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CHANGES IN THE INCIDENCE AND FATALITY OF SMALLPOX IN RECENT DECADES *

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A. International Aspects

It is a striking, but, by itself, a misleading, fact that of 26 countries reporting smallpox morbidity to the League of Nations from 1921–30, the United States showed the highest reported attack rate with the exception of British India. This questionable distinction may be due to some extent to better reporting in the United States than prevails in some other countries; but a more significant factor appears to be that the strain of smallpox endemic with us is of a mild variety, which is less than 1 percent as fatal as the classical or malignant type,[1] and is accordingly more difficult to control. Classical smallpox has a case fatality in partially vaccinated populations, such as ours, averaging roughly 25 percent; the variety endemic with us, however, has a fatality of 0.2 percent or less (*1a*, *2a*).

An examination of contrasts between different countries in respect of smallpox is interesting, and helps to suggest a possible reason for the predominance of mild smallpox over severe in this and certain other countries.

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[1] In discussions of smallpox, it is necessary to differentiate clearly between symptoms and causative virus. It is held by most observers that the virus itself runs true to type, or, at best, mutates rather rarely or gradually in passing from person to person (*1b*, *2a*). Symptoms, of course, vary greatly with host immunity, even when produced by the same virus. *In this paper, such expressions as "malignant" or "mild" smallpox ordinarily refer to the virus of variola major or minor, respectively, and not to the symptoms produced.*

This division into two types of virus is made largely on the basis of expediency, without losing sight of variation, or possible occurrence of intermediate types. Alastrim and Kaffir milk-pox of South Africa, of the West Indies, and other places are considered to be essentially variola minor.

SMALLPOX INCIDENCE IN VARIOUS COUNTRIES

In figure 1 is shown an approximate representation of the smallpox incidence in various parts of the world based mainly upon statistics for the period 1921–30, as reported to the League of Nations (*3*). The black areas represent the highest rates, i. e., those exceeding 50 per 100,000 population per year; the cross-hatched areas represent intermediate rates, i. e., from 5 to 50 per 100,000; and the stippled areas represent the lowest rates, that is, under 5 per 100,000. The unshaded areas are those from which satisfactory information is lacking. In table 1 are shown case rates for individual countries. While a large margin of error is to be attached to the individual rates, it is believed that the general relationships shown in the graph are substantially correct.

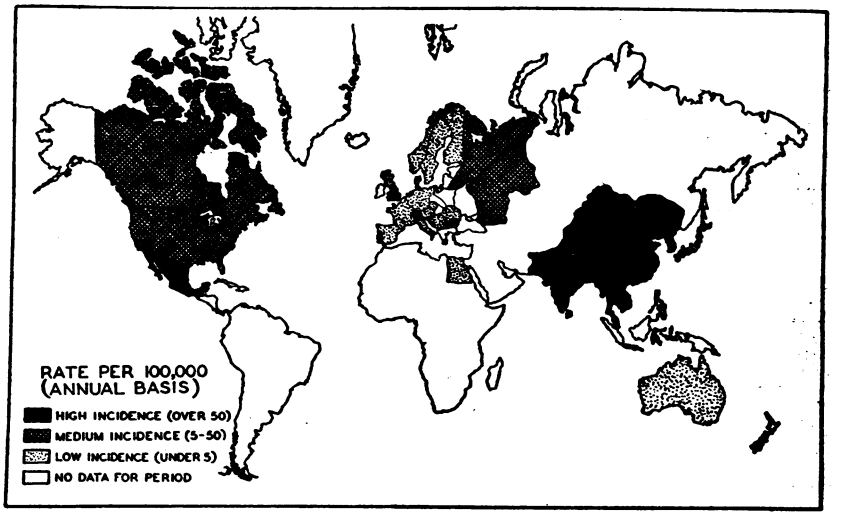

FIGURE 1.—Reported smallpox case rates in certain countries—average, 1921–30.

Summarizing the picture presented in figure 1, we note that very high rates appear to have occurred in India, China, and Mexico. In the absence of morbidity data for Mexico, a high case rate is deduced from the high mortality; the Mexican situation will be discussed later in greater detail. A high incidence in China is inferred from general statements appearing in the literature. It seems highly probable that large areas in Africa and South America also suffer high rates.

The intermediate rates, from 5 to 50 per 100,000, occurred during 1921–30 mainly in the Anglo-Saxon countries, including England, the United States, and Canada. Since 1930 the incidence in England has steadily fallen and in 1933 was at a very low level (table 3). Russia and Switzerland fall into this intermediate group, but are somewhat out of place there, in that they began the decade with an extremely high rate and ended with exceedingly low ones, due to widespread

vaccination campaigns, which reduced smallpox almost to the vanishing point.

The very lowest rates occurred mainly in continental Europe, Australia, and Japan. One may be inclined to doubt the genuineness of the low rates in some of the central European countries, but a ready explanation is found in the vaccination policies, which will be next reviewed briefly.

TABLE 1.—*Morbidity, mortality, and apparent case fatality from smallpox in various countries, for various periods, 1921–30* [1]

Geographic area	Number of cases for years indicated (1)	Reported annual case rate per 100,000 population (2)	Number of deaths for years indicated (3)	Reported annual death rate per 100,000 population (4)	Case fatality (deaths per 100 reported cases) (5)	Years included (6)
Mexico [2]	(3)	[4]163.0	96,526	69.9	(3)	1922-30
British India [5]	979,738	74.2	414,659	31.4	42.3	1926-30
United States [6]	381,890	40.4	3,483	.37	[7] 9	1921-30
Canada [2]	15,000	21.6	140	.20	[7] 9	1924-30
England and Wales	73,115	18.6	246	.06	.3	1921-30
Soviet Russia [8]	209,715	[9]18.2	(3)	(3)	(3)	1921-30
Switzerland	5,494	[9]14.1	16	.04	.3	1921-30
Chosen	20,721	[9]11.5	5,979	3.31	28.9	1921-30
Java and Madura	20,069	[9]5.3	3,695	.98	18.4	1921-30
Egypt	5,353	3.8	1,222	.88	22.8	1921-30
Yugoslavia	4,241	[9]3.4	915	.74	21.6	1921-30
Rumania	3,764	2.3	730	.44	19.4	1921-30
Italy	6,532	1.9	1,516	.43	23.2	1921-29
Ceylon	808	1.9	111	.27	13.7	1922-30
Japan	8,075	1.4	1,454	.25	18.0	1921-30
France	1,573	1.0	363	.22	23.1	1925-28
The Netherlands	728	.92	23	.03	[7] 3.2	1921-30
Scotland	452	.93	26	.05	[7] 5.8	1921-30
Finland	137	.44	14	.05	10.2	1921-29
Philippine Islands	318	.39	56	.07	17.6	1924-30
Germany	976	.15	161	.02	16.5	1921-30
Bulgaria	74	.15	14	.03	[10] 18.9	1921-30
Austria	39	.07	8	.01	[10] 20.4	1921-30
Denmark	32	.09	3	.01	[10] 9.4	1921-30
Norway	5	.02	0	.00	[10] 0.0	1921-30
Sweden	6	.01	4	.09	[10] 66.7	1921-30

[1] Data mainly from Epidemiological Reports of the League of Nations, especially R. E. 155 (Oct. 15, 1931), pp. 400–404.
[2] Data from the National Department of Health.
[3] Data not available.
[4] Estimated rate for malignant type only. See footnote 2, page 368.
[5] Provisional data for portion of India reporting 1926–30.
[6] Data for 35 States reporting during the entire period.
[7] Case fatality has declined appreciably in recent years.
[8] Without Ukraine.
[9] Cases have declined considerably during the latter part of the period.
[10] Rate based on less than 100 cases.

RELATION OF INCIDENCE TO VACCINATION

A review published by the League of Nations (*3a*) gives information concerning vaccination laws in 15 of the countries listed in table 1 as having case rates under five per 100,000 population. In 12 countries, or 80 percent, vaccination is compulsory, and in one half (Yugoslavia, Bulgaria, Rumania, Italy, France, Germany, and Japan) vaccination is required twice or oftener, usually shortly after birth, on admission to school, and at commencement of military service. The three

countries in this low-morbidity class, in which vaccination is not reported as strictly compulsory, are Austria, the Netherlands, and Norway. It is reported, however, that in Austria nearly three-quarters of the population of 7,000,000 were vaccinated or revaccinated in 1916, owing to the spread of virulent smallpox from Russia (*3b*); in the Netherlands, the proportion of primary vaccinations to births rose from 77 percent in 1920 to 95 percent in 1926; and in Norway, said to have a hotbed of the antivaccination movement among some religious sects in the southwest districts, roughly two-fifths of the infants are apparently vaccinated, although the proportion of first vaccinations to births each year has varied from 175 percent to 52 percent. I am assured by a representative of the Rockefeller Foundation, familiar with the central European countries, that the vaccination laws are ordinarily enforced there with faithfulness, and that the public, who have known the fear-inspiring malignant variety of smallpox almost exclusively, in the main regard vaccination as a boon and not a burden.

In the nations with intermediate case rates, 12 to 50 per 100,000, we find that, except in Russia, vaccination is not compulsory. In England, only about 45 percent of the infants were being vaccinated in 1925 as against 76 percent in 1905. In the United States, according to unpublished data of S. D. Collins to be cited later, surveys indicate that, roughly, half of the population have at one time or another been vaccinated; according to Woodward and Feemster (*5*) only 10 States have required vaccination; 6 have local option. In Switzerland and Canada local option seems to prevail.

Turning finally to the countries with very high smallpox rates, including India, China, and Mexico, we find that in India inoculation has long been practiced, and that gradually vaccination is being extended, but is far from satisfactory, being in a rudimentary stage at best. In China, vaccination is said to be practiced only in a few places, and there very meagerly. Inoculation is also practiced. Mexico is of especial interest to us. The sanitary code of 1926 prescribed compulsory vaccination at birth, and revaccination every 5 years, but correspondence with a number of sanitarians, cited later, confirms the suspicion engendered by the very high mortality rates that enforcement of the law must, at best, be a matter of gradual extension. At any rate, for the decade shown in table 1, Mexico must be classed as very incompletely vaccinated.

The international reports, incomplete as they are in some places, indicate rather definitely that well-vaccinated countries tend to have low attack rates and vice versa. A glaring exception to the rule occurs in Australia and New Zealand. In these countries, although less than 1 percent of the infants are vaccinated nowadays, smallpox is practically extinct. Australia has reported only five deaths from

smallpox in 10 years. In explanation, a letter from Dr. A. E. Keyes, secretary of the public health department at Melbourne, states:

Australia's freedom from smallpox is due to its isolation. The disease occurs there only when introduced from abroad, and thus far a vigilant medical inspection and quarantine at seaports, and similar vigilance in the interior, have been successful in preventing epidemics during recent years. Nevertheless, the health authorities in Australia are alarmed at the present state of affairs; although they have issued repeated warnings to vaccinate, there is little possibility at this time of a reinstatement of vaccination in the Australian states.

CASE FATALITY IN VARIOUS COUNTRIES

From column 5 of table 1 it is evident that smallpox of case fatality less than 1 percent seems to have been especially prevalent during recent decades in certain English-speaking countries—the United States, Canada, and England. It also reached Switzerland, but practically disappeared by 1926 (table 3). Mild smallpox is also known to be prevalent in certain African areas; in fact, the mild strain is believed by some to have reached America originally from Africa. The mild type appears to be the predominating form in the small amount of smallpox remaining in Spain (*3c*); it has also been observed to varying degrees in other parts of the world, but North America, England, and possibly South Africa seem to be its particular strongholds.

On the other hand, smallpox with high case fatality appears to be the predominating form in India, where case rates are high, as well as in many countries in which the disease has almost disappeared, for example, central Europe and Japan (table 1, col. 5).

In order to inquire into the high case fatality ratio reported for India, and to obtain further information from other foreign areas of interest, letters were sent to various individuals in such countries. A summary of the replies follows:

From Madras, India, Maj. A. M. V. Hesterlow, of the Indian medical service, writes: "Very rarely do we meet with a mild case of smallpox amounting to alastrim. Most of our cases are the severe type, running the usual secondary fever, with lesions which have permanent scars after recovery. The average case mortality was 36.9 percent from 1929–33."

From Delhi, India, Maj. A. J. Chatterji, writes: "In some of the Provinces the case mortality rate has been as high as 40 percent; in others only 13 percent; and in certain urban areas sometimes as low as 5.7 percent has been noticed * * * It is very difficult to say what proportion of cases are of mild type; but from general experience I may venture to say that they do not far exceed 30 percent of all smallpox cases."

From Colombo, Ceylon, Dr. R. Briercliffe, director of medical and sanitary service, writes: "Variola minor has not so far manifested itself in Ceylon. Ceylon is unusually free from smallpox, but in November 1932 the disease was introduced from India and an epidemic followed * * *. There were 443 cases, of which 78, or 17.6 percent proved fatal." [The writer wishes to acknowledge the courtesy of Dr. W. F. Jacocks, representative of the Rockefeller Foundation at

Colombo, Ceylon, through whose aid much of the information from India and Ceylon was obtained.]

From China, Dr. I-chin Yuan, of the department of public health, Peiping Union Medical College, submits detailed data concerning an outbreak in the Peiping first health district, on the basis of which he concludes that the fatality in a group of 181 cases was about 20 percent. From Nanking, China, Dr. S. C. Hsu, head of the department of vital statistics and epidemiology, central field health station, writes: "According to the opinions of a few authoritative physicians with whom I have consulted, about 60 percent of the cases are of the mild type, while the severe, classical type contributes about 40 percent. The case fatality in hospitals is about 14 percent." Data are not available for the interior of China.

From Brazil, advice (*6*) is received through Drs. Soper, Roças, and Lins that smallpox is rarely seen in Rio de Janeiro, where vaccination is thoroughly enforced. In the interior of Brazil, where vaccination has not been general, both smallpox and alastrim are seen. In Porto Alegre, with a population of 175,000, a diagnosis of alastrim was made in one of about 1,500 cases of smallpox. The case fatality of smallpox in Brazil is estimated at about 40 to 45 percent, and that of alastrim less than 1 percent.

Mexico.—The smallpox history of Mexico is of particular importance to the United States because, as will be seen later, epidemics of the malignant variety of smallpox have repeatedly been traced to importation from Mexico.

Satisfactory morbidity data are not available for Mexico, but the smallpox death rate, 69.9 per 100,000 population, is the highest of any of the countries shown in table 1. The annual data shown in table 2 indicate an epidemic crest about 1923–24, and again in 1930, when a mortality rate of 105.3 per 100,000 was attained. These high mortalities are evidence of the widespread prevalence of malignant smallpox in Mexico. It is estimated that, during 1922–32, the annual case incidence of the malignant variety alone must have been at least 163 per 100,000 population.[2]

Correspondence with Mexican hygienists (*7*) indicates that the mild virus is also present in Mexico. A table of cases and deaths for

[2] A rough, but conservative, estimate of the attack rate in Mexico from malignant smallpox is made possible by the fact that even if every person were assumed ultimately to contract mild smallpox, the expected deaths could account for only a fraction of the smallpox deaths which actually occur in Mexico. The remaining smallpox deaths form a basis for conservatively estimating malignant cases.

More specifically, the average lifetime in Mexico after the first few months of age, i e., for the age span most relevant to this problem, is doubtless 35 years or longer. (No life table is available for Mexico. In the United States the mean expectation of life at birth during this period was about 58 years (*17*). The expectation for Hawaiians in Hawaii, a disappearing race, was 29 years, in 1920; for Caucasian-Hawaiians it was 45 years (*18*).) We should expect, therefore, if everyone be assumed to contract mild smallpox eventually, that, on an average, not more than one thirty-fifth of the population would be attacked per year; accordingly, during 1922–32 the number of mild cases would, at most, have been one thirty-fifth of the mean population of 15,300,000, or about 437,000 cases per year. If the case fatality of the mild type is 0.2 percent (*1a, 2a*) (lower rates are seen in table 3 during some years for Switzerland and England, in spite of possible presence of some malignant cases), the expected deaths among the 437,000 mild cases would be about 874 per year. But, during 1922–32, the reported smallpox deaths actually averaged 10,885 per year (data from table 2); hence an average of at least 10,011 deaths per year, or over 92 percent of all smallpox deaths in Mexico, presumably were of malignant type. Assuming a case fatality of 40 percent for this type, or only 2½ cases per death, the estimated number of malignant cases becomes 25,027, a rate of 163 per 100,000 population or higher.

cities in 1932 shows for Irapuato 198 cases without a death, and for Toluca, in the State of Mexico, 222 cases, with only 3 deaths.

TABLE 2.—*Annual smallpox deaths and death rates per 100,000 population in Mexico, 1922–32* [1]

Year	Deaths	Death rates	Year	Deaths	Death rates
1922	11,966	84.4	1928	6,694	42.0
1923	13,074	90.3	1929	11,304	69.6
1924	12,964	87.8	1930	17,405	105.3
1925	11,003	73.1	1931	14,903	88.6
1926	5,477	35.7	1932	8,307	48.5
1927	6,639	42.4	Total, 1922-32	119,736	69.6

[1] Deaths from the National Department of Health of Mexico. Populations: 13,887,000 in 1921; 16,527,000 in 1930. (Populations from League of Nations Epidemiological Reports, January 1927 and January 1932.)

The following excerpts from a letter received from Dr. Francisco DeP. Miranda, chief of the division of interchange at the National Department of Health, throw further light upon the Mexican situation:

As a rule our cities are relatively free from smallpox, especially from severe forms of the disease. Usually the epidemics arise in rural villages inhabited by Indians. The States of Oaxaca and Guerrero may be cited as examples. [These States, in the south of Mexico, have the highest mortality rates (*3d*).] New roads have promoted smallpox control, as these villages used to be isolated, sometimes requiring 5 or 6 days on horseback to reach them.

Mexico City, notwithstanding continual efforts for vaccination, is not yet free from smallpox. The reason is that the Federal district is nearly surrounded by the State of Mexico, with a heavy Indian population scattered in many little villages; and these Indians frequently come to the city to sell their wares.

When an epidemic strikes a village inhabited by a nonimmune population, the disease is likely to be severe, in a confluent and even hemorrhagic form. In Mexico City proper, the last epidemic of severe form was in 1913. Unfortunately, rural health work is still lacking in many communities; to these we have occasionally sent what we call "sanitary brigades" in charge of vaccination, but sometimes these brigades arrive after an epidemic has passed. Full-time sanitary units are now functioning in Vera Cruz, Minatitlan, Puerto Mexico, and Cuernavaca, points which are now free of smallpox.

THE SPREAD OF MILD SMALLPOX

The mild virus of smallpox may be of great antiquity. Mild smallpox was observed by Jenner in Gloucestershire in 1798 (*16*), and the success of inoculation still earlier may have been due to selection of mild virus for transplantation; but the mild form of this disease first attracted general attention after its recognition in Florida in 1896. Its rate of spread in the United States is indicated by the fact that, within 10 years, the case fatality of smallpox in this country was down to about 0.6 percent (*1c*). The mild virus certainly was carried from here to other countries; but it would be unsound to assert that these importations represented first appearances in those countries.

In figure 2 is reflected the growing predominance of mild smallpox in various countries since 1910. The position of each square on the horizontal scale indicates its apparent case fatality at the time. (Names of countries discussed below are underlined, for convenient identification.) We note that during 1910–15 the United States was the only country of those shown in which mild smallpox predominated, the fatality for all cases being about 0.6 percent. In the remaining countries the fatality was at least 10 times this figure.

During the next quinquennium, that of the World War, the situation was not changed, except that in most countries the fatality rose slightly.

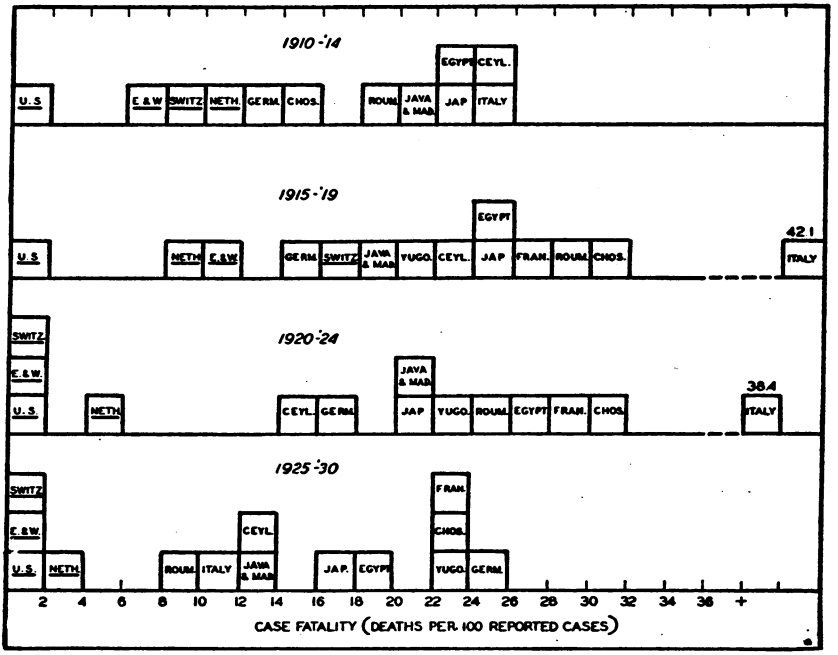

FIGURE 2.—Distribution of certain countries according to smallpox case fatality, during each of four quinquennia, 1910–30.

During 1920–24, the post-war quinquennium, mild smallpox clearly became predominant in England and Switzerland, the fatalities there declining to 1 and 3 percent, respectively. In Switzerland the mild form became heavily epidemic (table 3), but by 1925 was apparently wiped out by a national vaccination campaign (*3e*). In England, however, the incidence rose steadily to the end of the decade, and thereafter declined.

During 1925–30 the Netherlands entered the low fatality zone, with a fatality of 3.2 percent, attributable almost solely to an epidemic in 1929, which was controlled within the year. The case fatality declined markedly in most other European countries, however, which

raises the question whether central Europe, like the United States, Canada, and England, will permit mild smallpox to become endemic.

Figure 2 shows a hiatus on the case fatality scale between 2 percent and about 8 percent, this gap prevailing during each of the four quinquennia. Chapin's earlier data for the United States (*1c*) and data for England in table 3 of this paper show that when the case fatality began to decline, the movement was fairly rapid. This picture is not inconsistent with the prevalent view that (*a*) there are two principal strains or groups of smallpox virus, the one with fatalities distributed about an average of approximately 25 or 30 percent (higher in wholly unvaccinated communities) and the other with fatality considerably below 1 percent; and that (*b*) if there are strains of intermediate fatality, they have failed to establish themselves as successfully as have the very mild or the very severe strains. The crude data here presented, however, scarcely warrant more than raising questions on these points; the final answer must come from information which is far more precise.

ECOLOGY OF SMALLPOX TYPES

It is desirable to inquire why the mild form of smallpox should predominate so overwhelmingly in such countries as the United States and England, whereas the malignant type is still the predominant form in most of the remaining areas, whether smallpox be highly prevalent, as in Mexico or India, or almost extinguished, as in most of continental Europe and Japan. The contrast is especially interesting between Spain, which harbors a small amount of mild smallpox, and Portugal, where the malignant type is widely prevalent (*3f*). Importation *per se* cannot be a sufficient explanation, for mild smallpox is known to have been imported into England in 1902 (*1*), and doubtless into France, Germany, and nearby countries in 1921–25, from Switzerland and South Africa (*3e*); nevertheless, this form did not spread widely at those times. Nor can mass vaccination alone explain the circumstances, for we have seen that malignant smallpox is the predominating type (although rates may be low) in very thoroughly, as well as in incompletely, vaccinated countries.

Nevertheless, one cannot escape the conclusion that importation and especially vaccination do play important roles in determining the picture.

If we accept the prevailing belief that mutation from one strain of smallpox virus into another is at best very rare (*1*, *2*), then it follows, barring selective importation, that the ultimate predominance of one type or the other must depend upon relative dispersibility, or power to spread in the particular area involved. Thus, if, under the prevailing conditions, patients infected with type A produce, for example, 10 percent more new cases than those harboring type B,

TABLE 3.—*Annual cases, deaths, and case fatality ratios (deaths per 100 cases) in various countries* [1], *1911–33*

	1911	1912	1913	1914	1915	1916	1917	1918	1919	1920	1921	1922	1923	1924	1925	1926	1927	1928	1929	1930	1931	1932	1933
United States [2]:																							
Cases	[3] —	—	31,858	32,435	27,252	14,885	45,030	69,792	51,841	85,401	89,357	27,327	24,223	45,255	33,412	25,803	28,498	30,527	35,756	41,732	25,985	7,805	4,959
Deaths	—	—	245	98	200	203	308	373	310	402	481	595	105	814	695	330	113	95	117	132	80	32	26
Case fatality	—	—	0.8	0.3	0.7	1.4	0.7	0.5	0.6	0.5	0.5	2.1	0.4	1.8	2.1	1.3	0.4	0.3	0.3	0.3	0.3	0.4	0.5
England and Wales:																							
Cases	289	121	113	65	93	159	7	63	311	280	336	973	2,504	3,797	5,365	10,146	14,767	12,420	10,968	11,839	5,664	2,039	631
Deaths	23	9	10	4	13	18	3	2	28	30	5	27	7	13	9	18	47	53	39	28	9	3	2
Case fatality	8.0	7.4	8.7	6.2	14.1	11.3	42.8	3.0	9.0	11.7	1.5	2.8	0.3	0.3	0.2	0.2	0.3	0.4	0.4	0.2	0.2	0.1	0.3
Switzerland:																							
Cases	92	21	23	19	4	3	0	2	3	2	596	1,153	2,126	1,234	329	54	0	1	0	1	0	2	0
Deaths	11	3	0	0	2	0	0	0	0	0	7	3	2	2	1	1	0	0	0	0	0	0	0
Case fatality	12.0	14.3	0	0	50.0	—	—	—	—	—	1.2	0.3	0.1	0.2	0.3	1.9	—	—	—	—	—	—	—
Italy:																							
Cases	17,047	13,202	1,414	859	626	641	1,297	4,519	34,363	26,453	4,644	534	495	432	195	112	60	52	6	2	0	0	5
Deaths	4,828	3,336	150	45	19	16	114	924	16,380	11,037	1,360	37	16	46	13	10	5	21	[4] 8	—	—	0	—
Case fatality	28.3	25.3	10.6	5.2	3.0	2.5	8.8	20.4	47.7	41.7	29.3	6.9	3.2	10.6	6.7	8.9	8.3	40.4	—	—	—	—	—
Germany:																							
Cases	288	340	90	138	187	685	3,028	413	5,012	2,042	688	215	17	16	24	7	4	2	1	2	0	3	0
Deaths	37	35	12	19	20	91	448	60	704	332	109	26	10	6	9	0	1	0	0	0	0	0	0
Netherlands:																							
Cases	4	7	37	2	7	85	0	0	5	50	1	0	2	3	2	15	0	0	703	2	1	0	0
Deaths	0	1	4	1	1	8	0	0	0	3	0	0	0	0	0	2	0	0	21	0	0	0	0
Rumania:																							
Cases	16	70	44	62	228	[3] —	[3] —	[3] —	20,523	3,467	2,744	865	89	9	28	6	4	10	4	5	13	10	—
Deaths	11	10	7	12	58	—	—	—	5,834	781	560	153	11	1	2	1	1	0	1	0	2	0	6
Yugoslavia:																							
Cases	[3] —	[3] —	[3] —	[3] —	[3] —	[3] —	[3] —	[3] —	5,278	4,156	2,119	728	1,042	330	14	4	3	0	0	1	—	—	—
Deaths	—	—	—	—	—	—	—	—	1,100	941	483	165	198	64	3	2	0	0	0	0	—	—	—
Total 4 nations:																							
Cases	308	417	171	202	422	770	3,028	414	30,818	9,715	5,552	1,808	1,150	358	68	32	11	12	708	10	14	13	[3] —
Deaths	48	46	23	32	79	99	448	60	7,638	2,057	1,152	344	219	71	14	4	2	0	22	0	2	0	6
Case fatality	[5] —	[5] —	[5] —	[5] —	[5] —	[5] —	[5] —	[5] —	24.8	21.2	20.7	19.0	19.0	19.8	20.6	12.5	18.2	0	3.1	0	14.3	0	—

Egypt:																							
Cases	2,824	1,985	2,934	7,097	5,222	2,972	1,567	1,198	7,895	3,004	92	205	519	799	762	2,676	240	20	26	14	10	600	5,697
Deaths	737	456	706	1,568	1,262	802	409	347	1,938	805	24	90	145	221	158	542	34	4	4	0	0	142	979
Case fatality	26.1	23.0	24.1	22.0	24.2	30.4	26.1	25.5	24.4	26.5	25.8	29.1	27.9	27.7	20.7	20.3	14.2	20.0	15.4	—	—	23.4	17.2
Japan:																							
Cases	202	14	108	485	17	264	5,121	1,467	4,056	3,167	889	679	1,922	1,703	430	1,256	352	723	114	7	23	305	376
Deaths	34	1	39	110	3	48	1,158	285	1,115	844	212	124	381	266	81	174	92	110	12	2	8	45	56
Case fatality	16.8	7.1	36.1	22.7	17.6	18.2	22.6	19.4	27.5	26.6	23.8	18.3	19.8	15.6	18.8	13.9	26.1	15.2	10.5	28.6	34.8	14.8	14.9

[1] Foreign data from Epidemiological Reports of the League of Nations, mainly, R. E. 155, Oct. 15, 1931.
[2] Data from the United States are from the States indicated in footnote to table 6.
[3] A dash indicates that satisfactory data were not available for the years indicated; in the "case fatality" position the dash means that cases or deaths were too few for calculation of the ratios.
[4] The excess of deaths may relate to cases of the preceding year.
[5] Not comparable with the years 1919 et seq., as data for Rumania and Yugoslavia were not available for all of the earlier years.

then, ultimately, A must eventually become the predominating type, regardless of the initial distribution.

So far as we know, the factors affecting dispersibility of a disease like smallpox relate primarily to seed, soil, and sowing process; in other words, the virus, the host, and transference. Our problem, then, is to inquire how factors associated with this trio change from place to place, so as to favor the spread of a particular virus.

Turning first to the *virus:* It is generally agreed among observers that, under like conditions, the malignant virus has far greater power to infect exposed persons than has the mild (*2a, 4c, 16, 19a*). The measure of the ability of the virus to spread, e. g., the average number of secondary cases per initial case under standard conditions of immunity, contact, etc., we shall term the *infectivity* of the virus.[3] One reason for the superior infectivity of the malignant virus is its ability to overcome a higher degree of immunity than can the mild. Thus, a person vaccinated 10 years previously may be immune to the mild virus, but not to the malignant. The much larger area of pustules in malignant smallpox perhaps also increases infectivity.

The second factor, *herd immunity,* measures the ability of a population to resist attack upon exposure to smallpox virus of specified potency. As herd immunity rises, apparently a point may be reached where mild smallpox is practically suppressed, and spread of malignant smallpox is inhibited. With greater immunity, even malignant smallpox may be practically suppressed. Immunity is believed to vary with the frequency of vaccination, the potency of vaccine virus, its state of preservation, and probably other factors.

The third factor in determining dispersibility is the *contact rate,* or rate of transference of virus from one person to another. Since malignant smallpox renders the patient less ambulant, and the community enormously more fearsome, the rate of contact with patients must be less for malignant smallpox than for mild. However, since effective isolation demands considerable intelligence and technical knowledge, and is costly, it is reasonable to suppose that the discrimination against malignant smallpox must be commonest and most effective in countries where health organization abounds.

There are doubtless other factors than these three which affect the dispersibility of smallpox; how influential they are can only be surmised.

Although quantitative information is lacking, it seems almost certain that the most important factor in determining which type of smallpox shall predominate in any area is immunity of the population.

[3] Infectivity, as here used (following Stallybrass) (*4*), is not to be confused with dispersibility. Infectivity measures case production under *standard* conditions of immunity, contact, etc.; whereas dispersibility measures production under the *actual* conditions. Therefore, the infectivity of a given strain of virus is presumed to be essentially constant from place to place, but its dispersibility may, and does vary greatly, depending upon immunization and isolation practices, intelligence of the population, and similar factors.

The reason for placing immunity first is that it may vary from almost a zero (e. g., universal susceptibility to mild virus) to a high level, where practically all are immune to a very malignant virus. On the other hand, zero infectivity of virus and zero community contact rate are not likely to prevail in any sizable area; even benign smallpox, for example, is considered very "contagious". In other words, while we might find the proportion of immunes to be a hundred times as great in some places as in others, we should scarcely expect to find for contact or infectivity of virus a range of variation as great as five to one; hence we point to herd immunity as the chief of the factors controlling dispersibility of smallpox.

We assume, then, that dispersibility is the resultant of infectivity, contact rate, and susceptibility,[4] and that it varies in rough proportion with each of these factors. We ask next how well this relationship will explain the case fatality in the three types of populations discussed in connection with figure 1.

(*a*) In very well vaccinated countries, such as most of continental Europe, immunity of the population is so high that presumably the mild organism cannot maintain itself. The malignant form, being able to overcome a higher immunity, succeeds in making a feeble stand, and so the small amount of residual smallpox in such countries is expected to be of malignant type. Table 1 shows that recorded fatalities are consistent with this inference, in that countries with low case rates (usually reflecting high vaccination rates) tend to have a high case fatality.

(*b*) At the other extreme, in the very incompletely vaccinated countries, such as China, India, Mexico, and the pre-Jennerian world, the populations were probably not sufficiently skilled or organized to make an effective attack on either variety of smallpox. The malignant virus, therefore, probably encountered susceptibility and contact rates only slightly, if any, lower than did the mild, and therefore tended to predominate because of its greater power to infect and spread.

(*c*) Finally, in the United States and England, with highly organized health forces, the malignant type, where it appears, becomes surrounded with a barrier of immunes through selective vaccination, and the contact rate is reduced through isolation. The mild type, however, is combated far less vigorously; hence it has higher dispersibility and becomes the predominating type.

How greatly the campaign in this country discriminates against malignant smallpox is illustrated by the experience of Detroit. In

[4] In this and subsequent paragraphs it is assumed that the underlying relationship may be *approximately* represented by the expression $D=isc$, where D represents dispersibility; i, infectivity of virus; s, susceptibility of population; and c, contact rate, respectively.

Susceptibility is here used in place of immunity, because, as is pointed out on page 378, it bears a simpler relationship to dispersibility.

November 1923 when mild smallpox was epidemic, the health department conducted vigorous propaganda for vaccination through the press, motion pictures, and by other means. Nevertheless, the number of health department vaccinations averaged only about 6,000 per month, most of them of children. Shortly afterward, however, when malignant smallpox was imported from Canada, the vaccination rate increased enormously; a half million persons were vaccinated in 1 month, and nearly 800,000 (about 70 percent of the entire population) within 5 months (*13c*).

TABLE 4.—*Smallpox case and death rates per 100,000 population, and percentage case fatality, by States, 1921–31 average*

States	Population 1926	Cases reported, 1921–31	Average annual case rate	Deaths reported, 1921–31	Average annual death rate	Case fatality (deaths per 100 cases)
New England:						
Maine	786,110	454	5.25	3	0.035	0.66
New Hampshire	456,751	100	1.99	1	.020	1.00
Vermont	356,850	1,175	29.93	6	.153	.51
Massachusetts	4,096,826	366	.81	3	.007	.82
Rhode Island	655,541	112	1.55	0		
Connecticut	1,519,879	931	5.57	13	.078	1.40
Middle Atlantic:						
New York	11,740,819	4,007	3.10	9	.007	.22
New Jersey	3,700,784	970	2.38	63	.155	6.50
Pennsylvania	9,280,837	1,263	1.24	76	.074	6.02
East North Central:						
Ohio	6,305,430	36,771	53.01	168	.243	.46
Indiana	3,119,996	38,179	111.24	121	.353	.32
Illinois	7,190,124	28,342	35.83	132	.167	.47
Michigan	4,390,824	22,444	46.47	321	.665	1.43
Wisconsin	2,820,953	15,222	49.05	174	.561	1.14
West North Central:						
Minnesota	2,495,947	19,034	69.33	541	1.970	2.84
Iowa	2,445,199	19,670	73.13	124	.461	.63
Missouri	3,542,727	[1] 11,103	31.34	[1] 128	.361	[1] 1.15
North Dakota	667,776	5,743	78.18	13	.177	.23
South Dakota	671,191	8,847	119.83	20	.271	.23
Nebraska	1,346,586	12,798	86.40	46	.310	.36
Kansas	1,838,023	18,797	92.97	145	.717	.77
South Atlantic:						
Delaware	232,465	19	.74	1	.039	5.26
Maryland	1,561,569	413	2.40	2	.012	.48
District of Columbia	467,913	510	9.91	20	.389	3.92
Virginia	2,378,517	6,173	23.59	23	.088	.37
West Virginia	1,615,549	9,011	50.71	21	.118	.23
North Carolina	2,935,215	19,962	61.83	120	.372	.60
South Carolina	1,717,594	5,559	29.43	36	.190	.65
Georgia	2,903,632	[2] 8,744	30.11	[2] 97	.334	[2] 1.11
Florida	1,276,006	6,713	47.83	38	.270	.57
East South Central:						
Kentucky	2,538,448	[1] 4,436	[1] 17.48	[1] 64	.252	[1] 1.44
Tennessee	2,509,377	12,988	47.05	48	.174	.37
Alabama	2,531,600	13,429	48.22	108	.388	.80
Mississippi	1,925,510	8,100	38.24	50	.236	.62
West South Central:						
Arkansas	1,815,144	3,709	18.58	25	.125	.67
Louisiana	1,985,025	7,089	32.47	90	.412	1.27
Oklahoma	2,254,591	17,703	71.38	177	.714	1.00
Texas	5,377,984	[2] 18,352	34.12	[2] 140	.260	[2] .76
Mountain:						
Montana	541,947	7,038	118.06	18	.303	.26
Idaho	439,966	5,844	120.76	20	.414	.34
Wyoming	213,584	1,747	74.35	7	.300	.40
Colorado	998,807	6,517	59.32	342	3.114	5.25
New Mexico	399,098	848	19.32	12	.273	1.42
Arizona	396,574	2,357	54.04	198	4.539	8.40
Utah	485,366	[2] 6,813	140.37	[2] 31	.639	[2] .46
Nevada	85,801	822	87.06	4	.424	.49
Pacific:						
Washington	1,483,869	23,329	142.92	83	.509	.36
Oregon	888,251	12,690	129.87	33	.338	.26
California	4,811,715	36,169	68.35	421	.795	1.16

[1] Data not available for the year 1921.
[2] Data not available for the year 1922.
[3] Data not available for the year 1926.

The available statistics for the great majority of geographic areas of the world appear to support the indicated hypothesis; namely, that, both forms being present, and "other factors being equal", the malignant variety tends to be more prevalent than the mild; and that the predominance of the mild type is usually due to inequalities among the "other factors." We have seen that, in England and the United States, a very important biassing factor, though possibly not the sole one, is the selective attack against malignant smallpox. In Spain [5] it is barely possible that importation of mild smallpox from the Balearic and Canary Islands (*10*) may be a factor. Just why mild smallpox should predominate over severe in such areas as South

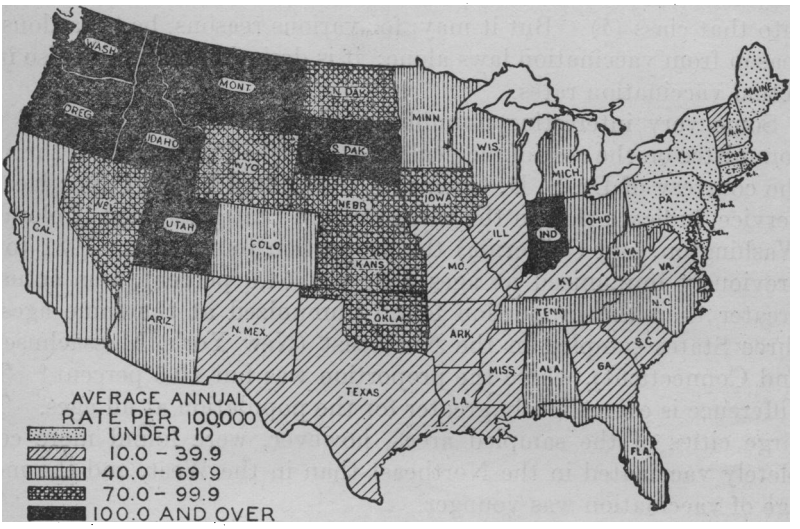

FIGURE 3.—Reported smallpox case rates by States—average, 1921-31.

Africa and the West Indies, if it does, is more difficult to say, in the light of the scanty information available. It is, therefore, left to the future to determine whether or not the experience in such areas is consistent with the explanation suggested above, or whether other causative factors must be sought to explain the distribution of mild and malignant smallpox in those areas.

B. Smallpox in the United States

We turn now to a more detailed consideration of smallpox in the United States. In figure 3 and table 4 it is seen that case rates are highest in the northwest and lowest in the northeast regions. The

[5] The low rate in Spain stands in sharp contrast to the high incidence of malignant smallpox in Portugal, at present the smallpox center of Europe. There were, in Portugal, 8,424 cases during 1931-33, a case rate of about 136 per 100,000. The case fatality was 25.2 percent (*3f*). I am informed that vaccination rates there are far lower than in Spain (*8, 9*). Production and distribution of vaccine are also said to be more rigorously supervised in Spain.

differences are pronounced, the rates in the Northwest, averaging well over 100 per 100,000, were during 1921–31 more than 40 times as high as the mean rate of 2.6 for the New England and Middle Atlantic States.

When information concerning vaccination in these two regions is examined, apparent contradictions are encountered, whose explanation promises to be instructive of the epidemiology of smallpox. It is doubtless true, as has repeatedly been pointed out, that laws requiring vaccination are far more common in the Northeast; thus, apparently all of the 9 States in the North Atlantic region except Maine and Vermont are said to have required vaccination or local option; whereas only 2 of the 11 westernmost States (Oregon and New Mexico) fall into that class (*5*). But it may, for various reasons, be hazardous to reason from vaccination laws alone; it is desirable to inquire also into actual vaccination rates.

Some very interesting unpublished data from the surveys of the committee on the cost of medical care, furnished to the writer through the courtesy of Dr. S. D. Collins, of the United States Public Health Service, indicate that in the three western States sampled (Colorado, Washington, and California) the proportion found about 1931 to be previously immunized at ages 5–9, viz, 54.9 percent, was actually greater than the proportion found immunized at the same ages in three States sampled in the Northeast (New York, Massachusetts, and Connecticut), where the proportion was but 40.5 percent.[6] The difference is even slightly greater for the population at all ages. The large cities of the sampled areas, however, were found more completely vaccinated in the Northeast than in the West, and the mean age of vaccination was younger.

In discussing this subject, it is more enlightening to speak in terms of susceptibility than immunity, since attack rates have a more direct relationship to susceptibles.[7] Thus, if immunes increase from 80 to 90 percent, the increase in immunes is only one-eighth; but, at the same time, susceptibles decrease by half. The latter ratio clearly measures the expected decline in risk of attack more directly than the former. Therefore, taking as the most available index of susceptibles the population found, about 1931, not previously immunized by vaccination or attack, we note from table 5 that at all ages, surveyed cities of 100,000 population or over, showed, in the West, a proportion of nonimmunized persons of 27.9 percent, which is about 60 percent greater than the proportion found in northeastern large cities (17.8 percent). At ages 5–9, where the relative difference is greatest, the

[6] In the three northeast States, the surveyed sample included a larger proportion of rural families than actually exists in the States. See reference in footnote 1, table 5.

[7] The terms "susceptibility" and "immunity" are here used relatively. The immunity from vaccination falls off progressively at different rates in different persons, and is usually incomplete against severe smallpox within 5 to 20 years if not renewed by revaccination.—Ed.

western large cities had three times the proportion of nonimmunized as the northeastern; at ages 10–14, about twice as many.

These relationships are reversed in the case of smaller cities, towns, and rural areas. Thus, at ages 5–9, the strictly rural parts of the Northeast had about 60 percent more nonimmunized than the West. In New York State vaccination is required for school attendance in large cities, but not for villages and rural territory, except at time of epidemics (*20, 21*). One could hardly assert, upon the evidence just cited, that the comparatively low rates of the Northeast are due solely to vaccination of city populations more completely and at earlier ages. In the discussion of this paper, Dr. Charles Armstrong pointed out that in the Northeast, under the required system, vaccination goes on year after year; whereas in the West, vaccination is oftener undertaken after an epidemic is under way; hence case rates are higher. Other factors than herd immunization, e. g., importation, may also have been operative in producing the contrast between eastern and western case rates. The role of the "other factors" is also emphasized in an official British report (*11a*) in a discussion of geographical distribution of variola minor. The problem clearly merits further study.

TABLE 5.—*Proportions found nonimmunized against smallpox, by types of community and by region, at all ages, and ages 5–9* [1]

Region of the United States	Persons enumerated [2]					Percentage found nonimmunized [3]				
	Cities 100,000 or over	Cities 5,000 to 100,000	Towns under 5,000	Rural	Total, all community types	Cities 100,000 or over	Cities 5,000 to 100,000	Towns under 5,000	Rural	Total, all community types
All ages										
Northeast	2,872	1,819	2,405	1,746	8,842	17.8	62.8	67.6	73.0	51.5
North Central	6,534	3,783	1,861	2,001	14,179	29.0	46.2	47.3	59.8	40.3
South	1,905	2,903	1,115	1,630	7,553	32.4	38.6	43.5	63.3	43.1
West	2,750	996	2,002	1,398	7,146	27.9	36.6	37.5	47.6	35.6
All regions	14,061	9,501	7,383	6,775	37,720	27.0	46.0	50.7	61.5	42.6
Ages 5–9										
Northeast	424	259	343	250	1,276	12.3	72.6	85.1	90.8	59.5
North Central	947	657	361	308	2,273	33.3	58.8	68.4	75.3	51.9
South	306	482	173	227	1,188	26.1	34.0	48.0	65.2	40.0
West	315	116	316	217	964	37.1	44.8	45.3	56.7	45.1
All regions	1,992	1,514	1,193	1,002	5,701	28.3	52.2	64.3	72.9	50.5

[1] These unpublished data are from the survey of the Committee on Costs of Medical Care, in 130 localities of 18 States, during 1928–31. The surveyed areas are described in Causes of Illness in 9,000 Families, Based on Nation-Wide Periodic Canvasses, 1928–31, by S. D. Collins, Pub. Health Rep., 48: 12, pp. 283–308 (Mar. 24, 1933). Reprint 1563.

[2] Enumerated persons with known vaccination status.

[3] Percentage found not to have been vaccinated or attacked by smallpox at any time prior to the survey. (Previous attacks were few in relation to vaccinations. The 2 were, therefore, combined.)

Case fatality changes in the United States.—Figure 4 shows the changes since 1913 in the case fatalities in the United States, and in

each of eight geographic regions thereof. If space permitted, it would be interesting to show in what an amazing proportion of instances even the smaller ripples in the regional case fatality curve can be allocated as to origin by reference to Chapin and Smith's detailed history (*1*). For example, the small peak in the case fatality in the New England region in 1915 was apparently due mainly to an epidemic of 26 cases and 10 deaths in New Bedford, Mass. The first case was reported to be an importation from the Cape Verde Islands. The rise in the Texas-Oklahoma region in 1916 (West South Central) was attributed to frequent importations from Mexico. In 1918 malignant smallpox was carried from Texas to Lake Charles, La., whence it gradually spread to New Orleans and the rest of Louisiana. The small rise for the Pacific region, about 1916–17, was attributed to importation into the Imperial Valley, Calif., from Mexico.

This sensitiveness of the case fatality curve emphasizes the importance of only a few smallpox deaths as a possible indicator of the introduction of the malignant virus into a region.

Many instances similar to those cited show that an important part is played in American smallpox history by the transmission of severe smallpox from place to place. We have in this circumstance a sharp contrast with such diseases as scarlet fever and measles, which are constantly present in the larger cities, and whose epidemic ebb and flow depend not so much upon migration and importation as upon the more or less periodic rise and fall of susceptible populations.

The role of the migrant in spreading malignant smallpox from place to place is strikingly illustrated in the interesting history of the 1922 and 1925 increases in case fatality, which are clearly evident in the graph.[8] In the first of these increases the case fatality rose at least a little in nearly every region of the United States; in the second outbreak three regions were mainly affected.

The first of these outbreaks (1921–22) apparently began in Kansas City and Denver; the second (1924–25) began in Detroit, in various cities in Minnesota, and in New Britain, Conn. These 1924–25 foci were apparently set up by two tramps and a boy, who were infected with malignant smallpox in Winnipeg, Manitoba, in January 1924 and carried the disease to Duluth, Minn., Detroit, Mich., and New Britain, Conn. The resulting epidemic, involving approximately 7,400 cases and 1,270 deaths, was the greatest outbreak of malignant smallpox in this country since 1904. In the writer's opinion, the 1921–22 and 1924–25 epidemics point forcibly to the disastrous effects that ensue when smallpox gains headway in large cities.

[8] Owing partly to the fact that deaths lag after cases, the annual case fatality, as here calculated (annual deaths divided by cases of the same year) is somewhat too low for 1921 and 1924, and too high for the years immediately following.

These great regional epidemics supplement the vaccination surveys referred to above in indicating that national protection from smallpox depends especially upon well-vaccinated cities. Endemically the smallpox death rate in the United States is about two to four times as high in the country as in the city, but the only two wide-spread

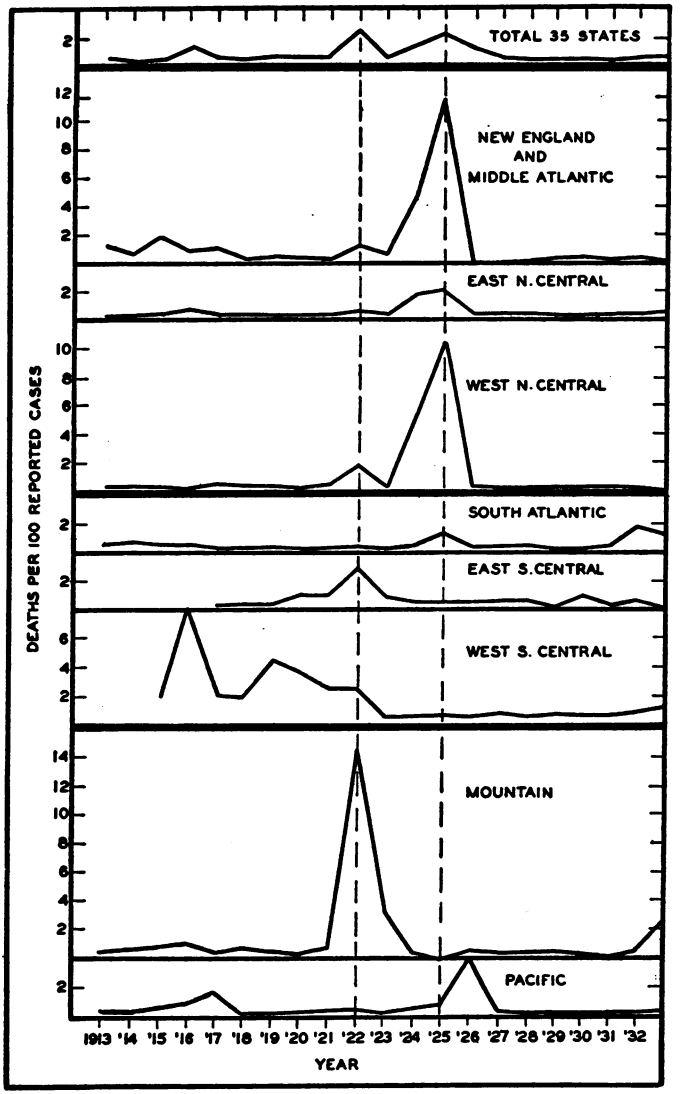

FIGURE 4.—Smallpox case fatality ratios, by U. S. regions, annually, 1913–33.

epidemics of malignant type shown in this graph resulted when outbreaks began in large cities. This is not an argument against rural vaccination; it simply stresses the critical importance of well-vaccinated cities.

TABLE 6.—*Smallpox cases and deaths in each of 8 geographic regions of the United States, annually, 1913 to 1933, inclusive*

Year	New England and Middle Atlantic		East North Central		West North Central		South Atlantic		East South Central		West South Central		Mountain		Pacific		Total	
	Cases	Deaths	Cases	Deaths	Cases	Deaths	Cases	Deaths	Cases	Deaths	Cases	Deaths	Cases	Deaths	Cases	Deaths	Cases	Deaths
1913	1,545	22	9,711	19	6,467	16	2,501	10	926	6	3,676	143	3,598	9	3,434	20	31,858	245
1914	1,716	9	13,553	28	7,846	24	4,501	23	—	—	—	—	2,929	8	1,890	6	32,435	98
1915	684	12	9,412	28	7,317	21	1,600	6	775	4	5,780	117	515	3	1,169	9	27,252	200
1916	495	4	5,311	8	4,833	5	565	3	—	—	1,952	164	739	6	990	13	14,885	203
1917	1,873	20	19,010	43	9,340	44	1,362	3	2,166	6	7,758	168	2,680	10	841	14	45,030	308
1918	1,973	3	26,660	78	14,084	48	3,352	9	7,248	32	7,878	161	5,359	35	3,238	7	69,792	373
1919	1,023	5	17,022	37	7,810	17	4,895	17	3,437	13	4,248	190	4,385	15	9,021	14	51,841	310
1920	1,092	3	32,024	65	16,803	32	7,446	20	4,590	52	4,941	185	4,875	10	13,630	35	85,401	402
1921	1,416	3	30,384	89	22,945	104	5,680	19	4,233	48	5,076	125	8,005	58	11,618	35	89,357	481
1922	856	12	8,634	57	5,322	101	1,389	8	1,352	40	2,981	77	1,928	275	4,865	25	27,327	595
1923	1,034	6	8,911	26	3,792	8	1,425	3	615	5	2,951	12	1,010	34	4,485	11	24,223	105
1924	1,364	64	16,468	324	6,012	325	1,666	9	3,105	11	3,343	17	1,068	3	12,229	61	45,255	814
1925	695	81	10,940	227	2,417	246	2,272	32	5,504	26	3,218	19	578	0	7,788	64	33,412	695
1926	376	0	7,677	22	2,481	5	1,676	6	1,924	8	3,946	12	959	5	6,764	272	25,803	330
1927	420	0	10,010	33	3,409	5	2,726	10	1,610	9	4,437	34	1,929	4	3,957	18	28,498	113
1928	652	1	8,467	26	5,126	11	1,944	8	712	4	6,337	30	2,367	7	4,922	8	30,527	95
1929	960	3	14,110	42	6,017	10	1,140	2	415	0	4,880	34	2,366	8	5,868	18	35,756	117
1930	483	2	17,553	51	8,340	12	1,304	3	496	5	5,930	40	1,355	2	6,271	17	41,732	132
1931	910	1	7,804	19	6,230	16	444	2	1,563	2	5,181	32	432	0	3,421	8	25,985	80
1932	593	2	2,066	7	1,872	2	103	2	1,107	7	2,075	20	248	1	1,523	4	9,587	45
1933	36	0	1,190	5	884	0	86	1	127	0	1,310	14	235	6	1,654	5	5,522	31

NOTE.—The 35 States included in this table, their distribution into regions, and regional populations are as follows:

Region	States included	Population	
		1920	1930
New England and Middle Atlantic	Maine,[1] Vermont, Massachusetts, Connecticut, New Jersey, New York, Pennsylvania	28, 614, 573	33, 274, 351
East North Central	Ohio, Indiana, Illinois,[1] Michigan, Wisconsin	21, 475, 543	25, 297, 185
West North Central	Minnesota, Iowa, North Dakota, South Dakota, Kansas	7, 843, 822	8, 289, 585
South Atlantic	Maryland, District of Columbia, Virginia, West Virginia,[1] South Carolina	7, 343, 844	8, 008, 216
East South Central	Alabama, Mississippi	4, 138, 792	4, 656, 069
West South Central	Arkansas,[1] Louisiana,[1] Oklahoma, Texas	10, 242, 224	12, 176, 830
Mountain	Montana, Wyoming, Colorado, Utah	2, 132, 316	2, 306, 809
Pacific	Washington, Oregon, California	5, 566, 871	8, 194, 433
		87, 357, 985	102, 203, 478

[1] States omitted for the years 1913–16, inclusive, because continuous data were not available. For the same reason Alabama, Oklahoma, and Texas are omitted in 1914; Montana and Colorado in 1915; Alabama, Oklahoma, and Utah in 1916; Oklahoma in 1918; Texas in 1919; Oklahoma and Utah in 1920; and Utah in 1922, 1924, 1932

TABLE 7.—*Smallpox case and death rates per 100,000 population, and percentage case fatality in each of 8 regions [1] of the United States, annually, 1913–1933*

Year	New England and Middle Atlantic			East North Central			West North Central		
	Case rate	Death rate	Case fatality	Case rate	Death rate	Case fatality	Case rate	Death rate	Case fatality
1913	6.09	0.087	1.423	72.48	0.142	0.196	95.37	0.236	0.247
1914	6.66	.035	.524	99.34	.205	.207	114.63	.351	.306
1915	2.62	.046	1.754	116.20	.334	.286	119.82	.304	.254
1916	1.87	.015	.808	76.05	.079	.703	73.54	.072	.098
1917	6.77	.072	1.067	92.08	.208	.226	121.84	.574	.471
1918	7.04	.011	.152	127.09	.372	.293	182.03	.620	.341
1919	3.60	.018	.489	79.88	.183	.229	100.02	.218	.218
1920	3.82	.010	.275	149.12	.303	.203	214.22	.408	.190
1921	4.87	.010	.212	138.95	.407	.293	290.83	1.318	.453
1922	2.89	.041	1.401	38.79	.256	.660	67.07	1.273	1.898
1923	3.44	.020	.580	39.34	.115	.292	47.51	.100	.211
1924	4.47	.210	4.692	71.47	1.406	1.967	74.90	4.049	5.406
1925	2.24	.261	11.655	46.68	.969	2.075	29.94	3.047	10.178
1926	1.19	—	—	32.22	.092	.287	30.56	.062	.202
1927	1.31	—	—	41.33	.136	.330	41.76	.061	.147
1928	2.01	.003	.153	34.40	.106	.307	62.44	.134	.215
1929	2.92	.009	.313	56.43	.168	.298	72.89	.121	.166
1930	1.45	.006	.414	69.12	.201	.291	100.47	.145	.144
1931	2.70	.003	.109	30.50	.074	.243	74.86	.192	.257
1932	1.74	.006	.337	8.02	.029	.339	22.45	.024	.107
1933	.10	0	—	4.59	.019	.420	10.58	0	—

Year	South Atlantic			East South Central			West South Central		
	Case rate	Death rate	Case fatality	Case rate	Death rate	Case fatality	Case rate	Death rate	Case fatality
1913	46.08	0.184	0.400	41.95	0.272	0.648	61.99	2.412	3.890
1914	81.88	.418	.511	—	—	—	—	—	—
1915	28.76	.108	.375	34.43	.178	.516	93.77	1.898	2.024
1916	10.02	.053	.531	69.09	—	—	44.50	3.738	8.402
1917	19.16	.042	.220	53.01	.147	.277	78.63	1.703	2.166
1918	46.54	.125	.268	176.46	.779	.442	97.91	2.001	2.044
1919	67.09	.233	.347	83.25	.315	.378	76.85	3.427	4.473
1920	101.81	.273	.269	110.90	1.256	1.133	60.15	2.252	3.744
1921	76.91	.257	.335	100.98	1.145	1.134	48.62	1.197	2.463
1922	18.63	.107	.576	31.85	.942	2.959	28.02	.724	2.583
1923	18.93	.040	.211	14.31	.116	.813	27.23	.111	.407
1924	21.92	.118	.540	71.36	.253	.354	30.29	.154	.509
1925	29.62	.417	1.408	124.98	.590	.472	28.64	.169	.590
1926	21.65	.078	.358	43.17	.179	.416	34.51	.105	.304
1927	34.89	.128	.367	35.70	.200	.559	38.15	.292	.766
1928	24.66	.101	.412	15.60	.088	.562	53.57	.254	.473
1929	14.33	.025	.175	8.99	—	—	40.57	.283	.697
1930	16.25	.037	.230	10.62	.107	1.008	48.50	.327	.675
1931	5.51	.025	.450	33.29	.043	.128	42.04	.260	.618
1932	1.27	.025	1.941	23.46	.147	.632	16.72	.158	.964
1933	1.06	.013	1.163	2.68	0	—	10.49	.112	1.069

Year	Mountain			Pacific			Total		
	Case rate	Death rate	Case fatality	Case rate	Death rate	Case fatality	Case rate	Death rate	Case fatality
1913	195.64	0.489	0.250	73.91	0.430	0.582	48.56	0.373	0.769
1914	155.45	.425	.273	39.47	.125	.317	55.53	.168	.302
1915	87.87	.512	.583	23.71	.183	.770	41.41	.304	.734
1916	47.60	.386	.812	19.52	.256	1.313	23.39	.319	1.364
1917	132.70	.495	.373	16.13	.269	1.665	53.44	.366	.684
1918	259.56	1.695	.653	60.47	.131	.216	83.55	.447	.534
1919	207.84	.711	.342	164.14	.255	.155	63.13	.378	.598
1920	289.68	.594	.205	244.84	.629	.257	100.65	.474	.471
1921	372.29	2.697	.725	199.06	.600	.301	100.57	.541	.538
1922	112.96	16.113	14.263	79.68	.409	.514	30.39	.662	2.177
1923	46.20	1.555	3.366	70.35	.173	.245	26.36	.114	.433
1924	61.72	.173	.281	184.04	.918	.499	43.68	.876	1.799
1925	26.01	—	—	112.64	.926	.822	35.19	.732	2.080
1926	42.82	.223	.521	94.16	3.786	4.021	26.74	.342	1.279
1927	85.44	.177	.207	53.09	.242	.455	29.08	.115	.397
1928	104.02	.308	.296	63.73	.104	.163	30.67	.095	.311
1929	103.16	.349	.338	73.42	.225	.307	35.38	.116	.327
1930	58.62	.087	.148	75.90	.206	.271	40.68	.129	.316
1931	18.62	—	—	40.76	.095	.234	25.12	.077	.308
1932	13.67	.055	.403	17.91	.047	.263	9.25	.043	.469
1933	10.06	.256	2.553	19.13	.058	.302	5.26	.030	.561

[1] The States included in the several regions are shown in table 6.

THE TRANSIENT AND VAGRANT AS SPREADERS OF SMALLPOX

Table 8, which is compiled from Chapin's study, lists the types of persons reported by him to have imported malignant smallpox into the United States. It is to be noted that, of about 20 individuals referred to, there were only 2 boys and 1 woman; the others were men. Note also the representation with respect to social and economic groups, especially in the later years—Mexican bootleggers, migratory laborers, sailors, and persons of similar transient groups. The Detroit epidemic and also an outbreak of malignant smallpox in Poteau, Okla., reported by Parran (*19b*), began with wanderers who came into the hands of the police. In reading the literature one is impressed with the number of outbreaks which began with tramps. Possibly one of the reasons that an epidemic in a large city becomes a menace to the entire nation is the astonishingly large number of homeless men passing through the large cities—vagrants, migratory laborers, and the like. Information on this point is scanty, but several books on the vagrant problem in Chicago agree in indicating that, during hard times, especially in the winter, the vagrant population of that city may become as large as 150,000 (*14*)—over 10 percent of the entire male population of the city of working age. This vast, restless horde, ever on the move, doubtless are very influential in the spread of epidemics.

TABLE 8.—*Types of persons transporting malignant smallpox*

Year	Place of epidemic	Type of person and origin
1900	Winnipeg, Manitoba	Traveler from Japan; infected before reaching Canada.
1901	Newark, N. J.	Peddler from New York City.
1903	Crook County, Oregon	Farmer traveling across the country.
1904	St. Louis, Mo.	Filipinos coming to St. Louis Exposition.
1907	Fall River, Mass.	Women arriving from England.
1909	Norfolk, Va.	3 cases in sailors from warship just arrived from abroad.
1913	Berkeley, Calif.	A man suspected of having been in Mexico.
1914	Elm Springs, Ark.	Boy, after 9 days' trip from Tampico, Mexico.
1915	New Bedford, Mass.	Sailor from Cape Verde Islands.
1916	Worcester, Mass., and Eveleth, Minn.	Immigrant from Sweden.
1921	Poteau, Okla.	Man who had come from Kansas City and was jailed in Poteau, and five prisoners escaped from the Poteau jail.
1924	Duluth, Minn.	Migratory laborer from Canada.
	Detroit, Mich.	Do.
	New Britain, Conn.	Boy traveling through Canada.
1925	Los Angeles, Calif.	Mexican bootleggers.

Figure 5 and table 9, showing smallpox case rates by age and sex in the Detroit epidemic of malignant smallpox, give further description of the type of individual who is especially subject to smallpox. Note the excessive case rate among the young adult males, ages 15 to 30. The graph also reflects the protection enjoyed by children of school age, when vaccination immunity is at its best.

Figure 6 is presented to illustrate several points, the first of which is the tendency of the smallpox incidence to rise and fall somewhat synchronously in different areas of the United States. It should be emphasized that this picture reflects mainly the movement of mild smallpox. The severe malignant form has, during the last two decades, never contributed as much as 10 percent of the total incidence of the United States, even during the 1921 and 1924 epidemics of malignant smallpox (*1c*). Note the tendency toward a peak in most regions in 1920, and again in 1924 and in 1930. Attention is especially directed toward the decline in almost all regions since 1930, i. e., a period of industrial depression. Similar declines have taken place during the depression in England, Canada, and Mexico. It is interesting to note that fairly general declines also took place in the United States during the industrial depression of 1921–22.

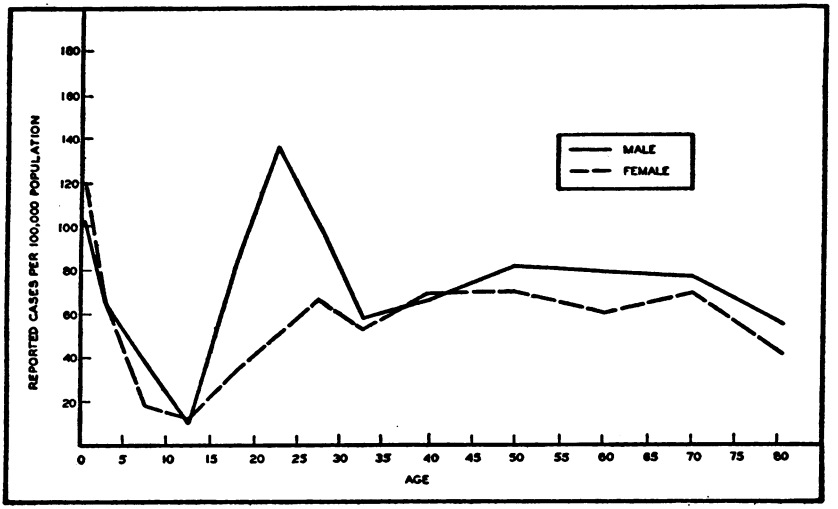

FIGURE 5.—Reported smallpox case rates by age-sex. Detroit, Mich.; 1924 epidemic.

Conversely, the rates tended to rise somewhat during the preceding periods of prosperity. It seems possible that the increases during prosperous periods reflect such forces as the movement of Negroes from the rural regions of the South into the industrial centers of the North and the importation of Mexican labor. Conversely, during periods of depression the movement tends to be from the city back to the farm; and Mexican laborers return to the mother country. A bulletin of the Department of Agriculture (*15*) indicates that, in 1933 or early 1934, the farm population of the United States had reached its all time peak. Opposed to the hypothesis that a rise and fall of smallpox reflects corresponding movements of migratory labor are the reports that the freight trains were never so loaded with migrants as during the depression. It seems possible, however, that these

migrants were mainly city people, who are usually vaccinated; whereas the prosperity migrations from rural regions consist more largely of unvaccinated persons.

TABLE 9.—*Smallpox case rates by age and sex, Detroit, Mich., Apr. 13, to Aug. 31, 1924*

Age	Estimated population [1]		Reported cases [2]		Case rate per 100,000 population [3]	
	Male	Female	Male	Female	Male	Female
All ages	663,902	582,194	472	313	71	54
Under 1	12,647	12,367	13	15	103	121
1–4	51,911	50,334	34	32	66	64
5–9	57,766	56,788	22	11	38	19
10–14	48,510	48,541	5	6	10	12
15–19	45,864	47,526	33	19	72	34
20–24	66,151	61,826	91	31	138	50
25–29	81,563	66,917	66	45	81	67
30–34	74,563	57,740	43	31	58	54
35–44	118,552	86,663	79	61	67	70
45–54	62,554	49,084	52	35	83	71
55–64	28,225	26,676	23	16	82	60
65–74	11,442	12,794	9	9	79	70
75+	3,526	4,676	2	2	57	43
Unknown	628	312	—	—	—	—

[1] Arithmetic interpolation between 1920 and 1930 censuses.
[2] Read from graph on p. 10 of Monthly Bulletin, Detroit Department of Health, April–May 1925, vol. VIII, no. 3.
[3] Rates are not on an annual basis but relate to the indicated period of about 3½ months.

Table 10, which again is taken from Chapin and Smith's data, shows that of 23 importations of malignant smallpox into the United States since 1915, 14, or 61 percent, were from Mexico. This raises the question whether with the return of prosperity and possible consequent smuggling of Mexican labor into the United States, we shall not again be confronted with an increase in malignant smallpox. Certainly the greatest vigilance in this respect is called for. Importation from Asia, some of it through Canada, ranks second in importance.

TABLE 10.—*Foreign sources of traced importations of malignant smallpox into United States, 1915–29*

Foreign sources	Smallpox importations
Mexico	14
Canada	3
Asia	2
Europe	1
Africa	1
Not specified	2
Total	23

There is some danger that the low incidence of the last few years, with possible laxity as to vaccination, may permit a highly susceptible population to develop, ready to be attacked when the move-

ments from farms and from Mexico and the Orient—particularly of smuggled labor—are resumed. In Europe, the chief source of danger is Portugal.

WARNING SIGNALS IN SMALLPOX

From the administrative standpoint, the interest of the health officer and epidemiologist in smallpox must center particularly in the

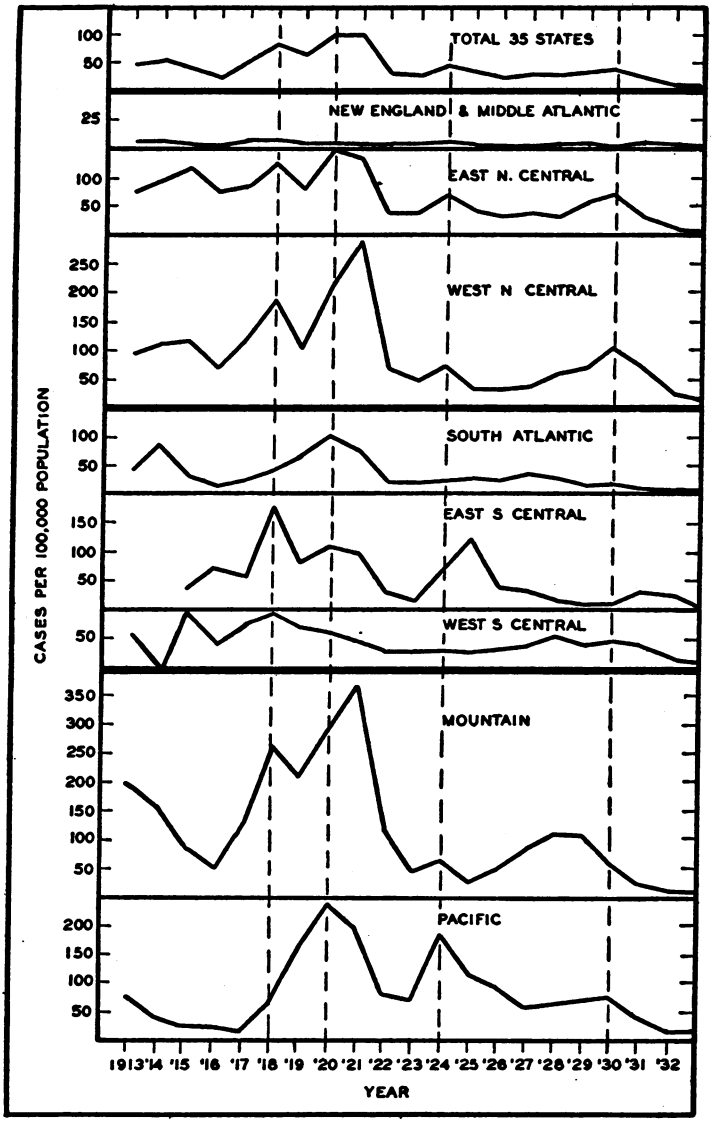

FIGURE 6.—Reported smallpox case rates, by U. S. regions, annually, 1913-33.

malignant variety, which disfigures for life or kills. We have seen that apparently from a single focus of this type in Winnipeg, Manitoba, there resulted 7,400 cases and 1,270 deaths, scattered in many places

throughout the United States. The occurrence of only one case, or a few malignant cases, especially in a large city, should, therefore, be of concern to health officials in many other communities.

It is, however, difficult to obtain current statistics of sporadic cases, or beginning epidemics of the malignant type. There are two main obstacles. The first is that initial cases of malignant smallpox in a community are frequently misdiagnosed by physicians as scarlet fever, measles, or other disease. Thus, in Duluth, the first case was admitted to a surgical hospital because of backache and general pains following an accident (*22a*); in Minneapolis, a hospital orderly apparently died of unrecognized hemorrhagic smallpox after an illness of 3 days (*22b*); in Detroit, the existence of the initial malignant case was not known until the epidemic of severe smallpox was well under way, and one of the early cases died under treatment for measles (*13b*).

A second obstacle to the scientific study and prevention of malignant smallpox is that, since the malignant and mild varieties are reported under the same name, the few malignant cases are concealed in the published statistical reports among the many cases of mild type. The difficulty of obtaining even the crudest quantitative notion as to the nonepidemic prevalence of malignant smallpox can be appreciated only by one who has seriously attempted the task.

For the present, smallpox deaths probably constitute the best available statistical index to local increases in malignant smallpox. It is of interest in this connection that Assistant Surgeon General R. C. Williams, in charge of the Division of Sanitary Reports and Statistics of the Public Health Service, has arranged to publish in the Public Health Reports weekly smallpox deaths for cities. The deaths will be recorded as footnotes to the case reports. In using such a table, it is well to remember that in recent years, less than a hundred smallpox deaths have been reported annually in the United States. Obviously the report of as few as 2 smallpox deaths within a few weeks from a State or city should be cause for suspecting the presence of the malignant smallpox virus, unless there are 200 or more cases per death.

The 1929 International Conference on Causes of Death recommended that smallpox deaths be classified under (*a*) variola vera, (*b*) variola minor, including alastrim, and (*c*) variety unstated. In England the medical practitioner simply reports a death as smallpox; the health department epidemiologist makes the differential diagnosis from clinical and epidemiological data. The procedure is regarded in England as practicable and useful (*11b*).

In the absence of such classification it is impossible to say from case and death reports whether, during the last few years, there has been a single case of malignant smallpox in the United States. It is to be repeated, however, that the importance of the smallpox problem must

not be gaged by the present small number of deaths, but by the probable results when, with the resumption of migration from Mexico and elsewhere, the virus of malignant smallpox begins to be reimported into a population as susceptible as ours. The lesson taught by the 1924–25 epidemic should not be forgotten.

In conclusion, there is, on behalf of scientific study and control of smallpox, and rational attitudes toward vaccination, need of more extensive and continuous knowledge of the immunity status of the population in different places. The exact mode of measurement is a matter for future research; but even so crude an index as the annual rate of vaccination in the different areas would be of distinct value.

Summary

The inferences of this paper are that—

(1) The predominance of the mild virus of smallpox in the United States and certain other countries during recent years is probably due primarily (*a*) to relatively low endemic vaccination rates, which permit the mild strain to maintain itself; and (*b*) to a more intense attack against the malignant form. Other factors may, however, have played an important part.

(2) High vaccination rates are particularly important for large cities, if national protection against malignant smallpox is to be maintained.

(3) The vagrant, migratory laborer, and people from unvaccinated rural regions have been influential in the spread of smallpox from place to place.

(4) There are indications that the smallpox incidence has increased during times of prosperity through intensified migration to industrial centers from rural areas, where vaccination rates are relatively low and attack rates endemically are higher than in cities. Conversely, during recent industrial depressions the smallpox incidence has declined.

(5) Particular vigilance is required to forestall the importation of the virus of malignant smallpox into the United States from Mexico, and in lesser degree from the Asiatic ports, if immigration, including smuggled labor from these sources, should be resumed with the return of prosperity.

(6) Smallpox deaths or case fatality ratios at present probably represent the best available index of malignant smallpox. The prompt publication of smallpox deaths in conjunction with cases is highly important.

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(7) Letter from Dr. Salvador Bermudez, professor of hygiene at the faculty of medicine, Mexico City, and Dr. Francisco de P. Mirando, chief of the division of interchange, Federal Department of Health. (I am indebted to Dr. C. A. Bailey, representative of the Rockefeller Foundation at Mexico City, and to Dr. R. K. Collins and Dr. H. P. Carr, for cooperation in this connection.)

(8) Statements of Drs. J. Moroder and I. Medarde, both in the national health service of Spain.

(9) Statements of Drs. C. H. D'Oliveira and F. N. Araujo, of the national health administration of Portugal.

(10) Estimate for the Canaries and Balearics in the difference between the League of Nations data, which include those islands, and the data for Continental Spain from the Bulletin Semestral of the Departmento National de Estadisticas, forwarded through courtesy of Dr. Manuel Pascua. Acknowledgment is also due to Dr. R. B. Hill, representative of the Rockefeller Foundation in Spain, in this connection.

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ACUTE RESPONSE OF GUINEA PIGS TO VAPORS OF SOME NEW COMMERCIAL ORGANIC COMPOUNDS

IX. PENTANONE (METHYL PROPYL KETONE) [1]

By W. P. YANT [2], F. A. PATTY [3], and H. H. SCHRENK [4]

This report on the acute response of guinea pigs to pentanone (methyl propyl ketone) vapor is the ninth of a series of similar reports [5] which deal with studies pertinent to establishing a criterion of toxicity of the vapor of some chemical products which have recently reached or promise to reach important domestic or industrial use.

The investigation was undertaken at the request of Stanco, Inc., and was conducted jointly by the United States Bureau of Mines and that company. The experiments were conducted by the Bureau of Mines at its Pittsburgh Experiment Station.

SCOPE OF WORK

The scope of the work included a study of the toxicity and physiological response of guinea pigs exposed to vapors of pentanone (methyl propyl ketone). Only the acute effects as produced by a single

[1] Contribution from the Pittsburgh Experiment Station, U. S. Bureau of Mines, Pittsburgh, Pa. Published by permission of the Director, U. S. Bureau of Mines. Work on manuscript completed May 15, 1935.

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exposure were studied. The experiments were planned to cover a range of concentrations which would produce but slight or no response, moderate response, and serious response.

CHEMICAL AND PHYSICAL PROPERTIES

The pentanone used in this study was a commercial grade of methyl propyl ketone sold for industrial use. It was water-clear and had an odor resembling that of acetone, but tended to be more ethereal in character. An examination of the material gave the following values for the physical properties:

Specific gravity

15.6°/15.6° C	0.8115
20°/15.6° C	.8075

Boiling range

Distillate, cumulative (percent)	Temperature, ° C., corrected to 760 mm	Distillate, cumulative (percent)	Temperature, ° C., corrected to 760 mm
Initial boiling point	98.5	60	101.7
1	99.0	70	102.0
2.8	99.5	80	102.4
5	99.9	90	103.0
10	100.4	95	103.4
20	100.8	97.2	104.4
30	101.2	98	105.2
40	101.3	99	106.5
50	101.5	99.7	109.0

Recovery, 99.7; residue, 0.1 percent; lost, 0.2 percent.

These values of the physical properties as determined by the Bureau of Mines agree closely with the specifications furnished by the manufacturer for this commercial product. The manufacturer also specified the product to be 88.7 percent ketone as determined by acetylation.

The boiling point of pentanone as given in the International Critical Tables [6] is 101.7° C.

SUGGESTED USES OF PENTANONE [7]

Pentanone is an organic solvent. It is reported to be a good solvent for nitrocellulose and Vinilite products and has possibilities of use in making lacquers and also varnish and lacquer removers.

TEST APPARATUS

The apparatus for preparing pentanone-air mixtures and for exposing animals was the same as that described in a previous report dealing with butanone.[8]

[6] International Critical Tables, first edition, 1926, vol. 1, p. 192.

[7] These suggestions are given to acquaint persons interested in industrial hygiene with the probable fields of use of this product. The Bureau of Mines has done no work on the use of this product, and the above suggestions are not intended to be complete.

[8] See footnote 5.

COMPUTATION AND ANALYSIS OF VAPOR-AIR MIXTURES

The method of computation and analysis was the same as that described in the report on butanone.[8] Table 1 gives the results of analyses of a standard aqueous solution of pentanone made to check the accuracy of the method of analysis.

TABLE 1.—*Results of the analysis of samples containing known amounts of pentanone*

Pentanone taken	Pentanone recovered	Recovery
Milligrams	*Milligrams*	*Percent*
16.2	16.85	104
32.4	34.4	106
32.4	34.4	106
48.6	51.5	106

As an average recovery of 106 percent was obtained (table 1) for known amounts of the standard solution of commercial pentanone, the values obtained for the amount of pentanone in the vapor-air mixtures used in animal experiments (table 2) were corrected by multiplying the determined value by 100/106, or 0.943. The high-percentage recovery probably is due to some secondary reaction, as discussed in the paper on butanone. [8]

Table 2 gives the results of the concentration computed from the volume of air and amount of pentanone vaporized, and the concentrations found by chemical analysis of vapor-air mixtures used in animal experiments. The calculation of percent by volume was made on the basis that 1 gram molecular weight of pentanone is equivalent to 22.4 liters of vapor at 0° C. and 760 mm mercury pressure.

TABLE 2.—*Results of analysis of exposure atmospheres* [1]

Concentration by—		Concentration by—	
Computation	Analysis	Computation	Analysis
(2)	[3] 4.7	0.47	0.46
(2)	[4] 4.6	0.48	.47
(2)	[4] 5.7	0.45	.44
	[4] 5.7	0.17	.16
1.4	1.2	0.15	.16
1.3	1.3	0.15	.16
1.4	1.4	0.14	.14
1.4	1.2	0.15	.14
0.51	.53	0.15	.17
0.46	.56		

[1] Concentration in percent by volume at 25° C. and 760 mm pressure. To convert to mg per liter, multiply by 35.2.
[2] Concentration obtained by recirculating air at 30° C. and 740 mm pressure across wicks wet with liquid pentanone. No computed concentration.
[3] Obtained by slow combustion analysis.
[4] Obtained by adsorption on air-equilibrated charcoal.

The maximum concentration attainable by recirculating air at 30° C. and 740 mm pressure over large-surface wicks wet with pentanone averaged approximately 5 percent. The remainder of the re-

[8] See footnote 5.

sults in table 2 represent experimental atmospheres prepared by continuously volatilizing a measured amount of pentanone in a measured volume of air, the number of air changes in the experimental chamber being two to three per hour. Tests have shown that this rate of change in the apparatus used is ample to prevent oxygen deficiency or significant increase in carbon dioxide. The general order of concentrations used in the experiment were 5.0, 1.3, 0.5, and 0.15 percent by volume.

TEST PROCEDURE; DESCRIPTION AND CARE OF ANIMALS

The test procedure and description and care of animals were the same as those described in a previous report of experiments with butanone.[8]

RESULTS OF TEST

This report presents summarized results pertinent to signs or symptoms, fatality, and gross pathology.

OBJECTIVE SYMPTOMS

Control animals.—No signs or symptoms were exhibited by the 24 control guinea pigs taken at random from the stock animals used in these tests. No deaths occurred.

Exposed animals.—The signs or symptoms exhibited by animals exposed to pentanone vapor in the order of their occurrence were as follows: Irritation of the nose and eyes, manifested by rubbing nose with the forepaws and squinting; lacrimation; incoordination; narcosis; gasping type of respiration; and death. Table 3 gives the average period necessary to produce these symptoms by various concentrations of pentanone vapor in air. The figures given in parentheses indicate that the particular symptom did not occur in the maximum period of exposure as given, whereas the other values indicate the average time for occurrence of the symptom.

TABLE 3.—*Signs and symptoms produced in guinea pigs exposed to vapors of pentanone*

Type of symptom	Concentration of vapor, percent by volume			
	5	1.3	0.5	0.15
	Duration of exposure (minutes)			
Nasal irritation (rubbing nose)	(1)	2	3	2 (810)
Eye irritation (squinting)	(1)	2	3	2 (810)
Lacrimation	(1)	2	5	2 (810)
Incoordination	2	17	270	2 (810)
Narcosis (unconsciousness)	6	47	460–710	2 (810)
Respiratory changes (dyspnea, gasping)	30	150–270	570–710	2 (810)
Death	50	300	2 (810)	2 (810)

[1] Occurred almost immediately after start of exposure.
[2] Not observed during the maximum exposure time as given in parentheses.

[8] See footnote 5.

No abnormal signs were observed during or following an exposure to 0.15 percent pentanone vapor in air by volume for 810 minutes. With exposure to 0.5 percent in air, signs of irritation of the nose and eyes occurred in 3 minutes, lacrimation in 5 minutes, incoordination in 270 minutes, and unconsciousness in 460 to 710 minutes, closely followed by dyspnea, but no deaths occurred during or following an exposure of 810 minutes. The time for occurrence of these symptoms decreased rapidly with increases in concentration,

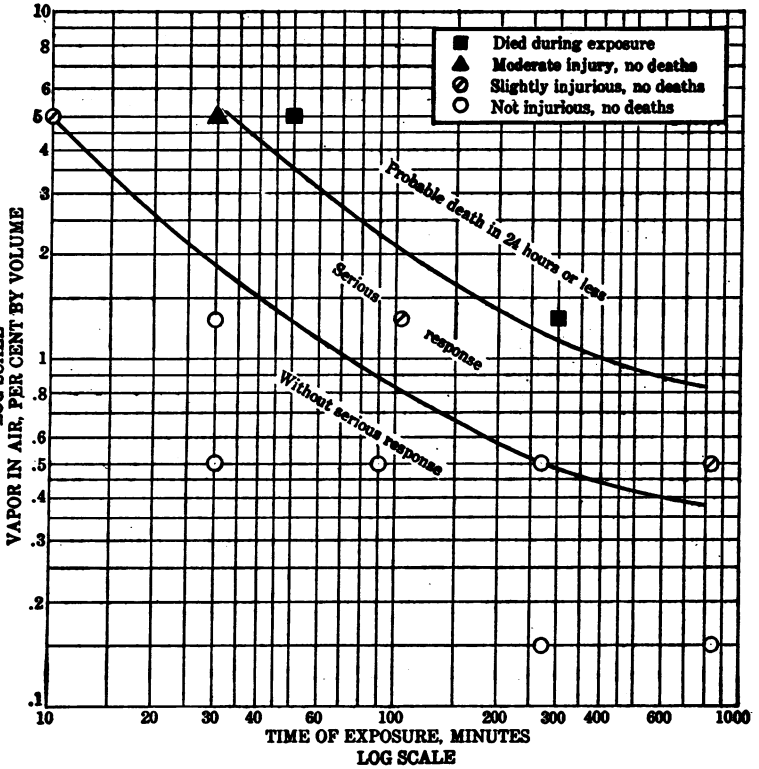

FIGURE 1.—Acute effects of exposure of guinea pigs to pentanone vapor in air.

and death was produced by an exposure to 1.3 and 5 percent vapor in air for 300 and 50 minutes, respectively.

GROSS PATHOLOGY

Control animals.—The 24 control animals killed for autopsy exhibited no significant gross pathology.

Exposed animals.—The gross pathological findings in animals that died during exposure (see table 3 and fig. 1) were slight congestion of the brain and marked congestion of the systemic organs. The lungs were emphysematous, edematous, and markedly congested. Exposure to conditions that caused marked incoordination, narcosis,

and a gasping-type respiration produced slight or no congestion of the brain and slight to moderate congestion of lungs, liver, and kidneys in animals killed immediately after exposure. These findings were absent in nearly all animals killed for autopsy 4 to 8 days following exposure. No gross pathology was found in animals exposed for 30, 90, and 270 minutes to 0.5 percent or exposure of 270 and 810 minutes to 0.15 percent vapor.

SUMMARY OF FATALITY AND PHYSIOLOGICAL RESPONSE

The fatality and summary of response of guinea pigs exposed to pentanone vapor in air are shown graphically in figure 1 and given in conventional degrees of response in table 4. The results of each experiment are designated by a symbol which represents one of four different degrees of severity. The symbols represent the most severe response for a majority or at least three of a group of six animals exposed to a given condition. The response of none of the animals deviated markedly from that which is representative of the group.

The four degrees of response are given in the legend on figure 1. In addition to representing the response of each group by symbols, the symbols have been separated into three general zones of probable response.

Table 4 gives concentrations (obtained by direct experiment or extrapolated from table 3 and fig. 1) which produce the degrees of response generally reported for noxious gases, These data may be compared with toxicological data for other compounds. [9] [10] [11] [12] [13] [14]

TABLE 4.—*Acute effects of exposure of guinea pigs to pentanone vapor in air*

Acute effects after various periods of exposure	Concentration, percent by volume in air
Kills in a few minutes	[1]
Dangerous to life in 30 to 60 minutes	3. 0–5. 0
Dangerous to life after several hours	0. 8–1. 0
Maximum amount for 1 hour without serious disturbance	[2] 0. 5
Maximum amount for several hours without serious disturbance	0. 2–0. 4
Maximum amount for several hours with but slight or no symptoms	[3] 0. 15

[1] Not produced by 5 percent, the highest concentration obtained in a closed chamber by extended recirculation of air (30° C., 740 mm pressure) over wicks wet with pentanone.
[2] This concentration was found to be very irritating to men even for short exposures.
[3] This concentration was found by men to have a strong odor and moderate to marked irritation of the eyes and nasal passages, although no definite reaction was noted in guinea pigs even after 810 minutes exposure.

[9] See footnote 5.

[10] Sayers, R. R., Yant, W. P., Thomas, B. G. H., and Berger, L. B.: Physiological response attending exposure to methyl bromide, methyl chloride, ethyl bromide, and ethyl chloride. Pub. Health Bull. 185 (1929).

[11] International Critical Tables, first edition (1927), vol. 2, p. 318; also see errata sheet, vol. 2.

[12] Henderson, Y., and Haggard, H. W.: Noxious gases. American Chemical Society Monograph No. 35. Chemical Catalog Co., New York. (1927).

[13] Flury, F., and Zernik, F.: Schädliche Gase. Berlin. Published by Julius Springer. (1931.)

[14] Fieldner, A. C., Katz, S. H., and Kinney, S. P.: Gas masks for gases met in fighting fires. U S. Bureau of Mines Technical Paper 248. (1921.)

CAUSE OF DEATH

Death apparently was due to a state of narcosis which terminated in death rather than to the irritation of the lungs. It is noteworthy that no animals died after exposure. They either died during exposure or survived the exposure and the 4- or 8-day post-exposure observation period. In some instances the animals were unconscious for several hours after removal from exposure (30 minutes to 5 percent, 105 minutes to 1.3 percent, and 810 minutes to 0.5 percent) but appeared normal in all instances 24 hours after exposure.

COMPARISON OF ACUTE TOXICITY OF BUTANONE AND PENTANONE

The acute toxicity of pentanone, as indicated by exposure of guinea pigs, is about twice that of butanone;[15] owing to its lower volatility, however, the maximum concentration obtained with pentanone was only about half that obtained with butanone. From a practical viewpoint, the lower volatility would under similar conditions of usage tend to compensate for the higher toxicity.

WARNING PROPERTIES AND HAZARDS OF ACUTE POISONING

Men momentarily exposed to 1.3 and approximately 5.0 percent pentanone vapor pronounced the atmosphere extremely disagreeable because of irritation to the eyes and nasal passages. One-half percent was found to be very disagreeable, and 0.15 percent vapor was found to have a strong odor and to produce a moderate to marked sense of irritation to the eyes and nasal passages.

Concentrations without apparent harm to guinea pigs after one exposure of several hours have warning properties of both odor and irritation that are very disagreeable to human beings.

WARNING PROPERTIES AND EXPLOSION HAZARDS

The explosive hazard of pentanone is minimized by the distinct warning properties of concentrations below the inflammable range, but cannot be ignored. A few determinations of the inflammable properties of the vapor of the pentanone used in this study indicated the limits to be, approximately, 1.5 (lower) and 8 percent (upper) by volume.

SUMMARY AND CONCLUSIONS

The acute physiological response of guinea pigs to air containing pentanone (methyl propyl ketone) vapor was determined. The concentrations of vapor ranged from those that produced death to those that produced no effect after several hours' exposure. The signs of response, fatality, and gross pathology are given. The warning properties as studied by the exposure of persons are described.

[15] See footnote 5.

1. Pentanone produces narcosis, terminating in death in the higher concentrations. Symptoms are principally eye and nasal irritation, followed by narcosis. Animals that did not die during exposure, recovered.

2. The principal gross pathological findings were congestion, edema, and hemorrhage of lungs, liver, and kidneys, as observed in the autopsies performed immediately after exposure.

3. At room temperature it was not possible to attain a concentration that would kill guinea pigs in a few minutes. Exposure to 3.0 to 5.0 percent vapor is considered dangerous to the life of guinea pigs after 30 to 60 minutes. One-half of 1 percent is considered the maximum amount for 60 minutes without serious disturbance. The maximum for several hours with but slight or no symptoms was 0.15 percent.

4. Pentanone has a distinct odor and is markedly irritating to the nose and eyes of human beings in concentrations found to be harmful to guinea pigs. It also has a strong odor and moderate to marked irritation to human beings in concentrations producing but slight to no sign of response in guinea pigs after several hours. The approximate inflammable limits are 1.5 (lower) and 8 percent (upper) by volume in air. The inflammable range of mixtures is extremely disagreeable to human beings because of odor, and eye and nasal irritation.

ACKNOWLEDGMENTS

Acknowledgment, with thanks, is made to Surgeon R. R. Sayers, United States Public Health Service, formerly Chief of the Health and Safety Branch, United States Bureau of Mines, for consultation and advice in this investigation, to John Chornyak, formerly medical officer in charge of the pathological laboratory, and to S. H. Black, formerly assistant surgeon, United States Bureau of Mines, for making pathological examinations.

DEATHS DURING WEEK ENDED MAR. 14, 1936

[From the Weekly Health Index, issued by the Bureau of the Census, Department of Commerce]

	Week ended Mar. 14, 1936	Corresponding week, 1935
Data from 86 large cities of the United States:		
Total deaths	10,082	8,738
Deaths per 1,000 population, annual basis	14.1	12.2
Deaths under 1 year of age	605	613
Deaths under 1 year of age per 1,000 estimated live births	55	56
Deaths per 1,000 population, annual basis, first 11 weeks of year	13.7	12.9
Data from industrial insurance companies:		
Policies in force	68,130,517	67,549,346
Number of death claims	15,158	14,022
Death claims per 1,000 policies in force, annual rate	11.6	10.8
Death claims per 1,000 policies, first 11 weeks of year, annual rate	10.9	10.9

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

CURRENT WEEKLY STATE REPORTS

These reports are preliminary, and the figures are subject to change when later returns are received by the State health officers

Reports for Weeks Ended Mar. 21, 1936, and Mar. 23, 1935

Cases of certain communicable diseases reported by telegraph by State health officers for weeks ended Mar. 21, 1936, and Mar. 23, 1935

Division and State	Diphtheria		Influenza		Measles		Meningococcus meningitis	
	Week ended Mar. 21, 1936	Week ended Mar. 23, 1935	Week ended Mar. 21, 1936	Week ended Mar. 23, 1935	Week ended Mar. 21, 1936	Week ended Mar. 23, 1935	Week ended Mar. 21, 1936	Week ended Mar. 23,1935
New England States:								
Maine	2	----	16	4	75	319	0	0
New Hampshire	----	----	----	----	2	8	0	1
Vermont	1	1	----	----	794	3	0	0
Massachusetts	5	6	----	----	888	447	12	4
Rhode Island	----	----	----	----	31	92	2	4
Connecticut	3	8	48	4	85	1,213	1	0
Middle Atlantic States:								
New York	38	38	[1] 40	[1] 17	2,739	2,433	31	15
New Jersey	10	19	64	11	193	1,300	5	2
Pennsylvania	26	53	----	----	952	5,717	6	6
East North Central States:								
Ohio	21	33	13	18	264	1,073	13	12
Indiana	11	19	49	42	8	440	5	0
Illinois	33	71	47	49	50	3,231	18	13
Michigan	7	13	7	6	88	3,825	4	0
Wisconsin	2	3	75	31	104	1,583	3	3
West North Central States:								
Minnesota	2	1	----	----	349	1,701	2	0
Iowa	18	12	12	15	4	1,496	5	1
Missouri	83	24	1,040	115	26	696	4	13
North Dakota	1	5	5	----	5	109	0	0
South Dakota	----	6	----	2	2	53	1	2
Nebraska	9	3	----	13	85	597	1	5
Kansas	13	14	12	10	----	1,694	1	1
South Atlantic States:								
Delaware	----	1	2	2	8	7	2	0
Maryland [2]	7	8	2	23	175	82	21	5
District of Columbia	13	19	4	4	37	77	4	12
Virginia	14	18	1,331	----	257	1,262	11	3
West Virginia	13	8	173	79	20	620	5	0
North Carolina	9	12	351	49	71	613	7	5
South Carolina	2	7	689	247	36	36	7	0
Georgia [2]	11	6	788	72	----	----	7	1
Florida	5	10	47	11	4	68	6	1
East South Central States:								
Kentucky	8	11	190	100	122	1,015	48	7
Tennessee	8	9	569	135	106	75	20	8
Alabama [2]	8	9	2,216	371	23	519	5	4
Mississippi [2]	4	8	----	----	----	----	0	1

See footnotes at end of table.

Cases of certain communicable diseases reported by telegraph by State health officers for weeks ended Mar. 21, 1936, and Mar. 23, 1935—Continued

Division and State	Diphtheria		Influenza		Measles		Meningococcus meningitis	
	Week ended Mar. 21, 1936	Week ended Mar. 23, 1935	Week ended Mar. 21, 1936	Week ended Mar. 23, 1935	Week ended Mar. 21, 1936	Week ended Mar. 23, 1935	Week ended Mar. 21, 1936	Week ended Mar. 23, 1935
West South Central States:								
Arkansas	8	7	607	110	4	192	6	3
Louisiana	15	28	385	70	84	208	2	0
Oklahoma [4]	7	10	305	163	15	103	5	5
Texas [3]	38	48	558	949	392	131	10	0
Mountain States:								
Montana	-------	4	7	-------	13	309	0	2
Idaho	1	-------	9	6	10	82	2	0
Wyoming	1	-------	-------	-------	6	169	0	0
Colorado	4	3	-------	-------	13	352	0	0
New Mexico	6	1	-------	18	29	18	2	5
Arizona	2	2	298	36	37	29	0	2
Utah [3]	2	-------	-------	-------	17	14	0	0
Pacific States:								
Washington	2	1	35	5	278	203	3	1
Oregon	4	1	134	85	399	175	2	4
California	30	37	1,187	83	1,985	984	8	8
Total	507	597	11,449	2,955	10,885	35,373	297	159
First 12 weeks of year	7,509	8,792	87,599	89,257	91,852	278,285	2,640	1,479

Division and State	Poliomyelitis		Scarlet fever		Smallpox		Typhoid fever	
	Week ended Mar. 21, 1936	Week ended Mar. 23, 1935	Week ended Mar. 21, 1936	Week ended Mar. 23, 1935	Week ended Mar. 21, 1936	Week ended Mar. 23, 1935	Week ended Mar. 21, 1936	Week ended Mar. 23, 1935
New England States:								
Maine	0	0	6	17	0	0	0	4
New Hampshire	0	0	2	18	0	0	0	0
Vermont	0	0	20	26	0	0	0	1
Massachusetts	0	0	280	255	0	0	1	2
Rhode Island	0	0	29	6	0	0	1	0
Connecticut	0	0	116	121	0	0	1	0
Middle Atlantic States:								
New York	1	0	1,153	1,160	0	0	8	9
New Jersey	0	1	640	166	0	0	0	2
Pennsylvania	1	0	522	756	0	0	7	7
East North Central States:								
Ohio	0	2	367	988	1	0	45	2
Indiana	0	0	337	171	5	0	1	0
Illinois	2	0	1,067	1,316	19	1	1	6
Michigan	0	0	326	487	2	0	0	4
Wisconsin	2	0	669	459	11	38	1	1
West North Central States:								
Minnesota	0	0	387	258	0	14	0	1
Iowa	1	0	283	102	27	2	4	5
Missouri	0	0	247	79	10	5	3	0
North Dakota	1	0	47	119	4	0	0	0
South Dakota	0	0	58	7	14	3	0	0
Nebraska	2	0	209	42	51	31	0	0
Kansas	0	0	378	52	74	29	0	0
South Atlantic States:								
Delaware	0	0	4	23	0	0	0	0
Maryland [2]	1	1	92	108	0	0	2	4
District of Columbia	0	0	19	144	0	0	1	0
Virginia	0	0	59	54	0	1	1	1
West Virginia	0	0	52	93	0	0	7	7
North Carolina	0	2	27	40	1	0	1	3
South Carolina	0	0	1	5	2	0	2	0
Georgia [3]	0	1	27	6	0	0	2	1
Florida	0	0	6	1	0	0	0	1

See footnotes at end of table.

Cases of certain communicable diseases reported by telegraph by State health officers for weeks ended Mar. 21, 1936, and Mar. 23, 1935—Continued

Division and State	Poliomyelitis		Scarlet fever		Smallpox		Typhoid fever	
	Week ended Mar. 21, 1936	Week ended Mar. 23, 1935	Week ended Mar. 21, 1936	Week ended Mar. 23, 1935	Week ended Mar. 21, 1936	Week ended Mar. 23, 1935	Week ended Mar. 21, 1936	Week ended Mar. 23, 1935
East South Central States:								
Kentucky	2	0	42	66	0	0	2	2
Tennessee	0	0	47	20	0	0	3	1
Alabama [3]	0	0	11	12	1	0	1	0
Mississippi [2]	0	0	10	11	0	0	0	3
West South Central States:								
Arkansas	0	0	17	8	1	0	0	1
Louisiana	0	1	15	15	0	1	5	9
Oklahoma [4]	0	0	34	30	2	0	1	1
Texas [3]	0	1	57	74	1	24	2	9
Mountain States:								
Montana	0	0	103	12	14	20	0	1
Idaho	0	0	31	4	2	0	0	2
Wyoming	0	0	45	22	0	19	0	0
Colorado	0	0	108	287	1	0	0	1
New Mexico	0	0	88	14	1	2	2	2
Arizona	0	1	27	22	0	0	0	0
Utah [2]	0	0	96	141	1	0	0	0
Pacific States:								
Washington	0	0	101	50	11	20	2	0
Oregon	0	0	43	50	2	2	2	1
California	5	5	347	240	14	4	2	3
Total	18	15	8,652	8,159	272	216	111	97
First 12 weeks of year	248	309	92,710	83,940	2,785	2,329	1,247	1,535

[1] New York City only.
[2] Week ended earlier than Saturday.
[3] Typhus fever, week ended Mar. 21, 1936, 10 cases, as follows: Georgia, 2; Alabama, 3; Texas, 5.
[4] Exclusive of Oklahoma City and Tulsa.

SUMMARY OF MONTHLY REPORTS FROM STATES

The following reports of cases reported monthly by States is published weekly and covers only those States from which reports are received during the current week.

State	Meningococcus meningitis	Diphtheria	Influenza	Malaria	Measles	Pellagra	Poliomyelitis	Scarlet fever	Smallpox	Typhoid fever
January 1936										
Massachusetts	17	55	-------	-------	1,629	1	1	1,303	0	7
February 1936										
Alabama	6	83	5,018	95	134	14	6	112	3	9
Arizona	4	13	1,042	-------	141	3	1	155	1	2
Georgia	18	41	4,575	57	16	17	0	110	-------	5
Idaho	8	3	34	-------	187	-------	1	632	18	2
Illinois	54	163	193	10	113	1	1	3,156	39	11
Maine	3	11	15	-------	1,749	-------	1	113	0	2
Maryland	41	32	149	-------	637	-------	1	353	0	5
Massachusetts	24	32	-------	-------	2,477	2	2	1,095	0	9
Minnesota	10	14	4	-------	824	-------	0	1,447	40	4
Montana	7	7	171	-------	126	-------	0	519	32	3
Nevada	1	1	139	-------	30	-------	0	29	1	0
New Jersey	15	52	120	-------	416	-------	3	1,417	0	6
New York	73	137	-------	1	7,685	-------	1	4,032	0	22
Oregon	5	10	532	-------	3,206	-------	4	185	7	6
Rhode Island	3	3	9	-------	287	-------	0	122	0	1
South Dakota	4	9	16	-------	22	-------	0	244	74	6
West Virginia	27	52	572	-------	50	-------	-------	169	1	5

January 1936

	Cases
Massachusetts:	
Anthrax	1
Chicken pox	1,893
Dysentery (bacillary)	5
German measles	245
Lead poisoning	1
Mumps	2,101
Ophthalmia neonatorum	85
Paratyphoid fever	1
Rabies in animals	6
Septic sore throat	17
Tetanus	1
Trachoma	2
Trichinosis	2
Typhus fever	1
Undulant fever	5
Whooping cough	357

February 1936

	Cases
Anthrax:	
Massachusetts	2
New Jersey	1
New York	2
Chicken pox:	
Alabama	229
Arizona	205
Georgia	164
Idaho	60
Illinois	1,881
Maine	308
Maryland	279
Massachusetts	1,220
Minnesota	528
Montana	88
Nevada	39
New Jersey	1,360
New York	2,509
Oregon	184
Rhode Island	99
South Dakota	148
West Virginia	329
Conjunctivitis:	
Georgia	2
Dengue:	
Georgia	5
Dysentery:	
Arizona (bacillary)	8
Georgia (amebic)	9
Illinois (amebic)	12
Illinois (amebic carriers)	17
Illinois (bacillary)	41
Maine (bacillary)	5
Maryland (bacillary)	2
Minnesota (amebic)	1
Montana (bacillary)	1
New Jersey (amebic)	1
New York (amebic)	2
New York (bacillary)	21
Epidemic encephalitis:	
Alabama	1
Arizona	1
Illinois	6
Maine	1
Maryland	1
Massachusetts	1
Minnesota	1
New Jersey	5
New York	6

February 1936—Continued

	Cases
Epidemic encephalitis—Continued.	
Rhode Island	1
West Virginia	1
German measles:	
Arizona	51
Illinois	35
Maine	136
Maryland	76
Massachusetts	424
Montana	6
New Jersey	261
New York	681
Rhode Island	32
Hookworm disease:	
Georgia	1,476
Impetigo contagiosa:	
Arizona	2
Maryland	13
Oregon	62
Lead poisoning:	
Illinois	3
Leprosy:	
Georgia	1
Mumps:	
Alabama	510
Arizona	432
Georgia	250
Idaho	202
Illinois	1,316
Maine	1,364
Maryland	382
Massachusetts	2,213
Montana	682
Nevada	11
New Jersey	1,122
Oregon	170
Rhode Island	227
South Dakota	127
West Virginia	194
Ophthalmia neonatorum:	
Alabama	1
Illinois	5
Maryland	1
Massachusetts	67
New Jersey	3
New York	7
Paratyphoid fever:	
Minnesota	1
New Jersey	1
New York	1
Puerperal septicemia:	
Illinois	2
Rabies in animals:	
Illinois	12
Maryland	1
Massachusetts	13
New Jersey	22
New York [1]	10
Oregon	5
Scabies:	
Oregon	60
Septic sore throat:	
Georgia	51
Idaho	5
Illinois	6
Maine	4
Maryland	20
Massachusetts	17
Minnesota	6
Montana	10
New York	111

February 1936—Continued

	Cases
Septic sore throat—Con.	
Oregon	17
Rhode Island	2
Tetanus:	
Alabama	5
Georgia	1
Illinois	2
Maryland	2
New Jersey	2
New York	1
Trachoma:	
Arizona	49
Idaho	15
Illinois	71
Massachusetts	2
New Jersey	1
Trichinosis:	
Georgia	1
Illinois	4
Massachusetts	2
New Jersey	1
New York	25
Tularaemia:	
Alabama	3
Georgia	3
Illinois	6
Maryland	1
New Jersey	1
Typhus fever:	
Alabama	10
Georgia	10
Massachusetts	3
New York	1
Undulant fever:	
Alabama	5
Arizona	1
Georgia	1
Illinois	2
Maine	2
Maryland	2
Massachusetts	4
Minnesota	6
New Jersey	2
New York	11
Oregon	1
Vincent's infection:	
Illinois	23
Maine	9
Maryland	10
New York [1]	95
Oregon	9
Whooping cough:	
Alabama	71
Arizona	82
Georgia	58
Idaho	16
Illinois	1,110
Maine	137
Maryland	143
Massachusetts	310
Minnesota	89
Montana	39
Nevada	1
New Jersey	414
New York	948
Oregon	47
Rhode Island	16
South Dakota	11
West Virginia	60

[1] Exclusive of New York City.

WEEKLY REPORTS FROM CITIES

City reports for week ended Mar. 14, 1936

This table summarizes the reports received weekly from a selected list of 140 cities for the purpose of showing a cross section of the current urban incidence of the communicable diseases listed in the table. Weekly reports are received from about 700 cities, from which the data are tabulated and filed for reference.

State and city	Diphtheria cases	Influenza		Measles cases	Pneumonia deaths	Scarlet fever cases	Smallpox cases	Tuberculosis deaths	Typhoid fever cases	Whooping cough cases	Deaths, all causes
		Cases	Deaths								
Maine:											
Portland	0	2	0	4	9	2	0	1	0	3	35
New Hampshire:											
Concord	0	------	0	0	0	0	0	1	0	0	10
Nashua	0	------	------	0	2	1	0	------	0	0	------
Vermont:											
Burlington	0	------	0	11	0	0	0	0	0	1	8
Rutland	0	------	0	50	0	0	0	0	0	0	8
Massachusetts:											
Boston	1	------	1	351	26	82	0	18	1	23	237
Fall River	0	------	2	1	3	8	0	2	0	2	38
Springfield	0	------	0	3	5	2	0	1	0	4	30
Worcester	0	------	0	1	11	24	0	2	0	10	63
Rhode Island:											
Pawtucket	0	------	0	0	0	2	0	0	0	0	20
Providence	0	------	1	19	13	14	0	1	0	5	67
Connecticut:											
Bridgeport	1	1	1	1	6	4	0	0	0	4	40
Hartford	0	1	0	0	8	6	0	0	0	6	47
New Haven	0	9	1	0	9	1	0	0	0	48	72
New York:											
Buffalo	0	2	1	29	17	86	0	6	0	15	148
New York	28	66	20	1,581	250	596	0	90	6	81	1,820
Rochester	0	------	0	0	17	6	0	3	0	0	112
Syracuse	0	------	1	32	2	7	0	0	0	3	42
New Jersey:											
Camden	2	------	0	0	1	10	0	1	0	0	33
Newark	0	52	0	6	19	241	0	9	0	10	122
Trenton	0	------	0	1	5	5	0	1	0	16	33
Pennsylvania:											
Philadelphia	5	27	13	456	75	89	0	23	1	48	650
Pittsburgh	2	14	6	42	37	105	0	6	0	11	222
Reading	0	------	0	3	4	2	0	1	0	0	27
Scranton	1	------	------	105	------	7	0	------	0	0	------
Ohio:											
Cincinnati	3	------	3	5	20	22	0	9	0	4	152
Cleveland	2	59	4	73	26	61	0	14	0	73	227
Columbus	0	1	1	1	7	17	0	4	0	8	86
Toledo	0	1	1	39	7	9	0	6	0	9	81
Indiana:											
Anderson	0	------	0	0	3	3	0	0	0	12	12
Fort Wayne	1	------	0	0	0	16	0	0	0	0	30
Indianapolis	3	------	1	1	18	58	0	5	1	27	118
Muncie	0	------	0	0	1	2	0	1	0	0	3
South Bend	0	------	1	1	2	1	0	1	0	9	18
Terre Haute	0	------	0	0	0	9	0	0	0	0	21
Illinois:											
Alton	0	------	0	0	2	2	0	0	0	0	14
Chicago	7	9	5	11	68	275	0	50	1	223	789
Elgin	0	------	0	0	2	3	0	0	0	1	11
Moline	0	2	0	0	0	9	0	1	0	1	8
Springfield	0	------	0	0	6	17	0	0	0	1	31
Michigan:											
Detroit	3	7	7	26	42	161	2	15	1	190	300
Flint	0	------	0	0	1	8	0	0	0	30	23
Grand Rapids	0	------	0	11	0	8	0	0	0	7	32
Wisconsin:											
Kenosha	0	------	0	1	0	5	0	0	0	1	12
Madison	0	------	0	0	1	10	0	1	0	7	12
Milwaukee	1	------	0	8	9	122	0	5	0	96	144
Racine	2	------	0	5	0	17	0	1	0	8	16
Superior	0	------	0	0	2	14	0	0	0	0	6
Minnesota:											
Duluth	0	------	0	1	2	3	0	0	0	11	15
Minneapolis	2	------	2	165	12	154	0	0	1	12	109
St. Paul	0	------	0	161	14	61	0	2	0	9	70
Iowa:											
Cedar Rapids	0	------	------	0	------	4	0	------	0	1	------
Des Moines	1	------	------	0	------	10	0	------	0	0	36
Sioux City	0	------	------	0	------	8	9	------	0	0	------
Waterloo	0	------	------	2	------	4	------	------	1	3	------

City reports for week ended Mar. 14, 1936—Continued

State and city	Diphtheria cases	Influenza		Measles cases	Pneumonia deaths	Scarlet fever cases	Smallpox cases	Tuberculosis deaths	Typhoid fever cases	Whooping cough cases	Deaths, all causes
		Cases	Deaths								
Missouri:											
Kansas City	3	11	11	1	36	62	0	3	0	0	147
St. Joseph	0	------	3	0	7	2	1	2	0	0	23
St. Louis	8	7	4	2	10	54	0	11	0	4	251
North Dakota:											
Fargo	0	------	0	0	1	4	1	0	0	2	10
Grand Forks	0	------	------	0	------	0	4	------	0	0	------
Minot	0	------	------	0	------	4	0	------	0	0	2
South Dakota:											
Aberdeen	0	------	------	0	------	5	0	------	0	0	------
Sioux Falls	0	------	------	3	------	10	0	------	0	0	8
Nebraska:											
Omaha	4	------	2	2	15	120	12	2	0	1	72
Kansas:											
Lawrence	0	86	0	0	0	0	0	0	0	0	6
Topeka	------	------	------	------	------	------	------	------	------	------	------
Wichita	0	1	1	0	5	15	1	0	1	2	34
Delaware:											
Wilmington	0	------	0	0	3	1	0	1	0	3	29
Maryland:											
Baltimore	0	40	9	43	44	37	0	15	1	31	280
Cumberland	0	1	0	0	1	4	0	0	0	0	10
Frederick	0	------	0	0	1	0	0	0	0	0	5
District of Columbia:											
Washington	25	3	2	63	32	24	0	11	0	8	196
Virginia:											
Lynchburg	0	------	1	3	2	1	0	0	0	7	15
Norfolk	------	31	0	0	4	1	0	1	0	0	34
Richmond	1	------	1	2	12	34	0	1	0	2	69
Roanoke	0	------	0	0	1	2	0	0	1	0	24
West Virginia:											
Charleston	0	11	1	0	4	3	0	0	0	1	29
Huntington	0	------	------	0	------	0	0	------	0	0	------
Wheeling	0	------	0	4	5	4	0	1	0	3	21
North Carolina:											
Gastonia	1	3	0	0	4	0	0	0	0	0	8
Raleigh	0	------	0	1	6	0	0	2	0	4	21
Wilmington	0	------	0	0	4	1	0	0	0	0	16
Winston-Salem	0	1	0	156	1	1	0	1	0	0	16
South Carolina:											
Charleston	0	51	1	0	4	1	0	5	0	1	29
Columbia	0	------	0	0	0	0	0	0	0	0	6
Florence	0	------	0	0	3	0	0	0	0	0	10
Greenville	1	------	0	18	2	1	0	5	0	0	17
Georgia:											
Atlanta	3	41	8	2	13	13	0	4	1	0	85
Brunswick	0	2	2	0	2	0	0	0	0	0	6
Savannah	1	45	7	0	5	2	0	1	1	0	35
Florida:											
Miami	0	------	0	1	3	0	0	1	0	3	36
Tampa	1	4	3	1	2	3	0	2	0	1	28
Kentucky:											
Ashland	0	9	------	0	------	0	0	------	0	2	------
Covington	3	2	0	2	1	3	0	0	0	0	20
Lexington	0	------	0	0	5	0	0	3	0	2	25
Louisville	0	2	2	3	9	8	0	0	0	11	86
Tennessee:											
Knoxville	1	------	1	47	3	1	0	3	2	0	28
Memphis	0	------	2	2	16	19	0	9	0	1	109
Nashville	2	------	2	0	6	0	0	3	0	4	59
Alabama:											
Birmingham	1	172	9	2	27	4	0	2	0	4	109
Mobile	1	8	6	0	7	2	0	0	0	0	36
Montgomery	0	3	------	0	------	0	0	------	0	1	------
Arkansas:											
Fort Smith	0	------	------	0	------	0	0	------	0	0	------
Little Rock	1	------	2	0	16	0	0	7	0	0	28
Louisiana:											
Lake Charles	0	------	0	0	0	0	0	0	0	0	1
New Orleans	9	13	7	26	23	6	0	18	3	30	197
Shreveport	0	------	0	33	12	0	0	5	0	0	46
Oklahoma:											
Oklahoma City	1	------	1	0	11	8	0	1	0	3	------
Texas:											
Dallas	5	4	3	106	14	8	0	6	0	4	81
Fort Worth	2	------	0	2	15	1	1	2	0	0	51
Galveston	2	------	0	0	7	0	0	1	0	0	19
Houston	6	------	5	18	14	3	0	2	1	0	78
San Antonio	1	------	2	2	1	2	0	2	0	0	84

City reports for week ended Mar. 14, 1936—Continued

State and city	Diphtheria cases	Influenza		Measles cases	Pneumonia deaths	Scarlet fever cases	Smallpox cases	Tuberculosis deaths	Typhoid fever cases	Whooping cough cases	Deaths, all causes
		Cases	Deaths								
Montana:											
Billings	0	------	0	0	2	8	0	0	0	0	11
Great Falls	1	------	0	0	2	9	0	0	0	4	11
Helena	3	------	0	0	0	0	0	0	0	0	11
Missoula	0	------	0	1	3	4	0	0	0	0	10
Idaho:											
Boise	0	------	0	11	0	8	0	0	0	0	12
Colorado:											
Colorado Spgs	0	------	0	1	2	9	0	2	0	7	9
Denver	0	------	5	8	15	24	0	5	0	11	97
Pueblo	0	------	0	0	2	23	0	1	0	3	9
New Mexico:											
Albuquerque	0	------	1	0	3	18	0	3	0	2	13
Utah:											
Salt Lake City	0	------	0	1	2	72	1	0	0	4	31
Nevada:											
Reno	------	------	------	------	------	------	------	------	------	------	------
Washington:											
Seattle	0	------	4	112	19	21	7	6	0	4	124
Spokane	0	2	2	3	12	12	0	0	0	4	54
Tacoma	0	------	1	60	5	3	0	1	0	0	38
Oregon:											
Portland	0	6	2	147	7	7	0	6	0	14	80
Salem	0	5	------	4	------	1	1	------	0	0	------
California:											
Los Angeles	13	121	7	557	35	88	0	30	1	18	437
Sacramento	2	8	2	14	2	2	0	5	0	8	29
San Francisco	1	5	0	548	5	89	0	6	0	25	156

State and city	Meningococcus meningitis		Poliomyelitis cases
	Cases	Deaths	
Massachusetts:			
Boston	6	1	0
Worcester	0	1	0
Rhode Island:			
Providence	1	1	0
New York:			
Buffalo	1	1	0
New York	23	[illegible]	2
Pennsylvania:			
Philadelphia	2	2	0
Pittsburgh	0	0	1
Ohio:			
Cincinnati	5	2	0
Cleveland	0	1	0
Columbus	0	1	0
Indiana:			
Indianapolis	1	1	0
Illinois:			
Chicago	6	4	1
Springfield	1	0	0
Michigan:			
Detroit	3	2	0
Flint	0	1	0
Grand Rapids	0	1	0
Minnesota:			
Minneapolis	2	1	0
Iowa:			
Des Moines	1	0	0
Missouri:			
Kansas City	2	2	0
St. Joseph	1	0	0
St. Louis	4	0	0
Nebraska:			
Omaha	1	0	0
Maryland:			
Baltimore	10	4	0
District of Columbia:			
Washington	2	0	0
Virginia:			
Norfolk	3	1	0
Richmond	1	1	0
Roanoke	1	2	0
South Carolina:			
Charleston	6	2	0
Georgia:			
Atlanta	4	4	0
Kentucky:			
Louisville	2	1	0
Tennessee:			
Knoxville	1	0	0
Memphis	0	1	0
Alabama:			
Birmingham	1	0	0
Arkansas:			
Fort Smith	1	0	0
Little Rock	0	1	0
Louisiana:			
Shreveport	0	1	0
Oklahoma:			
Oklahoma City	4	2	0
Texas:			
Galveston	2	1	0
Houston	8	1	0
Colorado:			
Denver	2	0	0
Utah:			
Salt Lake City	1	1	0
Washington:			
Seattle	1	0	1
Oregon:			
Portland	1	1	0
California:			
Los Angeles	3	5	2
Sacramento	1	0	0

Epidemic encephalitis.—Cases: Philadelphia, 2; Toledo, 1; Chicago, 1; Louisville, 1; Birmingham, 1; San Francisco, 1.

Pellagra.—Cases: Boston, 1; Baltimore, 1; Charleston, S. C., 2; Savannah, 3; Memphis, 1; Birmingham, 2; Dallas, 1; Los Angeles, 3; San Francisco, 1.

Typhus fever.—Cases: Atlanta, 1.

FOREIGN AND INSULAR

ARGENTINA

Buenos Aires—Poliomyelitis.—According to a report dated March 23, 1936, an epidemic of poliomyelitis had occurred in the city of Buenos Aires, Argentina, where 500 cases had been reported.

CANADA

Provinces—Communicable diseases—2 weeks ended March 7, 1936.—During the 2 weeks ended March 7, 1936, cases of certain communicable diseases were reported by the Department of Pensions and National Health of Canada as follows:

Disease	Prince Edward Island	Nova Scotia	New Brunswick	Quebec	Ontario	Manitoba	Saskatchewan	Alberta	British Columbia	Total
Cerebrospinal meningitis			1	5	4		1	1		12
Chicken pox		14	4	304	543	39	33	25	108	1,070
Diphtheria		12	4	48	8	10	13		2	97
Erysipelas				15	7	4	3	2	4	35
Influenza		15			314	13	41		781	1,164
Lethargic encephalitis				1						1
Measles	11	88	11	3,500	5,679	1,177	87	108	732	11,393
Mumps		5			913	135	1,387	76	261	2,777
Paratyphoid fever					1					1
Pneumonia					64		3		7	74
Poliomyelitis			1	1			1			3
Scarlet fever		33	2	291	674	99	43	122	50	1,314
Smallpox								7	1	8
Trachoma									1	1
Tuberculosis	4	2	15	111	89	26	15	4	23	289
Typhoid fever	1		5	29	10	9	4		2	60
Undulant fever				2	3					5
Whooping cough		23	117	165	352	21	58	9	72	817

Vital statistics—Third quarter 1935.—The Bureau of Statistics of the Dominion of Canada has published the following preliminary statistics for the third quarter of 1935. The rates are computed on an annual basis. There were 20.3 live births per 1,000 population during the third quarter of 1935 and 20.9 per 1,000 population in the same quarter of 1934. The death rate was 8.5 per 1,000 population for the third quarter of 1935 and 8.6 per 1,000 population for the third quarter of 1934. The infant mortality rate for the third quarter of 1935 was 63 per 1,000 live births and 69 in the corresponding quarter of 1934. The maternal death rate was 4.1 per 1,000 live births for the third quarter of 1935, and 4.5 for the same quarter of 1934.

The accompanying tables give the number of births, deaths, and marriages by Provinces for the third quarter of 1935, and deaths

from certain causes in Canada for the third quarter of 1935, and the corresponding quarter of 1934, and by Provinces for the third quarter of 1935.

Number of births, deaths, and marriages, third quarter 1935

Province	Live births	Deaths (exclusive of still-births)	Deaths under 1 year of age	Maternal deaths	Marriages
Canada [1]	55,998	23,557	3,520	230	22,655
Prince Edward Island	516	219	35	2	170
Nova Scotia	2,952	1,284	180	11	1,179
New Brunswick	2,556	1,070	237	7	1,093
Quebec	19,226	7,442	1,645	79	6,772
Ontario	16,126	8,133	785	81	7,934
Manitoba	3,442	1,333	167	9	1,389
Saskatchewan	4,931	1,350	237	17	1,190
Alberta	3,699	1,166	147	14	1,460
British Columbia	2,550	1,560	87	10	1,468

[1] Exclusive of Yukon and Northwest Territories.

Number of deaths, Canada, third quarter 1934 and 1935, and by Provinces, third quarter 1935

Cause of death	Canada[1] (third quarter)		Province, third quarter 1935								
	1934	1935	Prince Edward Island	Nova Scotia	New Brunswick	Quebec	Ontario	Manitoba	Saskatchewan	Alberta	British Columbia
Automobile accidents	429	406	1	22	17	119	158	21	19	11	38
Cancer	2,607	2,821	20	154	114	719	1,098	194	153	150	219
Diarrhea and enteritis	1,617	1,230	9	41	109	768	189	41	37	21	15
Diphtheria	49	46		1	4	23	10	4	3	1	
Diseases of the arteries	1,616	1,858	10	110	59	342	939	113	87	94	104
Diseases of the heart	3,539	3,341	24	159	110	786	1,436	182	194	181	269
Homicides	41	42		2		9	15	3	6	4	3
Influenza	185	218	2	13	9	75	69	10	15	13	12
Measles	24	41			3	16	11	4	2	3	2
Nephritis	1,252	1,425	11	80	38	623	426	51	56	51	89
Pneumonia	836	886	14	38	64	233	318	69	56	40	54
Poliomyelitis	40	23	2	1		2	5	4		8	1
Puerperal causes	258	230	2	11	7	79	81	9	17	14	10
Scarlet fever	36	31	1	1		18	9	1		1	
Smallpox											
Suicides	248	218	2	6	8	31	96	14	21	21	19
Tuberculosis	1,426	1,525	19	116	66	678	319	105	58	45	119
Typhoid fever and paratyphoid fever	90	92		2	5	48	21	3	6	3	4
Other violent deaths	1,284	1,454	16	66	65	382	522	95	91	89	128

[1] Exclusive of Yukon and the Northwest Territories.

CUBA

Habana—Communicable diseases—4 weeks ended March 14, 1936.—During the 4 weeks ended March 14, 1936, certain communicable diseases were reported in Habana, Cuba as follows:

Disease	Cases	Deaths	Disease	Cases	Deaths
Diphtheria	15		Tuberculosis	43	1
Malaria	[1] 26	1	Typhoid fever	[1] 29	1

[1] Includes imported cases.

Provinces—Notifiable diseases—4 weeks ended March 7, 1936.—During the 4 weeks ended March 7, 1936, cases of certain notifiable diseases were reported in the Provinces of Cuba as follows:

Disease	Pinar del Rio	Habana	Matanzas	Santa Clara	Camaguey	Oriente	Total
Cancer	1	2	1	1			5
Chicken pox		26	3	12	2	31	74
Diphtheria	1		1	1	3		6
Hookworm disease			1				1
Leprosy		5					5
Malaria	110	39	16	144	251	1,063	1,623
Measles	2	1		1	2		6
Poliomyelitis	1	1		1		3	6
Tuberculosis	12	23	15	33	15	24	122
Typhoid fever	4	25	10	22	6	37	104

EGYPT

Infectious diseases—Second quarter 1935.—During the second quarter of 1935, certain infectious diseases were reported in Egypt as follows:

Disease	Cases	Deaths	Disease	Cases	Deaths
Anthrax	3		Plague	26	14
Cerebrospinal fever	54	56	Poliomyelitis	2	
Chicken pox	735	8	Puerperal septicemia	122	104
Diphtheria	367	176	Rabies		8
Dysentery	629	125	Scarlet fever	14	1
Epidemic jaundice	1		Smallpox	40	3
Erysipelas	1,162	255	Tetanus	97	65
Influenza	2,159	165	Tuberculosis (pulmonary)	1,194	577
Leprosy	45	20	Typhoid fever	1,115	246
Lethargic encephalitis	2	2	Typhus fever	1,446	243
Malaria	712	10	Undulant fever	6	
Measles	2,870	862	Whooping cough	736	47
Mumps	346	11			

Vital statistics—Second quarter 1935.—Following are vital statistics for the second quarter of 1935 in all places in Egypt having a health bureau:

Population	4,603,100	Deaths per 1,000 population	32.8
Live births	45,924	Deaths from diarrhea and enteritis under 2 years	12,146
Births per 1,000 population	39.9	Infant mortality per 1,000 live births	298
Stillbirths	827		
Total deaths	37,737		

GERMANY

Vital statistics—Third quarter 1935.—Following are vital statistics for Germany for the third quarter of 1935:

Number of marriages	151,082	Total deaths	170,739
Number of marriages per 1,000 population	9.0	Deaths per 1,000 population	10.2
Number of live births	307,586	Deaths under 1 year of age	18,205
Number of live births per 1,000 population	18.4	Deaths under 1 year of age per 100 live births	5.9
Number of stillbirths	7,396		

CHOLERA, PLAGUE, SMALLPOX, TYPHUS FEVER, AND YELLOW FEVER

NOTE.—A table giving current information of the world prevalence of quarantinable diseases appeared in the PUBLIC HEALTH REPORTS for March 27, 1936, pages 349–361. A similar cumulative table will appear in the PUBLIC HEALTH REPORTS to be issued April 24, 1936, and thereafter, at least for the time being, in the issue published on the last Friday of each month.

Cholera

Siam.—According to information dated March 4, 1936, there had been a total of 3,540 cases of cholera with 2,280 deaths in the Kingdom of Siam. The total number of cases of cholera in Bangkok was 734 with 355 deaths. During the first 2 weeks of February 1936, there occurred 632 cases of cholera with 411 deaths in Siam, and 188 cases of cholera with 105 deaths in Bangkok. During January and February the number of admitted cases of cholera in Siam was 2,116 with 1,354 deaths, considerably more than for all the preceding 8 months of the epidemic.

Plague

Basutoland.—During the week ended February 29, 1936, 2 cases of plague, including 1 suspected case, were reported in Basutoland.

Smallpox

China—Hong Kong.—During the week ended March 7, 1936, 2 cases of smallpox with 1 death were reported at Hong Kong, China.

Colombia—Santa Marta.—During the month of February 1936, 1 death from smallpox was reported at the port of Santa Marta, Colombia.

Dutch East Indies—Palembang.—For the week ended March 7, 1936, 1 case of smallpox was reported at Palembang, Dutch East Indies.

Yellow Fever

Brazil.—Yellow fever has been reported in Brazil as follows: Minas Geraes State, for the period February 7–12, 1936, Altinopolis, 2 cases, 2 deaths; February 23, 1936, Santa Rita Cassia, 1 case, 1 death. Parana State: for the period February 16–25, 1936, Arthur Bernardes, 2 cases, 2 deaths; Barra Bonita, 1 case, 1 death; Guaraiava, 1 case, 1 death; Thomazina, 1 case, 1 death. February 28–March 1, 1936: Londrina, 2 cases, 2 deaths. Sao Paulo State, February 29, 1936, Batataes, 1 case, 1 death; February 26–29, 1936, Araraquara, 2 cases, 2 deaths; February 26–March 3, 1936, Rincao, 2 cases, 2 deaths; March 4, 1936, Cerqueira Cezar, 1 case, 1 death.

Colombia.—According to a report dated February 17, 1936, yellow fever has been reported in Colombia as follows: Department of Boyaca, 3 cases, and Intendencia of Meta, 3 cases.

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