Public Health Reports

Vol. 55 • MAY 31, 1940 • *No. 22*

PREVALENCE OF POLIOMYELITIS IN THE UNITED STATES IN 1939

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In 1938 an unusually low incidence of poliomyelitis was recorded in all sections of the United States, during which time 1,705 cases (1.3 per 100,000 population) were reported and 487 deaths (0.4 per 100,000 population) were registered. In contrast to this low incidence of the disease in 1938, there was a sharp increase in the number of cases reported in 1939, 7,331 cases (preliminary figure) or a rate of 5.6. In 1939 the distribution of the disease was characterized by a number of localized outbreaks in various sections of the country in addition to a fairly widespread occurrence in the Mountain States. As indicated in table 1, there were four States in which the case rate was 20 or more per 100,000 population, namely, New Mexico (26.1), South Carolina (23.9), Arizona (22.4), and Minnesota (20.5). Three States had case rates between 15 and 20, namely, Michigan (19.1), Utah (19.0), and California (16.6). In 1939 a total of 15 States reported rates in excess of the maximum (4.3) recorded in 1938.

The distribution of poliomyelitis cases by counties for 1939 is shown in the accompanying map (fig. 1) in the preparation of which the same scale of rates was used as in previous reports (*1*, *2*). This map clearly shows the location of the areas in which the incidence was high. The most extensive area included a group of counties in Arizona, Utah, New Mexico, Colorado, and northwestern Texas. The second largest area extended across central Minnesota and included a few counties in northeastern South Dakota. Smaller groups of counties in which the incidence was high were located in Michigan, New York, South Carolina, Kentucky, Iowa, and south central California. Two adjoining counties in New Jersey, and Philadelphia, Pa., comprised a very small area in which the incidence of poliomyelitis was moderately high. In these 9 areas 56 counties had case rates of 40 or more per 100,000 population, and 43 had rates ranging between 30 and 40. In 7 of these areas of high rates one or more counties had excessively high incidence, i. e., a rate of 100 or more, as shown in table 2. Seven of the 13 counties in which the rates exceeded

100 were located in the Mountain section but 4 of these had small populations and reported only a few cases. In 9 of the 13 counties listed in table 2 there had been relatively few cases reported in the 5-year period immediately preceding 1939, and in the remaining 4 none had been reported. These 13 counties as a group have predominantly rural populations. However, three of them contained cities of 10,000 or more population according to the 1930 census, namely, Charleston in Charleston County, S. C., St. Cloud in Stearns

TABLE 1.—*Poliomyclitis case rates and death rates per 100,000 population by States, 1935–39*

Division and State	Case rates					Death rates			
	1935	1936	1937	1938	1939	1935	1936	1937	1938
United States	8.6	3.5	7.3	1.3	5.6	0.8	0.6	1.1	0.4
New England States:									
Maine	19.0	5.0	16.1	1.7	.5	1.7	.4	2.0	.4
New Hampshire	9.5	.8	4.9	.2	.8	2.2	.2	.2	0
Vermont	17.7	2.1	7.6	2.3	8.4	1.9	0	1.0	1.0
Massachusetts	32.0	1.3	7.9	.4	1.7	1.4	.3	.5	.2
Rhode Island	51.5	.7	3.2	.9	.4	3.4	.1	.1	.1
Connecticut	23.4	.9	6.2	1.2	1.6	1.5	.4	.7	0
Middle Atlantic States:									
New York	22.2	1.5	4.9	1.1	8.0	1.1	.2	.5	.2
New Jersey	11.8	.6	3.6	.9	5.3	.8	.2	.5	.2
Pennsylvania	2.2	1.3	3.3	.8	4.2	.3	.2	.4	.2
East North Central States:									
Ohio	1.3	5.1	7.9	.8	2.3	.5	.8	1.0	.3
Indiana	1.4	1.5	4.2	.4	1.6	.3	.5	.9	.3
Illinois	3.0	8.8	9.9	1.4	2.4	.5	1.0	1.1	.2
Michigan	13.0	3.2	9.0	1.2	19.1	.9	.5	1.2	.3
Wisconsin	2.2	1.5	11.4	1.7	3.8	.2	.2	1.3	.2
West North Central States:									
Minnesota	3.6	1.2	12.6	1.6	20.5	.5	.2	1.9	.4
Iowa	2.5	3.0	9.4	1.5	7.7	.3	.5	1.6	.3
Missouri	1.3	2.7	9.9	.6	.7	.4	.6	1.9	.4
North Dakota	1.7	2.7	.9	1.1	1.9	.4	.4	.3	.1
South Dakota	2.1	1.9	5.7	4.0	3.6	.9	.1	1.0	.3
Nebraska	.9	1.7	16.0	.7	3.6	.8	.8	3.4	.5
Kansas	1.5	5.0	12.9	.6	2.3	.5	.5	1.8	.1
South Atlantic States:									
Delaware	2.0	.4	3.1	.8	3.1	.4	.4	.4	.4
Maryland	6.4	2.2	4.8	1.0	1.6	.3	.2	1.0	.1
District of Columbia	14.3	1.1	4.8	4.3	3.0	1.9	.3	.6	.5
Virginia	25.7	2.2	2.4	2.0	1.8	1.9	.5	.5	.4
West Virginia	2.2	3.4	3.7	.8	3.5	.7	1.1	1.1	.8
North Carolina	19.8	1.5	3.1	1.4	3.3	2.1	.5	.8	.4
South Carolina	2.1	1.2	1.2	1.4	23.9	.7	.9	.7	.6
Georgia	.8	4.8	2.7	1.9	3.1	.6	1.1	.8	.7
Florida	1.0	2.5	1.8	1.8	4.0	.4	.4	.3	.4
East South Central States:									
Kentucky	11.5	3.1	4.4	1.3	5.9	1.6	1.2	1.0	1.1
Tennessee	3.2	13.2	4.4	1.1	1.1	1.0	1.5	1.0	.7
Alabama	2.1	14.6	2.9	3.4	1.5	.5	1.5	.6	.6
Mississippi	.8	9.5	21.0	3.4	1.3	.5	1.0	2.9	.9
West South Central States:									
Arkansas	.8	2.7	16.2	1.6	2.4	.4	.9	4.2	.8
Louisiana	4.8	1.6	6.2	2.0	.9	.6	.4	.9	.5
Oklahoma	.5	5.0	18.1	1.1	2.2	.4	1.4	2.8	.6
Texas	1.3	1.1	10.7	1.0	3.8	.8	.6	2.1	.7
Mountain States:									
Montana	1.1	2.6	5.8	2.6	1.1	.2	.9	1.1	.6
Idaho	.9	4.3	3.9	2.4	7.2	.6	1.2	1.0	.2
Wyoming	.9	3.0	16.7	.4	3.5	.9	.4	2.6	1.3
Colorado	2.1	6.3	19.4	1.3	13.0	1.1	1.4	3.7	.7
New Mexico	2.4	7.4	6.1	2.6	26.1	.9	1.7	1.7	.9
Arizona	6.1	3.4	6.8	2.2	22.4	2.0	1.2	1.0	.7
Utah	2.1	1.3	6.4	.8	19.0	.2	.2	1.7	0
Nevada	2.0	2.0	5.0	0	2.0	0	0	1.0	1.0
Pacific States:									
Washington	2.4	4.7	5.3	1.1	1.7	.4	1.0	.5	.2
Oregon	4.6	3.6	6.0	1.5	5.2	1.6	.9	.7	.6
California	13.7	6.4	11.5	2.2	16.6	1.1	.6	1.3	.3

County, Minn., and Batavia in Genesee County, N. Y. Approximately one-half of the cases occurring in the three counties were reported from the cities mentioned.

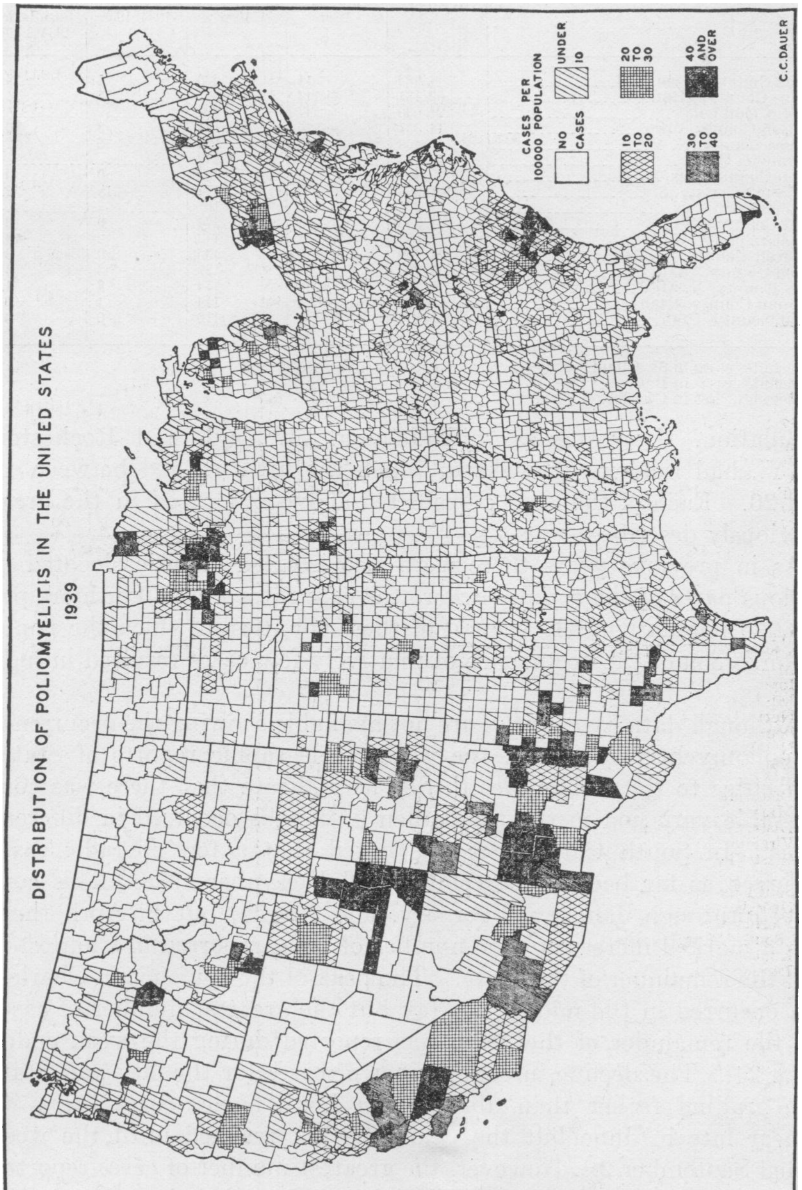

FIGURE 1.—Distribution of poliomyelitis cases in the United States during 1939, by counties.

Several large cities also reported outbreaks of poliomyelitis of varying severity. Buffalo, Camden, N. J., Detroit, and Minneapolis reported the highest incidence, between 30 and 60 cases per 100,000

TABLE 2.—*Number of cases and case rates in certain counties in 1939 and 1934–38*

County	Population 1930	Number of cases reported 1939	Case rate per 100,000 population 1939	Number of cases reported 1934–1938	Average annual case rate per 100,000 population 1934–1938
Alcona County, Mich	4,989	11	220	1	4.0
Stearns County, Minn	62,131	[1] 113	182	5	1.6
St. Cloud City	21,000	47	224		
Madison County, Iowa	14,331	26	181	3	0.4
Genesee County, N. Y	44,468	[2] 80	180	6	2.7
Batavia City	17,375	42	242		
Sutton County, Tex	2,807	4	179	0	0
Charleston County, S. C	101,050	[3] 179	177	13	2.5
Charleston City	62,265	100	161		
Floyd County, Ky	41,942	73	174	0	0
De Baca County, N. Mex	2,893	4	142	2	14.0
Roosevelt County, N. Mex	11,109	15	135	0	0
Carson County, Utah	17,798	23	129	3	3.4
Curry County, N. Mex	15,809	18	114	8	1.1
San Juan County, Utah	3,496	4	114	1	5.7
Grand County, Utah	1,813	2	110	0	0

[1] Includes cases in St. Cloud.
[2] Includes cases in Batavia.
[3] Includes cases in Charleston City.

population. Los Angeles, Philadelphia, St. Paul, and Rochester, N. Y., had milder outbreaks in which the rates ranged between 10 and 20. Each of the large cities listed above is located in the areas previously described.

As in previous years there were also isolated counties located in various parts of the country where the case rates were 30 or more per 100,000 population. In several of these counties in which the population is small, the occurrence of relatively few cases resulted in high rates.

Although data by counties are not available showing the occurrence of poliomyelitis by weeks, the weekly telegraphic reports of States and cities to the Public Health Service indicate that there was considerable variation in the time when outbreaks occurred in different areas. In South Carolina it was noted that a few sporadic cases occurred as far back as November and December 1938. This continued through January, February, and March, but in April there was a marked increase in the number of cases reported in Charleston and the remainder of the State. The peak of the epidemic in Charleston occurred in the middle of May but the greatest number of cases for the remainder of the State was reported during the week ended June 24. The decline in the number of cases for the city and State was gradual rather than abrupt. In Los Angeles cases began to appear late in June but the peak was not reached until the week ended September 2. However, the greatest number of cases reported in the State of California was for the week ended August 5. The outbreak began early in July in Detroit, and late in the month in Michigan, exclusive of Detroit. The peak of the outbreak was reported during the week ended August 26 in Detroit and a week later in the remainder of the State. In the other areas of high incidence, the peaks of the outbreaks were reported in September and early October, except in Kentucky and Iowa where the largest number of cases was reported during the week ended October 21 in the former and November 11 in the latter. In Iowa a relatively large number of cases continued to be reported through December 1939, and January 1940.

The early appearance of large numbers of cases in South Carolina was not unusual in that section of the country, for in 1935 cases likewise were reported in fairly large numbers from North Carolina as early as April and May. In Michigan the 1939 outbreak appeared several weeks earlier than in the 1931 or 1935 epidemics. However, in Kentucky the disease occurred several weeks later than in 1935. Thus during 1939 poliomyelitis cases were occurring in relatively large numbers in one locality after another over a period of 9 months, i. e., from April to December, inclusive.

There was a marked variation in age distribution of poliomyelitis cases in different localities where epidemics occurred in 1939. For instance, in Charleston County, S. C., 68 percent of the cases were under 5 years of age (13 percent under 1 year) while in Genesee County, N. Y., only 14 percent were under 5 years (1.5 percent under 1 year). In Detroit and Buffalo approximately 30 percent were under 5 years of age. The proportion of cases in the older age groups showed similar variations. In Charleston County 22 percent of the cases were 5 to 9 years of age, 5 percent were in the 10- to 14-year group and 4 percent were 15 years of age and over. In Genesee County, 25, 29, and 30 percent of cases were in the corresponding age groups, while in Buffalo the percentages were 41, 19, and 11, respectively.

In Charleston County a much higher proportion of the cases among colored persons were under 1 year and 1 to 4 years of age than among white persons. The youngest case reported was a month-old colored infant which had a definite paralysis of the left leg. However, the high proportion of cases in the younger age groups in Charleston County in 1939 was not materially different from the distribution of cases reported in North Carolina in 1935.

Data from a few areas, Charleston County, Buffalo, and Minnesota, indicate that case fatality rates were comparatively low in 1939, at least in the localities mentioned. The fatality rates varied between 2.5 and 9 percent in these areas.

Comparatively few States in their reports segregate paralytic from nonparalytic and abortive cases of poliomyelitis. The segregation as to types is important for two reasons. First, a much better comparison of incidence by States or counties could be made by comparing numbers of paralytic cases in one area with those in another area, and similarly with nonparalytic cases. For instance, in 1939, 68 percent of cases reported in Minnesota were paralytic and in Charleston County, S. C., 78 percent were paralytic cases. Another reason for segregation of cases as to type is becoming increasingly apparent to some public health officials and other investigators with the proof of the existence of other neurotropic virus diseases in many localities. The seasonal occurrence of the St. Louis type of encephalitis and equine encephalomyelitis infections in man is almost identical with that of poliomyelitis, and mild cases of the former may easily be diagnosed incorrectly when these diseases occur sporadically. The possibility of the existence of these newly recognized forms of neurotropic virus infections must also be borne in mind when making a diagnosis of the abortive form of poliomyelitis.

During 1939 the results of several investigations on poliomyelitis were published, the most important of these studies being that of Armstrong (*3*, *4*). He was able to infect the eastern cotton rat, *Sigmodon hispidus hispidus*, with a strain of poliomyelitis virus obtained from the brain of a fatal case which occurred in Lansing, Mich., in 1937. Successful transmission was obtained by intracerebral inoculation after a fourth monkey passage of the virus. Not only has Armstrong been able to maintain this virus through more than 50 passages in the cotton rat, but he also has been able to infect white and house mice with the same strain. Unlike the monkey, in which the infection can be produced by nasal instillation of virus, the cotton rat and mice have been refractory to infection except by intracerebral inoculation of the Lansing strain. The importance of Armstrong's discovery lies in the fact that laboratory studies on poliomyelitis on a much larger scale will be made possible at a much lower cost than has been possible when monkeys were the only animals available for experimental purposes.

During the epidemic of poliomyelitis in Charleston, S. C., Paul, Trask, and Culotta (*5*) obtained samples of sewage from an area in which the hospital used for isolating poliomyelitis cases was located, and they were able to recover the virus from these specimens. Kramer, Gilliam, and Molner (*6*) reported the recovery of the virus from the stools of 3 out of 12 healthy contacts of poliomyelitis cases occurring in an institution in Detroit, and also from the stools of 2 out of 3 children who were classified as abortive cases. Silverman (*7*), in a personal communication, stated that the presence of the virus was demonstrated in the stools of 3 cases of poliomyelitis in an institutional outbreak in Syracuse, where a total of 6 cases was reported in March and April of 1939.

Although previous studies have demonstrated the presence of poliomyelitis virus in the stools of patients, particularly mild and abortive cases, these recent reports seem to indicate a much wider distribution of the virus than heretofore suspected. However, there have been no studies made in which the virus was recovered from the stools of apparently healthy persons living in a community where the disease is either absent or occurring sporadically. These reports on the recovery of the virus from the stools of mild cases and contacts, and from sewage obtained from an epidemic area, have not thrown any new light on one of the unsolved problems in the epidemiology of the disease, namely, the mode of transmission. Although experimental evidence has, according to several investigators (*8*, *9*, *10*), tended to question the validity of the most commonly accepted belief that the virus gains entrance into the human body through the nasal passages, none of the recent studies has been inconsistent with the theory of transmission of infection by direct contact with cases and carriers.

The morbidity data on poliomyelitis by counties used in the preparation of the map accompanying this report were taken from the files of the Division of Sanitary Reports and Statistics of the Public Health Service. Special thanks are due Mr. H. G. Eubank and his staff for making these data available. Acknowledgment is also made to Dr. E. L. Stebbins, New York State Department of Health, Dr. O. McDaniel, Minnesota Department of Health, and Dr. F. E. Fronczak, Health Commissioner of Buffalo, for supplying information for this report. Dr. A. G. Gilliam, National Institute of Health, permitted the use of certain data from his files for Charleston County, S. C.

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THE COURSE OF DISABLING MORBIDITY AMONG INDUSTRIAL WORKERS, 1921–38 [1]

By William M. Gafafer, *Senior Statistician, United States Public Health Service*

During the past few years industry has become increasingly interested in the keeping of records of absenteeism, realizing more and more that it is necessary to know something of the magnitude and nature of the problem of illness in industry before any measurable progress can be made in the protection and improvement of the health of the working population. It is, therefore, particularly appropriate to present an historical paper based on industrial morbidity records.

It is appropriate also to recall the remarks published almost a quarter of a century ago by a committee under the chairmanship of Sir George Newman. In referring to indications of sickness the committee wrote, "Every case of lost time or absence calls for inquiry. It should be properly recorded. A study of such records is certain to disclose the existence of adverse influences or circumstances, today unsuspected, which may denote the beginning of sickness" (*1*).

For many years the Division of Industrial Hygiene of the National Institute of Health has stimulated the keeping of records through appropriate committee memberships, contacts with those interested, and pertinent publications. Of the various publications on industrial absenteeism from the Division, reference is made to the quarterly contributions to the Public Health Reports on disabling morbidity among industrial workers, since the present paper and the quarterly reports are based upon data from the same source.

The quarterly reports on disabling morbidity have appeared for approximately 20 years and are based on the reported experience of the memberships of industrial sick benefit organizations comprising mutual sick benefit associations, group insurance plans, and company relief departments. It is important to recognize that data of this type have a number of inherent limitations, which have been referred to in some detail in recent studies (*2*, *3*). These limitations, among others, have to do with the exclusion from membership of workers engaged in certain occupations, or because of age, presence of certain chronic diseases, and particular physical defects found at examination at the time of application for membership. While all of the sick benefit organizations do not subscribe to all of the limiting factors referred to, nevertheless the memberships may be considered, to some extent, selected groups.

In connection with factors probably imposing limitations upon the data it should be mentioned that the time period selected for study,

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[1] From the Division of Industrial Hygiene, National Institute of Health.

Read before the Annual General Motors Medical Conference, November 2, 1939, at Dayton, Ohio. This paper appeared with some minor changes in Industrial Medicine, February 1940.

namely, the years 1921 through 1938, was unique in that it contained an economic depression characterized chiefly by unemployment of extraordinary magnitude. Briefly, this unemployment was reflected in the memberships of the sick benefit organizations not only by decreases in size but also probably by changes in relative constitution with respect to certain factors.

With regard to the geographic location of the industries, none was situated in the South or in the far West.

With the recognition of the type of data available it is purposed in the present paper to show the course of disabling morbidity during the period 1921–38 as determined by reported cases of sickness and nonindustrial injuries among the memberships of various industrial sick benefit organizations. In particular, the time changes in morbidity will be measured in terms of the average annual frequency of cases causing disability for 8 consecutive calendar days or longer and attention will be directed, among other things, to sex differences

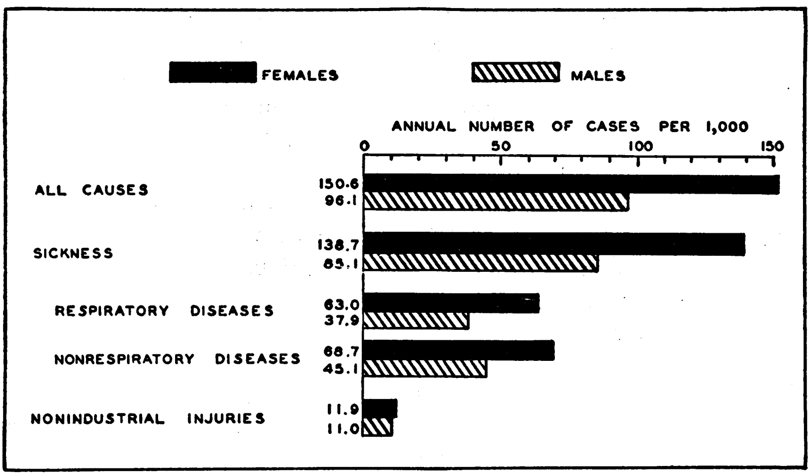

FIGURE 1.—Annual number of cases per 1,000 workers causing disability lasting 8 calendar days or longer, according to broad cause groups, males and females compared, 1921-38, inclusive.

specific for broad cause groups, and differences among industrial groups with respect to cause.

ANALYSIS OF THE DATA

The available data for the 18 years represent 2,652,759 years of exposure for males and 238,240 years for females. The male exposure may be classified according to industrial groups, as follows: Iron and steel, 1,144,326 years (43 percent), public utilities, 560,638 years (21 percent), and miscellaneous, 947,795 years (36 percent), the last comprising industries making chemicals, plumbing fixtures, electrical equipment, paper, paper novelties, timepieces, hats, underwear, flour, soap, and certain other products. For statistical purposes the 18 years have been grouped into the 6 triennia.

Sex differences by broad cause groups, 1921–38.—Among other things table 1 shows for males and females the annual number of cases per 1,000 employees according to broad cause groups. Thus the annual rate for all causes with respect to cases that began during 1921–38 among females is 150.6, while the corresponding rate for males is 96.1. These rates and the corresponding ones for broad cause groups are presented graphically in figure 1. It will be observed that, with the exception of the rates for nonindustrial injuries which show only a slight sex difference favoring the males, all of the rates for the females are definitely greater than the corresponding ones for the males, the percentage excess in each instance being more than 50 percent.

TABLE 1.—*Frequency of sickness and nonindustrial injuries causing disability lasting 8 consecutive calendar days or longer by broad cause groups according to triennium in which cases began,* MALE *and* FEMALE *employees in various industries, 1921–38, inclusive*

Triennium in which cases began	Sickness and nonindustrial injuries [1]	Nonindustrial injuries	Sickness [1]	Respiratory diseases	Nonrespiratory diseases	Ill-defined and unknown causes	Total person-years of membership
	Annual number of cases per 1,000 males						
1921-38	96.1	11.0	85.1	37.9	45.1	2.1	2,652,759
1921-23	94.1	8.3	85.8	40.8	42.7	2.3	222,460
1924-26	104.6	10.6	94.0	44.2	47.5	2.3	347,582
1927-29	109.8	11.6	98.2	46.2	50.3	1.7	523,473
1930-32	95.4	12.4	83.0	34.8	46.2	2.0	524,387
1933-35	81.8	11.6	70.2	27.5	40.9	1.8	484,805
1936-38	90.8	11.5	79.3	33.6	43.1	2.6	550,052
	Annual number of cases per 1,000 females						
1921-38	150.6	11.9	138.7	63.0	68.7	7.0	238,240
1921-23	139.5	8.0	131.5	63.7	53.8	14.0	21,047
1924-26	159.4	10.9	148.5	67.6	71.6	9.3	47,704
1927-29	167.3	12.8	154.5	75.5	73.6	5.4	37,530
1930-32	155.2	13.9	141.3	61.8	74.8	4.7	39,374
1933-35	139.9	12.8	127.1	51.5	71.7	3.9	45,280
1936-38	142.1	12.6	129.5	58.0	67.0	4.5	47,305
	Ratio of female rate to male rate						
1921-38	1.57	1.08	1.63	1.66	1.52	3.33	----------
1921-23	1.48	.96	1.53	1.56	1.26	6.09	----------
1924-26	1.52	1.03	1.58	1.53	1.51	4.04	----------
1927-29	1.52	1.10	1.57	1.63	1.46	3.18	----------
1930-32	1.63	1.12	1.70	1.78	1.62	2.35	----------
1933-35	1.71	1.10	1.81	1.87	1.75	2.17	----------
1936-38	1.56	1.10	1.63	1.73	1.55	1.73	----------

[1] Industrial injuries and venereal diseases are not included.

Sex differences by broad cause groups and triennia.—The observation that the frequency rates covering the entire time period were greater among the females than among the males raises the question of how the rates behaved during the time period, for example, by triennia. Table 1 presents these data and figure 2 shows them graphically. It will be seen that again with the exception of nonindustrial injuries the frequencies for the females are definitely greater than those for

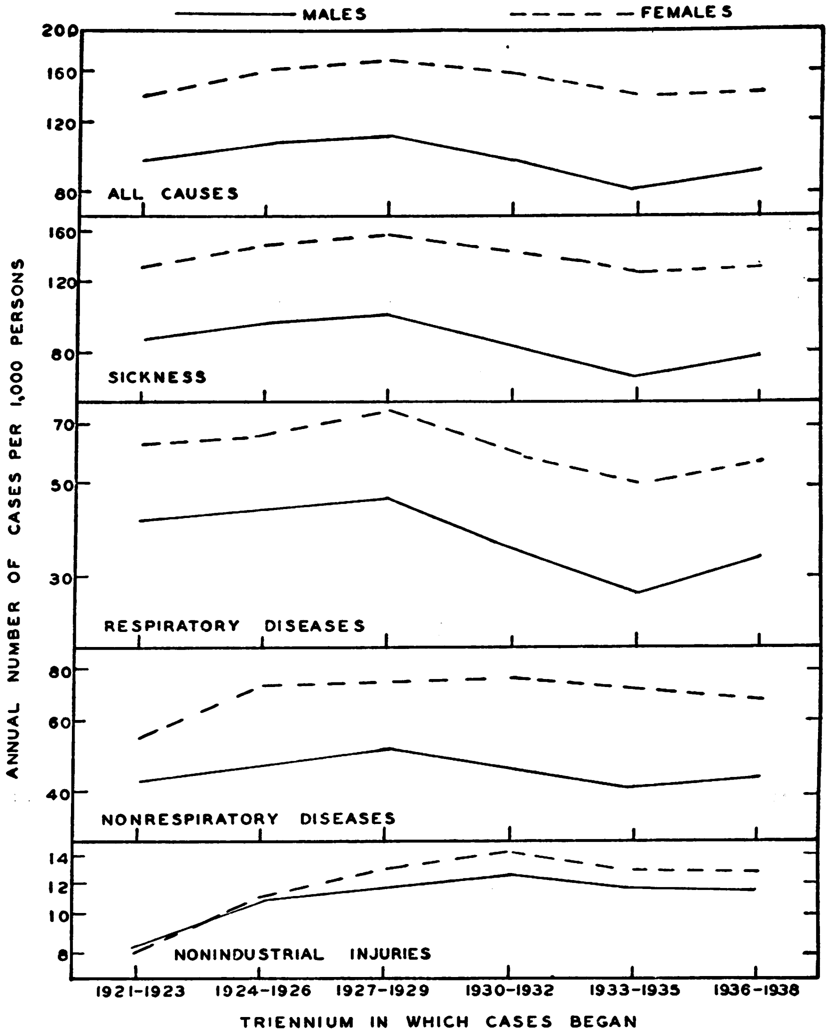

FIGURE 2.—Annual number of cases per 1,000 workers causing disability lasting 8 calendar days or longer, according to broad cause groups, by triennium in which cases began, males and females compared, 1921-38, inclusive. (Vertical logarithmic scale.)

the males, the lowest of all the triennial rates for any cause group among the females being greater than the highest triennial rate shown by the corresponding cause group among the males.

Of interest is the minimum shown by the triennial respiratory rate for 1933-35 among both sexes. It will be noted that the size of the rate is sufficiently small to be reflected in the curves for all sickness as well as for all causes. Of considerable interest also are the trends of the frequencies. When straight trend lines are fitted by hand to the various curves representing the cause groups it will be observed that for all causes the trends for both sexes decrease slightly. With respect to the nonrespiratory group the males show a slight downward trend while the trend for the female workers appears to increase slightly. The lines representing the movement of all sickness, that is, all causes without nonindustrial injuries, show a downward trend which is more in evidence among the males, the principal determining factor of movement being the respiratory group with its downward trend for the females and the pronounced downward trend for the males. The

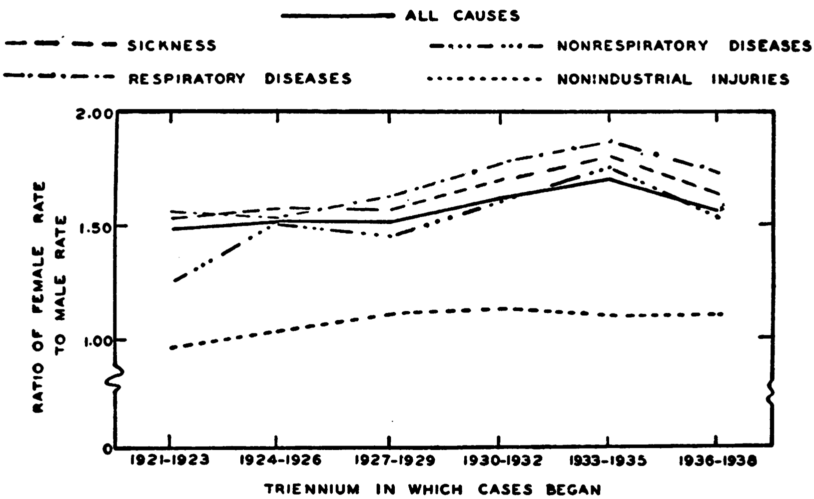

FIGURE 3.—Ratio of female rate to male rate, according to broad cause groups, by triennium in which cases began, 1921–38, inclusive. ("Rate" refers to the annual number of cases per 1,000 workers causing disability lasting 8 calendar days or longer.)

group, nonindustrial injuries, on the other hand, shows an upward trend among females as well as males, corresponding triennial frequencies showing only small sex differences.

Sex ratios of frequencies by broad cause groups and triennia.—Attention has been directed to the behavior of the frequencies by cause groups for each sex, and reference was made to the generally higher rates for the females. Sex differences may be further examined with the use of the ratio of the female frequency to that of the corresponding male frequency which ratio thus shows the variation of the female frequency in terms of that for the males. Such ratios are shown in table 1, and their time changes may be seen graphically in figure 3. Most striking is the peak corresponding to the triennium 1933–35, shown by all of the curves except that for nonindustrial injuries. This triennium, as indicated in the last section, showed minimum rates among males and females for the respiratory group of causes, which minima were reflected in the curves for all sickness as well as for all causes. Thus while the respective frequencies for males and females were at a minimum, the frequency for females was sufficiently greater than the corresponding one for males to produce a maximum ratio.

The following will also be observed: First, with the exception of the ratio, 0.96, for nonindustrial injuries corresponding to the first triennium, all ratios are greater than 1. Second, the curves representing the ratios corresponding to the 3 cause groups (respiratory diseases, nonrespiratory diseases, and nonindustrial injuries) are distinct in that they do not cross each other; for a particular triennium the respiratory ratio is largest, followed by the nonrespiratory ratio, and then by that of the nonindustrial injuries. And, third, the trends of the ratios for the 3 cause groups rise, those representing the respiratory and nonrespiratory causes almost at the same rate while the nonindustrial injury trend rises more slowly. The 18 years' experience thus shows that not only were the frequencies for the females greater than those for the males with respect to the respiratory and nonrespiratory diseases and nonindustrial injuries (first triennium excepted), but relative differences between corresponding frequencies showed a perceptible rise. This observation is of considerable interest, and particularly so in the instance of the respiratory group when it is recalled that the male and female trends for this group of causes showed a sensible decline.

Frequencies among males by specific causes and triennia.—The available data for males but not for females are sufficiently extensive to permit the examination of frequencies by cause. Rates for specific causes only will be examined since the previous sections deal with the broad cause groups. Table 2 gives the requisite rates, and a close inspection of their fluctuation from triennium to triennium reveals a number of causes with upward or downward trends, some more pronounced than others.

Causes showing downward trends are bronchitis, diseases of the pharynx and tonsils, pneumonia, respiratory tuberculosis, diseases of the stomach, diarrhea and enteritis, the rheumatic group,[2] neurasthenia, nephritis, diseases of the skin, and cancer.

Those causes showing an upward trend are appendicitis, and diseases of the circulatory system.

Causes apparently showing a reasonably level trend are influenza and grippe, hernia, and infectious and parasitic diseases.

The minimum morbidity, which occurred in 1933–35, is shown by bronchitis, diseases of the pharynx and tonsils, influenza and grippe,

[2] The rheumatic group includes: Rheumatism, acute and chronic; neuralgia, neuritis, and sciatica; and diseases of the organs of locomotion except diseases of the joints.

TABLE 2.—*Frequency of sickness and nonindustrial injuries causing disability lasting 8 consecutive calendar days or longer by triennium in which cases began according to cause,* MALE *employees in various industries, 1921–38, inclusive*

Cause (Numbers in parentheses are disease title numbers from the International List of the Causes of Death, 1929)	Triennium in which cases began						Average, all triennia
	1921–1923	1924–1926	1927–1929	1930–1932	1933–1935	1936–1938	
Sickness and nonindustrial injuries [1]	94.1	104.6	109.8	95.4	81.8	90.8	96.1
Nonindustrial injuries	8.3	10.6	11.6	12.4	11.6	11.5	11.0
Sickness	85.8	94.0	98.2	83.0	70.2	79.3	85.1
Respiratory diseases	40.8	44.2	46.2	34.8	27.5	33.6	37.9
Bronchitis, acute and chronic (106)	5.5	5.8	5.7	3.9	3.3	4.6	4.8
Diseases of the pharynx and tonsils (115a)	5.6	6.8	6.5	5.2	4.4	4.9	5.6
Influenza and grippe (11)	18.8	21.8	24.2	18.1	12.7	15.5	18.5
Pneumonia, all forms (107–109)	3.4	3.2	3.3	2.2	2.0	2.6	2.8
Tuberculosis of the respiratory system (23)	1.7	1.4	1.3	1.0	.9	.8	1.2
Other respiratory diseases (104, 105, 110–114)	5.8	5.2	5.2	4.4	4.2	5.2	5.0
Digestive diseases	12.5	14.2	15.1	13.9	12.5	13.6	13.6
Diseases of the stomach, except cancer (117, 118)	4.1	5.0	4.8	4.3	3.4	4.0	4.2
Diarrhea and enteritis (120)	1.9	1.7	1.4	1.2	1.1	1.2	1.4
Appendicitis (121)	3.0	3.6	4.4	3.7	3.7	4.1	3.8
Hernia (122a)	1.6	1.4	1.7	1.8	1.4	1.6	1.6
Other digestive diseases (115b, 116, 122b–129)	1.9	2.5	2.8	2.9	2.9	2.7	2.6
Nonrespiratory-nondigestive diseases	30.2	33.3	35.2	32.3	28.4	29.5	31.5
Infectious and parasitic diseases (1–10, 12–22, 24–33, 36–44)	2.4	3.1	3.4	3.3	2.5	2.3	2.8
Rheumatism, acute and chronic (56, 57)	5.0	6.2	6.1	5.4	4.3	4.0	5.2
Neuralgia, neuritis, sciatica (87a)	1.8	2.1	2.3	2.2	2.1	2.2	2.1
Neurasthenia and the like (part of 87b)	1.7	1.7	1.4	1.3	.9	1.1	1.4
Other diseases of the nervous system (78–85, part of 87b)	.5	.8	1.0	1.1	1.4	1.1	1.0
Diseases of the heart (90–95)	1.8	1.7	2.1	2.2	2.2	2.5	2.0
Other diseases of the circulatory system (96–103)	2.3	2.4	2.9	3.0	2.7	3.1	2.7
Nephritis, acute and chronic (130–132)	.8	.7	.8	.7	.5	.5	.7
Other diseases of the genitourinary system (133–139)	1.7	2.0	2.2	2.3	2.4	2.3	2.2
Diseases of the skin (151–153)	3.5	3.6	4.4	3.2	2.6	3.0	3.4
Diseases of the organs of locomotion except diseases of the joints (156b)	3.0	3.4	3.8	3.4	2.7	2.9	3.2
Cancer, all sites (45–53)	.6	.7	.5	.6	.5	.5	.5
All other diseases (54, 55, 58–77, 88, 89, 140–150, 154–156a, 157, 162)	5.6	4.9	4.3	3.6	3.6	4.0	4.3
Ill-defined and unknown causes (200)	2.3	2.3	1.7	2.0	1.8	2.6	2.1
Number of person-years of membership	222,460	347,582	523,473	524,387	484,805	550,052	2,652,759

[1] Industrial injuries and venereal diseases are not included.

pneumonia, diseases of the stomach, hernia, neurasthenia, and diseases of the skin.

Frequencies among males according to broad cause groups and certain selected causes by industrial group and triennium.—Thus far the data have been examined without reference to specific industries. The question arises of how closely the frequencies for specific industries follow the trend for all industries combined. The magnitude of the available data makes it possible to classify the cooperating industries into three broad groups, namely, iron and steel, representing 43 percent of the total male membership, public utilities, representing 21 percent, and miscellaneous industries, representing 36 percent. For each industrial group the time changes in the frequencies will be examined for the broad sickness groups and for certain selected causes,

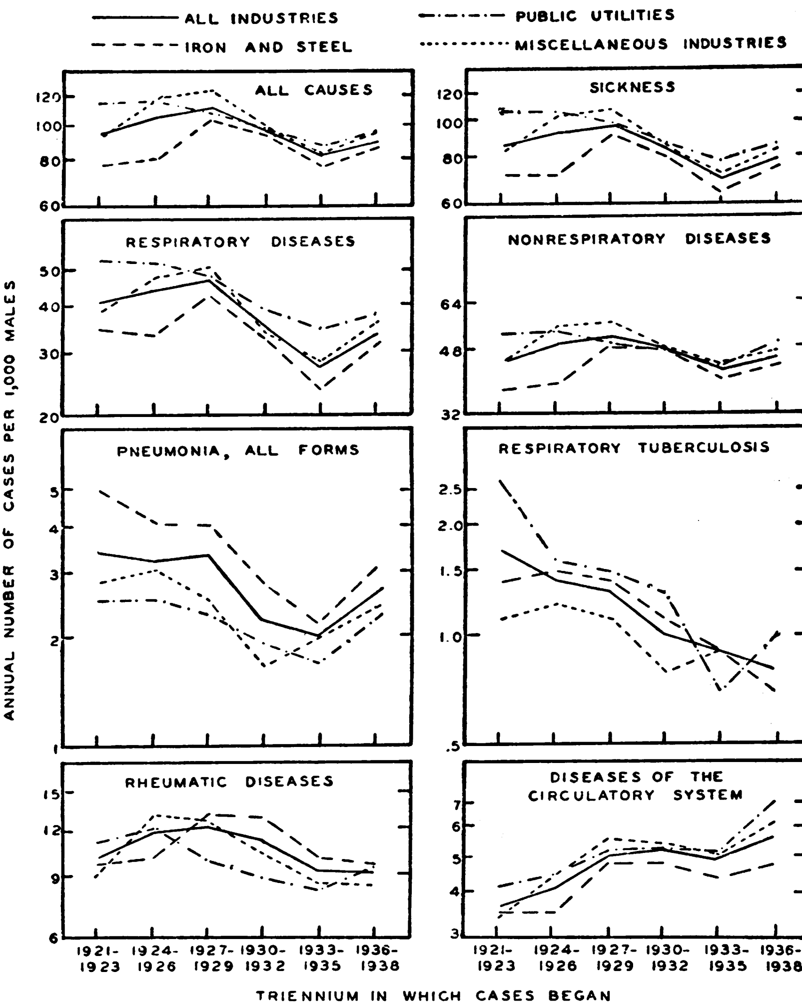

FIGURE 4.—Annual number of cases per 1,000 males causing disability lasting 8 calendar days or longer, according to broad cause groups and certain selected causes, by industrial group and triennium in which cases began, 1921-38, inclusive. (Vertical logarithmic scale.) Note that in the instance of respiratory tuberculosis the points for "all industries" and "miscellaneous industries" coincide in the triennia 1933-35 and 1936-38.

including pneumonia, respiratory tuberculosis, rheumatic diseases, and diseases of the circulatory system (including diseases of the heart). Table 3 presents the pertinent data and figure 4 shows them graphically.

TABLE 3.—*Frequency of sickness and nonindustrial injuries, classified according to broad cause groups and certain selected causes, causing disability lasting 8 consecutive calendar days or longer by triennium in which cases began according to industry,* MALE *employees, 1921–38, inclusive*

Industry	Annual number of cases per 1,000							Ratio to rate for 1921–1938					
	1921–1938	1921–1923	1924–1926	1927–1929	1930–1932	1933–1935	1936–1938	1921–1923	1924–1926	1927–1929	1930–1932	1933–1935	1936–1938
	Sickness and nonindustrial injuries												
All industries	96.1	94.1	104.6	109.8	95.4	81.8	90.8	0.98	1.09	1.14	0.99	0.85	0.94
Iron and steel	89.8	78.2	80.9	104.8	94.3	77.2	87.7	.87	.90	1.17	1.05	.86	.98
Public utilities	102.3	114.7	115.2	107.9	96.1	88.3	95.7	1.12	1.13	1.05	.94	.86	.94
Miscellaneous industries	99.8	93.5	116.6	120.5	96.1	83.3	93.8	.94	1.17	1.21	.96	.83	.94
	Sickness												
All industries	85.1	85.8	94.0	98.2	83.0	70.2	79.3	1.01	1.10	1.15	0.98	0.82	0.93
Iron and steel	78.0	71.8	72.5	93.1	80.9	64.7	74.9	.92	.93	1.19	1.04	.83	.96
Public utilities	93.0	106.6	106.2	98.4	86.5	78.3	86.7	1.15	1.14	1.06	.93	.84	.93
Miscellaneous industries	87.7	83.1	103.5	107.4	83.0	71.9	83.0	.95	1.18	1.22	.95	.82	.95
	Respiratory diseases												
All industries	37.9	40.8	44.2	46.2	34.8	27.5	33.6	1.08	1.17	1.22	0.92	0.73	0.89
Iron and steel	33.4	34.5	33.5	43.0	32.9	23.7	31.3	1.03	1.00	1.29	.99	.71	.94
Public utilities	43.4	53.3	51.9	47.8	39.1	34.4	37.2	1.23	1.20	1.10	.90	.79	.86
Miscellaneous industries	38.3	38.0	48.0	51.0	34.1	28.0	35.9	.99	1.25	1.33	.89	.73	.94
	Nonrespiratory diseases [1]												
All industries	47.2	45.0	49.8	52.0	48.2	42.7	45.7	0.95	1.06	1.10	1.02	0.90	0.97
Iron and steel	44.6	37.3	39.0	50.1	48.0	41.0	43.6	.84	.87	1.12	1.08	.92	.98
Public utilities	49.6	53.3	54.3	50.6	47.4	43.9	49.5	1.07	1.09	1.02	.96	.89	1.00
Miscellaneous industries	49.4	45.1	55.5	56.4	48.9	43.9	47.1	.91	1.12	1.14	.99	.89	.95
	Pneumonia, all forms												
All industries	2.8	3.4	3.2	3.3	2.2	2.0	2.6	1.21	1.14	1.18	0.79	0.71	0.93
Iron and steel	3.3	5.0	4.1	4.0	2.8	2.2	3.0	1.52	1.24	1.21	.85	.67	.91
Public utilities	2.2	2.5	2.5	2.3	1.9	1.7	2.2	1.14	1.14	1.05	.86	.77	1.00
Miscellaneous industries	2.3	2.8	3.0	2.5	1.7	2.0	2.4	1.22	1.30	1.09	.74	.87	1.04
	Tuberculosis of the respiratory system												
All industries	1.2	1.7	1.4	1.3	1.0	0.9	0.8	1.42	1.17	1.08	0.83	0.75	0.67
Iron and steel	1.1	1.4	1.5	1.4	1.1	.9	.7	1.27	1.36	1.27	1.00	.82	.64
Public utilities	1.4	2.6	1.6	1.5	1.3	.7	1.0	1.86	1.14	1.07	.93	.50	.71
Miscellaneous industries	1.0	1.1	1.2	1.1	.8	.9	.8	1.10	1.20	1.10	.80	.90	.80

[1] Includes a small number of cases of ill-defined and unknown diagnosis.

TABLE 3.—*Frequency of sickness and nonindustrial injuries, classified according to broad cause groups and certain selected causes, causing disability lasting 8 consecutive calendar days or longer by triennium in which cases began according to industry,* MALE *employees, 1921–38, inclusive*—Continued

Industry	Annual number of cases per 1,000							Ratio to rate for 1921–1938					
	1921–1938	1921–1923	1924–1926	1927–1929	1930–1932	1933–1935	1936–1938	1921–1923	1924–1926	1927–1929	1930–1932	1933–1935	1936–1938
	Rheumatic diseases [3]												
All industries	10.5	9.8	11.7	12.2	11.0	9.1	9.1	0.93	1.11	1.16	1.05	0.87	0.87
Iron and steel	11.1	9.5	10.0	13.0	12.7	10.0	9.6	.86	.90	1.17	1.14	.90	.86
Public utilities	9.8	11.0	12.0	9.9	8.9	8.2	9.3	1.12	1.22	1.01	.91	.84	.95
Miscellaneous industries	10.2	9.1	13.0	12.5	10.3	8.5	8.4	.89	1.27	1.23	1.01	.83	.82
	Diseases of the circulatory system (including diseases of the heart)												
All industries	4.7	3.6	4.1	5.0	5.2	4.9	5.6	0.77	0.87	1.06	1.11	1.04	1.19
Iron and steel	4.5	3.5	3.5	4.7	4.8	4.4	4.7	.78	.78	1.04	1.07	.98	1.04
Public utilities	5.3	4.1	4.5	5.2	5.2	5.1	6.9	.77	.85	.98	.98	.96	1.30
Miscellaneous industries	5.2	3.4	4.4	5.5	5.4	5.1	6.2	.65	.85	1.06	1.04	.98	1.19
	Number of person-years of membership												
All industries	2,652,759	222,460	347,582	523,473	524,387	484,805	550,052	----	----	----	----	----	----
Iron and steel	1,144,326	76,066	111,888	262,752	226,172	200,691	266,757	----	----	----	----	----	----
Public utilities	560,638	62,505	89,637	111,105	116,935	86,357	94,099	----	----	----	----	----	----
Miscellaneous industries	947,795	83,889	146,057	149,616	181,280	197,757	189,196	----	----	----	----	----	----

[3] Rheumatism, acute and chronic, diseases of the organs of locomotion except diseases of the joints, neuralgia, neuritis and sciatica.

An inspection of figure 4 reveals that the trends, while not precisely the same, are downward for the three industrial groups in respect of all sickness, respiratory diseases, pneumonia, and respiratory tuberculosis, and upward for diseases of the circulatory system. In the remaining three instances the trends among the industrial groups differ from the corresponding trends for the combined industries. In each of these three instances iron and steel appears to be the responsible factor; thus, in respect of all causes, the rheumatic diseases, and the nonrespiratory diseases, respectively, where the trends are generally downward, iron and steel shows a level trend in the first two instances and an upward one in the last instance.

In connection with the trend in the iron and steel industry attention should be directed to its isolated position in the graphical presentation of all causes, all sickness, respiratory diseases, and pneumonia, respectively; in the first three instances the iron and steel curve is the lowest of all curves, while for pneumonia the curve lies definitely above all others. Attention is also directed particularly to the position of iron and steel with reference to the nonrespiratory diseases and diseases of the circulatory system.

Ratio of triennial frequencies to frequency for 1921–38 according to industrial groups by broad cause group and certain selected causes.—The behavior of the absolute frequencies yielded by the industrial groups was examined in the preceding section and the findings are believed sufficiently striking to demand further inspection. Among others, questions may be raised concerning the magnitude of the excesses or defects in the triennial frequencies with respect to a "normal" frequency rate.

A reasonable normal frequency for a particular industrial group and cause may be defined as the average annual frequency yielded by that industrial group and cause, and based on the entire experience of 18 years. Thus the average annual number of cases of pneumonia per 1,000 iron and steel workers for the period 1921–38 was 3.3, and this is the defined normal frequency for pneumonia among iron and steel workers. The determination of the pneumonia excess or defect for a particular triennium follows by obtaining the ratio of the triennial frequency to the normal frequency. For example, table 3 shows, among other things, the pneumonia rate for 1921–38 among iron and steel workers to be 3.3; the corresponding rate for 1921–23 was 5.0. The ratio for 1921–23, therefore, is 5.0 to 3.3 or 1.52, which means that the triennial pneumonia rate for 1921–23 was 52 percent in excess of the normal pneumonia rate among iron and steel workers. The whole procedure may be summed up by stating that the different triennial rates are expressed in terms of corresponding average rates determined by the entire experience of 18 years.

Before examining the magnitudes of the specific ratios it is illuminating to observe the normal rates upon which the ratios are based. These normal rates are shown in the first column of table 3.[3] It will be observed that each cause group and cause, with the exception of the nonrespiratory diseases, presents great variation in the size of the normal values. Thus while iron and steel shows relatively low normals with respect to all causes, all sickness, respiratory diseases, respiratory tuberculosis, and diseases of the circulatory system, respectively, the normals for the same industrial group are relatively high with respect to pneumonia and the rheumatic diseases.

Having referred briefly to the magnitude of the values defined as normal it is now logical to examine the excesses and defects as determined by the ratios. The ratios are presented in table 3 and a particular percentage in excess or defect may be determined at sight. Figure 5 shows graphically the behavior of the ratios with time. Interest centers round the area, for each cause group and cause, in

[3] Some of these values are shown graphically in figure 1, the difference in the instance of the nonrespiratory diseases being accounted for by the ill-defined and unknown causes.

which the ratios operate,[4] particularly the size of the zone determined by the upper and lower limits of the ratios (regardless of industrial group) and the degree of concentration presented by the

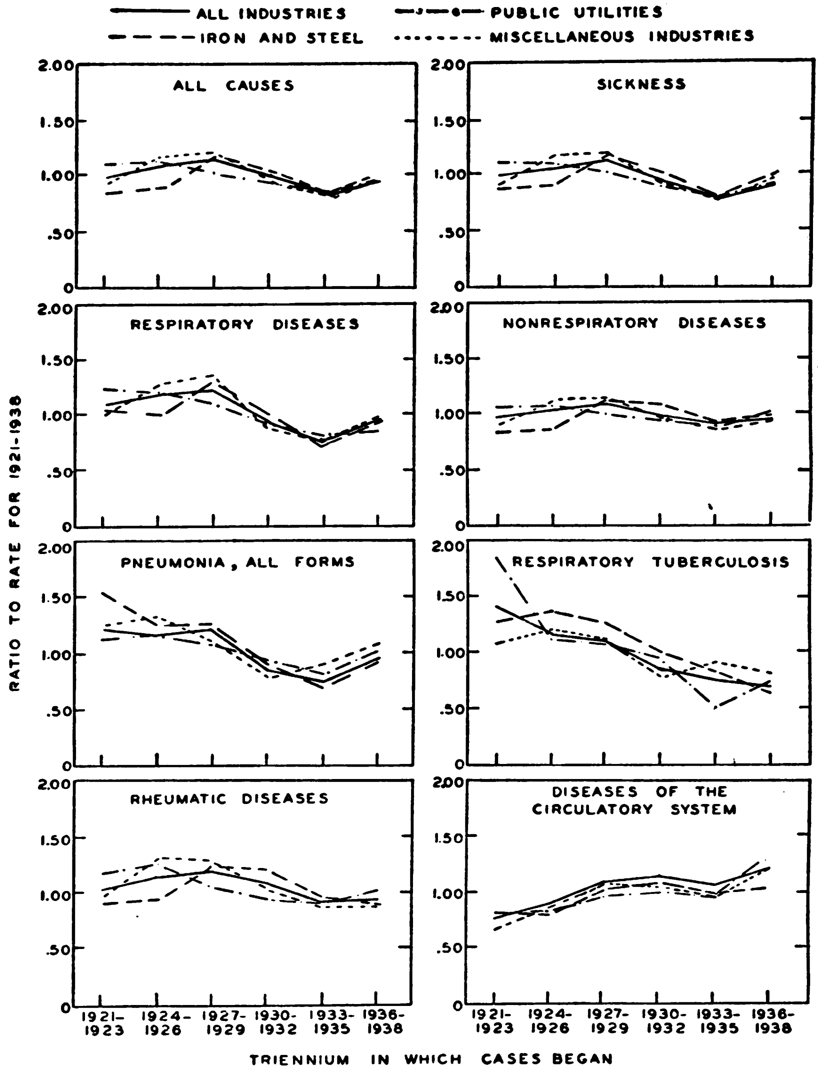

FIGURE 5.—Ratio of rates for each triennium to rate for 1921-38, inclusive, according to broad cause groups and certain selected causes, by industrial group, 1921-38, inclusive. ("Rate" refers to the annual number of cases per 1,000 males causing disability lasting 8 calendar days or longer.)

pattern comprising the individual curves. Thus the largest zone of activity is presented by respiratory tuberculosis, moving as it does from an excess of 86 percent to a defect of 50 percent, both percent-

[4] The trends of the ratios may be shown graphically by plotting on semilogarithmic graph paper; this has not been done since these trends would be precisely the same as those shown by the absolute frequencies in figure 4.

ages, as it happens, being from the public utilities. The most concentrated pattern is presented by diseases of the circulatory system, indicating similarity of activity among the different industrial groups.

SUMMARY

This paper, dealing with the time changes (1921–38) in the frequency of sickness and nonindustrial injuries causing disability lasting more than 1 week, is based on the reported experience of the memberships of industrial sick benefit organizations. The results may be briefly summarized as follows:

1. All sickness shows a downward trend which is more in evidence among males than among females, the principal determining factor of movement being the respiratory diseases.
2. Nonindustrial injuries show an upward trend among females as well as males.
3. The trends of the female-to-male ratio rise, those representing the respiratory and nonrespiratory groups almost at the same rate while the nonindustrial injury trend rises more slowly.
4. Among males, diseases of the circulatory system, including diseases of the heart, and appendicitis show an upward trend.
5. While not precisely the same, the trends among males are downward for the three industrial groups, iron and steel, public utilities, and miscellaneous industries, in respect of all sickness, respiratory diseases, pneumonia, and respiratory tuberculosis, and upward for diseases of the circulatory system including diseases of the heart.

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STUDIES OF SEWAGE PURIFICATION

XIII. THE BIOLOGY OF *SPHAEROTILUS NATANS* KUTZING IN RELATION TO BULKING OF ACTIVATED SLUDGE

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INTRODUCTION

The term bulking, as applied to sewage disposal plants, is usually definable only in terms of its user. It may mean rising of the sludge blanket until the sludge passes the weir or it may mean great increase in sludge volume accomplished by loss of density. In any case, it means that the operator has lost control of the sludge. Its causes likewise vary according to the type of bulking, whether we are dealing with a given mass of sludge occupying several times the volume it normally should, whether there is flotation of the floc by gas bubbles, or by filamentous organisms, or other causes. In one sense, the end result is the same. The effluent is no longer clear but contains objectionable putrescible matter.

Sewage usually contains a variety of filamentous growths ranging from bacteria, which develop in masses because of confluent gelatinous sheathlike secretions, to ramifying branched mycelia of the true molds. A number of these filamentous organisms have been isolated from sewage and one, *Sphaerotilus natans* Kutzing, has long been associated with bulking. Sometimes it is regarded as the cause of bulking and again as merely being associated with it. The first description of the organism recorded it from "factory water" and it is almost invariably found in polluted waters. Butcher (*1*) has shown roughly the conditions of its principal occurrence in nature and no sewage polluted stream seems clear of it. Naumann and Wanselin (*2*) have shown that heavy growths of *Sphaerotilus natans* in polluted streams are accompanied by oxygen depletion, creation of a septic mud, and even obstruction of stream flow. They consider luxuriant growths a basis for legal action.

Sphaerotilus is not normally an abundant growth in an activated sludge chamber, although a few filaments may usually be seen on microscopic examination. But a bulking sludge frequently contains enormous quantities of it. Ardern and Lockett, according to Martin (*3*), had connected bulking with filamentous growths prior to 1922. Hoyle (*4*) in 1927 reported *Sphaerotilus natans* as the cause of severe bulking. Morgan and Beck (*5*) reported a similar case in 1928 and Ruchhoft and Watkins (*6*) studied the *Sphaerotilus* from this bulking sludge in pure culture. Larsen (*7*) considers the fungus merely incidental to bulking and McLachlan (*8*) questions causation of bulking by the fungus.

Smit (*9*, *10*) investigated a filamentous organism which he called the "causative organism" of bulking, although he was not sure it was *Sphaerotilus*. He called it a facultative anaerobe. Naumann (*11*) showed a huge use of oxygen by *Sphaerotilus* and found a high biochemical oxygen demand for *Sphaerotilus* mud. Ingols and Heukelekian (*12*) state that bulking "produced by carbohydrates is a direct response of *Sphaerotilus* to a relatively long contact with an available energy food." It appears then that *Sphaerotilus* or organisms akin to it have been shown to be intimately associated with sewage pollution and have been repeatedly investigated in connection with the bulking of activated sludge.

ISOLATION AND CULTURE

Because of the association shown above, filamentous growths have been isolated and studies made of these pure cultures at the Stream Pollution Investigations Station, Cincinnati, Ohio. In the course of the work several genera of fungi and fourteen *Sphaerotilus* strains have been obtained in bacteria free culture. *Sphaerotilus* cultures have been obtained from the Station experimental plant, both when bulking and when not bulking, from raw Cincinnati sewage, from a sewage polluted stream in a Cincinnati park, from the Ohio River at Cincinnati, and from bulking sludge obtained at the Lima, Ohio, plant.

One significant point is that, despite diverse origins, all *Sphaerotilus* strains have behaved alike in culture, and all have shown sufficient variability under experimental conditions to enable them to be classified at various times as several of the described species of *Sphaerotilus*. We believe all our strains to be *Sphaerotilus natans* Kutzing, and are of the opinion that the species is capable of considerable variation in a changing environment.

The original isolation was obtained from sludge in which only an occasional strand of fungus was to be found. These strands were placed in 8-liter pyrex bottles containing an enrichment of 1,000 p. p. m. of sucrose, and then aerated in the laboratory. Fed by the fill and draw method twice a day, such bottles usually showed an abundant growth of *Sphaerotilus* in a few days. From this material small flocs consisting largely of fungus were picked, teased, and washed. The usual bacteriological technique was followed, shaking the fungus-laden sludge flocs to pieces with glass beads, diluting, and plating on nutrient agar, from which sterile colonies were subsequently picked. Fungus flocs were also washed 8 to 10 times in sterile dilution water, then streaked on sterile agar plates. Such flocs usually carried bacteria, but around the margin of the colony long sterile filaments grew out in about 24 hours, some of which were cut off and transferred to fresh plates. Agar was first made up according to the formula of Ruchhoft and Watkins (*6*), but subsequently only 1.5

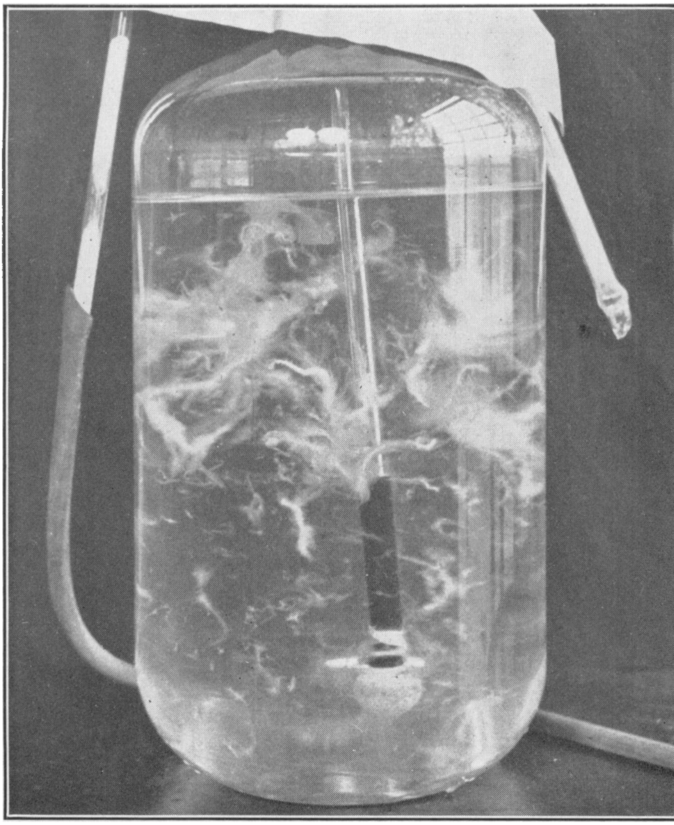

FIGURE 1.—Free flocs of *Sphaerotilus* in aeration bottle. Air stopped to show the ragged, irregular flocs.

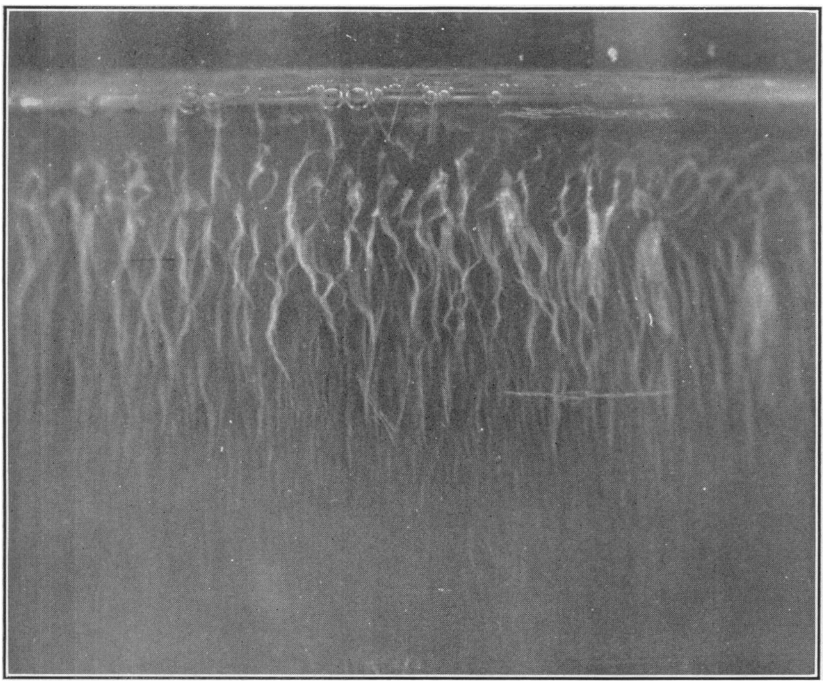

FIGURE 2.—Close-up of side of bottle to show tenuous nature of attached *Sphaerotilus*.

percent filtered sewage agar was used. Overgrowth of plates rarely occurred, the maximum growth being secured in about 24 hours at 37° C. or 48 hours at room temperature. Overgrowth of plates frequently occurred when certain bacteria were present, especially at 37° C. A filamentous bacterium tentatively identified as *Bacillus mycoides* was often mistaken for *Sphaerotilus*, but isolations of the bacterium on sewage agar grew about 4 to 8 times as fast as *Sphaerotilus;* the amount of mycelium formed was greater and its strands had a characteristic whorled appearance to the naked eye. In liquid media it did not form flocs.

Growth of *Sphaerotilus* in liquid media was slower than that of the various bacteria used. Sterile filtered sewage plus dextrose, and synthetic sewage plus dextrose were good menstrua. In 12 to 48 hours large flocs were formed. The following are the most successful synthetic media:

L medium		*Synthetic sewage (S medium)*	
$NaNO_3$	25.0 mg.	Na_2HPO_4	50.0 mg.
$MgSO_4$	10.0 mg.	NaCl	15.0 mg.
K_2HPO_4	10.0 mg.	KCl	7.0 mg.
KH_2PO_4	15.0 mg.	$CaCl_2$	7.0 mg.
$CaCl_2$	45.0 mg.	$MgSO_4$	5.0 mg.
Peptone	100.0 mg.	Peptone	100.0 mg.
Dextrose	500.0 mg.	Dextrose	500.0 mg.
Water	1 liter	Water	1 liter

Many variations of these two media were used, but no great differences in growth were found unless the concentrations of one or more components were raised or lowered greatly.

These concentrations were made up in 6-liter quantities in pyrex serum bottles and sterilized. The mineral salts used in preparing the basic media were kept in solutions of convenient strengths. After seeding from a plant or liquid medium, the bottles were continuously aerated through a ball diffuser. No attempt was made to determine the rate of aeration. Incoming air passed through a filter of sterilized cotton; the exit tube was also plugged with a cotton filter. Very little trouble was experienced with contamination. Inoculation from a liquid culture was preferable because inoculations from agar plates often failed to show growth in 24 or 48 hours. But cultures on agar plates remain viable as long as 30 days, and on agar slants for even longer periods. Once isolated, *Sphaerotilus* may be easily grown and maintained.

CHARACTERISTICS AND IDENTIFICATION OF THE ORGANISM

According to Bergey (*13*), Kutzing first described the species as "an attached, colorless, thread-like filament, showing false branching." The strands are cylindrical with a thin, firm sheath. The sheath is slimy and optically invisible but can be demonstrated in India ink mounts or by several staining methods. The cells, cylindrical or ovoid in longitudinal section, vary in diameter from 1 to 3 microns, and in length from 3 to 8 microns, according to age, source (for wild cultures), and culture medium.

The filaments are colorless, but in streams masses of the fungus may be light brown, even with little enmeshed foreign matter. This is probably due to age and dead cells. Single filaments may be several millimeters long, and often many are entwined in a braided manner giving a cordlike appearance. A single strand ends abruptly if free; if attached it ends in a small disc. Flocs are often 1 cm. in diameter and 5 cm. in length if free floating and are very ragged in contour. When attached they are long and plumose. Attachment in

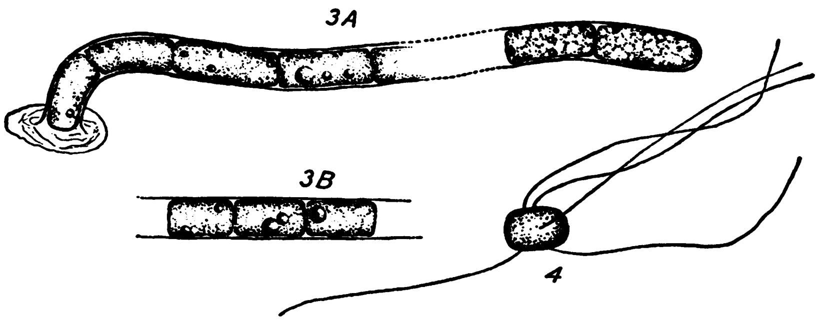

FIGURE 3.—A. Attached strand of *Sphaerotilus*. Note the basal disc and the granular cytoplasm. B. Young cells, shorter than old slower growing cells.
FIGURE 4.—Conidium, motile reproductive cell with irregularly attached flagella.

pure culture depends simply on the degree of agitation of the water by bubbles from the diffuser. Figures 1 and 2 show cultures in serum bottles demonstrating free flocs due to turbulent aeration and attached flocs due to slight aeration.

The small size precludes determination of much cellular detail. Young cells (fig. 3) show a relatively homogenous cytoplasm with a few vacuoles. Often a few granules are seen. The vacuoles take up neutral red and are presumably sap vacuoles. Differential staining of granules with hematoxylin and acid stains has not been accomplished. Such chromatin as is present is in very small particles. In old cells the vacuoles become quite large and appear as white spaces after methylene blue, fuchsin, or hematoxylin staining. The filament sheath stains faintly with hematoxylin after Schaudinn's fixative, but not after Flemming with or without acetic acid. It does not stain with methylene blue or fuchsin. The reproductive cells (conidia), which are simply vegetative cells fragmented from a filament, have flagella which are very difficult to stain. We have not been able to demonstrate them with cytological fixatives, but by using air drying fixation followed by Gray's flagella stain they can be shown, as in figure 4. Such conidia are then seen to have one to several long flagella, subapically inserted. Where there is apparently only one flagellum this is probably due to the aggregation of several on air drying. According to Bergey's Manual (*13*) motile conidia have a clump of flagella near one end.

These conidia are very active. They swim in only one direction and eventually attach themselves by one end, whereupon a long filament grows out from the substrate. Attachment is by the non-flagellated end, for attached conidia still move their free ends for a time. Conidia inoculated into a Petri dish of nutrient medium will grow into filaments several millimeters long overnight.

Colonies on sewage or nutrient agar are very delicate, irregular in contour, and rarely thick enough for a definite color to be seen. Occasionally on agar slants a gray or white color is seen.

The above morphological observations are largely in accord with those of Smit (*10*) and our preparations from agar and sludge so closely resemble his that further illustration of this nature seems unnecessary. But some cultural and physiologic differences are noteworthy. The demonstration of a sheath has been easily accomplished in our cultures. False branching has likewise been frequent, and swarming cells (conidia) have been produced in abundance with all our strains. Smit is not certain that his organism was *Sphaerotilus*, whereas ours corresponds closely to the original meager description of Kutzing and there is no doubt that ours is the predominant organism in such well-defined cases of bulking as we have seen. The question of attachment seems to depend, as stated above, merely on the degree of agitation in the culture flask. With slight turbulence most of the growth is on the walls of the containing vessel, but with an increase in turbulence most of the growth consists of unattached flocs of all sizes, very ragged and very light. If the air is shut off they settle slowly, but better than the flocs in bulking sludge. The slightest current keeps these flocs in suspension. This explains why *Sphaerotilus* is so objectionable in bulking. Growing out in all directions from sludge flocs, their buoyancy is greatly increased. The fungus also decreases the relative weight of the sludge flocs and assists in trapping air bubbles with which to produce a rising sludge.

Attempts to grow *Sphaerotilus* on a nidus other that the flocs of activated sludge have failed. Sawdust, as soon as waterlogged, settles to the bottom, and has so far failed to provide attachment. Asbestos has likewise failed to act as a center of attachment.

RELATIVE SETTLING RATES OF SOME SLUDGE ORGANISMS

We have found few other fungi to produce bulking experimentally. A branching form, possibly *Gleotrichoides paludosus* Smit, caused bulking in a laboratory sludge. It appeared in May 1938, in a bottle of activated sludge to which 500 p. p. m. of glucose had been added periodically and gave a heavy growth for several days, during which time the settling power of the sludge was almost completely lost. Eventually the branching fungus was displaced by *Sphaerotilus*. Isolation of it on sewage agar showed a colorless aerial and subsurface mycelium, with moderate fruiting. On peptone agar the subsurface mycelium was yellow brown, the aerial white, and fruiting heavy. Fruiting and growth were heavy in synthetic sewage. Since it appeared only once in a lengthy series of experiments designed to produce bulking, it has not been further studied.

Several other fungi and organisms have been found to interfere with sludge settling but have not been studied extensively. Under laboratory conditions sludges have developed at times excessive growths of various branching fungi, filamentous bacteria, yeasts, and colonial vorticellid ciliates belonging to the genera *Epistylis* and *Opercularia*. Table 1 gives the relative time of settling of some of these in pure culture, using a synthetic sewage. In some cases (yeasts, *B. mycoides*) the effluent is turbid; in others the effluent is clear but contains large masses of suspended matter. This is true of the Phycomycete colonies shown in figure 5. In pure culture these form balls as large as marbles in aerating bottles of enrichment media and they will settle quickly. But if a current is present they remain in suspension and will pass out in the effluent. The senior author recalls that large colonies of *Opercularia* were rising and passing over the effluent weir at the Tenafly, N. J., sewage treatment plant some years ago.

TABLE 1.—*Relative time of settling of certain sewage organisms*

	Time required for—		
	10 percent settling	50 percent settling	90 percent settling
Sludge flocs alone	1 min	2 min	3-5 min.
Sphaerotilus on sludge flocs	30 min	1-2 hours	2-5 hours.
Sphaerotilus flocs	30 min	1-3 hours	3-12 hours.
Zooglea flocs	1 min	4 min	7 min.
Penicilium colonies	30 sec	1 min	1 min.
Other Phycomycete colonies	30 sec	1 min	1 min.
Yeast alone	30 min	12 hours	Indefinite.
Bacillus subtilis alone	No settling		
Bacillus mycoides alone	40 min	6 hours	12 hours.

NOTE.—The above rates of settling were determined by allowing the culture under investigation to stand in a 1-liter glass graduate.

Laboratory conditions under which the yeasts, *Bacillus subtilis* and *B. mycoides*, were produced in nonsettleable quantities rarely if ever obtain in sewage disposal plants. Table 1 indicates that organisms other than *Sphaerotilus* will rarely be found associated with or causing bulking.

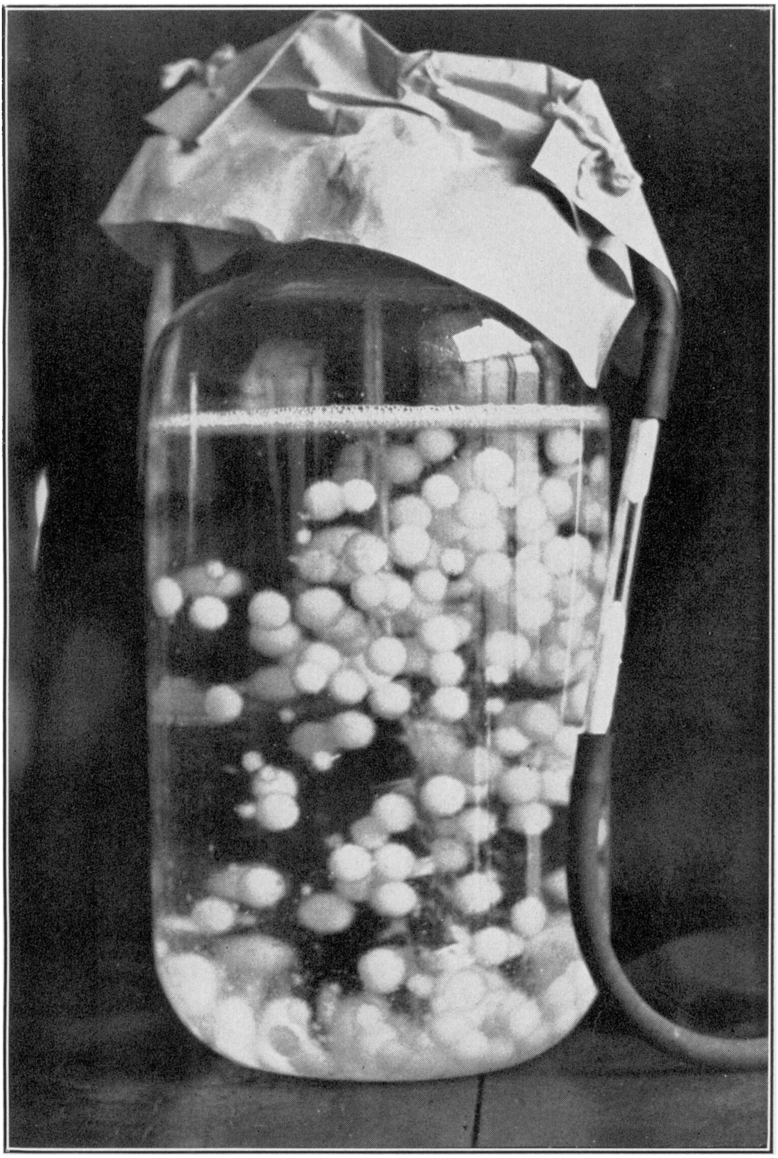

FIGURE 5.--Ball-like nature of a branching fungus. The dense masses of mycelium settle quickly.

Sphaerotilus AND BULKING—CAUSE OR EFFECT?

Since bulking of activated sludge may occur in the absence of *Sphaerotilus,* it is not the cause of all bulking. But it is the most abundant organism in most cases of bulking. That it plays a part in this condition is quite evident from a comparison of the settling rate of *Sphaerotilus*-infested sludge flocs and sludge flocs with no *Sphaerotilus.* If we could identify and rectify the conditions leading to excessive growth of this fungus, we would undoubtedly cure many cases of bulking. With this in view, many substances were tested to see if they would stimulate the organism to excessive growth. Both mixed cultures and pure cultures were thus tested. The results are shown in table 2.

TABLE 2.—*Effects of various substances on growth of* Sphaerotilus

Mixed or pure culture	Basic medium	Substance added	Range in p. p. m.	Growth of *Sphaerotilus*	Settling quality	Condition of culture at end
Mixed	Activated sludge.	Sucrose	1,000–5,000 twice daily.	Good	Poor	*Sphaerotilus* dominant.
Do	do	do	1,000 four times daily.	do	do	*Sphaerotilus* replaced.
Do	do	do	5,000 four times daily.	do	do	Do.
Do	do	do	20,000 once only	Poor	do	Yeasts dominant.
Do	do	Glucose	1,000–5,000 twice daily.	Good	do	*Sphaerotilus* dominant.
Do	do	Starch	1,000–5,000 twice daily.	Poor	Good	Poor.
Do	do	Whole wheat	5,000 once only	do	do	Sludge good
Do	do	Peptone	100–1,000 once only.	Slight	do	*Sphaerotilus* replaced.
Do	do	Sulfite liquor	5 percent once only.	do	do	Do.
Pure	Sterile raw sewage.			Poor	Good	*Sphaerotilus* present.
Do	do	Sucrose	1,000–10,000 once only.	Good	Poor	*Sphaerotilus* thriving.
Do	do	do	1,000 four times	do	do	Do.
Do	do	Glucose	1,000–10,000 once only.	do	do	Do.
Do	do	do	1,000 four times daily.	do	do	Do.
Do	do	Maltose	1,000–10,000 once only.	do	do	Do.
Do	L+100 p. p. m. peptone.	Sucrose	50–1,000 once only	do	Fair	Do.
Do	do	do	10,000–60,000 once only.	Fair	No growth at 60,000.	
Do	do	Glucose	50–1,000 once only	Good	Fair	*Sphaerotilus* thriving.
Do	do	do	10,000–60,000 once only.	Fair	No growth at 60,000.	
Do	do	Maltose	50–10,000 once only.	Good	Fair	*Sphaerotilus* thriving.
Do	do	Lactose	do	do	do	Do.
Do	do	Glycerol	do	None		
Do	do	do	do	do		
Do	do	Whole wheat	100–40,000 once only.	Poor		
Do	do	White flour	1,000–5,000 once only.	None		
Do	do		100–5,000 once only.	do		
Do	L–6	Laundry soap	50–200 once only	Good		*Sphaerotilus* thriving.
Do	L	Sodium oleate	50–1,000 once only	None		
Do	L	Sodium stearate	do	do		
Do	L	Oleic acid	do	do		
Do	L	Stearic acid	do	do		
Do	L	Peptone	do	Fair	Fair	*Sphaerotilus* thriving.
Do	L	do	1,000–30,000 once only.	Poor to none.		

TABLE 2.—*Effects of various substances on growth of* Sphaerotilus—Continued

Mixed or pure culture	Basic medium	Substance added	Range in p. p. m.	Growth of *Sphaerotilus*	Settling quality	Condition of culture at end
Pure	L	Meat extract	500-1,000 once only	do		
Do	L-6	NaCl	5-200 once only	Variable to poor.		
Do	L-6	Sulfite liquor	5 percent once only	Good		
Do	L	Ammonium glycero-phosphate.	100-1,000 once only	Slight		
Do	L, dextrose	Urea	50-100 once only	Good		
Do	Synthetic	Dextrose, 500 p. p. m.	Peptone 100 p. p. m. once only.	do	Fair	
Do	do	do		None		
Do	do	do	Urea, 100 p. p. m. once only.	Fair		
Do	do	Dextrose 1,000 p. p. m.	Glycerine 250 p. p. m. once only.	Slight		
Do	do	do	$NaNO_3$ 112 p. p. m. once only.	Fair		
Do	do	Dextrose 500 p. p. m.	l-tyrosine 100 p. p. m. once only.	Slight		
Do	do	do	l-cystine 100 p. p. m. once only.	do		
Do	do	do	l-asparagin 100 p. p. m. once only.	Good		
Do	do	do	l-leucine 50 p. p. m. once only.	Slight		
Do	do	do	dl-alanin 100 p. p. m. once only.	Good		
Do	do	do	d-glutamic acid 100 p. p. m. once only.	Very poor		
Do	do	do	Sarcosine 100 p. p. m. once only.	Slight		
Do	do	do	Creatine 100 p. p. m. once only.	Very poor		
Do	do	do	Sodium glycholate 100 p. p. m. once only.	Slight		
Do	do	do	Globulin 100 p. p. m. once only.	None		
Do	do	do	Isatin 100 p. p. m. once only.	do		
Do	do	do	Acetonitrile 100 p. p. m. once only.	do		
Do	do	do	dl-alanin 100 p. p. m. once only.	do		
Do	do	do	Na-gluconate 500 p. p. m. once only.	Fair		

Medium L—mineral salts and water.
Medium L-6—same as medium L, with dextrose and peptone added.
Medium synthetic—organic salts and water, no nitrate.

The following facts are shown by table 2: (1) It is possible to start with a normal activated sludge and by using heavy dosages of disaccharoses frequently to obtain a bulking sludge in which *Sphaerotilus* is very abundant. (2) Sugars will not always produce a heavy growth of *Sphaerotilus*. Sometimes other filamentous fungi grow excessively, or sometimes yeasts. Ruchhoft (*14*) has also shown that an activated sludge may be conditioned so that it will normally remove up to 1,000 p. p. m. of glucose without bulking or unusual growths of organisms. (3) No other substance tested produced heavy growths of *Sphaerotilus* in mixed culture. (4) Both mono- and di-saccharoses produced heavy growths of *Sphaerotilus* in pure culture. (5) No polysaccharose gave good growths in pure culture. (6) Both organic and inorganic sources of N were utilized. (7) Peptone, alanin, and asparagin were the only nitrogenous substances giving a definite stimulus to growth in pure culture. (8) Increasing the inorganic salt content from about 100 p. p. m. to about 300 p. p. m. did not materially affect growth, but above 300 p. p. m. a limiting effect on growth set in. (9) We have not been able to produce bulking experimentally without using high concentrations of substances not usually found in sewage. (10) We have not been able to produce growths comparable to those in polluted streams by using river water and adding small amounts of growth-stimulating substances.

The experimental work represented by table 2 suggests that excessive growth and consequent difficulty with this organism is not usually due to growth-promoting substances present in sewage. Exceptions are always possible, as shown by the experience of Morgan and Beck (*5*) at Maywood. It appears more probable that some feature of plant operation is likely to be the cause. In the case of a disposal plant troubled with bulking, a quick microscopic examination of the sludge, followed by a test for sugars either in raw sewage or sludge, might quickly determine whether the cause should be sought in the sewage or in plant operation.

SPECIFIC NUTRITIVE REQUIREMENTS

A basic medium was made up containing the following:

$NaNO_3$	25 mg.
K_2HPO_4	5 mg.
KH_2PO_4	5 mg.
$MgSO_4$	10 mg.
$CaCl_2$	45 mg.
Dextrose	1, 000 mg.
Distilled water	1 liter

This medium gave a slight growth although there was a great excess of sugar. It was then varied by leaving out one after another of the mineral salts, and in each case no growth resulted. Other variations were to leave out a salt, increasing the concentration of others. This again failed, except for the mono and dibasic potassium phosphate; 10 p. p. m. of either would support slight growth in the absence of the other provided the remaining three salts were present. The minimal growth threshold seems to be about 5 p. p. m. each of $NaNO_3$, KH_2PO_4, K_2HPO_4, $MgSO_4$, and $CaCl_2$, plus dextrose. Leaving out any one of the salts at this concentration stopped growth, and living *Sphaerotilus* could not be recovered from such a medium after 3 days' aeration. Any variation of this medium, using less than the eleven chemical elements contained therein, appeared not to support growth.

Maximum growth of the fungus appears possible on as little as 200 p. p. m. of mineral salts. Increasing salts beyond this, either with or without increasing the nitrogen and sugar, failed to increase the amount of fungus produced. The cell wall or colony sheath, and the protoplasm of this organism apparently contain very little mineral matter.

Under laboratory conditions the greatest food requirements necessary to heavy growth seem to be sugars and organic nitrogen. If the synthetic sewage medium is made up with dextrose and no nitrogen, growth is not expected and does not occur; if glycine is substituted for the dextrose, no growth occurs; if peptone is substituted for the dextrose, poor growth results; but if both dextrose and peptone are present, heavy growth results, and some growth results if almost any combination of these two is used.

Nitrogen requirements of *Sphaerotilus* are also very general. Table 3 shows the sources of nitrogen which were tried and the relative growth produced. It will be noted that the best growths were secured from organic sources, alanin, asparagin, and peptone, but fair growths were also secured on the inorganic salts. This fungus thus presents a broad adaptability in its nutritive requirements and this characteristic is probably an important factor in making it such a successful inhabitant of rivers and sewage disposal plants. In addition to its wide nutritive range, it exhibits a relatively wide range of pH tolerance, growing between 5.5 and 8.0. It grows well in a solution of 200 p. p. m. of laundry soap, but only if dextrose and peptone are present, i. e., it does not use soap. Curiously enough, it apparently uses nitrogen freely in the formation of amines. Agar plates inoculated with *Sphaerotilus* and then placed in Novy jars will not grow if the air is exhausted, if nitrogen is substituted, or if CO_2 is substituted. No growth results in bottles into which nitrogen is bubbled, and thriving cultures are soon killed if nitrogen is substituted for the air. The same is true for methane. Evidently the plant is an aerobe, but a thriving culture in a substrate with abundant protein or peptone has a characteristic odor which our chemists (*14*) have stated to be due to primary amines. The organism thus dissimilates proteins or peptones in an anaerobic manner even in the presence of abundant oxygen. The oxidative processes of *Sphaerotilus* in relation to oxygen, sugar, and nitrogenous matter, and the building of protoplasm and cell walls (fungus cellulose) will be discussed in another paper.

TABLE 3.—*Forms of nitrogen used by* Sphaerotilus *in synthetic sewage* (*S. medium*)

Form of nitrogen	Growth	Form of nitrogen	Growth
Nitrites	None.	dl-alanin	Good.
Nitrates	Fair.	d-glutamic acid	Poor.
Ammonium salts	Do.	Isatin	None.
Urea	Do.	l-asparagin	Good.
Glycine	Poor.	Sarcosine	Poor.
l-tyrosine	Do.	Peptone	Good.
l-cystine	Do.	Gelatin	None.
l-leucine	Do.	Autoclaved wheat	Do.

CONTROL OF *Sphaerotilus*

Inasmuch as the organism grows excessively because of some substance in sewage or some defect in plant operation, knowledge of the cause and control of growth is useful, both for prevention and cure of the condition. Smith and Purdy (*15*) suggested chlorine for control of growth and it has since been extensively used with good results. Laboratory experiments were carried out by us to find, if possible, some specific killing agent for *Sphaerotilus*. The results are shown in table 4. None of the substances tried seem to be specific, although silver nitrate and some of the dyes are toxic at low concentrations, and malachite green, 5 p. p. m., is not toxic to a number of other organisms of the activated sludge community. Present cost of this dye would make its use prohibitive in comparison to chlorine; in fact, the relatively low cost of chlorine has discouraged any extensive search for killing agents. The method of using the chlorine depends largely on the individual plant, but it seems probable that chlorination of the returned sludge is most feasible.

TABLE 4.—*Effects of possible toxic agents on growth of* Sphaerotilus

Culture	Toxic agent	Method of application	Effect
Mixed activated sludge	Toluene vapor	Bubbled into normal sludge	None.
Mixed activated sludge, bulking.	do	Bubbled into bulking sludge	Do.
Do	Chloroform	do	Toxic.
L-6, heavy culture	Chlorine, as H. T. H.	Dosed to a residual of 0.5 p. p. m.	Do.
L-6, inoculated with *Sphaerotilus*.	Chlorine added	0.5 to 3.0 p. p. m. before inoculation.	No growth.
L-6, heavy culture	$AgNO_3$	0.5 to 2.5 p. p. m. added to heavy culture.	Toxic.
L-6, inoculated with *Sphaerotilus*.	do	0.5 to 2.5 p. p. m. before inoculation.	No growth.
Mixed activated sludge, good culture.	do	0.5 to 2.5 p. p. m. to heavy culture.	Toxic at 2 p. p. m.
Do	Phenol	1.0 p. p. m. to heavy culture	No effect.
Do	do	5.0 to 50 p. p. m. to heavy culture.	Toxic, variable.
L-6, heavy culture	do	1.0 p. p. m. to heavy culture	No effect.
Do	do	5.0 p. p. m. to heavy culture	Toxic.
Mixed activated sludge, good culture.	Acetic acid	50 p. p. m. to heavy culture	Do.
Do	Citric acid	100 to 1,000 p. p. m. to heavy culture.	*Sphaerotilus* replaced.
Do	Lactic acid	do	Do.
Do	Brilliant green	5-20 p. p. m. to heavy culture	Toxic at 5 p. p. m.
Do	Fast green	5-25 p. p. m. to heavy culture	Nontoxic.
Do	Malachite green	5-10 p. p. m. to heavy culture	Toxic at 5 p. p. m.
Do	Janus green	5-20 p. p. m. to heavy culture	Toxic at 20 p. p. m.
Do	Eosin W	5-15 p. p. m. to heavy culture	Variable.
Do	Methylene blue	5-20 p. p. m. to heavy culture	Toxic at 20 p. p. m.
Do	Gentian violet	5-15 p. p. m. to heavy culture	Toxic at 10 p. p. m.
Do	Uranin	5-200 p. p. m. to heavy culture.	Nontoxic.

DISCUSSION

We have shown herein that the production of a bulking sludge by heavy dosages of sugars is relatively easy. Other substances have practically failed to produce such results.

Associated with bulking in most cases is the filamentous organism, *Sphaerotilus natans* Kutzing. Repeated isolations have succeeded in producing but a single type of this organism. Butcher (*1*), studying polluted streams, called the species *natans* of Kutzing var. *typica*, and added four other varieties, but was of the opinion they were ecologic varieties. Organisms taken in the field by us have shown some variation, but when we have isolated them and grown them under similar conditions all have behaved alike, so it seems probable that the term "ecologic varieties" is well chosen. Smit (*10*) called his organism a *Sphaerotilus*, but noted some differences from the usual definition and reserved his opinion as to placing it definitely. Elsewhere (*16*) he described what is presumably his original organism as *Sph. paludosus*, without pseudodichotomous branching and no motile cells. Since all strains of our organism exhibit pseudodichotomous branching and form motile reproductive cells abundantly, it seems probable that our organism is *Sphaerotilus natans* Kutzing and that such cases of bulking as we have studied have been associated with *Sphaerotilus natans*. We have isolated an organism which agrees with Smit's *Sphaerotilus paludosus* morphologically, but so far it has refused to grow abundantly in the several synthetic media in use. Beger (*17*) found *Sphaerotilus natans* in activated sludge, but reported a new species which he named *tenuis* as more abundant. His description is very meager. He did not study pure cultures.

If Beger's species is valid, there appear to be five recognized species of *Sphaerotilus*—*S. tenuis* Beger, *S. paludosus* Smit, *S. natans* Kutzing, *S. dichotomus* (Cohn) Migula, and *S. fluitans* (Migula) Schikora. Our cultures illustrate the described morphological characteristics of *Sphaerotilus natans* very well, but not the nutritive characteristics. On the other hand, our organism has the same nutritive characteristics as *Sphaerotilus dichotomus*. *Sphaerotilus dichotomus* has been accepted by some workers as *Cladothrix dichotoma* Cohn. It is certainly closely related to *Sphaerotilus natans*, but we have been unable to isolate any organism close to *Sphaerotilus natans* which exhibits dichotomous branching. In our opinion *Sphaerotilus fluitans* should be further investigated before it is included as a separate species, and it appears that the whole group might be carefully investigated especially with regard to cultural characteristics.

CONCLUSIONS

It is possible to produce experimental bulking of activated sludge, such as occurs in sewage disposal plants by heavy dosages of sugars, or mixtures of nitrogenous and carbonaceous compounds. Such bulking may be associated with several organisms, but usually the predominant organism is the filamentous bacterium, *Sphaerotilus natans* Kutzing.

Only one species has been isolated in this laboratory, and its cultural characteristics have been constant, although field collections from which some of these isolations were made have shown morphologic differences.

The organism has been shown to give abundant growth on solutions of sugar if a suitable source of nitrogen is present. Inorganic nitrogen is readily used, but only two of several amino acids, alanin and asparagin, have given good growth. Peptone has proved a good source of nitrogen.

No substance common, or apt to occur normally in sewage has been found which stimulates excessive growth.

A number of other fungi have been grown in pure culture but have not shown such poor settling qualities as *Sphaerotilus* and only yeasts, *Bacillus subtilis* and *Bacillus mycoides*, have shown a very slow settling rate.

Toxic effects toward *Sphaerotilus* of a number of substances have been investigated. No toxic substance cheaper or more available than chlorine has been found.

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221745°—40——3

AN UNIDENTIFIED DISEASE IN NEVADA BELIEVED TO BE TRANSMITTED BY RODENTS

Under date of May 1, 1940, Surgeon L. B. Byington, of the Public Health Service, reported the occurrence of an infectious disease in man in the Ruby Valley, Nev., believed to be associated with muskrats, and designated by local physicians as "muskrat fever."

The clinical course of the disease, as described by local physicians, is as follows: The presenting complaint is a painful ulcer, practically always on the hand or forearm. This usually begins as a papule, which progresses to a vesicle and then to an ulcer. Frequently these ulcers are multiple. Fever begins with the onset of the papule and generally continues until recovery. The febrile course is not well known, as temperature charts have rarely been kept. The ulcers are accompanied by adenopathy, often requiring incision and drainage. The ulcers are chronic, necrotic, coalescing in type with a greenish serosanguinous exudate. The other symptoms are those common to any infection.

The degree of prevalence of the disease was not determined. The infection apparently occurs in persons living in the vicinity of Ruby Lake, a large swamp 60 miles south of Wells, Nev., where large numbers of muskrats and beavers are trapped. The trappers were the persons principally infected, although physicians report the occurrence of the malady in children and women not associated with rodent trapping. The disease is stated to occur only during the trapping season in the fall and winter. So far as known, no deaths have been reported to have resulted from it.

At the time of the brief investigation made in March of this year, there were no human cases available for study, and few animal specimens could be secured, as parts of the valley were inaccessible on account of snow. The results of agglutination tests (against *P. pestis*, *B. tularense*, and *Br. abortus* and *melitensis*) of blood samples from persons recovered from the disease and inoculation of laboratory animals with animal tissue and ectoparasites were negative, except that tests pointed to tularaemia in one or two cases.

Although the results of the investigation were not conclusive, after including some of the cases as possibly being simple furunculosis, there was evidence of a rodent-transmitted infection. Further study will be necessary to establish the identity and epidemiology of the disease.

COURT DECISION ON PUBLIC HEALTH

Food inspection ordinance held invalid.—(Kansas Supreme Court; *McCulley et al.* v. *City of Wichita et al.*, 98 P.2d 192; decided January 27, 1940.) An ordinance of the city of Wichita made it "unlawful for any person, firm, or corporation engaged in the retailing of either cooked or uncooked perishable foods, or foods subject to contamination, to sell, offer for sale, or expose for sale such foods at any time other than the hours of the day and the days of the week when inspection of such foods and the places where such foods are sold is available by the health department of the city." Under the ordinance such inspection was to be provided each day from Monday through Friday during the hours from 7 a. m. to 6:30 p. m., and on Saturday from 7 a. m. to 9 p. m. By its terms the ordinance did not apply to "foods cooked, baked, or prepared on the premises for immediate consumption on or off the premises" nor to milk, ice cream, and frozen desserts. Further, it was provided in section 2 that "The term either cooked or uncooked perishable foods or foods subject to contamination when used in this ordinance shall apply only to such foods as are usually sold under the classification of provisions, groceries or meats."

To determine the validity of the ordinance an action under the declaratory judgment act was brought by certain residents of the city engaged in the grocery business against the city and its officers. In a second cause of action it was sought to enjoin the enforcement of the ordinance. The trial court concluded that the ordinance was based upon an arbitrary classification, constituted an unwarranted and unreasonable interference with the carrying on of lawful business, and was unconstitutional. On appeal to the supreme court the judgment of the lower court in favor of the plaintiffs was affirmed.

The appellate court said that it thought it quite apparent that section 2 of the ordinance "was about as clearly designed to prohibit operators of grocery stores and meat markets from functioning at other than the specified hours as if such operators had been specifically named" and that it was evident that "the first exemption was as clearly intended for the benefit of operators of hotels, restaurants, coffee shops, hamburger stands, drug stores, or other similar places where foods are prepared for sale, as though they had been definitely named." The court cited examples to illustrate the unreasonableness in the classification of foods and the discriminatory and oppressive effect of the ordinance upon a legitimate business and then said:

> While municipalities have authority to enact ordinances designed to safeguard and protect the public health, discriminations as to particular classifications of food or business affected by such enactments must be based upon real and substantial distinctions and not upon fictitious distinctions which have no reasonable or substantial relation to the public health or general welfare of the inhabitants. This court, on numerous occasions, has considered and denied the power of municipalities to enact ordinances relating to various subjects where the ordinance did not conform to the above principle. See *City of Atchison* v. *Beckenstein*, 143 Kans. 440, 54 P.2d 926, wherein former cases of this court were reviewed. In those cases it was held the ordinance was violative of both the State and Federal constitutions. The instant ordinance is invalid for the same reasons.

DEATHS DURING WEEKS ENDED MAY 11 AND 18, 1940

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

Week ended May 11, 1940

	Week ended May 11, 1940	Corresponding week, 1939
Data from 88 large cities of the United States:		
Total deaths	8,617	8,612
Average for 3 prior years	8,370	
Total deaths, first 19 weeks of year	175,331	175,368
Deaths under 1 year of age	518	525
Average for 3 prior years	509	
Deaths under 1 year of age, first 19 weeks of year	9,716	10,252
Data from industrial insurance companies:		
Policies in force	65,659,862	67,406,340
Number of death claims	12,097	15,187
Death claims per 1,000 policies in force, annual rate	9.6	11.7
Death claims per 1,000 policies, first 19 weeks of year, annual rate	10.6	11.7

Week ended May 18, 1940

	Week ended May 18, 1940	Corresponding week, 1939
Data from 88 large cities of the United States:		
Total deaths	8,390	8,009
Average for 3 prior years	8,185	
Total deaths, first 20 weeks of year	183,711	183,377
Deaths under 1 year of age	492	463
Average for 3 prior years	499	
Deaths under 1 year of age, first 20 weeks of year	10,214	10,715
Data from industrial insurance companies:		
Policies in force	65,523,880	67,365,626
Number of death claims	12,182	15,291
Death claims per 1,000 policies in force, annual rate	9.7	11.8
Death claims per 1,000 policies, first 20 weeks of year, annual rate	10.5	11.4

PREVALENCE OF DISEASE

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

UNITED STATES

REPORTS FROM STATES FOR WEEK ENDED MAY 25, 1940

Summary

As compared with the preceding week, slight increases are shown during the current week in the incidence of poliomyelitis, typhoid fever, and whooping cough, and decreases for the other six important communicable diseases reported in the following table. The current incidence of each of these nine diseases, except influenza and poliomyelitis, is below the 5-year (1935–39) median expectancy—smallpox (57 cases) less than one-fourth of the median (269 cases) and meningococcus meningitis (25 cases) about one-fifth of the median (120 cases).

Washington State reported 10 cases of poliomyelitis, California 9 cases, and Michigan 2 cases. No other State reported more than 1 case. Pennsylvania reported 5 cases of meningococcus meningitis (all in Luzerne County), but no other State reported more than 2 cases. Of 57 cases of smallpox, Iowa reported 15, Tennessee 8, and Wisconsin 6 cases. Of 141 cases of typhoid fever, Pennsylvania reported 15 (16 last week), and Georgia and Louisiana 14 cases each. A total of 19 cases of Rocky Mountain spotted fever were reported for the current week, of which 18 occurred in the northwestern States and 1 case in North Carolina. Of 23 cases of endemic typhus fever, 7 cases each were reported in Georgia and Texas and 5 cases in Alabama.

For the current week the Bureau of the Census reports 8,280 deaths in 88 large cities, as compared with 8,390 for the preceding week and with 8,232 for the 3-year (1937–39) average for the corresponding week.

Telegraphic morbidity reports from State health officers for the week ended May 25, 1940, and comparison with corresponding week of 1939 and 5-year median

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

Division and State	Diphtheria			Influenza			Measles			Meningitis, meningococcus		
	Week ended		Median, 1935–39	Week ended		Median, 1935–39	Week ended		Median, 1935–39	Week ended		Median, 1935–39
	May 25, 1940	May 27, 1939		May 25, 1940	May 27, 1939		May 25, 1940	May 27, 1939		May 25, 1940	May 27, 1939	
NEW ENG.												
Maine	1	0	0	------	------	2	449	106	156	0	0	0
New Hampshire	0	0	0	------	------	------	28	0	3	1	0	0
Vermont	1	0	0	------	------	------	13	168	140	0	0	0
Massachusetts	3	2	6	------	------	------	869	943	697	0	1	2
Rhode Island	0	0	0	------	------	------	188	133	70	0	0	0
Connecticut	2	1	2	3	1	1	17	818	219	1	3	0
MID. ATL.												
New York	20	21	28	[1] 7	[1] 8	[1] 5	888	2, 181	2, 904	0	5	5
New Jersey	7	7	7	4	5	5	990	48	708	0	1	3
Pennsylvania	17	23	35	------	------	------	453	141	1, 969	5	6	8
E. NO. CEN.												
Ohio	9	11	11	7	------	5	25	67	1, 241	1	1	9
Indiana	1	8	8	1	3	7	5	13	159	2	0	3
Illinois	16	36	36	3	54	54	174	44	417	0	0	4
Michigan [2]	4	16	12	2	6	2	0	667	667	1	1	2
Wisconsin	7	0	1	53	35	22	1, 162	785	785	0	2	1
W. NO. CEN.												
Minnesota	1	0	1	1	5	1	140	254	359	0	0	0
Iowa	4	3	3	------	4	1	416	207	207	0	0	0
Missouri	5	9	9	6	------	25	25	22	30	0	0	0
North Dakota	0	1	1	------	2	2	5	109	32	0	0	0
South Dakota	0	2	1	------	8	------	2	210	4	0	0	0
Nebraska	1	2	1	------	3	------	16	354	191	0	0	0
Kansas	3	5	3	1	------	1	392	97	97	0	1	1
SO. ATL.												
Delaware	1	0	0	------	------	------	0	13	12	0	0	0
Maryland [2 3]	3	3	5	4	3	3	17	165	165	1	0	4
Dist. of Col	2	3	11	------	------	------	4	316	146	0	0	0
Virginia	6	3	10	57	26	------	286	474	465	2	0	6
West Virginia [3]	6	9	5	9	17	28	32	7	93	2	1	1
North Carolina [4]	3	9	9	4	3	3	110	715	298	0	1	2
South Carolina [3]	5	2	3	299	244	104	5	12	62	2	0	0
Georgia [3]	7	8	6	23	54	------	112	72	26	0	0	0
Florida	1	6	6	3	27	3	152	0	19	0	0	0
E. SO. CEN.												
Kentucky	3	9	7	12	9	9	113	35	148	0	1	2
Tennessee	5	2	5	16	12	16	133	40	40	0	0	2
Alabama [3]	2	1	8	34	31	14	165	149	119	2	2	2
Mississippi [3]	2	6	4	------	------	------	------	------	------	1	1	1
W. SO. CEN.												
Arkansas	2	4	4	16	23	38	39	71	71	0	2	0
Louisiana [3]	1	4	12	13	7	7	4	109	24	2	0	1
Oklahoma	3	1	4	21	17	18	13	175	65	0	1	1
Texas [3]	13	23	26	126	179	138	1, 350	482	216	1	2	3
MOUNTAIN												
Montana [4]	0	1	2	9	10	10	81	232	84	0	0	0
Idaho [4]	0	2	0	------	3	3	40	79	14	0	0	0
Wyoming [4]	0	0	0	3	------	------	16	71	26	0	1	0
Colorado [4 5]	16	8	7	2	12	------	29	231	231	0	1	1
New Mexico	4	0	3	8	1	2	87	10	43	0	0	0
Arizona [3]	1	2	0	55	40	31	118	21	22	0	0	0
Utah [2 4]	0	0	0	------	3	2	507	73	50	0	0	0
PACIFIC												
Washington [4]	0	3	3	------	------	------	502	1, 300	286	1	0	0
Oregon	3	0	1	10	28	21	519	83	83	0	1	0
California	8	24	24	64	31	32	272	2, 285	1, 612	0	0	7
Total	199	280	370	876	914	608	10, 963	14, 587	14, 587	25	35	120
21 weeks	6, 849	9, 031	10, 693	164, 052	146, 309	135, 752	161, 950	288, 402	288, 402	848	1, 003	2, 995

See footnotes at end of table.

Telegraphic morbidity reports from State health officers for the week ended May 25, 1940, and comparison with corresponding week of 1939 and 5-year median—Con.

Division and State	Poliomyelitis			Scarlet fever			Smallpox			Typhoid and paratyphoid fever		
	Week ended		Median, 1935–39	Week ended		Median, 1935–39	Week ended		Median, 1935–39	Week ended		Median, 1935–39
	May 25, 1940	May 27, 1939		May 25, 1940	May 27, 1939		May 25, 1940	May 27, 1939		May 25, 1940	May 27, 1939	
NEW ENG.												
Maine	0	0	0	13	14	14	0	0	0	0	0	0
New Hampshire	0	0	0	3	4	7	0	0	0	0	0	0
Vermont	0	0	0	4	5	5	0	0	0	0	1	0
Massachusetts	0	0	0	120	157	204	0	0	0	4	0	1
Rhode Island	0	0	0	4	6	16	0	0	0	0	4	0
Connecticut	0	0	0	75	51	98	0	0	0	0	4	1
MID. ATL.												
New York	1	1	1	948	486	703	0	15	0	5	10	6
New Jersey	0	0	0	362	221	181	0	0	0	1	1	2
Pennsylvania	1	0	0	401	274	564	0	0	0	15	8	8
E. NO. CEN.												
Ohio	1	0	0	213	300	300	0	11	1	7	8	8
Indiana	0	0	0	115	94	90	1	25	9	6	5	2
Illinois	0	1	1	797	364	512	2	10	10	4	5	5
Michigan [2]	2	1	1	268	440	381	0	10	0	3	3	3
Wisconsin	0	0	0	149	161	289	6	1	5	1	0	2
W. NO. CEN.												
Minnesota	0	0	0	74	73	130	4	11	11	1	0	0
Iowa	0	0	0	78	61	88	15	41	33	1	6	4
Missouri	0	0	0	37	55	55	2	44	11	3	1	1
North Dakota	0	0	0	6	7	32	1	1	2	1	0	1
South Dakota	0	0	0	6	8	11	2	17	10	0	0	0
Nebraska	0	0	0	7	25	47	0	6	6	1	1	0
Kansas	0	0	0	60	53	84	0	11	28	0	2	1
SO. ATL.												
Delaware	0	0	0	4	4	6	0	0	0	0	1	1
Maryland [2] [3]	0	0	0	23	26	50	0	0	0	1	3	3
Dist. of Col	0	0	0	26	13	15	0	0	0	0	1	1
Virginia	0	0	0	26	5	17	0	0	0	5	5	5
West Virginia [3]	0	1	0	34	24	23	0	0	0	4	0	5
North Carolina [4]	0	0	1	8	18	16	0	0	0	4	3	6
South Carolina [3]	1	22	0	5	6	4	0	0	0	1	6	6
Georgia [3]	0	3	1	12	6	7	0	0	0	14	8	8
Florida	1	1	1	3	7	4	1	0	0	2	7	7
E. SO. CEN.												
Kentucky	1	1	1	30	24	24	0	2	0	5	3	8
Tennessee	0	0	0	71	25	9	8	38	0	8	1	5
Alabama [3]	1	0	1	6	5	5	1	2	0	1	1	4
Mississippi [3]	0	1	0	6	1	4	0	0	0	3	2	4
W. SO. CEN.												
Arkansas	0	0	0	5	4	5	0	9	9	1	3	3
Louisiana [3]	1	1	1	6	10	10	0	1	0	14	8	10
Oklahoma	0	0	0	6	16	16	3	6	2	2	6	6
Texas [3]	0	0	0	24	21	49	4	6	5	7	14	9
MOUNTAIN												
Montana [4]	0	1	0	15	14	21	0	2	12	1	2	0
Idaho [4]	1	0	0	10	4	4	0	0	6	1	0	1
Wyoming [4]	0	0	0	1	4	13	0	0	2	0	0	0
Colorado [4] [5]	0	0	0	20	44	45	3	2	3	3	2	2
New Mexico	0	0	0	7	10	11	1	0	0	1	0	1
Arizona [3]	0	2	0	10	11	11	1	2	0	0	1	1
Utah [2] [4]	1	0	0	10	15	20	1	0	0	0	0	0
PACIFIC												
Washington [4]	10	0	0	37	36	38	0	4	4	0	2	1
Oregon	1	0	0	10	9	22	0	2	4	4	2	2
California	9	2	4	117	133	202	1	17	16	6	10	5
Total	32	38	22	4,272	3,354	5,438	57	296	269	141	150	156
21 weeks	497	451	432	100,689	101,249	140,683	1,498	7,311	6,508	1,811	2,510	2,510

See footnotes at end of table.

Telegraphic morbidity reports from State health officers for the week ended May 25, 1940, and comparison with corresponding week of 1939 and 5-year median—Con.

Division and State	Whooping cough	
	Week ended—	
	May 25, 1940	May 27, 1939
NEW ENG.		
Maine	34	178
New Hampshire	4	2
Vermont	36	47
Massachusetts	161	95
Rhode Island	7	42
Connecticut	37	81
MID. ATL.		
New York	313	410
New Jersey	100	342
Pennsylvania	277	232
E. NO. CEN.		
Ohio	200	181
Indiana	27	92
Illinois	87	249
Michigan [2]	195	239
Wisconsin	108	125
W. NO. CEN.		
Minnesota	40	44
Iowa	50	23
Missouri	21	24
North Dakota	3	1
South Dakota	4	0
Nebraska	7	27
Kansas	63	28
SO. ATL.		
Delaware	10	11
Maryland [2] [3]	106	40
Dist. of Col.	5	27
Virginia	66	35
West Virginia [2]	60	24
North Carolina [4]	87	250
SO. ATL.—continued		
South Carolina [3]	23	61
Georgia [3]	11	32
Florida	15	29
E. SO. CEN.		
Kentucky	88	9
Tennessee	64	38
Alabama [3]	28	70
Mississippi [2]	------	------
W. SO. CEN.		
Arkansas	12	33
Louisiana [3]	54	26
Oklahoma	31	23
Texas [3]	434	186
MOUNTAIN		
Montana [4]	0	30
Idaho [4]	16	2
Wyoming [4]	5	0
Colorado [4] [5]	9	80
New Mexico	67	40
Arizona [3]	75	18
Utah [2] [4]	200	52
PACIFIC		
Washington [4]	83	22
Oregon	20	19
California	462	187
Total	3, 805	3, 806
21 weeks	66, 492	83, 808

[1] New York City only.
[2] Period ended earlier than Saturday.
[3] Typhus fever, week ended May 25, 1940, 23 cases, as follows: Maryland, 1; South Carolina, 1; Georgia, 7; Alabama, 5; Louisiana, 1; Texas, 7; Arizona, 1.
[4] Rocky Mountain spotted fever, week ended May 25, 1940, 19 cases, as follows: North Carolina, 1; Montana, 4; Idaho, 1; Wyoming, 8; Colorado, 1; Utah, 2; Washington, 2.
[5] Colorado tick fever, week ended May 25, 1940, Colorado, 3 cases.

WEEKLY REPORTS FROM CITIES

City reports for week ended May 11, 1940

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.

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								
Data for 90 cities:											
5-year average	137	107	44	6,485	606	2,108	21	397	25	1,272	-------
Current week [1]	75	75	17	3,216	379	2,671	1	362	12	1,020	-------
Maine:											
Portland	0	------	0	182	2	0	0	0	0	1	22
New Hampshire:											
Concord	0	------	0	2	1	0	0	0	0	0	17
Manchester	0	------	0	0	0	1	0	0	0	0	16
Nashua	6	------	0	9	0	0	0	0	0	0	5
Vermont:											
Barre	0	------	0	0	0	0	0	0	0	0	2
Burlington	0	------	0	0	0	0	0	0	0	0	11
Rutland	0	------	0	0	0	0	0	0	0	0	2
Massachusetts:											
Boston	1	------	0	147	13	67	0	10	0	73	192
Fall River	0	------	0	38	1	0	0	3	0	5	28
Springfield	0	------	0	2	1	7	0	0	0	6	35
Worcester	2	------	0	28	2	9	0	0	0	4	48
Rhode Island:											
Pawtucket	0	------	0	0	0	0	0	0	0	0	14
Providence	0	------	0	112	2	8	0	0	0	2	54
Connecticut:											
Bridgeport	0	------	0	0	2	3	0	0	0	0	30
Hartford	1	------	0	2	2	9	0	1	0	2	32
New Haven	0	------	0	0	2	5	0	0	0	7	42
New York:											
Buffalo	0	------	0	4	7	18	0	5	0	8	131
New York	19	16	0	244	84	744	0	94	2	90	1,574
Rochester	1	3	0	5	0	24	0	1	0	7	63
Syracuse	0	------	0	0	0	9	0	1	0	1	59
New Jersey:											
Camden	1	------	0	0	4	18	0	1	0	0	35
Newark	0	1	0	418	3	44	0	0	0	21	100
Trenton	0	------	0	1	1	6	0	2	0	4	37
Pennsylvania:											
Philadelphia	3	------	0	107	14	130	0	27	1	25	546
Pittsburgh	4	1	2	2	12	19	0	6	0	12	166
Reading	0	------	0	1	0	0	0	0	0	11	22
Scranton	0	------	-------	0	-------	1	0	-------	0	0	-------
Ohio:											
Cincinnati	3	1	1	0	2	13	0	10	0	25	160
Cleveland	1	12	0	5	8	68	0	9	1	29	188
Columbus	4	2	2	1	1	8	0	3	0	4	104
Toledo	0	1	0	0	3	69	0	2	0	6	74
Indiana:											
Anderson	0	------	0	0	0	3	0	0	0	3	8
Fort Wayne	0	------	0	7	3	0	0	1	0	3	30
Indianapolis	0	------	3	5	5	15	0	4	0	10	106
Muncie	0	------	0	0	2	2	1	0	0	0	10
South Bend	0	------	0	0	0	4	0	0	0	0	16
Terre Haute	0	------	0	0	0	2	0	2	0	0	18
Illinois:											
Alton	0	------	0	0	0	0	0	0	0	4	7
Chicago	4	1	1	66	26	458	0	48	0	58	743
Elgin	0	------	0	0	1	1	0	0	0	0	9
Moline	0	------	0	1	0	0	0	1	0	0	13
Springfield	0	------	0	2	3	3	0	0	0	0	25
Michigan:											
Detroit	1	2	1	191	13	85	0	21	1	93	293
Flint	0	------	0	11	4	21	0	0	0	4	29
Grand Rapids	0	------	0	9	2	17	0	0	0	21	38
Wisconsin:											
Kenosha	0	------	0	63	0	2	0	0	0	0	11
Madison	0	------	1	37	1	5	0	0	0	2	9
Milwaukee	0	------	0	106	4	22	0	3	0	0	98
Racine	0	------	0	0	0	1	0	0	0	6	23
Superior	0	------	0	64	0	0	0	0	0	0	5

[1] Figures for Galveston estimated: report not received.

City reports for week ended May 11, 1940—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								
Minnesota:											
Duluth	0	------	0	21	0	1	0	0	0	0	22
Minneapolis	0	------	0	2	6	18	0	0	0	13	83
St. Paul	0	------	0	2	1	2	0	2	0	6	60
Iowa:											
Cedar Rapids	0	------	------	32	------	0	0	------	0	3	------
Davenport	0	------	------	2	------	8	0	------	0	3	------
Des Moines	0	------	0	22	0	9	4	0	0	0	30
Sioux City	1	------	------	0	------	0	0	------	0	0	------
Waterloo	1	------	------	8	------	2	0	------	0	3	------
Missouri:											
Kansas City	0	------	0	10	4	6	0	4	0	0	94
St. Joseph	0	------	0	0	4	3	0	0	0	0	37
St. Louis	4	------	0	1	18	20	0	3	1	15	216
North Dakota:											
Fargo	0	------	0	0	0	0	0	0	0	0	6
Grand Forks	0	------	------	0	------	0	0	------	0	3	------
Minot	0	------	0	0	0	0	0	0	0	0	4
South Dakota:											
Aberdeen	0	------	------	0	------	0	0	------	0	0	------
Sioux Falls	0	------	0	0	0	2	0	0	0	0	12
Nebraska:											
Lincoln	1	------	------	3	------	1	0	------	0	2	------
Omaha	0	------	0	8	2	5	0	2	0	7	37
Kansas:											
Lawrence	0	------	0	0	0	0	0	1	2	1	8
Topeka	0	------	0	21	0	1	0	0	0	0	3
Wichita	0	------	0	11	3	0	0	0	0	14	34
Delaware:											
Wilmington	0	------	0	0	3	2	0	0	0	0	24
Maryland:											
Baltimore	0	------	0	1	7	13	0	9	0	109	222
Cumberland	0	------	0	0	0	2	0	0	0	0	7
Frederick	0	------	0	0	0	0	0	0	0	0	5
District of Columbia:											
Washington	4	1	1	5	13	47	0	15	0	12	165
Virginia:											
Lynchburg	0	------	0	0	1	1	0	0	0	6	9
Norfolk	0	2	0	108	3	4	0	0	0	9	18
Richmond	0	------	1	0	0	3	0	1	0	2	57
Roanoke	0	------	0	11	2	4	0	2	0	9	20
West Virginia:											
Charleston	0	------	0	0	2	0	0	0	1	0	17
Wheeling	8	------	------	2	------	0	0	------	0	0	------
North Carolina:											
Gastonia	0	------	------	0	------	0	0	------	0	0	------
Raleigh	0	------	0	0	1	6	0	1	0	0	9
Wilmington	0	------	0	0	1	0	0	1	0	0	16
Winston-Salem	0	------	0	0	0	1	0	1	0	0	11
South Carolina:											
Charleston	0	2	1	0	2	0	0	1	0	0	20
Florence	0	------	0	0	2	0	0	0	0	0	9
Greenville	0	------	0	0	1	0	0	1	0	0	8
Georgia:											
Atlanta	0	2	0	11	5	4	0	6	0	3	81
Brunswick	0	------	0	0	0	0	0	0	1	0	3
Savannah	0	10	1	1	1	0	0	2	0	0	31
Florida:											
Miami	0	------	0	1	0	0	0	2	0	0	39
Tampa	0	------	0	70	0	0	0	1	0	0	25
Kentucky:											
Ashland	0	------	0	1	1	0	0	0	0	1	9
Covington	0	------	0	2	1	0	0	0	0	0	15
Lexington	0	------	0	22	0	1	0	0	0	4	17
Louisville	1	------	0	8	7	44	0	2	0	48	85
Tennessee:											
Knoxville	0	------	2	4	1	11	0	1	0	0	86
Memphis	0	5	0	22	2	10	0	5	0	14	88
Nashville	0	------	1	2	4	1	0	1	0	4	40
Alabama:											
Birmingham	0	2	0	5	6	1	0	8	1	2	82
Mobile	0	------	0	0	2	0	0	5	0	0	23
Montgomery	0	------	0	4	------	2	0	------	0	0	------

City reports for week ended May 11, 1940—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								
Arkansas:											
Fort Smith	0			0		0	0		0	0	
Little Rock	0		0	1	4	0	0	2	0	0	
Louisiana:											
Lake Charles	0		0	0	0	0	0	0	0	0	10
New Orleans	0	2	0	8	14	4	0	15	0	29	149
Shreveport	0		0	0	1	0	0	4	1	0	44
Oklahoma:											
Oklahoma City	0		0	0	2	2	0	1	0	4	47
Tulsa	0			6		0	0		0	17	
Texas:											
Dallas	2		0	478	3	1	0	3	0	33	49
Forth Worth	0		0	3	1	1	0	1	0	50	41
Galveston											
Houston	2		0	26	4	7	0	3	1	4	73
San Antonio	0	1	0	6	9	1	0	3	0	3	80
Montana:											
Billings	0		0	0	2	0	0	0	0	0	7
Great Falls	0		0	17	2	2	0	0	0	0	7
Helena	0		0	0	0	0	0	0	0	0	2
Missoula	0		0	0	0	4	0	0	0	1	7
Idaho:											
Boise	0		0	0	0	0	0	0	0	0	10
Colorado:											
Colorado Springs	0		0	1	1	1	0	1	0	0	7
Denver	3		2	23	4	9	0	4	0	5	94
Pueblo	0		0	11	2	3	0	1	0	0	7
New Mexico:											
Albuquerque	0		0	0	0	0	0	4	0	17	13
Utah:											
Salt Lake City	0		0	262	2	2	1	0	1	96	26
Washington:											
Seattle	0		0	309	2	5	0	1	0	20	77
Spokane	0		0	4	1	2	0	0	0	0	37
Tacoma	0		0	7	4	12	0	0	0	0	26
Oregon:											
Portland	1		0	135	0	2	2	1	0	6	70
Salem	0			2		0	0		0	0	
California:											
Los Angeles	7	7	0	19	3	24	0	0	0	43	300
Sacramento	5		0	7	1	3	0	1	0	19	25
San Francisco	0	4	0	6	6	8	0	8	0	19	164

State and city	Meningitis, meningococcus		Poliomyelitis cases	State and city	Meningitis, meningococcus		Poliomyelitis cases
	Cases	Deaths			Cases	Deaths	
Rhode Island:				**North Carolina:**			
Providence	0	1	0	Wilmington	1	0	0
Iowa:				**Louisiana:**			
Sioux City	1	0	0	New Orleans	1	0	0
New York:				**Texas:**			
Buffalo	2	0	0	Houston	3	0	0
New York	2	1	1				
Maryland:							
Baltimore	1	0	0				

Encephalitis, epidemic or lethargic.—Cases: New York, 1; Charleston, W Va., 1; Great Falls, 2; San Francisco, 1.

Pellagra.—Cases: Atlanta, 11; Savannah, 4; Los Angeles, 1.

Rabies in man.—Deaths: Memphis, 1.

Typhus fever.—Cases: Savannah, 2; Mobile, 1.

FOREIGN REPORTS

CANADA

Provinces—Communicable diseases—Week ended April 27, 1940.—During the week ended April 27, 1940, 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		2		3	3	1	1	2		12
Chickenpox		6	8	200	320	30	11	12	102	689
Diphtheria				24	2	5	1		3	35
Dysentery				24						24
Influenza		31			29		2		7	69
Measles	2	1		214	334	544	272	10	60	1,437
Mumps		3		26	401	4	15	1	16	466
Pneumonia	4	7			14		4		15	44
Poliomyelitis									2	2
Scarlet fever		6	10	126	124	15	6	16	4	307
Trachoma						2			2	4
Tuberculosis	8	15	13	77	62	11	22	8		211
Typhoid and paratyphoid fever			1	17	8	3		1	1	31
Whooping cough		32	2	110	118	24	59	18	23	386

CUBA

Habana—Communicable diseases—4 weeks ended May 4, 1940.—During the 4 weeks ended May 4, 1940, certain communicable diseases were reported in Habana, Cuba, as follows:

Disease	Cases	Deaths	Disease	Cases	Deaths
Diphtheria	9	1	Tuberculosis		2
Scarlet fever	1		Typhoid fever	83	9

FINLAND

Communicable diseases—4 weeks ended March 23, 1940.—During the 4 weeks ended March 23, 1940, cases of certain communicable diseases were reported in Finland as follows:

Disease	Cases	Disease	Cases
Diphtheria	284	Poliomyelitis	10
Dysentery	1	Scarlet fever	651
Influenza	1,848	Typhoid fever	11
Paratyphoid fever	32		

PANAMA CANAL ZONE

Notifiable diseases—January-March 1940.—During the months of January, February, and March 1940, certain notifiable diseases were reported in the Panama Canal Zone and terminal cities as follows:

Disease	January		February		March	
	Cases	Deaths	Cases	Deaths	Cases	Deaths
Chickenpox	7		13		17	
Diphtheria	2		8		8	
Dysentery (amoebic)	12		3	2	5	1
Dysentery (bacillary)	6	2	5		2	1
Leprosy	3	1	1		1	
Malaria	271	6	205	6	102	3
Measles	1		1			
Meningococcus meningitis	2	1				
Mumps	5		1		2	
Paratyphoid fever			1		1	
Pneumonia		15		8		13
Poliomyelitis	3					
Relapsing fever	1		1			
Scarlet fever	1					
Tuberculosis		30		30		31
Typhoid fever					2	
Typhus fever					3	

SWITZERLAND

Notifiable diseases—February 1940.—During the month of February 1940, cases of certain notifiable diseases were reported in Switzerland as follows:

Disease	Cases	Disease	Cases
Cerebrospinal meningitis	110	Paratyphoid fever	2
Chickenpox	150	Poliomyelitis	3
Diphtheria	86	Scarlet fever	502
German measles	55	Tuberculosis	277
Influenza	5,627	Typhoid fever	2
Lethargic encephalitis	1	Undulant fever	9
Measles	1,377	Whooping cough	184
Mumps	118		

Vital statistics—Year 1939.—The following table shows the number of marriages, births, and deaths in Switzerland during the year 1939:

Number of marriages	31,513	Deaths from—Continued.	
Number of births	63,837	Heart disease	7,456
Number of deaths	49,484	Influenza	1,994
Deaths from:		Pneumonia	2,794
Arteriosclerosis	6,229	Suicide	1,001
Cancer	6,631	Tuberculosis	3,363

WORLD DISTRIBUTION OF CHOLERA, PLAGUE, SMALLPOX, TYPHUS FEVER, AND YELLOW FEVER

From medical officers of the Public Health Service, American consuls, International Office of Public Health, Pan American Sanitary Bureau, health section of the League of Nations, and other sources. The reports contained in the following tables must not be considered as complete or final as regards either the list of countries included or the figures for the particular countries for which reports are given.

CHOLERA

[C indicates cases; D, deaths]

NOTE.—Since many of the figures in the following tables are from weekly reports, the accumulated totals are for approximate dates.

Place		January-February 1940	March 1940	April 1940—week ended— 6	13	20	27
ASIA							
India		7,774					
Bassein	C					2	10
Calcutta	C	258	282	72	78	49	69
Madras	C	1					
Porto Novo	C	1					
Rangoon	C	20	10		1		
India (French)	C	6	2				
Indochina (French)	C	315	121				
Thailand	C	52	180	1		1	

PLAGUE

[C indicates cases; D, deaths]

Place		January-February 1940	March 1940	April 1940—week ended— 6	13	20	27
AFRICA							
Belgian Congo	C	3					
British East Africa:							
Kenya	C	6					
Uganda	C	35	14				
Egypt	C	99	141	38	19	32	26
Madagascar	C	283	62				
Morocco [1]	C						
Rhodesia, Northern	C	1					
Senegal: **Dakar**	D				[2] 1		
Union of South Africa	C	4	2	6			
ASIA							
Dutch East Indies: Java and Madura	C	98					
India	C	6,556					
Bassein	C	1	7		1	3	3
Cochin	C	1					
Plague-infected rats		3					
Rangoon	C	[2] 1	3				
Indochina (French)	C	2					
Thailand:							
Bangkok	C	3					
Bisnulok Province	C	3					
Dhonpuri Province	C	1					
Jayanad Province	C	3					
Kamphaeng Bajr Province	C	28	1				
Kanchanapuri Province	C	8	4				
Nagara Svarga Province	C	22	8				
Noangkhay Province	C		4				
Sukhodaya Province	C	15	7				
EUROPE							
Portugal: Azores Islands	C	2					
NORTH AMERICA							
United States. (See issue of May 17, p. 907.)							
SOUTH AMERICA							
Argentina:							
Salta Province	C	1	1				
Santiago del Estero Province	C				[3] 5		
Peru:							
Lambayeque Department	C	[4] 5					
Libertad Department	C	[4] 25					
Lima Department	C	[4] 11					
Piura Department	C	[4] 3					
Venezuela.[5]							
OCEANIA							
Hawaii Territory: Plague-infected rats		6	4			2	

[1] A report dated May 11, 1940, stated that there was an epidemic of bubonic plague in southern Morocco, where several hundred cases had been unofficially reported.
[2] Imported.
[3] Reported as glandular plague.
[4] For the month of January only.
[5] For the period Dec. 7, 1939, to Jan. 4, 1940, 11 cases of plague with 8 deaths were reported from the interior of Venezuela.

WORLD DISTRIBUTION OF CHOLERA, PLAGUE, SMALLPOX, TYPHUS FEVER, AND YELLOW FEVER—Continued

SMALLPOX

[C indicates cases; D, deaths]

Place		January-February 1940	March 1940	April 1940—week ended—			
				6	13	20	27
AFRICA							
Algeria	C		1				
Angola	C	[1] 20					
Belgian Congo	C	792	212	90	95		
British East Africa	C	3					
Dahomey	C	17					
French Guinea	C				13		
Gibralter	C		[2] 1				
Ivory Coast	C	[3] 66	31				
Nigeria	C	687	141				
Niger Territory	C	146	156				
Nyasaland	C	5	1				
Rhodesia, Southern	C	80	29	4			
Senegal	C	14	53				
Sierra Leone	C		5				
Sudan (Anglo-Egyptian)	C	103	101	12	6	36	30
Union of South Africa	C	45	1				
ASIA							
Arabia	C	95	160				
China	C	240	128	43	37	9	51
Chosen	C	11					
Dutch East Indies—Sabang	C		4				
India	C	39,420					
India (French)	C	5					
Indochina (French)	C	607	103				
Iran	C	54	38				
Iraq	C	57	25	3	9	2	17
Japan	C		[4] 262				
Straits Settlements	C	1					
Sumatra	C		1				
Thailand	C			2	1	2	
EUROPE							
Great Britain	C	2					
Greece	C	16					
Portugal	C	40					
Spain	C	144	51				
Turkey	C	53					
NORTH AMERICA							
Guatemala	C	1					
Mexico	C	22	18				
SOUTH AMERICA							
Brazil	C	1					
Colombia	C	99					
Venezuela (alastrim)	C	54	31				

[1] For January only.
[2] Imported.
[3] For February only.
[4] For January, February, and March.

WORLD DISTRIBUTION OF CHOLERA, PLAGUE, SMALLPOX, TYPHUS FEVER, AND YELLOW FEVER—Continued

TYPHUS FEVER

[C indicates cases; D, deaths]

Place		January-February 1940	March 1940	April 1940—week ended—			
				6	13	20	27
AFRICA							
Algeria	C	313	254	------	115	108	------
Belgian Congo	C	1,188	6	------	16	------	------
British East Africa	C	1	------	------	------	------	------
Egypt	C	670	1,038	116	214	------	179
Morocco	C	44	108	16	20	6	22
Tunisia	C	------	------	------	------	------	247
Union of South Africa	C	74	------	------	------	------	------
ASIA							
China	C	58	215	------	------	------	------
Chosen	C	5	------	------	------	------	------
India	C	1	------	------	------	------	------
Iran	C	102	64	------	------	------	------
Iraq	C	3	26	2	8	29	4
Palestine	C	13	7	3	4	3	------
Trans-Jordan	C	13	------	------	------	------	------
EUROPE							
Bulgaria	C	41	7	4	1	------	4
Germany	C	------	24	------	------	------	------
Greece	C	2	4	6	2	------	------
Hungary	C	13	23	6	6	2	2
Lithuania	C	22	------	------	------	------	------
Rumania	C	566	302	24	40	32	13
Spain	C	3	------	------	------	------	------
Turkey	C	320	------	------	------	------	------
Yugoslavia	C	91	64	------	------	------	------
NORTH AMERICA							
Guatemala	C	99	28	------	------	------	------
Mexico	C	127	52	------	------	------	------
Panama Canal Zone	C	------	3	------	------	------	------
SOUTH AMERICA							
Chile	C	30	6	------	------	------	------
Ecuador	C	------	1	1	------	------	------
Venezuela	C	3	1	------	------	------	------
OCEANIA							
Australia	C	6	2	------	------	------	------
Hawaii Territory	C	4	3	------	2	1	2

YELLOW FEVER

[C indicates cases; D, deaths]

Place		January-February 1940	March 1940	April 6	April 13	April 20	April 27
AFRICA							
Cameroon: Nkongsamba	C	[1] 1	------	------	------	------	------
French Equatorial Africa: Fort Archambault	C	[1] 1	------	------	------	------	------
Gold Coast	C	------	------	1	------	------	------
Ivory Coast	C	1	------	------	------	------	------
Nigeria:							
Enugu	C	------	------	[1] 1	------	------	------
Oshogbo.[2]							
SOUTH AMERICA							
Brazil:							
Espirito Santo State	D	[3] 28	------	------	------	------	------
Rio de Janeiro State	D	[3] 1	------	------	------	------	------
Colombia:							
Antioquia Department—San Luis	D	2	------	------	------	------	------
Caldas Department—							
La Pradera	D	1	------	------	------	------	------
Samana	D	------	1	------	------	------	------
Victoria	D	1	------	------	------	------	------

[1] Suspected.
[2] During the week ended May 4, 1940, 1 suspected case of yellow fever was reported in Oshogbo, Nigeria.
[3] Jungle type.

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