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A STATISTICAL STUDY OF MEASLES.

FREDERICK S. CRUM, PH.D., *Assistant Statistician, The Prudential Insurance Company of America.*

Measles, from the time of its recognition as a distinct form of disease, has been considered relatively harmless by the great majority of the laity and by not a few of the medical profession. This belief, still shared by so many in all walks of life, is almost incredible in view of the long history and wide extent of the ravages of measles, not merely in the form of a large mortality but also in the form of non-fatal, but very numerous and serious physical impairments, directly chargeable to this disease. From the time of the Middle Ages,* at least, measles has levied a heavy toll on the populations of such civilized countries as have kept any records of the causes of death. Just what the extent of this mortality was in the early centuries can never be known, as the records are too uncertain and fragmentary for its determination. We do, however, have authentic records of great epidemics of measles in England and Scotland from the early part of the seventeenth century, and after Sydenham's description of the London epidemics of 1670 and 1674 there remains no doubt of the more or less continuous and wide havoc wrought in Great Britain and Europe by this particular form of eruptive fever. Epidemics of measles were frequent, widespread and fatal throughout the eighteenth century, and ever and increasingly so throughout the nineteenth century.

Measles is the one sickness to which we are all most susceptible, unless immunized by a previous attack and, as a corollary to this proposition, it is the one ailment from which fewest of us escape. The most reliable statistics show that from 1 to 6, or more, per cent. of all cases of measles terminate fatally. This percentage varies greatly with the circumstances of time and place, but particularly according to the age of the persons

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* See "Two Hundred and Fifty Years of Smallpox in London," by William A. Guy, Journal of the Statistical Society, September, 1882, Vol. 45, p. 409.

attacked, the economic and social condition in which they live, and the general state of their health. · The proportion of fatal cases is almost uniformly higher, for illustration, in patients of ages under one year of age, and remains high in the second and third years of life, after which the percentage of fatal cases falls rapidly, until by age fifteen it is almost negligible and remains so throughout adult life, under any but extraordinary circumstances. Again, over-crowding usually means a higher attack-rate from measles and also a higher case-fatality ratio. Close segregation of population in cities, in schools, in other institutions, in recruiting stations, in camps, or elsewhere favors the rapid spread of measles' contagion when once an affected person comes in contact with those susceptible to this morbid poison. In Glasgow, Scotland, a careful investigation revealed the fact that the attack-rate of measles among infants and young children was ten times higher in families living in one-room tenements than in families living in tenements of four or more rooms.* In Aberdeen, Scotland, statistics for the general population covering a ten-year period disclosed the fact that the case-fatality ratio of measles in that city was eight times higher in one-room tenements than in those of four or more rooms.† The experiences of Glasgow, London, and other localities where similar statistics have been compiled, yield similar results. Finally, that the health condition of the person attacked is a factor of great importance in the effect which measles produces, is evident from the unanimous opinions which have been recorded by hundreds of qualified observers.

Mortality from Measles. The most reliable international mortality statistics show that, on an average, in the countries of the temperate zones more than 1 per cent. of all the deaths are caused by measles. This statement is based upon statistics of twenty-two countries, covering the five-year period, 1906 to 1910. The percentage which measles formed of all deaths in these countries averaged, to be exact, one and one-eighth. That this is a fair average is evident from the fact that it is derived from an aggregate mortality from all causes of 32,626,651 and an aggregate of 366,262 deaths from measles. The percentage of the total mortality, chargeable to measles, varied considerably in the different countries for which the facts were available, or from 0.23 per cent. in Australasia and 0.28 per cent. in Japan, to 2.18 per cent. in Scotland, 2.14 per cent. in Belgium, and 1.98 per cent. in England and Wales. Of the twenty-two countries in the temperate zones for which the data are available, one-half showed percentages under 1.0, and one-half percentages above 1.0.

In the registration area of the United States the percentage which measles contributed to the total mortality during 1906 to 1910 was 0.71. Other

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* Report of the Medical Officer of Health of the city of Glasgow, 1908, p. 99.

† Report of the Medical Officer of Health of the city of Aberdeen, 1904, p. 48.

countries with similar percentages were Switzerland, with 0.73 per cent.; Roumania, with 0.62 per cent.; Iceland, with 0.83 per cent.; and the cities of Denmark with 0.78 per cent. Other countries with relatively high percentages were Hungary, with 1.77; the Netherlands and Spain, each with 1.59; Chile, with 1.54; Austria, with 1.48, and Italy, with 1.41.

Whether or not the average contribution of measles to the total mortality is as large in the non-temperate as in the temperate zones, it is impossible to state with certainty, for the quantity and quality of the vital statistics in most of the countries of the tropical and of the frigid zones are too incomplete and unreliable to warrant a final conclusion. More or less fragmentary data, however, for certain countries, such as Cuba, Jamaica and Ceylon, and for various of the larger cities of the tropics, such as Mexico City, Mexico; Havaná, Cuba; Rio de Janeiro, Brazil; Cairo and Alexandria, Egypt; Calcutta and Rangoon, India; and Manila, Philippine Islands, furnish sufficient proof that the virus of measles is capable of diffusing itself quite as readily in hot as in cool or temperate climates. So, too, the statistics of the cold temperate countries and the occasional outbreaks of measles in the Faroe Islands, Iceland and Alaska prove, conclusively, that the Arctic Circle is not a bar to the spread of measles.

From a careful study of the mortality from measles it appears to be reasonably certain that this infection is today one of the most ubiquitous with which man is afflicted. Its geographical distribution appears to be world-wide and all races and classes of men are apparently susceptible to its morbid virus.

As a partial basis for this paper, the mortality statistics, so far as they are available, have been compiled for all the principal countries of the world, for one hundred of the larger cities of the United States, and for more than fifty representative large cities located in various other countries throughout the world.* For this general comparison the death-rates have been uniformly calculated on the basis of 100,000 population of all ages. Although the more exact method would have been to calculate the death-rates with distinction of age, that method is impossible in any such wide comparison as is here attempted, for the reason that the necessary information in many cases is not available in such detail.

In the various countries of the world for which fairly reliable statistics are available for the five-year period, 1906 to 1910, the average annual death-rate from measles has varied from 48.4 per 100,000 population in Chile and 44.3 in Hungary, to 2.4 in Australasia, 3.4 in New Zealand and 6.3 in both Jamaica and Sweden. Other countries with relatively high average annual death-rates were Spain, 38.5; Scotland, 35.2; Belgium,

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*A set of five charts in black and white, illustrative of the morbidity and mortality statistics of measles, may be had upon application to the author.

35.0; Austria, 33.2; Italy, 29.7; and England and Wales with a death-rate of 29.1. The average annual death-rate from measles in the registration area of the United States during 1906 to 1910 was 10.8 per 100,000 total population. The death-rate from measles in the United States was only about one-half that in the twenty-four other countries of the world combined, or 10.8 as against 20.5 for the remainder of the world for which statistics are available. It is interesting in this connection to note that in the registration area of the United States, during the twelve years from 1900 to 1911, 50,000 deaths from measles were recorded, and on the assumption that approximately the same death-rate prevailed in the non-registration area, over 100,000 deaths were caused by measles in the continental United States during the twelve-year period, 1900 to 1911.

The death-rates from measles in one hundred large cities of the United States during a twelve-year period, 1900 to 1911, show a great variation not only as between cities but from year to year in each of the respective cities. The annual death-rates from measles per 100,000 population in these one hundred cities have ranged from 85.7 in Covington, Ky., in 1901 and 85.2 in Schenectady, N. Y., in 1900, to zero one or more times in 62 cities, and 158 times altogether out of the 1,200 instances recorded in the table. The average death-rate during 1900 to 1911 for all registration cities in the registration area was 11.1 and this rate was equalled or exceeded 379 times out of the 1,200 instances tabulated; and it was exceeded one or more times in 97 of the 100 cities, the only exceptions being Portland, Me., Portland, Ore., and Spokane, Wash. Pittsburgh, Pa., had the highest average death-rate from measles during 1900 to 1911, or 26.5 per 100,000 population; and Portland, Me., had the lowest average rate, or 3.3. I may add that Pittsburgh has just experienced another epidemic, and beginning with the week ending September 7, 1912, and up to and including the week ending August 2, 1913, a period of 48 weeks, there were 10,117 cases of measles reported in that city, with 186 deaths.

The periodicity in the death-rates from measles in American cities illustrates the fairly well-known fact that in large urban centers of population almost everywhere throughout the world, measles is almost constantly present, and an epidemic generally recurs just as soon as the population under five years of age is surcharged with non-immune persons by the addition, through births, of one or two annual crops of children. Careful observations have disclosed the apparent fact that when many more than 30 per cent. of the youthful population in a densely crowded area are non-immune, an outbreak of measles is almost certain to occur. Observations extending over long periods of time and embracing wide areas have taught us that any apparent regularities in the recurrence of epidemics of measles in any given locality are probably dependent solely

on two factors, the time of importation of the morbid poison, and the number of persons susceptible to it.*

In fifty representative great cities of the world other than those in the United States, the death-rates from measles in recent years have varied even more widely than in the urban centers of this country. During the years of the period beginning with 1900 for which the statistics are available, the average annual death-rates in these cities have ranged from 147.4 in Cairo, Egypt, and 90.8 in Alexandria, Egypt, to 3.2 in Sydney, New South Wales, and 1.1 in Manila, Philippine Islands.

The mortality statistics of American and foreign cities illustrate three facts: first, that epidemics of measles are relatively numerous; second, that measles is apparently present, to some extent at least, throughout those parts of the world for which we have reliable or approximately accurate information; and, third, that there are great variations in the death-rates from measles, both geographically and historically.

The history of the many disastrous epidemics of measles in the urban centers of the world and among savage and semi-civilized tribes and peoples is one of the most interesting chapters in historical pathology. Enough has already been said of the epidemics in urban centers, but brief mention may be made of a few of the more notable epidemics of the other character. The virus of measles was imported into the Faroe Islands in 1846, and it is reported that the resulting epidemic affected three fourths of the total population. In 1874 measles was imported into the Fiji Islands, and the havoc wrought among the natives was frightful, it being reported that from one fourth to one fifth of the total population, or some 20,000 of the natives, succumbed to the disease. History records just as serious epidemics elsewhere among uncivilized peoples when the virus of measles has found them unprotected by previous attack. But we need not go far back in history to witness the effects of measles upon ignorant, superstitious peoples who have few or no qualified medical advisers. In Tutuila, one of the islands of American Samoa, an epidemic of measles occurred as recently as 1911, causing at least 219 deaths by July 23 of that year, and the mortality in some villages was reported to be nearly 10 per cent. of the total population. And yet this disease is today considered comparatively harmless by the majority of the laity in this and many other countries. The natives of the South Pacific Islands, however, have a wholesome respect for measles, which they dread more than any other quarantinable disease, not excepting even the plague, beri-beri, smallpox or yellow fever. There are many recent instances of epidemics of measles among Indians in schools, in camps, and on reservations in the United States and Canada. The disease is often quite exceptionally fatal, particularly where, as is so often true, the sanitary and hygienic conditions

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* Hirsch: Handbook of Geographical and Historical Pathology, Vol. 1, p. 161.

are unsatisfactory, and a large proportion of the population attacked are in poor general health. Measles, as a rule, runs a fatal course when its victims are tuberculous, and nowhere is this better illustrated than in the detailed accounts of measles among the Indians as returned in the annual reports of the United States Commissioner of Indian Affairs and in the annual reports of the Department of Indian Affairs of Canada.

Measles and Race. Clemow, in his Geography of Disease, states that "all races are susceptible to it [measles], and it has been shown that it is just as capable of attacking the Chinaman, the Hindu, and the Negro as the European. It appears on the whole, however, to be decidedly less common in the African negro than in most races."* Hirsch, also, in his Handbook of Geographical and Historical Pathology, states that the susceptibility to the virus of measles is "uniformly shared by the whole of mankind, of whatever *races* or *nationalities.* And if," he goes on to assert "among the colored peoples, measles puts on its severest forms and leads to disastrous results exceptionally often, the reason of that does not lie in their physiological peculiarities, but mainly in the unfavorable hygienic conditions amidst which they live."†

ATTACK RATE FROM MEASLES BY COLOR AND AGE, WASHINGTON, D. C.·
1908–1912.

Ages.	White.			Colored.		
	Population.	Cases.	Attack rate per 10,000 population.	Population.	Cases.	Attack rate per 10,000 population.
Under 1....	20,125	347	172.4	7,320	108	147.5
1–4........	76,680	3,392	442.4	29,220	763	261.1
5–9........	90,545	4,766	526.4	36,015	1,080	299.9
10–19......	184,410	1,252	67.9	79,395	368	46.4
20–over	805,085	671	8.3	320,375	220	6.9
All ages ..	1,180,640‡	10,428	88.3	474,705‡	2,539	53.4

The statistics of measles certainly show that all races are susceptible to this disease, but, it is doubtful if there is yet sufficient proof to warrant the assertion that all races and nationalities are equally susceptible to it. Recent statistics for various cities of this country seem to bear out the statement by Clemow that measles is "decidedly less common in the African negro than in most races." Statistics of four American cities give an average annual attack-rate from measles of 89.0 per 10,000 of white popu-

* Clemow: The Geography of Disease, p. 280.
† Hirsch: Handbook of Geographical and Historical Pathology, Vol. 1, p. 170.
* Includes population of ages not stated.

lation, as against a rate of only 41.1 for the negro, or less than one-half that for the whites.*   In Washington, D. C., where the cases have been reported with distinction of color and age since April 9, 1907, the figures for the five years, 1908 to 1912, show that the attack rate was highest for the white population at all ages.   These figures are so interesting that they are presented in detail in the table on page 294.

Although the attack rate seems to be lower among negroes than among the whites, there is no certainty that the death-rate is more favorable among the negroes, for the case-fatality ratio is almost invariably higher among negroes than among the whites in the same localities.   In the statistics for Washington, D. C., the case-fatality ratios are shown to be higher for the negroes than for the whites at ages under one and at ages 1 to 4.   The figures in detail are presented in the following table:

CASE FATALITY FROM MEASLES BY COLOR AND AGE, WASHINGTON, D. C., 1908–1912.

Ages.	White.			Colored.		
	Cases.	Deaths.	Fatality rate per 1,000 cases.	Cases.	Deaths.	Fatality rate per 1,000 cases.
Under 1	347	12	34.6	108	5	46.3
1–4	3,392	34	10.0	763	15	19.7
5–9	4,766	1	0.2	1,080	1	0.9
10–19	1,252	2	1.6	368	—	—
20–over	671	2	3.0	220	—	—
All ages ..	10,428	51	4.9	2,539	21	8.3

The comparative death-rates from measles show that in some cities the negroes have experienced a higher mortality than the whites, and in other cities the reverse has been true.   The facts in detail are presented in the table on page 296.

From this table it appears that the average annual death-rate from measles per 100,000 population, all ages, was higher among the negroes than among the whites in Washington, Richmond and Memphis, while in New Orleans and Savannah the average death-rates of the whites have been higher than for the colored.

In Havana, Cuba, during the five years 1904 to 1908, the white death-rate from measles was higher than for the colored every year, except 1905, and the average annual death-rate was 11.8 per 100,000 population for

*It is quite probable that the white cases are more fully reported than are the colored cases.

MORTALITY FROM MEASLES, ALL AGES, IN FIVE AMERICAN CITIES, WITH DISTINCTION OF COLOR, 1902–1911.

(Rates per million population.)

Cities.	White.			Colored.		
	Population.	Deaths.	Rate.	Population.	Deaths.	Rate.
Washington, D. C.	2,205,182	103	46.7	922,275	60	65.1
New Orleans	2,352,420	201	85.4	856,427	38	44.4
Richmond	710,502	62	87.3	416,747	39	93.6
Savannah	297,965	12	40.1	314,805	8	25.4
Memphis . . . . : .	694,165	20	28.8	516,125	17	32.9
Total	6,260,234	398	64.1	3,026,379	162	53.5

the whites, against 7.9 for the colored. In Cuba, as a whole, during the four years, 1908 to 1911, the average death-rates were 4.6 for the white population and 3.3 for the colored population.

That the American Indian is highly susceptible to measles has long been attested by the frequent and often quite exceptionally fatal outbreaks of this disease among the various tribes and in various localities in the United States, Canada and elsewhere.

During the period 1888 to 1893 in an aggregate agency population in the United States of 852,679 there were 6,330 cases of measles reported by the agency physicians. This gives an average annual case or attack rate of 74.2 per 10,000 population. This rate is, so far as we are able to judge, fully as high as the average attack rate among the white urban population of this country. The corresponding death-rate among these Indians averaged 44.5 per 100,000 population, and the case-fatality ratio was 53.8 deaths to every 1,000 cases. These facts would seem to warrant the conclusion that the American Indian is quite as highly susceptible to measles as his white brother, and the history of the numerous epidemics among them is replete with instances in which a very large percentage of the total population of the tribe, or agency, have been attacked by this disease, and often with quite exceptionally disastrous results.

That the negro and the American Indian are susceptible to measles and suffer a high mortality from the disease is, therefore, quite evident, but more and better statistics are needed before the relative degree of susceptibility of these races at the various age periods can be accurately determined.

In Manila, during the period 1903 to 1912, there were 23 deaths of Filipinos officially reported as due to measles. Of this number 14 were

reported during 1912. This limited experience proves that the Filipino is by no means immune to measles. That the natives of the various South Pacific Islands are highly susceptible to measles has been proven at different times by widespread and disastrous epidemics. Reliable statistics for Japan and various cities of that empire demonstrates that the Japanese are probably quite as susceptible to measles as the Caucasian races, and what is true of the Japanese appears, from fragmentary data, to be true also of the Chinese.

Sex and Measles. It is doubtful if there is any other disease that shows less sex preference either in attack incidence or mortality-rate than does measles. Any sex differences which have thus far been revealed in the statistics of this disease seem to have been accidental rather than persistent. In the statistics for Aberdeen, Scotland, 1883 to 1902, the average annual attack rate per 1,000 of population, with distinction of sex and age, was as follows:

Age.	Males.	Females.	Age.	Males.	Females.
Under 1	42.2	45.4	9	10.9	12.5
1	84.2	87.6	10	6.4	7.1
2	80.9	91.1	11	4.2	4.6
3	73.2	86.1	12	3.4	4.7
4	75.6	75.2	13	2.5	3.4
5	86.7	85.9	14	2.2	2.9
6	74.3	76.2	15–24	1.4	1.3
7	44.9	49.6	25–59	.33	.33
8	20.9	20.9	60 and over	.07	.07

The case-fatality ratio from measles in Aberdeen, 1883–1902, by sex and with distinction of age is shown on page 298.

In Massachusetts the average annual death-rate from measles during the fifty years, 1863 to 1912, was, for males, 44.52 per 100,000 male population, ages under ten, and for females the rate was 42.75. The statistics by five-year periods, however, show that the rates were higher for females than for males during 1873 to 1877, 1883 to 1887, and 1893 to 1897. Other more or less fragmentary data seem to confirm the conclusion that measles manifests no decided sex preference, either as a disease or as a cause of death, which cannot be accounted for on grounds other than physiological differences.

Age and Measles. In the registration area of the United States during the twelve years, 1900 to 1911, only 6 per cent. of all the deaths from measles were at ages twenty and over. Nearly 82 per cent. were at ages under five; 8.4 per cent. were at ages five to nine, and 3.7 per cent. were at ages ten to nineteen. The summary of the mortality by ages is given in the table at the bottom of page 298.

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CASE FATALITY FROM MEASLES IN ABERDEEN, SCOTLAND, 1883–1902, WITH DISTINCTION OF SEX AND AGE.

Age.	Males.			Females.		
	Cases.	Deaths.	Deaths per 100 cases.	Cases.	Deaths.	Deaths per 100 cases.
1–3 mos.	115	13	11.3	129	6	4.7
4–6 "	358	36	10.1	307	28	9.1
7–9 " `	669	100	14.9	594	86	14.5
10–12 "	417	77	18.5	445	80	18.0
Under 1 year	1,559	226	14.5	1,475	200	13.6
1 year	2,643	288	10.9	2,579	238	9.2
2 "	2,651	96	3.6	2,544	82	3.2
3 "	2,434	37	1.5	2,619	45	1.7
4 "	2,439	23	0.9	2,347	20	0.9
5 "	2,758	18	0.7	2,594	17	0.7
6 "	2,400	9	0.4	2,228	12	0.5
7 "	1,340	4	0.3	1,478	10	0.7
8 "	624	2	0.3	634	3	0.5
9 "	321	1	0.3	351	3	0.9
10 "	194 •	1	0.5	212	—	—
11 and over	875	4	0.5	1,025	7	0.7
All ages	20,288	709	3.5	20,086	637	3.2

MORTALITY FROM MEASLES, WITH DISTINCTION OF AGE, UNITED STATES REGISTRATION AREA, 1900–1911.

Age.	Number of deaths.	Per cent. of total at specified ages.
Under 5..................................	40,931	81.9
5–9......................................	4,213	8.4
10–19....................................	1,830	3.7
20 and over.............................	3,028	6.0
Total.....................................	50,002 -	100.0

In countries or cities where measles have been long prevalent and the susceptible persons are practically limited to the infants and youths the age distribution of the deaths from measles is quite different from that in the registration area of the United States. In England and Wales, for illustration, about 93 per cent. of all the deaths from measles occur at ages under five.*

* Forty-first Annual Report of the Local Government Board, England, 1911–12, p. XXV.

Various investigations into the mortality-rate of measles by age and on the basis of population indicate that the second year of life is the age period when an attack of measles is most apt to prove fatal. The following table represents with approximate accuracy the death-rate from measles in the registration area of the United States with distinction of age:

MORTALITY FROM MEASLES, BY AGE, REGISTRATION AREA OF THE UNITED STATES, 1909–1911.

Age.	Population.†	Deaths.	Rate per 100,000 population specified age.	Age.	Population.	Deaths.	Rate per 100,000 population specified age.
Under 1.	3,956,760	4,106	103.8	20–29.....	30,666,203	398	1.3
1.......	3,538,256	5,498	155.4	30–39.....	23,942,597	301	1.3
2.......	3,880,669	2,504	64.5	40–49.....	17,383,981	205	1.2
3.......	3,861,646	1,222	31.6	50–59.....	11,807,308	98	0.8
4.......	3,785,554	737	19.5	60–69.....	7,051,587	75	1.1
5–9.....	17,382,981	1,464	8.4	70–over...	3,935,769	70	1.8
10–19...	32,470,097	697	2.1				
				All ages...	163,990,391‡	17,380	10.6

From these statistics it is clear that in this country the death-rate from measles is highest in the second year of life; it is comparatively high also in the first year of life, particularly in the second half; in the third year of life the death-rate is less than one-half that in the second year; in the fourth year it is only one-half that in the third; and from the fifth year of life the mortality-rate declines rapidly until by age twenty the rate is only about 1 in every 100,000 of population.

In England and Wales, during the five years, 1906 to 1910, the average death-rate from measles has been as follows by months during the first year of life as given in table on next page.

These statistics indicate that the mortality from measles in the first year of life is fully twice as high in England and Wales as in the registration area of the United States.

On the basis of survivors, the average death-rates from measles from the second to the fifth years of life in England and Wales, 1906 to 1910, were as shown in second table on page 300.

In England and Wales, as in the United States, the mortality from measles in the second year of life is fully twice as high as in the first year of life, and is more than twice as high as in the third year of life. The mortality-rate declines rapidly from the second year and in England and

† Estimated from ages of population in Continental U. S. Census of 1910.
‡ Includes population of ages not stated.

AVERAGE NUMBER OF DEATHS FROM MEASLES TO EVERY 100,000 BIRTHS,
ENGLAND AND WALES, 1906–1910.

Age.	Rate.	Age.	Rate.
Under 1 month	2.0	7th month of life	16.2
2d month of life	2.6	8th " " "	26.0
3d " " "	2.2	9th " " "	35.0
4th " " "	2.0	10th " " "	42.2
5th " " "	4.6	11th " " "	47.8
6th " " "	9.2	12th " " "	53.4

Total under one year 243.2

AVERAGE NUMBER OF DEATHS FROM MEASLES PER 100,000 SURVIVORS,
ENGLAND AND WALES, 1906–1910.

Age.	Rate.
2d year of life	508.2
3d " " "	210.8
4th " " "	113.0
5th " " "	70.4

Wales the death-rate in the fifth year of life is less than one seventh of that in the second year. In the United States this ratio was one-eightht or the rate was 19.5 per 100,000 in the fifth as against a rate of 155.4 in the second year of life.

There is evidence to support the theory that as population becomes more and more segregated the mortality from measles is shifted from the higher to the lower ages, and particularly upon ages under three. As children become more and more segregated in schools, and as measles, in greater degree than scarlet fever or diphtheria, spreads in the home to the children of pre-school ages if it be introduced into the home by a school-attending child, there is a shifting of attack incidence and mortality to the pre-school ages.*

The case-fatality ratio of measles is highest in the second year of life, but it is almost as high in the first year. The ratio in the third year of life is less than one-third that in the second year, and in the fourth year it is only one-eighth that in the second year of life.

These statistics for Glasgow are corroborated by similar data for Aberdeen, London, and elsewhere.

* Report, Public Health Commissioner, London County Council, 1905, p. 30.

CASE FATALITY IN RELATION TO AGES, GLASGOW, SCOTLAND, 1908.†

Age.	Cases.	Deaths.	Deaths per 100 cases.
Under 1 year................................	1,575	256	16.2
1–2 years..................................	2,690	509	18.9
2–3 "	3,334	178	5.3
3–4 "	3,091	76	2.4
4–5 "	2,956	40	1.3
5–15 "	8,026	56	0.7
	21,672	1,115	5.1

Before leaving the subject of age in its relation to measles it is of interest to note that measles forms an important proportion of the total mortality at ages under ten. The details for the registration area of the United States for the two years, 1910 and 1911, were as follows:

MORTALITY FROM MEASLES IN THE UNITED STATES REGISTRATION AREA, 1910–1911.

Ages.	Deaths from all causes.	Deaths from measles.	Ratio per 1,000.
Under 6 mos............................	231,501	769	3.3
6–11 mos...............................	72,194	2,090	28.9
1 year.................................	64,442	3,788	58.8
2 years................................	28,307	1,809	63.9
3 "	17,736	903	50.9
4 "	12,621	543	43.0
5–9 "	36,055	1,089	30.2
10–19 years...........................	64,999	567	8.7
20–29 "	129,512	326	2.5
30–39 " ....•......................	141,382	254	1.8
40–49 "	149,914	175	1.2
50–over...............................	693,949	202	0.3
All ages............................	1,644,696	12,520	7.6

From these statistics it appears that in the third year of life 6.4 per cent. of all the deaths were caused by measles; in the second year, 5.9 per cent., and in the fourth year, 5.1 per cent., while at ages over ten the deaths from measles did not cause as much as 1 per cent. of the total mortality.

Urban vs. *Rural Mortality from Measles.* Other things equal, segregated populations, whether in urban centers, in armies, or elsewhere, favor the

† Report, Medical Officer of Health of the City of Glasgow, 1908. p. 96.

spread of measles and a comparatively high mortality therefrom. This fact is illustrated in a most convincing way in the mortality statistics of the registration area of the United States, where distinction is made of the urban and rural areas. The statistics are presented for the twelve-year period, 1900 to 1911, in the following table:

COMPARATIVE MORTALITY FROM MEASLES IN RURAL AND URBAN AREAS, REGISTRATION STATES, UNITED STATES, 1900–1911.

Years.	Urban.			Rural.		
	Population.	Deaths.	Rates per 100,000 population.	Population.	Deaths.	Rates per 100,000 population.
1900–1905	69,498,082	7,929	11.4	55,487,115	4,019	7.2
1906–1911	132,949,400	16,626	12.5	120,478,830	10,928	9.1
1900–1911	202,447,482	24,555	12.1	175,965,945	14,947	8.5

From these data it is shown that in the registration urban area of the United States the average mortality from measles during the twelve years was 12.1 per 100,000 of population, all ages, against an average rate of 8.5 for the registration rural area. The average urban death-rate from measles was, therefore, 42.5 per cent. higher than the average rural death-rate. The different age distribution of the population in the city and country districts would affect these mortality rates somewhat but in a way to increase rather than diminish the difference in favor of the country. The percentage of the total urban population at ages under ten was only 18.8 in 1910, as against 25.1 for the rural population, and as measles is preëminently a disease of infancy and early youth, other things equal, we would expect a higher attack incidence and mortality from this disease in the country districts than in the urban areas. The facts show that segregation of population in the cities of the United States, as elsewhere throughout the world, is one of the most important factors favoring the diffusion of measles.*

- The following statistics seem to indicate that in this country, as is also probably the fact elsewhere throughout the world, the proportion of the total deaths from measles which falls upon children under ten is considerably higher in the large cities than in the small cities and rural districts.

* For English conditions, see Thirty-ninth Annual Report of the Local Government Board, 1909–10, App. X, A., No. 1, pp. 1–2, Report of Medical Officer.

MORTALITY FROM MEASLES IN THE REGISTRATION STATES OF THE
UNITED STATES, 1909.

Ages.	Registration states.		Cities with over 100,000 population.		Remainder of registration states.	
	Number of deaths.	Per cent. distribution by age.	Number of deaths.	Per cent. distribution by age.	Number of deaths.	Per cent. distribution by age.
Under 5....	3,791	85.7	1,783	92.8	2,008	80.3
5–9........	334	7.6	103	5.4	231	9.2
Under 10 ...	4,125	93.3	1,886	98.2	2,239	89.5
All ages ..	4,423	100.0	1,922	100.0	2,501	100.0

These statistics show very clearly that as our population becomes more and more segregated in cities there is a shifting of the mortality from measles from the higher to the lower ages. This is due primarily to two factors, first, the greater liability in urban centers to attack from measles at an early age, and, second, the universally higher case-fatality from this disease at the early ages. These are probably the more powerful factors which coöperate to bring about the comparatively high proportion in cities of the total deaths from measles which occur at ages under five and under ten, but there are other contributory factors, such as housing, overcrowding, and other socio-economic conditions which are apt to press harder in the cities than in villages and rural districts.

The medical experience of our Civil War is replete with proof that a large proportion of the rural population at that time attained to adult ages without having had measles. Frequently the majority of the soldiers in a regiment raised in the rural districts would be attacked by measles, the exempt often being only those who had had a previous attack.* Many of the companies recruited from the rural districts, both Union and Confederate, were so seriously crippled by measles that temporary disbandment was found necessary. This drastic action was seldom, if ever, resorted to in companies or regiments recruited from cities.

What was true at the time of the Civil War is still true, but not to the same extent, for measles is now more widely diffused, even in the rural districts, than in the fifties † and sixties of the nineteenth century. In

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* Outlines of the Chief Camp Diseases of the U. S. Armies; by Joseph J. Woodward, M. D., Philadelphia, 1863; pp. 268, 277. Also, U. S. Sanitary Commission Memoirs; edited by Austin Flint, M. D., New York, 1867; pp. 13, 219, 228, 230, 231.

† Diseases of the Interior Valley of North America, by Daniel Drake, M. D., Philadelphia, 1854, Vol. II, p. 586.

1911, for illustration, a serious outbreak of measles occurred among the United States troops stationed at Columbus Barracks, resulting in 1,101 cases and 25 deaths. *   "Epidemics of this character still occur frequently at the large recruiting depots."†

Season and Measles.   The statistics of the morbidity and mortality of measles show that, as a general rule, cases increase in number with the beginning of the cold season.   This may or may not be due directly to temperature change, but a more plausible explanation would seem to be that, with the beginning of the colder season, children are more closely segregated in schools; ventilation is generally less adequate and other factors more or less dependent upon cold weather react to bring about more sick cases and more deaths from measles than occur in the summer months.

A careful study of the recorded cases of measles and the reported deaths from the same in New York City and Philadelphia by weeks for a seven-year period (1906–12) disclosed the fact that as the actual number of cases decrease the case fatality-ratio increases.   This phenomenon was corroborated by the combined returns by weeks for fourteen large American cities during 1912, and it was also noted by Dr. Wilson when he made his investigation of the statistics of measles in Aberdeen, Scotland, during the twenty years, 1883 to 1902.

I am unable to do more than offer some suggestions as to why this is so. Possibly the cases are not so fully reported during the vacation period as during the school year; possibly the deaths, or a fair proportion of them, refer back to cases reported some weeks earlier; and possibly the higher case fatality is due to reduced general vitality coincident with the hot summer months.   This latter explanation is in part confirmed by the industrial experience of The Prudential.   An analysis of the primary complications in 190 fatal cases of measles which occurred in the months of July, August and September, showed that 9.5 per cent. of the total were digestive, against 1.9 per cent. during the other nine months of the year.   On the other hand, during July, August and September, 65.3 per cent. of the total primary complications were of a respiratory character, against 80.7 per cent. during the other nine months of the year.

Increase or Decrease in Mortality from Measles.   The question whether or not there has been a decrease in the mortality from measles admits of reasonable doubt.   The crude death-rates for the various countries of the world show in most cases a decline, but when correction is made for age, this apparent decline is often almost, if not completely, offset by the decline in the birth-rate.   In other words, in countries where the birth-rate is steadily declining, the proportion of the total population of ages under five steadily diminishes also, and it is at ages under five that this disease is most fatal.

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* Report of the Surgeon-General, U. S. A., Washington, D. C., 1912, pp. 78, 79.
† Report of the Surgeon-General, U. S. A., Washington, D. C., 1911, p. 72.

In the registration area of the United States there has been an increase in the crude death-rate from measles, if comparison is made of the two six-year periods, 1900 to 1905, and 1906, to 1911, as the following summary statistics show:

MORTALITY FROM MEASLES IN THE REGISTRATION AREA OF THE UNITED STATES, 1900–1911.

(Rates per million population, all ages.)

Registration area.	1900–1905.			1906–1911.		
	Population.	Deaths.	Rate.	Population.	Deaths.	Rate.
Urban..........	69,498,082	7,929	11.4	132,949,400	16,626	12.5
Rural..........	55,487,115	4,019	7.2	120,478,830	10,928	9.1
Total........	124,985,197	11,948	9.6	253,428,230	27,554	10.9

In the urban portion of the registration area the mortality from measles has increased from 11.5 during 100 to 1905 to 12.5 during 1906 to 1911, or 8.7 per cent.; the rural rate has increased from 7.2 to 9.2, or 27.8 per cent.; and the rate for the whole registration area has increased from 9.6 to 10.9 or 13.5 per cent. In the United States, therefore, it is quite probable that the death-rate from measles, if it could be calculated on the basis of population and deaths under five years of age, would show a much larger increase, for there is no question that the birth-rate has declined appreciably in this country in recent years.

In the state of Massachusetts it has been possible to calculate the death-rate from measles at ages under ten for a fifty-year period, 1863 to 1912, and the comparison of the average rates in the first and last decades of the period is presented in the table at the top of page 306, together with similar rates from scarlet fever, whooping-cough and diphtheria.

In Massachusetts there seems to have been a decline in the average death-rate from measles at ages under ten from 6.74 per 10,000 population of these ages during 1863 to 1872 to 3.43 during 1903 to 1912, or 49.1 per cent. The mortality in Massachusetts from measles at ages under ten by five-year periods is presented for a fifty-year period in the second table on page 306.

These statistics show that even in Massachusetts the mortality from measles has remained fairly constant since 1872, the average rate during 1908 to 1912 being very little lower than during 1873 to 1877. The quinquennial rates varied during the fifty years from 7.8 in 1868 to 1872 to 3.1 during 1893 to 1897.

COMPARATIVE MORTALITY FROM MEASLES, SCARLET FEVER, WHOOPING-
COUGH, AND DIPHTHERIA AND CROUP, MASSACHUSETTS, 1863–1872,
AND 1903–1912.

(Rates per 10,000 population, ages under ten.)

Causes of death.	1863–1872.		1903–1912.		Per cent. decrease.
	Number of deaths, ages under 10.	Rate.	Number of deaths, ages under 10.	Rate.	
Measles..............	1,986	6.74	2,017	3.43	49.1
Scarlet Fever..........	9,641	32.75	1,999	3.40	89.6
Whooping Cough.......	2,949	10.02	2,824	4.80	52.1
Diphtheria and Croup ..	9,291	21.56	6,127	10.41	67.0

Population, Ages under Ten: 1863–1872—2,943,520
1903–1912—5,884,654

MORTALITY FROM MEASLES, AGES UNDER TEN, MASSACHUSETTS, 1863–1912.

(Rates per 10,000 population, ages under ten.)

Period.	Population.	Number of deaths.	Rate per 10,000.
1863–1867.....................	1,406,227	785	5.6
1868–1872.....................	1,537,293	1,201	7.8
1873–1877.....................	1,677,862	679	4.0
1878–1882.....................	1,752,137	776	4.4
1883–1887.....................	1,818,939	1,177	6.5
1888–1892.....................	2,009,421	762	3.8
1893–1897.....................	2,309,685	717	3.1
1898–1902.....................	2,648,036	1,074	4.1
1903–1907.....................	2,765,993	889	3.2
1908–1912.....................	3,118,661	1,128	3.6

On the other hand, in several large cities of this country there seems to
have been a very material reduction in the death-rate from measles during
the last thirty years and a summary statistical statement is herewith pre-
sented of the mortality in ten cities for which the information is available
by age.   For the sake of brevity and because 92.1 per cent. of all the deaths
from measles in these ten cities occurred at ages under five, this compari-
son is limited to that age period.

COMPARATIVE DEATH-RATES FROM MEASLES, IN TEN AMERICAN CITIES.

(The average annual death-rates per 10,000 population, ages under five, for 1883–1887, compared with the average rates for 1908–1912.)

Cities.	Death-rates per 10,000 population.		Change in rate.	
	1883–1887.	1908–1912.	Actual.	Per cent.
Boston......................	20.1	14.9	− 3.2	−25.9
Cleveland....................	14.9	6.9	− 8.0	−53.7
New Haven...................	18.4	8.5	− 9.9	−53.8
New York City...............	45.6	15.1	−30.5	−66.9
Philadelphia.................	13.0	11.4	− 1.6	−12.3
Providence...................	21.7	21.6	− 0.1	− 0.5
Reading.....................	28.5	2.7	−25.8	−90.5
St. Louis....................	6.6	9.1	+ 2.5	+37.9
San Francisco................	8.4	9.2	+ 0.8	+ 9.5
Washington, D. C.............	18.7	3.9	−14.8	−79.1
Total.....................	25.7	13.0	−12.7	−49.4

These statistics indicate that the mortality from measles has diminished considerably in certain cities during the last thirty years. In Providence, however, no appreciable change has taken place, and in *St. Louis* and *San Francisco* the rates have actually increased. The improvement in the rate has been most marked in Reading, Pa., where the death-rate from measles at ages under five decreased from 28.5 in 1883 to 1887 to 2.7 in 1908 to 1912, or 90.5 per cent. These facts are significant for they seem to prove that the mortality from measles can be materially reduced when efforts are wisely directed, and proper coöperation of health authorities, school authorities and the public generally is secured and a campaign of education is carried on with energy and persistence.

Control of Measles. Measles and whooping-cough are probably today, of all the widely diffused diseases, the least amenable to sanitary control. At any rate, these two infectious diseases have thus far been less subjected to control than any other of the equally important diseases of this class with which humanity is afflicted. In the case of measles there are several reasons to account for its being difficult to control. Among the more important of these are:

First. Incomplete knowledge of the identity and nature of its virus.

Second. The fact that it has an infectivity period of forty-eight hours or more previous to its eruptive appearance in an infected individual.

Third. The curious fact that it has always and almost everywhere been considered a mild and comparatively harmless disease by a large proportion of the population.

Fourth. Because it is so widely diffused, so highly contagious and so largely a disease of infancy and early youth,

Much remains to be learned of the character of the virus of measles, but the recent researches of Anderson and Goldberg indicate that even this morbid poison can be subjected to critical analysis which will yield valuable results. If, for illustration, it can be demonstrated conclusively that measles can be conveyed only by direct contact it will mean a tremendous saving of school attendance, for in that event a child of school age, immune by previous attack, need not be excluded from school when its brothers, sisters or other members of the family are ill with this disease.* If complete statistics could be had of school exclusions now required of children immune to measles, this statement would be greatly strengthened.

More statistics are needed to determine the infectivity period of measles. A most excellent recent study of this kind, based upon practical experience, has been made by Dr. E. C. Levy, health officer of Richmond, Va. His conclusion, based upon observations made during the Richmond epidemics of 1910 and 1912, seems to confirm absolutely those of other observers, namely, that measles is highly infectious at least four days previous to the appearance of the eruptive rash. This conclusion has also been confirmed by the Anderson and Goldberg laboratory investigations. This fact makes it highly important that known cases of measles be notified at the earliest possible moment in order that exposed susceptible persons may be isolated until it is definitely determined whether or not they have caught the disease. This follow-up method has been more effective than any other effort yet made to minimize the number of cases and also to minimize the mortality from existing cases.

Authorities have in the past been in disagreement as to the benefits of compulsory notification of measles but those opposed to notification have been so because of practical difficulties in the form of expense, lack of sufficiently large health department staffs, lack of hospital accommodation for isolation of patients, etc. Presumably, however, there is quite general agreement that notification of cases of measles must be a preliminary requirement, and a necessary part of any complete program for the better control of measles. The best modern practice seems to be that whereby coöperation is effected between parents, school teachers, medical inspectors of schools, visiting nurses and health departments. When such coöperation can be brought about the control of measles is very greatly facilitated by making it possible for the health authorities to get early information of the appearance of the disease in any given community.

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* A new regulation of the Department of Health of New York City (1913) provides that children, and other members of the family who have had measles, may continue in school provided that quarantine at home is properly observed.

Having this early knowledge of the appearance of the disease, steps can at once be taken to guard against its spread by special instruction to the parents, by exclusion from schools of non-immune children who are suspected of having been infected, through warning notices to teachers, etc. In addition, and quite as important, it is possible for the health department to emphasize the necessity that the patient sick with measles shall get proper care and treatment, by pointing out to the parents the dangerous character of the disease due to its frequent and fatal complications and many serious after-effects.

The follow-up method has been found to be particularly effective by reason of the much-needed educational work which can thus be done where most urgently required, that is, at the points of infection. Not only can the ignorance of parents be largely overcome, but their interest can be aroused by emphasizing the grave danger of measles when proper safeguards are not thrown about the patient. One of the most serious obstacles in the way of sanitary control of measles is the indifference to it so widely manifest almost everywhere. This indifference is not only prevalent among the laity but it is frequently met with among the medical fraternity. In 1910 a health officer of a large city in this country made the following astonishing statement:

"There were no deaths from this disease and there were but a few cases. In this climate this disease seldom assumes a malignant form and probably strong, healthy children, under careful control, would do well to contract the disease to escape the malignancy of the disease in adult age." *

This misinformation is of a kind with that put forth in a popular way by a widely read physician-author, who, in a book entitled "Preventable Diseases," makes the amazing assertion that "Fortunately neither scarlet fever *nor measles* usually becomes acutely infectious until the rash appears." †
Surely when doctors fail to realize the significance of the well-known facts relating to measles we cannot hope to accomplish the best preventive results without a vigorous and continuous campaign of education as a necessary accompaniment of any and all other measures.

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* Reports of the City Officers of the City of Savannah, Ga., 1910, p. 215.

† "Preventable Diseases," by Woods Hutchinson, A. M., M. D., Houghton Mifflin Co., 1909, p. 257.