CHAPTER X.

A GENERAL DISCUSSION OF THE EPIDEMIOLOGY OF INFLUENZA.

In previous chapters we have described the observations upon the late epidemics made by ourselves or communicated to us by other British epidemiologists and the clinical and bacteriological facts have been recounted by experts. It remains to redeem the promise of our preliminary chapter, to indicate the modifications of general epidemiological theory relative to influenzas which are imposed by the events of the last three years. This chapter, then, will be devoted to a general study of the events, and is intended not to expound any " official" theory, but to suggest to other epidemiologists trains of thought, the pursuit of which may lead to the attainment of important truths and will at least tend to a clarification of ideas. It is the merest sciolism to imagine that the necessarily partial and incomplete investigations of a few months or even years can authorise the promulgation of a symmetrical and comprehensive theory of such events as we have witnessed. The problem of influenza is still unsolved ; its solution will be one of the great events in the history of medicine.

Notwithstanding the prominence accorded to the epidemics both in the newspapers and in common talk, it may be doubted whether the general public or even the medical profession have realised that the epidemics of 1918-19 rank in respect not only of absolute but even of relative mortality not lower than third and perhaps second upon the roll of great pestilences. No epidemic of smallpox or cholera, not even the typhus periods of the earlier years of the 19th century, can vie with the influenza of 1918-19 as agents of destruction. Some of them, indeed, were more deadly within a narrow circle—the famine typhus of Ireland is an example—and in the worst years of the new cycle of Indian plague some parts of that Empire suffered more than in 1918-19. But the gross mortality due to influenza in the autumn of 1918 far exceeded that of any year or of any three or four years in the recent annals of the bubonic plague. There are in fact only two loimological events which can be brought into comparison with the late pandemic, the plague of Justinian's reign and the 14th century Black Death.

Of the pestilence in Justinian's time, little can be said. " In " time, its first malignity was abated and dispersed ; the disease " alternately languished and revived ; but it was not till the " end of a calamitous period of 52 years that mankind recovered " their health or the air resumed its pure and salubrious quality. " No facts have been preserved to sustain an account, or even a " conjecture, of the numbers that perished in this extraordinary

mortality. I only find that during three months 5,000, and at length, 10,000 persons died each day at Constantinople ; that many cities of the East were left vacant, and that in several districts of Italy the harvest and the vintage withered on the ground. The triple scourge of war, pestilence, and famine afflicted the subjects of Justinian, and his reign is " disgraced by a visible decrease of the human species, which has never been repaired in some of the fairest countries of " the globe."*

Our knowledge of the 14th century pandemic is a little more exact, and, for reasons which will appear in the sequel, we shall devote some paragraphs to the study of this pestilence which may fairly claim the first place among the " captains of the men of death."

The European position in 1347 with respect to plague differed from that relating to influenza in 1918 in one important particular. While, as we have seen, *an* influenza had been domiciled for some time before 1918, there is no certain evidence of localised plague and no evidence at all of pandemic plague in Europe between 1348 and the century following the pandemic of Justinian's reign. It is, however, known that for generations before 1348 plague had been endemic both in China and in foci to the north of Hindustan ; it is equally sure that commercial intercourse between Europe and the East, carried on by the overland route, had been constant and frequent for at least a century ; indeed there was more intercourse between the two civilisations than obtained during the two succeeding centuries, when, for a variety of reasons, the overland trade was suspended. The subsequent identification of China with Cathay and of Peking with Marco Polo's Cambulec was a product of maritime explorations in the Elizabethan era. We have, therefore, to learn why plague was only effectively imported into Europe so late, and the natural explanation would be that towards the middle of the 14th century the plague in China became especially infective, and as a token of this we should expect to find the years immediately before 1348 thick set with records of pestilence in the Chinese annals.

These annals have been studied by several epidemiologists, with a result entirely contrary to the expectation. The events which secure pride of place in the annals of the half-century before 1348 are not pestilences, but famines and earthquakes. It is not until 1352, *i.e.,* after the great European death, that plagues become conspicuous in the Chinese records. As Creighton observes : " Every year from 1352 to 1363, except " 1355, has an entry of ' great pestilence ' or 'great plague' " (yi-li), in one province or another, although the old tale of

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* Gibbon, *Decline and Fall of the Roman Empire,* Chapter XLIII. (Gibbon derived his medical knowledge from Mead; the duration in time of the plague was probably much greater than 52 years).

" floods and famines lias come to an end in the annals. The " last of the nearly continuous series of great pestilences is in " 1369, when there was a great pest in Fukien, and ' the dead " lay in heaps on the ground.' "*

It is, therefore, not true that before the Great Death epidemic plague was exceptionally virulent in its original home. Another point to mark is that the Great Death at its inception was an epidemiological type of plague which has never since appeared in epidemic or pandemic form upon European soil. The plague experience of London in later times and of much of Western Europe towards the end of the 17th century was strictly *in pari materia* with that of modern India, a typical bubonic plague. Of the original form of the Black Death and of its subsequent change of type we have the witness of Gui de Chauliac, the surgeon of Pope Clement VI. at Avignon, where the plague began in January 1348. " It was," he says, " of two kinds ; the first lasted two months, with con- ' stant fever and blood-spitting, and of this people died in " three days. The second lasted for the rest of the time with ' continuous fever, buboes, and carbuncles *(apostematibus et* " *anthracibus)* in the outward parts, especially the armpits and " groins. These died within five days. Such was the con- " tagiousness, especially when there was a spitting of blood, " that not only by remaining with but merely by gazing upon " the sick, one took the disease, so that they died without " attendants and were buried without priests. A father would " not visit his son nor a son his father ; charity was dead and " hope prostrate."†

Even if we could adopt a sceptical attitude towards the statement that the clinical form was a *primary* plague pneumonia, we must hesitate to suppose that infection was conveyed only indirectly as in modern instances. How special the modification of biological characters in the *bacillus pestis* must be to agree with the epidemiological facts need not be enlarged upon. Most epidemiologists, especially perhaps Sticker, have recognised that the formula, rat-flea-man, does not describe the primary pandemic of 1348.

We have then to account for :—(1) The importation of the disease at a time not *prima facie* favourable to importation, certainly no more favourable than any year for a century before ; (2) A very special clinical and epidemiological type of disease after importation. Let us turn to the immediate circumstances attending its introduction. These are furnished in the contemporary narrative of Gabriel de Mussi, to whose testimony

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* *History of Epidemics in Britain,* vol. *L,* p. 153. It is of some interest to note that in 1888 and 1889 serious floods occurred in China, and large numbers of persons were rendered homeless. *(Influenza,* E. Symes Thompson, London, 1890, p. 415.)

† Transcripts of all the important original descriptions of the Black Death are printed by Haeser, *Geschichte der Medicin,* Bd. III., pp. 157-182.

Haeser, Creighton, and Gasquet all attach importance. De Mussi traces the direct origin of the European plague to a company of Italian traders who, with their merchandise, had taken refuge from predatory hordes of "Tartars" in the Crimean town of Caffa. In this town the merchants stood a siege of, he says, three years. They were, it seems, grossly overcrowded, but not famished. (Ibique hostium exercitu infinito vallati, vix poterant respirare, licet navigio alimenta ferrente, illud talle (sic) subsidium intrinsecis spem modicam exhyberet.) Eventually a plague broke out amongst the besiegers, from whom it was communicated (it is said by hurling corpses into the town) to the townsfolk. So great was the mortality that the siege was raised. The clinical form of disease amongst the besiegers was *bubonic* plague—the expressive words are : " signati corporibus in juncturis, humore coagulato in inguinibus, febre putrida subsequente," and the surviving merchants took ship to Europe. Wherever survivors landed, first at Genoa, subsequently at Venice and Marseilles, the plague broke out, spreading under the forms and with the mortality which are historic*

The epidemiological importance of this train of events is considerable. Intercalated between the plague in its primordial home and the western pandemic is a period of maturation within a besieged city ; from the fugitives of that city the subsequent extension of the plague through Europe can be can be followed unequivocally. It is difficult to resist the conclusion that the specialised exaltation of virulence sustained by the *materies morbi* was a consequence of frequent passage from host to host within the beleaguered town. Of significance, too, is the fact that those in contact with the group of persons who, by hypothesis, provided the field of variation and development, experienced the sickness at least as severely as—perhaps more severely than—the original hosts. The " Tartars " were ravaged and the mortality in Europe was prodigious.

It will naturaly be objected that inferences from the handful of statements not characterised by obvious rhetorical exaggeration, which are our sole criterion of the 14th century plague, are dangerous, and that we should at least bring into comparison some modern epidemic of like nature. We cannot, of course, cite any epidemic on the same scale, but in the winter of 1910-11, Manchuria and China experienced an outbreak of primary pneumonic plague resembling in its broad features the great death of the 14th century, although its dispersive power was much smaller.

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* Gabriele de Mussi was a notary, of Piacenza, and died in 1356; he was not present at Caffa during the events he described. Caffa, sometimes known as S. Feodosia, was an important trading centre of the Genoese and the cathedral city of a diocese. At the time of the plague it was the centre of almost all commerce between Asia and Europe—vid. Canale, *Delia Crimea, del suo commercio e dei suoi dominatori,* I., p. 208, cited after Gasquet, *The Black Death,* 2nd edition, London: 1908, p. 5.

It is full of epidemiological interest to notice that, although experts differed as to whether the original source were the conveyance from a rodent, the " Tarbagan," to man of a primarily bubonic infection subsequently modified by passage, or whether the primary source were naturally occurring sporadic pneumonic plague, there is no doubt that one stage of the epidemiological evolution was completed in a temporarily overcrowded town. The epidemic was traced to Manchouli, an Asiatic town, the normal population of which was 500 Russians and 2,000 Chinese, but, during the Tarbagan season, the Chinese increased to 10,000, and " they crowd into very poor hovels or inns, where, with " piles of raw pelts, they may often be found living, sleeping, " and eating, from 20 to 40 in the smallest of badly-ventilated " rooms."'* Dr. Petrie adds the significant remark : " Curiously " enough, it is stated that the hunters are free from the disease " during their sojourn in the open country, and that it is only ' when they congregate in the overcrowded caravansaries of " Manchouli and Hailar that they are subject to attack from " Plague."

In other words, a period of intensive overcrowding separated the endemic from the pandemic stage in Manchuria within our own memory, precisely as occurred 570 years ago in the Crimea. We do not, of course, press this analogy far. We have no evidence that the overcrowding in the hunters' settlement was more intense in 1910 than in any of the previous years which did not witness a dispersive plague. Yet, as we think, the parallelism is illuminating.

The inferences to be drawn from this history are that the infective power of a *materies morbi* may be specialised and exalted if it be given an opportunity of repeated passage through a considerable number of hosts, and that when the newly-acquired property has become temporarily stable, dissemination of the organism will lead to a pandemic, and that for the realisation of a pandemic it is not essential that the conditions initially needed to produce the modification shall be present.

We have now to consider whether the facts elicited respecting a disease essentially unlike influenza in one respect, viz., the specific determination of its *materies morbi* and its usual clinical evolution, similar to it on this present occasion by virtue of its extreme diffusibility and original predilection for causing death by an apparently primary pneumonia, throw any light upon the recent pandemics.

We must first of all contrast as sharply as we can the epidemiological findings of 1918-19 with those of earlier pandemics. The first wave, that of, in England and Wales, the summer of 1918, both with regard to the form of the case curve plotted against time as an abscissa, and with regard to the fatality rate, differed little, if at all, from the experience of

* Report of the International Plague Conference held at Mukden, April 1911, printed at Manila, 1912. p. 413.

1889-90. True it occurred not in winter but summer, but the summer influenza of 1782 is a sufficiently recent precedent on a large scale to admit of our judging season to be a non-essential. On the other hand, the age incidence of the disease was different —we think significantly different—from that of previous local epidemics or of the pandemics of earlier years, such as 1889-1893 or of 1907-8. In this primary manifestation we detect a shade of difference. It already appears that the *materies morhi* had suffered a change, making it apt to develop within the bodies of the young adults, not yet, however, prone to destroy them.

The autumn wave accentuates the distinctions and minimises the agreements between past and present. As points of agreement, we still have a reasonable concordance between the form of the wave and that of earlier secondaries, but even here it is to be observed that the interval was shorter between the sucessive phases than on any previous occasion. The distinctions are a continuance of heavy incidence upon the young adults and an exacerbation of the rate of mortality. The proportional death rate at ages 20-40 continued to rise ; hence, as the incidence rate upon these ages was relatively slighter than in the summer, the fatality rate must have increased. The third wave, although it exhibited some tendency to revert toward the earlier type—that of the 90's—was more like the secondary than any predecessor.

It follows, then, that we have no complete parallel with the Black Death ; the train of events is a longer one. If we bring the two later waves of influenza into comparison with the European history of the Great Death, there is a similarity. The first of these secondary waves corresponds to the initial form of the plague, its first few months of severity. The second resembles the subsequent manifestations, which, although greatly more fatal than later epidemics (save a few special instances, such as the London plague of 1665), conformed more nearly to the natural type of epidemic bubonic plague, as the last wave of influenza differed less from the classical form (although absolutely it differed much) than its predecessor.

If, then, there be any aetiological similarity, we must discover in the circumstances immediately prior to and during the first wave of influenza something akin to what took place within the walls of Caffa in 1346-47.

But this is no difficult task. The circumstances of the ancient Crimean town were reproduced in countless foci throughout the world. Whether it be larger or smaller aggregations of troops in the theatres of war, training units in the belligerent states, aggregations of operatives within the factories of both belligerents and neutrals, temporary or long-continued congestions of humanity due to dislocation of transport or to altered distribution of population, all these were occurring, not in one state but universally.

But there remains a broad distinction between the two pandemics, inasmuch as throughout the whole of western Europe, in the early summer of 1918, influenza was epidemic, with a modified age incidence, but retaining its former low fatality. The distribution seems not to have been so widespread in the new world, but, over and above such camp outbreaks as that of Funston, it is plain that in various States of the North American Union a mild influenza was epidemic in the spring of 1918. It might therefore seem otiose to seek in the disseminated foci of human concentration the source of that exaltation of virulence which characterised the second and really calamitous outbreak rather than in the general sanitary and economic circumstances of the populations of the different centres. We think that an explanation of the sort last indicated is impossible, for the following reasons: There is no evidence in the general vital statistics collected by Dr. Low and discussed elsewhere in this report that the mortality caused by the second influenzal wave was proportionally higher in those countries or populations especially affected by war privations. We have called attention to the case of Ireland, and we would note that of New Zealand. In New Zealand the havoc wrought by influenza much exceeded that experienced in the crowded cities of Great Britain. We have also pointed out in an earlier chapter that the correlation of the influenzal death rates in the first wave with the pre-war standardised death rates of the great towns in England was substantial, but very much lower in the second wave. The interpretation of these statistics is not, indeed, simple. There is some reason to think that the distribution of mortality rates in the second wave was influenced by the acquirement of a partial immunity, but a broad view of the whole of the facts inclines us to suppose that the intensification of virulence must be referred, not to the general conditions of the population so far as these pertain to domestic housing or nutrition, but to the continued operation of some special factors.

If we suppose that the first modification of the *materies morbi* which called into being the epidemiological type of the first wave, differing from previous influenzas in its selective affinity for young lives, but not highly virulent, was indeed the widely scattered distribution of centres of acute demographic congestion, in camps, factories, &c.; then, as these conditions were not relieved but intensified as the war approached its crisis, it is natural to think that a further modification of the virus which had already become adapted to multiply in the tissues of that section of the population which had previously exhibited great resistance, a modification importing not merely high infectivity but extreme toxicity was generated by the conditions still acting. This hypothesis will account for the almost incredible fatality of the second influenza, not only in transports but also in some civilian communities, such as New Zealand, into which it was directly introduced from crowded

ships, *i.e.,* from the very milieu which we suppose to be a prime factor of the imposed modifications both of infectivity and toxicity. We shall also understand why there is little evidence that *domestic* conditions of overcrowding affected the distribution of the disease within an infected town.

Our general theory of the epidemiology of influenza may now be enunciated.

It will appear that the *materies morbi* of the disease is and has long been wide spread but that neither in dispersiveness nor toxicity was it often able to maintain itself upon a high level of efficiency. At irregular intervals some strain or strains of the organism acquired a high power of diffusibility. Since, at least in English experience prior to 1889, the development of an influenzal wave was preceded by peculiar changes in the public health, in particular a prevalence, sometimes for more than a year of anomalous fevers and nervous illnesses, we can suppose either that the *materies morbi* was undergoing a series of modifications, of which these strange illnesses were the clinical manifestations, or that the acquirement of effective dispersiveness was not so much a consequence of bacterial modification as of change in the properties of the human host. The former explanation, in view of our general epidemiological history and the special researches into morbid periodicity which we owe to Brownlee, is the more probable.

Towards the close of the 19th century some general change took effect, either the *materies morbi* was able to retain, whether generally or locally a higher grade of diffusiveness than it had formally possessed save at long intervals, or the demographical conditions which lead to the evolution of that property were stabilised, with a consequence that, subsequently to 1889, epidemics or pandemics have recurred at much shorter intervals and have been characterised by a higher virulence than before. It is probable that both factors have concurred. The comparatively abrupt change in the year 1889 pointed to a biological modification or sport, the subsequent events to the continued operation of the cause group, perhaps decentralised housing and the expansion of means of communication, of a demographic order. The causative organism having now acquired a relatively high and stable power of diffusibility due to the co-operation of factors mentioned, there remained the possibility of a further modification in the direction of increased virulence. The historical facts of the Great Plague of 1347-50 suggest that a very remarkable intensification of virulence may be effected if *materies morbi* is afforded frequent opportunities of transfer amongst a number of hosts confined within narrow limits but absolutely numerous enough to afford considerable variations of soil. In effect, the virulent and diffusive infection which destroyed half the inhabitants of Europe in the middle years of the 14th century seems to have passed through a Crimean ante-chamber wherein it developed the special properties

which characterised it during the subsequent pandemic and differentiated it from either earlier (in the east) or later (both in east and west) manifestations of epidemic plague. It appears that the part played by the Crimean focus in that pandemic has been played by many different foci throughout Europe and America during the year 1918, that to these we must attribute the temporary fixation by the organism or organisms of influenza of its second and deadly property.

The story then of the germ of influenza is divided into three phases. The first which lasted for many centuries was, if we may be permitted to use teleological language, a series of attempts to maintain a high level of infectivity or dispersiveness, which attempts were unsuccessful. The second phase ushered in by the year 1889 is marked by a partial victory of the germ, a fairly constant infective power has been secured and much infection is produced throughout the world at frequent intervals, but the toxicity relatively to the infectivity is still slight. The final phase is of complete victory, infective power is maintained, even enhanced, and to this is added a toxicity surpassed by few epidemiological competitors*. Viewed as a contest between man and " germ," it would seem that in the congestion of public transport and the multiplication of public assemblies and entertainments, features which increasingly characterise the development of the European type of civilisation, a strategical advantage was given to the enemy. Finally in the provision of countless incubators, whether in garrisons, war-time factories or abnormally over-crowded and ill-ventilated means of transport and places of entertainment, the opportunity was afforded for the development of destructive powers which secured to the enemy a decisive and overwhelming victory.

Such is the general theory of epidemiology which we are led to adopt as a working hypothesis. We must distinctly and categorically assert that it is *only* a working hypothesis and one which further research may altogether displace. Confronted with the usual explanation, viz., the random occurrence of an extreme variation, a sport of the *materies morbi* in an unidentified nidus, it does, we think, offer advantages. The latter explanation does not fit in the other parts of the puzzle; it leaves as merely fortuitous concurrences, so far as influenza is concerned, both the general demographic changes of the past 40 years and the special alterations of human life which have been imposed by the war: in a word it regards the pandemic as "an act of God." Our hypothesis does, at least, assign to works of man an intelligible role in the evolution of the drama. Man first by facilitating the intercourse and close temporary aggregation of human beings with various biological

* If the Middlesbrough epidemic (*supra*, p. 17, footnote) be regarded as an "influenza," considerable toxicity and slight dispersive power have been combined in particular outbreaks before 1890.

aptitudes, has afforded opportunities of bacterial modification and selection, has done so with, steady increasing persistence for many years. Since the war he has involuntarily experimented in intensive cultivation ; both these actions have, in our view, been essential links of the chain of causality. But that what we have postulated is no more than a working hypothesis is sufficiently demonstrated by the fact that the very events in the history of the Black Death which fit so aptly into our scheme were used by Creighton skilfully and successfully to interpret the Black Death in the sense of Pariset's hypothesis that plague is a soil disease due to putrefactive changes in the earth dependent upon the presence of corpses and engendered by the soil disturbances of the east following a succession of great floods and earthquakes. No reader of Creighton's chapter on this subject unacquainted with the subsequent history of epidemiological and bacterial investigations into plague could deny that the hypothesis was an excellent working hypothesis, describing adequately the facts then known. Equally no reader familiar with subsequent events can doubt that the hypothesis is entirely false. Such may be the fate of our own speculation. Yet it is false science to neglect the teaching of a working hypothesis, the practical inferences deducible from it, because it may ultimately have to be rejected. It has often happened in the history of the human mind that a hypothesis subsequently discarded has prompted inferences both true and valuable, as happened in the instance of the corpuscular theory of light or even the phlogistic theory of heat. Not all the inferences of Galen and Aristotle from faulty physiological premises have perished with the hypothesis originally authorising them.

The first inference from our hypothesis is that in the seeming conflict between man and his microscopic competitors, there can never be a time when man is securely master of the universe. Intoxicated by the victories achieved over the plague (in Europe) over the enteric group, over typhus (in western Europe) and over small-pox, we are too apt to suppose that the campaign has ended in our favour, that we have little more to fear from the typically epidemic diseases and may concentrate against the endemic group. That we have just passed through one of the great sicknesses of history, a plague which within a few months has destroyed more lives than were directly sacrificed in four years of a destructive war, is an, experience which should dispel any easy optimism of the kind. No instructed epidemiologist can say that the world may not have to endure during the next half century other plagues of the first order of severity.

The second inference is the essential solidarity of all mankind in the matter of epidemic sickness. In a narrow sense, this solidarity has been realised since the beginnings of western civilisation. The conception of a sanitary cordon, the barring out or sealing up of an infected territory is, indeed, an old

notion. But our hypothesis extends this conception greatly, and enables us to see that the sanitary cordon is but a very small part indeed of a supra-national system of preventive medicine. The dangers to the world from epidemic sickness in this matter of influenza are enhanced in two ways. The inevitable trend of the movement of population will keep the infectivity of the organism at a high level. This we may face with equanimity. But if anywhere in the world there be large collections of men, whether through war or economic strife, or through that dissolution of civil society, which a certain degree of collective misery and disorganisation entails, herded together *en masse,* there will be opportunities for the other modification of the *materies morbi* which renders it apt to conquer the world. No sanitary cordon, no quarantine, will shield us from this danger. The porters of the infection may not be sick ; to exclude even the sick has often been found a task beyond the powers of a quarantine authority; land quarantine has, in fact, never yet succeeded. To realise that the material well-being of the inhabitants of a foreign—perhaps even a hostile—country is a pressing concern of ours is very hard. Yet the teaching of this pandemic is that it is a hard truth. \ Any supra-national organisation for the control of epidemics will need to face it. The popular belief that misery breeds disease is strictly true, and the influenza of 1918-19 is no exception to the rule The history of the world has never yet provided an instance of a mortal and highly-dispersive illness among the antecedents of which human misery did not assume a prominent place. Not necessarily, indeed, a universal misery; the town of Caffa, in 1347, was not typical of mediaeval Europe, nor was Ireland of the potato famine, nor were the industrial towns of Lancashire at the end of the 18th century generally characteristic of their time. Yet the absolute extension of misery has always been great before a plague, and has assumed a form different from that afflicting the populations in settled times.

If our general diagnosis be correct, what is the world's outlook upon future pestilences or dangers of pestilence ? It is, we think, gloomy. The conclusion to which we are led is that the generation of a great pestilence such as influenza or pneumonic plague is dependent upon disturbance of social order involving for absolutely large numbers of human, beings the endurance of conditions of insalubrity which afford for invading parasites a suitable field of modification. So soon as the new properties have been stabilised no barrier against the pandemic or epidemic extension will avail, nor will those individuals or nations who have not suffered the primary evils be more resistant to the disease than their fellows.

No impartial spectator can doubt that at the present time, and almost certainly for a generation to come, there will exist in many nations and over wide tracts of country precisely the type of misery which we suspect to be the

appropriate forcing house of a virulent and dispersive germ. In ancient times, at least after the breakdown of the primary civilisations, when there was nearly as much misery in the world as now, the non-centralised character and relative insignificance of manufacturing industries hindered the development of urban aggregations upon a large absolute scale (relatively, in terms of inhabitants per house or per room, mediaeval cities were probably more overcrowded than most modern towns). At present the poor and miserable must herd together, and will not die quietly in their hovels. These are evils the removal of which is not within the province of epidemiologists to discuss. We can but note them and remark that no technical device of the sanitarian, no resource of the laboratory, can have any effect in the reduction of death and sickness from epidemic or even endemic disease at all commensurate with the consequences which must follow a *universal* improvement of the standard and conditions of life.

Admitting, then, as highly probable that destructive epidemics or pandemics of respiratory disease will recur during the present generation, it remains to inquire what conjectures we may properly make as to their time of occurrence and the form likely to be taken, and then finally to consider what palliatives are available.

Epidemiologists owe a considerable debt of gratitude to Dr. John Brownlee, Statistician to the Medical Research Committee, for his introduction to epidemiological research of the method of harmonic analysis. When a long series of data is available it is possible by arithmetical methods to determine *(a)* whether the phenomenon is periodic, recurrent, and *(b),* if periodic, what is the probable interval between successive maxima or minima. Hence, if the conditions as to data be realised, it is possible to determine beforehand when an assigned epidemic disease may be expected to prevail with a more than average intensity. Some who have not sufficiently attended to the matter have objected that the conception is fatalist, that it amounts to postulating of epidemic diseases an inevitableness which deprives sanitary administration of any hope or basis of success. The very reverse of this is the proper inference. What periodic analysis suggests is that the *materies morbi,* like other forms of life, pass through cycles of change, rendering them more or less apt to succeed in the struggle for successful existence which is the law of all life. In the most favourable case, we shall be able to predict, not that a great and devastating epidemic will occur at an assigned time, but that then the conditions will be most favourable for the generation of an epidemic. This being known, we can so act, not that there will be no epidemic, but that its ravages may be mitigated, perhaps altogether checked; If, for instance, we could suppose that the conditions favourable to the eruption of an influenza would be exceptional, say, during the month of February 1921, we should take pains to

limit the occasions of exultation of virulence upon which, we have dwelt above ; we should also bring into operation the other palliatives of which we have yet to speak.

In an appendix to this report we have reproduced Dr. Brownlee's contribution to the subject, and we have elsewhere indicated the material limitations to which it is necessarily subject. We may say generally that the principal practical weakness of the method in its application to the study of influenza is that the *materies morbi* of the disease is evidently subject to rapid evolution of type, and that we have no sufficient grounds for supposing that the characters acquired have now become so stable that deductions from past records will afford a secure basis of prediction of future events. Hence, although we consider that the epochs of emergence predicted by the method should be looked upon as times worthy of special administrative attention, we do not think the occurrence of devastating epidemics at times not predictable by the process can be deemed very unlikely.

We have next to consider the probable fatality and age of attack in future epidemics.

History teaches us that, both in interpandemic periods and in pandemics before the late events, influenza endangers the extremities of life. There is also evidence that in the late pandemic the final phase was indicating some reversion to what had been the normal type. No doubt Ave cannot put much weight upon this, since the season of the third wave in this country was a time of year normally fatal to the very young and very old ; but it is permissible to think that manifestations of epidemic influenza in the near future are likely to revert still more towards the previously stable type of age incidence, and that toll will be taken of the very aged. We must not, however, omit to notice that if oar general hypothesis be correct, and if the opportunities of modification are still provided lavishly throughout the world, we may again witness an intensification of the young adult and early middle age type of infection which has done so much mischief.

Thirdly, Ave must inquire whether any material limitation of invalidity or mortality is likely to follow the survival of a large number of persons attacked in the recent pandemic.

We have discussed this matter of naturally acquired immunity at such length in Chapter VI. that we can express our general conclusions briefly. It is, Ave think, probable that, on the average and in the majority of districts, a previous attack of influenza confers some protection upon those again exposed. But from the complete failure to discern any protection in particular districts and the large number of second attacks within a short interval in most districts, it seems probable that the prophylactic value of a previous attack depreciates rapidly and cannot be depended upon to create any national or communal protection against a second or third visitation.

Summarising our conclusions, we think that recurrences of influenza in epidemic or even pandemic form during the next few years are very likely to be seen ; that they will exhibit a partial reversion to the age type known before 1918 ; and that naturally acquired immunity, although real, is inconstant.

Finally we shall discuss the palliatives which seem of most value. Amongst measures of public sanitation, we have remarked above that limitation of the occasions of casual crowding are probably the most important. Improvement of means of public conveyance, whether by additions to rolling stock or by acceleration of service, should at least mitigate the congestion of the suburban railways. It is a matter of common observation that there has been no improvement, rather a deterioration, in this respect since the armistice. We view the conditions under which outworkers are still conveyed to and from London and other large cities with anxiety.

The thronging of theatres and picture houses is, we think, a source of danger, although we are unable to say that this is a more serious danger than that the travelling public is forced to endure. It may perhaps be doubted whether exhibitions of moving pictures ought to form so large a fraction of the amusements of our urban populations ; but the prohibition of such spectacles, even were it practicable, would leave so much casual overcrowding untouched, and the actual effect of closing picture houses and theatres upon the progress of an epidemic has been so doubtful, that we do not expect that much can be usefully done in this way. It is, however, reasonable to demand that a high standard of ventilation should be attained.

A national resort to prophylactic inoculation is a measure upon which we cannot yet express an opinion. It is plainly desirable that the medical profession and the public should have ample opportunities to test a method which, at the worst, can do no harm, and steps to that end have already been taken by the Ministry of Health. Until the resistance of the inoculated has been tested by exposure to the disease, judgment must be reserved.

The possibility of keeping a virulent infection at bay by imposition of quarantine has been considered. The Medical Director of the Quarantine Service of the Australian Commonwealth, Dr. J. H. L. Cumpston* has collected data which suggest that the application of strict quarantine to vessels bound from infected countries delayed the outbreak of influenza within the Commonwealth, the disease not appearing in epidemic form until January 1919 and causing proportionally and absolutely many fewer deaths than in New Zealand where similar rules were not enforced.

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* Influenza and Maritime Quarantine in Australia. Service Publication No. 18, Quarantine Service. Melbourne, 1919.

The recorded facts are certainly consistent with Dr. Cumpston's hypothesis, but in view of the great variations of mortality and appreciable variations of date of incidence in states which did not and could not apply the Australian system in its full rigour, it may be doubted whether any certain inferences should be drawn. So far as the passenger traffic of this country is concerned it may be regarded as probable that no methods of general quarantine would be of the least effect. In the event, however, of the arrival of a vessel upon which a severe outbreak had occurred and which harboured persons still gravely ill it is a matter for consideration whether a few day's isolation might not be enforced.

We have dealt elsewhere with the question of hospital treatment and think there is no doubt that a carefully arranged scheme of nursing and hospital accommodation would diminish the number of deaths attributable to an epidemic. This, however, in so far as it has not been dealt with elsewhere, is a question of administration the details of which must vary with local needs and does not, therefore, come within the scope of this general discussion.

Thus far we have considered prophylactic or palliative measures a responsibility for the application of which must chiefly rest upon the community or its executive officers. There remain the things which each individual can do for himself. We have no doubt that faithful attention to the petty details of personal hygiene, measures directed to securing hygienic habits of life, the avoidance of excess, in a word obedience to the plain rules of physiology are as important as any more specific measures we can devise.

With these remarks we may conclude our examination of the events of the great pandemic. We hope that the information collected in this report will be of service to the student both of medicine and of sociology and that the record of phenomena has not been obscured by the avowedly provisional interpretations which we have offered. Much still remains to be done and perhaps the next decade will provide the key of mysteries still locked securely against us. We hope that the mechanism of pandemic and epidemic sickness will be unveiled and that a far more precise description of the successive phases of its evolution will be rendered, such a description as is possible for but few diseases now, perhaps for malaria and bubonic plague alone. Yet we do not doubt that the basal conception, the notion inhering in the very word plague will remain unshaken. Not that a plague is the arbitrary stroke of some supernatural power, but that it is the inevitable reaction of human society to a disturbance of social hygiene and is, therefore, ultimately within our control, not through the utilisation of specifics but by an harmonious adjustment of living between the members of all the human family.