitis, infectious, cases	Influenza		Measles cases	Meningitis, meningococcus, cases	Pneumonia deaths	Poliomyelitis cases	Scarlet fever cases	Smallpox cases	Typhoid and paratyphoid fever cases	Whooping cough cases
			Cases	Deaths								
PACIFIC												
Washington:												
Seattle	1	0	------	0	-------	0	2	9	0	0	0	3
Spokane	0	0	------	0	-------	0	0	9	1	0	0	------
Tacoma	0	0	------	0	-------	0	0	3	2	0	0	1
California:												
Los Angeles	3	0	------	0	11	1	3	30	8	0	0	14
Sacramento	0	0	------	0	-------	0	2	0	0	0	0	1
San Francisco	1	0	------	0	1	1	5	2	4	0	0	3
Total	51	5	36	6	86	21	220	420	194	0	7	665
Corresponding week, 1945	62	------	21	8	175	------	217	------	272	0	27	730
Average, 1941–45	60	------	35	[1] 8	[2] 150	------	[1] 234	------	291	0	29	847

[1] 3-year average, 1943–45.
[2] 5-year median, 1941–45.

Anthrax.—Cases: Philadelphia 1.
Dysentery, amebic.—Cases: Boston 1; New Haven 1; Buffalo 2; New York 3; Rochester 1; Philadelphia 1; Indianapolis 1; Chicago 1; St. Paul 1; Los Angeles 1.
Dysentery, bacillary.—Cases: New York 4; Detroit 1; Charleston, S. C. 1; Los Angeles 3.
Dysentery, unspecified.—Cases: San Antonio 2.
Rocky Mountain spotted fever.—Cases: Nashville 1.
Tularemia.—Cases: Lynchburg 1; New Orleans 1.
Typhus fever, endemic.—Cases: Atlanta 3; Tampa 1; Mobile 1; Little Rock 6; New Orleans 10, including monthly reports from Charity Hospital; Houston 2.

Rates (annual basis) per 100,000 population, by geographic groups, for the 86 cities in the preceding table (estimated population, 1943, 34,162,000)

	Diphtheria case rates	Encephalitis, infectious, case rates	Influenza		Measles case rates	Meningitis, meningococcus, case rates	Pneumonia death rates	Poliomyelitis case rates	Scarlet fever case rates	Smallpox case rates	Typhoid and paratyphoid fever case rates	Whooping cough case rates
			Case rates	Death rates								
New England	2.6	0.0	0.0	2.6	24	2.6	41.8	44.4	24	0.0	0.0	256
Middle Atlantic	6.5	0.5	1.9	0.5	13	2.3	36.6	22.7	24	0.0	3.2	56
East North Central	4.3	2.5	0.6	0.0	10	4.3	25.1	97.5	39	0.0	0.0	196
West North Central	6.0	0.0	2.0	2.0	4	2.0	36.2	215.2	20	0.0	0.0	46
South Atlantic	20.1	0.0	40.2	1.7	17	3.3	38.5	11.7	45	0.0	0.0	85
East South Central	23.6	0.0	35.4	11.8	24	11.8	100.3	11.8	12	0.0	0.0	24
West South Central	8.1	0.0	0.0	0.0	0	0.0	44.5	31.6	29	0.0	0.0	36
Mountain	26.0	0.0	0.0	0.0	35	8.7	26.0	130.0	52	0.0	0.0	139
Pacific	7.9	0.0	0.0	0.0	19	3.2	19.0	83.8	24	0.0	0.0	35
Total	7.9	0.8	5.6	0.9	13	3.3	34.2	64.3	30	0.0	1.1	103

PLAGUE INFECTION IN PLACER COUNTY, CALIF.

Under date of September 23, 1946, plague infection was reported proved, on September 20, in Placer County, Calif., in pools of 30 fleas from 3 ground squirrels, *C. beecheyi*, 14 fleas from 16 chipmunks, *Eutamias* sp., and 17 fleas from 2 tamarack squirrels, *Sciurus douglasii albolimbatus*, all shot 1 mile north of Kings Beach, Lake Tahoe, and in a pool of 9 fleas from 7 golden mantled ground squirrels, *Callospermo-*

philus sp., shot on the Brockway-Truckee road northwest of Kings Beach. All specimens were received at the laboratory on September 5, 1946.

TERRITORIES AND POSSESSIONS

Puerto Rico

Notifiable diseases—4 weeks ended September 7, 1946.—During the 4 weeks ended September 7, 1946, cases of certain notifiable diseases were reported in Puerto Rico as follows:

Disease	Cases	Disease	Cases
Chickenpox	3	Poliomyelitis	67
Diphtheria	55	Syphilis	124
Dysentery, unspecified	8	Tetanus	11
Gonorrhea	134	Tuberculosis (all forms)	400
Influenza	76	Typhoid and paratyphoid fever	6
Malaria	391	Typhus fever (murine)	15
Measles	2	Whooping cough	28

* * *

DEATHS DURING WEEK ENDED SEPTEMBER 21, 1946

[From the Weekly Mortality Index, issued by the National Office of Vital Statistics]

	Week ended Sept. 21, 1946	Corresponding week, 1945
Data for 93 large cities of the United States:		
Total deaths	8,248	8,205
Average for 3 prior years	8,206	
Total deaths, first 38 weeks of year	345,835	341,548
Deaths under 1 year of age	701	607
Average for 3 prior years	609	
Deaths under 1 year of age, first 38 weeks of year	24,378	23,051
Data from industrial insurance companies:		
Policies in force	67,286,004	67,310,855
Number of death claims	10,914	11,633
Death claims per 1,000 policies in force, annual rate	8.5	9.0
Death claims per 1,000 policies, first 38 weeks of year, annual rate	9.6	10.2

FOREIGN REPORTS

CANADA

Provinces—Communicable diseases—Week ended September 7, 1946.—During the week ended September 7, 1946, cases of certain communicable diseases were reported by the Dominion Bureau of Statistics of Canada as follows:

Disease	Prince Edward Island	Nova Scotia	New Brunswick	Quebec	Ontario	Manitoba	Saskatchewan	Alberta	British Columbia	Total
Chickenpox		4		9	166	9	12	26	18	244
Diphtheria				25	8	1		1	1	36
Dysentery, bacillary									3	3
Encephalitis, infectious									1	1
German measles					4		1	3	5	13
Influenza					8	2				10
Measles		7	78	19	65	11	36	22	9	247
Meningitis, meningococcus		1			1	1		1	1	5
Mumps				8	78	19	41	13	24	183
Poliomyelitis	4	4	12	120	45	3	5	10	2	205
Scarlet fever	1		6	23	23	7		4	1	65
Tuberculosis (all forms)		7	4	126	40	20	15	49	25	286
Typhoid and paratyphoid fever				10	1	2		1	9	23
Undulant fever				1	1	1			5	8
Venereal diseases:										
Gonorrhea	3	29	21	125	135	42	46	43	72	516
Syphilis		14	3	105	72	17	11	2	40	264
Other forms		1								1
Whooping cough		15	1	80	50	5		4	2	157

NEW ZEALAND

Notifiable diseases—4 weeks ended September 7, 1946.—During the 4 weeks ended September 7, 1946, certain notifiable diseases were reported in New Zealand as follows:

Disease	Cases	Deaths	Disease	Cases	Deaths
Actinomycosis	1		Ophthalmia neonatorum	1	
Cerebrospinal meningitis	20	2	Poliomyelitis	3	
Diphtheria	139	6	Puerperal fever	5	
Dysentery:			Scarlet fever	117	1
Amebic	4		Tetanus	3	
Bacillary	5		Trachoma	1	
Erysipelas	14		Tuberculosis (all forms)	180	50
Food poisoning	10		Typhoid fever	8	6
Malaria	1		Undulant fever	2	

REPORTS OF CHOLERA, PLAGUE, SMALLPOX, TYPHUS FEVER, AND YELLOW FEVER RECEIVED DURING THE CURRENT WEEK

NOTE.—Except in cases of unusual incidence, only those places are included which had not previously reported any of the above-named diseases, except yellow fever, during recent months. All reports of yellow fever are published currently.

A table showing the accumulated figures for these diseases for the year to date is published in the PUBLIC HEALTH REPORTS for the last Friday of each month.

Cholera

China.—Cholera has been reported in China as follows: Fukien Province—August 11–20, 1946, 55 cases, 3 deaths including 54 cases with 3 deaths reported in Foochow; Hopeh Province—August 11–20, 1946, 20 cases, 8 deaths, August 21–31, 1946, 19 cases, September 1–10, 1946, 3 cases all in Tientsin; Hunan Province—August 11–20, 1946, 250 cases, 148 deaths; Kwangtung Province—August 1–10, 1946, 138 cases, 37 deaths, August 11–20, 1946, 200 cases, 60 deaths.

Manchuria—Jehol Province.—For the period August 1–10, 1946, 91 cases of cholera with 73 deaths were reported in certain localities of Jehol Province, Manchuria.

Plague

Ecuador—Loja Province—Pindal.—During the month of August 1946, 4 cases of plague with 2 deaths were reported in Pindal, Loja Province, Ecuador.

Typhus Fever

Ecuador.—During the month of August 1946, 118 cases of typhus fever with 25 deaths were reported in Ecuador. Provinces reporting the highest incidence are: Cotopaxi, 26 cases, 17 deaths; Pichincha, 26 cases, 5 deaths in Quito; Loja, 23 cases, 1 death; Chimborazo, 10 cases.

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