

During the last pandemic this phenomenon of explosive onset was noticed chiefly in connection with military units where association in closely related groups was one of the exigencies of military life. It was quite evident in at least one of the epidemics which we had occasion to study that the characteristics of the outbreak in the military groups differed in this respect considerably from those prevailing at the same time among the surrounding population. Thus, at Chaumont, while the outbreak among the Marines and in some of the other military units took the form of the steep peak which we have described above, the disease extended more gradually and trailed along more irregularly and for a longer time among the clerical force who were scattered in many different billets and offices. And this was still more noticeable as regards the civilian inhabitants of the town, among whom the percentage morbidity was much lower and was scattered much more widely both as to time and place.

Moreover, even in military units like the Marine Company mentioned above, where the explosiveness seemed extreme and "mysterious," simple analysis removes much of the mystery. If we take this little outbreak as an example we see that 6 recognized cases had occurred on the two days preceding the sudden appearance of 19 cases on a single day. These 6 had been in the incubation stage for at least twenty-four and forty-eight hours previously, and probably did not represent the total of infected men; for it is more than likely that there were a number of others who were not sufficiently ill to report at sick call. If we consider, therefore, that at least 6 and probably more men circulated freely among the remaining 166, and ate and slept in close association with them, we find that the apparent suddenness of the rise in morbidity on the third and fourth days of the outbreak is not out of keeping with the assumption of contact infection. The impression conveyed by the steep graphs of such outbreaks is, therefore, apt to be misleading.

### *Secondary outbreaks*

In the wake of almost all influenza epidemics there have followed secondary outbreaks which are often spoken of as "waves." This has apparently been the case in all the large epidemics of which we

have definite knowledge. Leichtenstern has commented upon it extensively in connection with his study of the '89 epidemic.

After the epidemic of 1729 to 1730 there were secondary waves in 1732 and 1733.

The 1789-1791 outbreak did not become entirely quiescent until a definite secondary wave had followed in 1792.

The 1798 epidemic was followed by one in 1800.

After the outbreak of 1836 to 1837, others followed in 1838 and 1841.

The 1847 to 1848 epidemic was followed by another within a year, and conditions in the world did not return to normal until 1851.

Parsons writing for the British Isles states that there were three definite waves from 1889 to 1892. The first began in the winter of 1889 to 1890. Another occurred in the spring of 1891, a third in the winter of 1891 to 1892. The following chart (page 282) taken from the article by Frost and tabulated by months, from 1887 to 1916 for Massachusetts, from death rates per 100,000 from influenza and from all forms of pneumonia, shows that here, too, the epidemic of 1889 to 1892 developed in three distinct waves, the first one coming to a head in January, 1890, the second in April and May, 1891, and the third in January, 1892. The same thing occurred all over the world, and tabulations of individual cities like New York, New Orleans, Chicago, as well as studies in other parts of the world indicate a similar wave-like repetition.

Brownlee has attempted to find a law of periodicity for the large intervals between pandemics, and the intervals between the separate waves of each outbreak. Since statistical studies of pure uncomplicated influenza alone would for many reasons hardly be accurate enough as a basis for such calculations, Brownlee, Frost and other epidemiologists have reduced the factor of error by making their calculations both from influenza statistics and from total reports of all pneumonias, comparing these with the pneumonia incidence and mortality of interepidemic years. Brownlee has studied the weekly number of deaths for London from 1870 on. He finds the period between influenza outbreaks, between 1889 and 1896, to be about thirty-three weeks. There is no such periodicity in regard to bronchitis and pneumonia in the absence of influenza, and Brownlee concludes that if such periodicity appears after the return of influenza,

TABLE 1

*Death rates per 100,000 of population from pneumonia (all forms) and from influenza in Massachusetts, 1887-1916, inclusive*

## PNEUMONIA

YEAR	TOTAL PER YEAR	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
1887.....	138.8	19.5	16.7	1.9	22.6	16.1	7.7	5.5	4.1	5.6	9.0	14.8	15.3
1888.....	172.7	24.7	25.1	26.4	21.3	16.4	8.0	5.5	4.0	6.2	11.4	9.8	13.9
1889.....	156.6	17.9	16.3	21.1	19.8	14.9	7.5	5.3	5.2	5.4	10.6	13.2	19.3
1890.....	180.0	47.8	17.7	17.6	20.1	12.7	8.5	6.2	4.8	5.0	9.4	11.8	18.3
1891.....	188.5	20.6	16.4	20.6	25.1	23.9	10.1	5.9	4.0	4.0	7.7	13.8	36.4
1892.....	213.0	61.5	25.2	23.1	21.4	17.0	8.3	5.4	4.2	6.8	8.5	12.5	19.0
1893.....	225.8	27.3	25.4	28.6	33.1	27.3	11.1	8.0	5.0	6.1	9.8	14.3	31.9
1894.....	166.0	32.8	19.9	22.7	18.5	14.0	8.5	5.1	5.1	6.8	8.2	11.3	13.6
1895.....	184.1	19.1	34.4	30.8	20.9	14.4	7.6	5.6	5.3	4.7	10.5	13.4	17.3
1896.....	182.0	19.5	20.7	24.9	25.9	18.7	10.3	7.6	4.5	7.6	10.7	12.7	18.8
1897.....	181.6	21.1	24.9	31.5	19.7	15.2	10.2	7.0	4.5	6.0	11.7	13.1	16.9
1898.....	156.0	18.8	17.1	18.5	18.7	15.7	6.6	6.0	4.8	5.6	10.6	12.8	21.0
1899.....	181.3	37.5	25.8	20.6	18.4	14.0	8.9	5.0	4.8	5.8	8.2	13.2	19.0
1900.....	188.3	22.7	21.1	42.0	30.5	17.6	8.7	5.3	4.3	5.3	6.2	9.9	14.7
1901.....	167.7	22.6	26.6	26.2	19.9	13.9	7.7	3.4	3.4	5.7	9.1	14.2	15.1
1902.....	158.9	15.7	18.9	19.9	16.8	15.5	8.0	6.2	5.3	5.7	11.8	14.5	20.6
1903.....	172.5	25.2	25.8	25.4	18.1	16.8	8.2	7.0	4.5	4.6	7.7	13.3	18.9
1904.....	172.1	22.6	22.7	24.1	21.2	14.2	6.7	5.9	4.4	6.5	9.4	15.0	19.5
1905.....	178.3	24.7	27.7	23.6	17.1	15.5	8.5	5.6	4.8	6.2	8.9	15.8	20.0
1906.....	174.1	22.5	21.9	24.1	21.7	14.9	5.1	6.2	5.0	6.0	9.4	13.8	21.0
1907.....	180.4	25.5	24.4	23.4	18.3	14.3	9.5	5.1	5.1	7.1	9.3	12.7	26.9
1908.....	165.8	26.6	22.2	21.1	19.4	13.5	6.6	4.9	5.8	6.4	9.2	12.4	17.6
1909.....	170.3	22.1	20.0	26.1	20.1	16.0	9.7	5.1	5.0	5.4	8.9	13.6	18.3
1910.....	197.6	24.1	20.7	27.5	23.3	16.9	9.7	7.3	6.3	9.1	12.3	17.0	23.6
1911.....	174.4	22.6	27.1	23.9	20.2	16.9	7.2	6.7	6.1	6.7	9.0	11.8	16.2
1912.....	152.0	19.8	20.2	21.2	16.4	13.3	6.2	5.0	4.1	5.8	9.5	10.5	19.9
1913.....	172.2	23.5	22.8	24.9	19.3	17.1	10.7	6.2	5.4	6.7	8.3	10.4	16.8
1914.....	166.0	22.9	20.1	23.2	20.4	15.2	8.2	5.1	5.5	6.0	10.1	12.6	16.8
1915.....	176.0	17.8	19.3	28.5	27.7	13.6	6.6	7.1	5.8	6.0	8.8	9.8	22.1
1916.....	176.6	35.6	25.5	23.0	17.3	14.0	7.4	5.3	4.1	5.9	7.6	12.8	18.3

Taken from Frost, Public Health Reports, U. S. Public Health Service, xxxiv, no. 33, p. 4.

it must be definitely associated with this disease. From 1876 to 1889 the thirty-three-week recurrence was missed in regard to bronchitis and pneumonia, but in the years 1889 to 1896 it was marked. Comparing the monthly statistics of Glasgow, Aberdeen and Massachusetts he finds that there is nothing which differentiates them in principle from the phenomenon in London. Stallybrass supports these calculations of Brownlee, and speaks of a minor cycle of thirty-three weeks within the pandemic periods and major one of about ten years between pandemics. We are not ourselves in a position to comment upon these findings.

Pearl's paper "Influenza Studies" published in 1919, incidental to an analysis of the mortality curves of 40 American cities takes up the time manifestations as they occur in local outbreaks. He finds that such curves are of two main types, one showing a single well-defined peak, others showing a first high peak followed by one or more smaller ones. The latter type was of the usual form. A further analysis of these curves showed that there was a definite tendency for the "two-peak" curves to fall into two groups. About one-third of them had their second mortality maximum about eight weeks after the first peak. The remaining two-thirds had their second mortality maximum on an average of about thirteen weeks after the first peak. Those in which there was a third peak had their second one about 7.1 weeks after the first, and the third on an average of about 13.1 after the second. Pearl believes that according to this, the cycle in such successive waves appears to be nearer a multiple of seven rather than of ten weeks.

A great many statisticians, far more capable of judging of these matters than ourselves, are now engaged in a study of the cyclic phenomena and no doubt will publish their conclusions in time. Meanwhile, we wish merely to mention the matter as one of the important problems of influenza study undertaken at the present moment.<sup>2</sup>

The second and third waves of epidemics have been marked by a number of characteristics which are of important significance. Both

<sup>2</sup> For a more extensive discussion of the problem of periodicity and its probable significance, we may refer the reader to the extensive monograph of Warren T. Vaughan, published since this paper was first prepared.

Parsons and Frost find that in the epidemic of thirty years ago the mortality was progressively higher during the 1891 to 1892 waves than during the original outbreak in 1889. Leichtenstern states that although the mortality, which of course is largely due to secondary infection, is greater during the secondary waves, the general morbidity of influenza is smaller. This corresponds with the observations of Wutztorff who analyzed the epidemic in Germany with considerable care. Wutztorff admits that it was extremely difficult to obtain accurate estimates of influenza morbidity during the later waves of the pandemic. But, although he finds that in some towns, especially in North Germany, the 1891 to 1892 wave was almost as extensive as that of 1889 to 1890 had been in other places, in general the morbidity in Germany was much lower. To some extent his conclusions are derived from indirect evidence such as, for instance, the fact that the hospitals in the various cities were not taxed to overflowing during these later waves as during the first, massive infection of the entire personnel of many industries and of railroads did not take place to the same extent, and the statistics of the government physicians stationed in various parts of Germany showed that a much lower percentage of the population sought medical advice. As a rule, from 6 to 7 per cent of the population sought treatment during the first epidemic, whereas only from 2 to 3 per cent reported during the later waves. It would be impossible to reproduce the extensive statistical and other evidence brought forth by Wutztorff in support of his contention, but we may assume as probably correct that in the later waves morbidity is usually lower and the percentage mortality somewhat higher than during the first.

Noticeable also is the fact that secondary epidemics do not travel with the same speed and to the same geographical extent as does the first wave. There is generally slower progress, a greater scattering of cases, and a somewhat more prolonged period of prevalence in the subsequent waves; and, judging from the careful study of mortality statistics in years following the pandemics, it is more than likely that after the so-called third wave there may be a succession of what we may term gradually diminishing "ripples" which finally fade out, in the course of some years, into practical quiescence. Leichtenstern seems to believe also that the secondary outbreaks are characterized

by the fact that they originate in many different foci simultaneously instead of proceeding (as he and some others assume that first waves do) from a single focus. Netter holds the same opinion. He says of the secondary waves of the 1889 pandemic that "they have appeared in separate, synchronous or successive explosions, and we have not been able to trace any connection between various reappearances in different places, as this was possible in 1889. There seems to have been an independent reawakening of the epidemic in different localities." In a general way this is probably true, but we will see, when we come to discuss the course of the first wave of the last pandemic that some of the most experienced epidemiologists are reluctant to assume that this outbreak proceeded from any single world focus.

*The origin of influenza epidemics with particular reference to the origin and course of the last pandemic outbreak (1918)*

In a recent address to the Congress of American Physicians and Surgeons, Flexner made the interesting suggestion that perhaps the most effective method of forestalling epidemics in the future would be to search out and attempt to circumscribe the endemic foci in which the cinders of disease are constantly smouldering during the inter-epidemic periods. This method of procedure has been effectually initiated in the case of yellow fever, and would seem to be an eminently logical one for application to other insect borne diseases. It might also be successfully applied in plague and conditions like it in which interepidemic propagation is carried on largely in animals. In regard to other diseases the promise of even partial success would be directly dependent upon the question as to whether the particular condition is kept alive, between outbreaks in special centers in the world or whether the foci are widely scattered in all populations in the persons of carriers, constantly increasing in number along the trail of sporadic cases, as in typhoid and the paratyphoid fevers, etc.

The idea is an extremely important one since any step in the direction of interepidemic control of foci, if attended by even a slight degree of partial success, would accomplish more at smaller expense than the most energetic attempts at suppression after epidemics have started. Moreover, the splendid efforts which are being made, at the present time, to internationalize public health activities pro-