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The Croonian Lectures  
OR  
PLAGUE

SIMPSON



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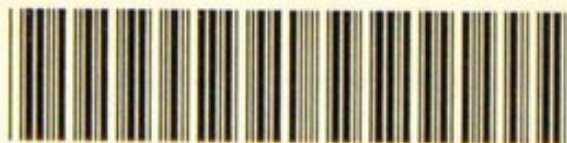
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# The Croonian Lectures

ON

## PLAGUE

*Delivered before the Royal College of Physicians of London  
on June 18th, 20th, 25th, and 27th, 1907*

BY

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OF PLAGUE IN HONG-KONG, 1902, ETC.

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# The Croonian Lectures

ON

## P L A G U E.

### LECTURE I.

*Delivered on June 18th.*

#### INTRODUCTION.

MR. PRESIDENT AND FELLOWS,—I esteem it a great honour to have been asked to deliver the Croonian lectures for this year and it is with a deep sense of responsibility that I undertake the duties. My predecessors in this important office have placed before the College the results of their scientific researches in anatomy, physiology, and pathology which have afterwards proved to be of the greatest practical value to the physician and surgeon in the domain of curative medicine. I am not in a position to follow in their footsteps, my province lying in another direction, and it would therefore be presumptuous on my part to attempt to throw light on my subject from that point of view. If I therefore depart from the usual course adopted in these lectures, with perhaps the exception of the late Sir John Burdon Sanderson who in 1891 lectured "On the Progress of Discovery Relating to the Origin and Nature of Infectious Diseases," it is because my work has been mainly concerned with the application of scientific medicine in its preventive aspects.

The subject I have selected for these lectures is plague. It is one which a few years ago could only have been treated from a historical point of view; now it is of intense interest, for it has suddenly become the most important epidemic disease of the present day. Plague has within ten and a half years caused in India over five million deaths, of which over four millions have occurred during the past five years. It is because of this mortality and because it is generally

supposed, erroneously, I think, that so far as Europe is concerned plague is a disease of the past and will not prevail in epidemic form again, that I propose to lecture on this subject. I am further encouraged in doing so because the Royal College of Physicians has taken a very considerable interest in the recrudescence and development of plague, more particularly with reference to the great mortality it is producing in India, and has shown that interest by the deputation, headed by the President, which waited on the Secretary of State for India in July, 1905, representing to him the gravity of the situation in India.

#### DISCOVERY OF THE PLAGUE BACILLUS AND ITS RESULTS.

Plague is a very ancient disease but the recent discovery of the causal agent is so epoch-making that it divides its history into two distinct periods of very unequal length. The first period is that previous to 1894, before the discovery of the bacillus of plague by Kitasato and Yersin. The second covers the years which have elapsed since that discovery. One extends over several thousands of years at least; the other is only some 13 years old.

The fact that the specific bacillus is found in the buboes of the bubonic form, in the blood of the septicæmic variety, in the contents of the vesicles and pustules that sometimes appear on the skin, and in the sputum of pneumonic cases places the physician in a more favourable position for diagnosis of this disease than he ever was before. It provides him with a test, confirmatory or otherwise, of the suspicions he may have arrived at from the clinical symptoms of the disease and enables him to come to a conclusion with a degree of certainty which was previously impossible. It should also put an end in future to the controversies and discussions similar to those which invariably arose in former times when an epidemic threatened and which resulted in loss of valuable time before measures were taken to check the epidemic.

Smears from the contents of plague buboes or from the hæmorrhagic effusion around them and from the sputum of pneumonic cases show usually on staining large numbers of bipolar microbes. In some cases, however, the microbes are few in number and in rare cases their presence is not dis-



coverable by the microscope but only by culture and inoculation into susceptible animals. Fewness in number is practically the rule for the blood in septicæmic cases and also in bubonic cases a short time before death. The typical plague bacilli with their bipolar staining and ovoid shape are frequently mixed with others less typical having a great variety of forms, including long and slender bacilli, and taking on the stain more faintly. Spherical-like and disc forms may be found in old buboes during life and in affected tissues after death. These swollen and irregular-shaped bacteria do not stain well in their advanced stages and ultimately present only a mere outline. The importance of these forms lies in the fact that they are prone to lead to mistakes unless the great variations which the plague microbes may undergo are borne in mind. Valuable as the morphological and staining characteristics of the plague bacilli are in times of plague, they cannot be wholly depended on to decide whether the first cases of an unknown or suspected disease in a hitherto healthy locality are plague. Resort has then to be had to cultures which in the case of plague give particularly trustworthy results.

The stalactite growth in peptone broth which was discovered by Haffkine is the surest culture test in that no other bacilli give a similar stalactite formation. A few drops of oil or butter fat may be added to the peptone broth. In either medium kept in a condition of perfect quietness the plague germs grow from the surface downwards into the fluid in the form of stalactites. To obtain the formation the flask has to be secured against the slightest vibration and against sudden changes of temperature, especially if applied to one side of the flask. In London in the vicinity of the Underground Railway such are the vibrations that the stalactite formation is very difficult to obtain. If nutritive gelatin is used instead of broth and the culture is kept in the incubator at 35° C. the medium remains fluid and the stalactite formation is more easily obtained and is particularly typical.

The involution forms which the plague bacilli assume in dry agar are also very distinctive. They only appear in bacilli which have been recently removed from the bodies of plague patients and are generally lost when the microbe has been cultivated for some time in the laboratory. The involution forms when quite typical are spheres and cells of various sizes resembling yeast cells and are many times



larger than the bacilli themselves. They undergo various changes according to the age of the culture. Normal at first, they become slightly swollen and rounded; later their size increases and they may reach in volume as much as 20 times that of the original bacillus. These forms at first take the stain well but subsequently portions of the cell stain more faintly. Later the whole cell refuses to stain and ultimately there are seen only powder-like granules indicating the position of the cell. In other cases the involution takes another form such as pear and crescent shapes and filaments of unequal diameter.

A third characteristic is the appearance of the culture on dry agar. When the plague bacillus is spread uniformly over the surface of dry agar from which all condensation fluid has been evaporated the growth on culture is uniform and possesses a peculiar appearance. When the tube is held in a horizontal position with the growth downwards and is examined through the depth of the agar by reflected light it has the appearance of the sheen seen in the back of a looking-glass. Unless dry agar is taken this appearance is not obtained, and instead of a shining uniform growth there will be a layer of microbes of varying thickness and strewn over this growth will be colonies of different sizes suggesting contamination by extraneous microbes. Inoculation of the microbe into susceptible laboratory animals, such as rats, guinea-pigs, and mice, furnishes an additional test in these earlier cases.

The certainty of diagnosis which has thus been acquired by the physician is of inestimable value on the first appearance of suspicious cases in a community. Thus the public health authorities in this and other countries are able at once to determine whether a suspicious illness or death reported to them is plague or not and on the information so obtained to take immediately, if necessary, the requisite measures to check the spread of the disease. Certainty of diagnosis is not the only advantage derived from the discovery of the bacillus. Investigations into plague have been given a precision which was impossible before and many observations can now be confirmed by experiments. For instance, it is now absolutely proved that the epizootic of rats which has been observed so frequently as associated with plague epidemics is plague in rats. The relationship was formerly suspected, but now it is established. The isolation of the



bacillus has also led to the discovery of Haffkine's prophylactic, the value of which as a preventive of plague is, as will be shown later, well established. Whether sufficient advantage has been taken of the new knowledge thus acquired will be considered afterwards.

It would be a mistake to suppose that because the present period has been so fruitful of results from a scientific and practical point of view that the past is sterile. On the contrary, it is full of observations of the highest importance, the value of which is only being slowly realised as greater experience in plague epidemics is gained. The clinical aspects of plague are as well described by the older authors as by the most recent, the mortality is as great to-day as formerly, the variation in the types of the disease was known, and the epizootic among rats and other animals, and the rôle which some of them play in the spread of the disease were recognised, although not proved to demonstration as now, and formed the bases of some of the preventive measures employed to check the disease. It will accordingly not be wasting time to refer briefly in this first lecture to some of the more salient facts connected with the history of plague. The antiquity of the disease, its endemic centres, its pandemics and epidemics, which are all so well described by Dr. J. F. Payne, a distinguished Fellow of this College, need not detain us.

#### THE PANDEMICS OF THE SIXTH AND FOURTEENTH CENTURIES.

Pandemics of great magnitude are fortunately few in number and far between. There have been several pandemics, but two only are recorded as standing out conspicuously as scourges of a particularly devastating character and the effects of which were felt for many years after they had disappeared. These were the Justinian pandemic in the sixth century and the Great Pestilence of the fourteenth century, later called the Black Death. The long interval of 800 years intervened between these two great pandemics of plague. Between them were many epidemics of plague in Europe, Asia, and Africa, some of which assumed more or less pandemic proportions, but none reached the dimensions of these two. The origin of neither is known,



but in both great commercial centres played a prominent part in maintaining and distributing the infection. The Justinian plague, which continued over 50 years, first attracted attention by its outburst at Pelusium, which was then an emporium for the produce of the East and the West. The endemic centres of Mesopotamia, Arabia, and Æthiopia were in commercial relationship with Pelusium, and it is probable that the infection came from one of these. The balance of evidence is in favour of Æthiopia. It is a matter of interest to note that within recent years endemic centres of plague have been discovered in German East Africa and Uganda. The town in which plague reaches such dimensions as to attract more than local attention is seldom the one in which it originates. For instance, at the present day the pandemic now prevailing is commonly attributed to Hong-Kong and Canton, whereas the disease was brought to these cities from the Chinese endemic centre of Yunnan.

The great pandemic of the fourteenth century was also associated with large commercial centres, for it entered Europe by the important emporiums and marts situated at that period on the Volga and in the Crimea and which, as pointed out by Creighton, were the terminal marts of the northern caravans from China and the Far East. It should be mentioned, however, that they were also the marts connected with the trade routes from India. The origin of the pandemic has been ascribed to China and to India. The Russian records place its starting point in India. Clemow, in his recent work entitled "The Geography of Disease," points out that plague prevailed in India in 1332 and that probably the Russian chroniclers are correct. Wherever the pandemic arose there appears to have been for several years a wide diffusion of the disease in the large dominions belonging to the Tartars and the Turks who at that time ruled over the greater part of Asia. Galfridi le Baker Swynebroke set down the period of prevalence in Asia before plague entered Europe as seven years. When it did arrive it is estimated to have destroyed 25,000,000 of its inhabitants. England and Wales at the lowest computation lost 2,500,000 of its inhabitants, or about half of its total population.

For over 300 years after this visitation Europe suffered from fresh invasions of plague, which reinforced the languishing infections already existing from previous ones. In the countries attacked there were some epidemics in



towns, which, though continuing only for a few months, are memorable for their great mortality. For instance, the epidemic in Venice in 1576 caused 70,000 deaths; that in Moscow in the same year, 200,000 deaths; that in Naples in 1656, 300,000 deaths; that in Rome in the same year, 145,000 deaths; that in Genoa, 60,000 deaths; and the epidemic in London in 1665, nearly 70,000 deaths. It was exceptional for an epidemic to recrudescence and occur year after year, which in India is almost the rule, so that in the latter case the mortality, though smaller in individual epidemics, gradually accumulates, with very few exceptions, to a proportion as great if not greater than that recorded in former times. Thus, for instance, in Poona, which is a town with a population of 120,000, over 40,000 of its inhabitants have died from plague in ten years, which is proportionally at least twice the mortality of the great plague of London in 1665. In Bombay over 150,000 of its inhabitants have been destroyed by plague. In this respect the history of plague tends to repeat itself. In the pandemic of the sixth century it is recorded that "if it passed over any place only slightly or mildly touching the inhabitants it returned there afterwards, leaving untouched the neighbours against whom it had spent its rage before, and it did not depart from there until it made up the full measure of the dead in proportion to the amount of destruction which it had brought on its neighbours."<sup>1</sup>

#### THE EFFECT ON THE LIVING OF GREAT EPIDEMICS OF PLAGUE.

Great epidemics of plague not only destroy large numbers of people but they leave their traces on the living. The effects on the living have usually been very marked and very similar. They are mostly psychological and social in their nature. Great numbers of the living are unable to bear the strain of the scenes around them and the uncertainties of life which the epidemic brings too plainly before them. Minds which have hitherto been sober and calm become overwrought, unhinged, and hysterical. Excitability and suspicion are engendered, often leading to illusions, delusions, and excesses of all kinds, which in some instances

<sup>1</sup> Procopius *De Bello Persico*, Lib. II., cap. xxii. et xxiii.



become contagious and dangerous. The change is not sudden but comes gradually. First of all, the normal courage, solicitude for the sick, hope, and religious trust which belong to the healthy mind are unaffected, but later these are associated with intense pity, exaggerated religious fervour, and the deepest despair. Then they are followed by panic and a total revulsion of feeling in which the predominant features are fear, selfishness, callousness, and heartlessness, and later still, if the scourge continues, there is a display of all the most sordid and worst passions on the part of the unbalanced portion of the population.

Plague, above all disasters, tends to bring out for a time the weak points in humanity and seldom the virtues. Hecker gives an account of the frenzy and mania caused by the mental strain brought on by the terrible events associated with the Black Death. He describes the doings of the flagellants in Germany, Hungary, Poland, Bohemia, Silesia, and Flanders, who marched through the cities in well-organised processions and who bore triple scourges, tied in three or four knots, in which points of iron were fixed and with which they flogged themselves. Harmless and welcome at first they later became a terror to the inhabitants of every place they visited. He describes also the epidemic of dancing mania that followed and he gives an account of the cruel and fanatical persecution and wholesale massacre of the Jews who were accused of poisoning the wells and thus causing the plague. He says: "Already in the autumn of 1348 a dreadful panic caused by this supposed empoisonment seized all nations; in Germany especially the springs and wells were built over that nobody might drink of them or employ their contents for culinary purposes, and for a long time the inhabitants of numerous towns and villages used only river and rain water. .... By this trying state of privation, distrust and suspicion, the hatred against the supposed poisoners became greatly increased and often broke out in popular commotions which only served still further to infuriate the wildest passions." The suspicion and rumours regarding the poisoning of the wells in the Punjab are only the reappearance of a part of the credulity and delusions which prevailed during the time of the Great Pestilence of the fourteenth century.

There were other effects besides these disorders of the mind. The whole social structure became seriously dis-



organised owing to vast tracts of country becoming waste land and an immense number of huts and houses becoming tenantless. Prices of commodities rose, rents fell, payment of the taxes on land could not be obtained. There were agrarian, labour, and political troubles. Labourers and workmen were scarce and demanded higher wages, and it was found impossible by laws, imprisonment, fines, or any other methods, to bring them to conform to the older order of things. A new era with a new spirit sprang into existence which in the course of years and after many struggles banished the old.

#### THE PERIODIC QUIESCENCE AND RECRUDESCENCE OF PLAGUE.

The epidemics of the East and West have generally been more or less synchronous with one another. The last pandemic of plague was in full activity in the seventeenth century and covered a large portion of Asia, Africa, and Europe, but towards the end of the century the disease began to contract its limits, leaving Western Europe free in the course of a few years, a freedom which, with one notable exception, has continued. That exception was the epidemic in 1720 in Marseilles, when 60,000 of its inhabitants died from plague which had been imported from the East. As regards the rest of Europe the retrocession continued, and in the course of 150 years plague not only disappeared from Europe altogether, but also showed a remarkable cessation in its old endemic centres of Mesopotamia and Arabia. What remained of the disease was shown by Tholozan to pass through a very definite stage of development, being mild at first, then virulent and again mild, and the preponderating element was mildness. The mild plague consisted of glandular swellings unaccompanied by fever, the swellings showing themselves in the groin, armpit, or neck. The epidemics which Tholozan studied were observed by him to be self-limiting in their extension and, as he points out, were not controlled by the plague measures which were often adopted after the plague outbreak had ceased. Within recent years the plague epidemics that arose from the old centres in Mesopotamia and Arabia were apparently incapable of wide extension and even under conditions seemingly most favour-



able for their spread. The conclusion from Tholozan's researches appeared to be that for epidemic plague endowed with qualities of diffusion, whatever that may mean, no quarantine on land would stop its progress, while for other epidemics of a self-limiting character quarantine on land was not required.

Following the retrocession and contraction of plague Europe has remained free for over 60 years, broken only by a short but virulent outbreak on the Volga in 1879, investigated by Dr. J. F. Payne and Surgeon-Major H. Colville; by a small outbreak at Oporto in 1899, and a few cases at Glasgow and Naples in 1900. Western Europe has been free for nearly 200 years, the last epidemic being at Marseilles nearly 187 years ago. The Great Plague of London occurred more than 240 years ago.

Quiescence of plague for varying periods is not a new feature in the history of the disease. It is necessary to emphasise this fact, for the long quiescence in Western Europe has given rise to the view that Europe has seen the last of its plague epidemics, and accordingly the epidemic now prevailing in India is viewed with regrettable complacency. I think this view of the invulnerability of Europe is as likely to be as correct as the prevalent notion that London was freed of plague by the Great Fire, irrespective of the fact that plague remained in London for 14 years after and that the disease disappeared from the whole of England and most of Western Europe about the same time.

Subsequently to the Justinian plague and its offshoots Europe, with the exception of an epidemic in Constantinople in 697 and another in Sicily, Calabria, and Constantinople in 749, remained free from plague for 400 years, and Syria, which is nearer the endemic centre of Mesopotamia, remained free for 200 years. Bagdad itself in the centre of the endemic area remained free for some 50 years at the commencement of the Abbasidic dynasty at a period of unexampled prosperity. Moreover, Egypt, which has suffered at varying intervals from devastating epidemics of plague during the past 2000 years, remained free from the disease from the eighth to the eleventh century, or a period of 300 years. Long immunity of towns as of countries is also not uncommon in regard to plague epidemics even when plague is in the country. When Bombay was attacked with plague in 1896 it had been free from the disease for 184 years, when Moscow



was attacked in 1771 it had been free for 150 years, and when London was attacked in 1499 it had been free for 150 years.

Various explanations have been given of the retrocession of plague from Europe. It has been ascribed to the social and sanitary improvement of the people since the seventeenth century; it has recently been set down to the invasion of the *Mus decumanus* at the beginning of the seventeenth century and the retirement, except from the seaports, of the *Mus rattus*; and it has been attributed to the abandonment of overland routes as the principal means of transport and communication between the East and West, to the substitution of sea routes, and to the introduction of quarantine at seaports trading with infected countries. None of these explain in a satisfactory manner the sudden retrocession of plague which stands as a remarkable epidemiological fact, but individually and collectively they may have exercised an important influence in keeping the disease in check once it had receded. Probably the most powerful of these was the change of land routes to sea routes whereby the transport of goods from the East to Western Europe was no longer effected by caravans which passed through the endemic centres of plague in Mesopotamia and Arabia. It was a change which must have materially lessened the chances of infection and of importation of the disease. From this point of view the new railway schemes which are to link the East with the West and reopen the old overland trade routes are not unlikely, unless special precautions are taken, once more to bring with them the risks of plague importation.

#### THE GENERAL CLINICAL FEATURES OF PLAGUE.

Clinically, plague presents the same features to-day as those described by the most ancient writers on the subject. The accounts of the disease are remarkably alike whether given by Dioscorides and Posidonius in the third century before the Christian Era and referred to by Rufus a century later when writing of the plague prevailing in Lybia, Egypt, and Syria, or by Procopius in the sixth century, or by Guy de Chauliac in the fourteenth century, or by Skeyne in the sixteenth century, or by Diemerbroeck, Lodge, Hodges, or



Boghurst in the seventeenth century, or by the numerous writers on plague since that time up to the most recent years.

The glandular swellings in the bubonic form, the coughing of blood in the pneumonic, the extreme prostration, pallor, muscular weakness, delirium and rapid death in the septicæmic, and the appearance of boils or blains in the carbuncular type have been observed and described in both ancient and modern epidemics of plague. Procopius graphically describes the sudden onset and fever, the appearance on the day of attack or the next day or a few days later of the bubo in the groin and armpit and sometimes in the neck, the drowsiness in some, the madness in others, the desire to wander, and the difficulty of keeping some patients in bed; he mentions the large size and suppuration of the bubo as indicating a milder attack and the reverse a severe and fatal illness and he draws attention to a feature which every physician soon learns for himself—viz., the uncertainty of prognosis. The patient's appearance is most deceptive and cannot be taken as a guide; patients pronounced to be getting well will not infrequently suddenly die and others in whom all hopes of recovery are abandoned recover with a rapidity that is marvellous. Procopius does not forget to record the comparative immunity of physicians and attendants.

The description by Guy de Chauliac of the epidemic of Avignon in 1348 is of special interest because it is written by a medical man of high standing in his day and because it distinguishes more clearly than others before him the pneumonic and bubonic forms of plague. Guy de Chauliac was himself attacked with plague towards the end of the epidemic but recovered. He says: "I felt a continued fever with a swelling in the groin and was ill more than six weeks in such great danger that all my friends thought I should die, but the swelling ripening under the treatment I have described, I escaped by the mercy of God." The treatment consisted in the application of figs and cooked onions mixed with plantains and butter, to ripen the swellings, followed by incisions and the usual treatment of open sores. Describing the epidemic he says: "The plague commenced in January, it continued seven months during which time it appeared in two forms. During the first two months it was accompanied by a continuous fever and with a coughing of blood. All who were attacked died in three days. During the other



months the continuous fever was accompanied with tumours and boils which appeared on the external part of the body chiefly in the armpits and the groin. Those who were thus attacked died in five days. The disease was so severe and so contagious, especially that which was attended by coughing of blood, that it was contracted not only by visiting and living together with the sick, but by being in their presence, so that people died without service and attendants. Men were buried without priests and without religious rites, the father abandoned the son, and the son approached not the father. Charity was dead and every hope lost."

The very infectious character of pneumonic plague as distinguished from the other forms of the disease is now fully established, and it is the one form which is dangerous to medical men, nurses, and attendants on the sick. The sputum and blood coughed up teem with plague bacilli, as was first shown by Major L. F. Childe of the Indian Medical Service. Fortunately, most epidemics of plague partake more of the bubonic than the pneumonic variety, otherwise the liability to infection would be as great as it is in influenza.

#### VARIATION IN TYPE AND BEHAVIOUR OF DIFFERENT EPIDEMICS.

All epidemics are not alike, although their general characters are similar. The bubonic, pneumonic, septicæmic, and carbuncular varieties of the disease may vary much in their relative proportions in different epidemics, and symptoms may be present in some epidemics which are absent in others. The situation and relative position of the buboes may differ, and instead of being with the usual frequency in the groin, armpit, and neck may be found in the popliteal space, elbow, and other positions. In older epidemics carbuncles and tokens or petechiæ were observed, but they have been rare in later epidemics. In the epidemic of the sixth century affections of the throat and withering of the limbs and gangrene were added to the buboes, carbuncles, and black boils, or pustules; in the fourteenth century the pneumonic form was particularly prevalent; in the sixteenth and seventeenth centuries sweats were a distinct feature. In the plague of London there were



coloured sweats. Hodges says: "These sweats also of the infected are not only profuse, but also variously coloured; in some of a citron hue, in others purple, in some green or black, and in others like blood. The sweat of some would be so foetid and intolerable from a kind of empyreumatic disposition, possibly of the juices, that no one could endure his nose with the stench." Nothing of this kind has been recorded in recent epidemics, nor have the carbuncles which formed a very conspicuous and common feature in many epidemics been observed of late years with much frequency; when they have been observed the type of plague has generally been of a milder character. This mildness was also noticed in a number of the Egyptian epidemics contrasting much with other epidemics in which the carbuncles always signified a very fatal form of the disease. The comparative absence of nervous symptoms and septicæmic cases gave to the Cape Town epidemic a character differing in these respects from that of the Hong-Kong and Bombay epidemics which I saw. The Poona epidemic of 1906 also struck me as presenting fewer of the nervous disturbances which I witnessed there in the epidemic of 1897. It is noticeable that when the disease is comparatively mild views as to its non-contagiousness prevail, whereas when severity is its distinguishing feature contagion is in favour. Recent observations would indicate that both contagionists and non-contagionists were right to some extent, though their views were of the most opposite character. Pneumonic plague is directly infectious from man to man, the bubonic is not directly infectious, while the septicæmic may possibly be both directly and indirectly infectious. It would accordingly depend on the proportion of each of these varieties in an epidemic as to the contagiousness or the non-contagiousness of the disease being most predominant.

The great proportion of pneumonic cases in the epidemic of 1348 and the contagiousness of this form of the disease probably account for the rapidity which characterised its spread and which has recently been observed to be a marked feature in small local outbreaks of this form of the disease. If this pandemic be excepted together with a number of small local outbreaks of plague one of the peculiarities of plague is its slow progress from place to place, districts and towns close to those infected remaining for a long time free from the disease.



A frequently quoted instance is the Great Plague of London taking six months to travel from St. Giles's to Stepney. In Bombay the plague confined itself to the dock quarters before it spread to other districts. At Poona over six months elapsed before the disease established itself at Kirkee which was in daily communication with Poona and only separated by a river spanned by a bridge. During the first outbreak in Canton in 1894 in which 80,000 out of 1,000,000 inhabitants died from plague, the disease never crossed the narrow creek, some 20 yards wide, which separated plague-infected houses in the Chinese town from the European settlement of Shamien; neither Europeans nor the Chinese servants on the premises nor the rats in the foreign settlement were affected. The water here provided a check to the spread of the disease. It was also observed that the Chinese population living on the river did not suffer from the epidemic, which reminds one of a similar observation during the Great Plague of London. It is facts such as these and that animals living in the ground were affected by plague that gave rise to the view held by the Chinese and the older non-contagionists in Europe that plague was a soil disease and that the spread of it was due to miasmata from the ground. The discoveries of Manson and Ross have revolutionised our notions of miasmata, and from this new standpoint the miasmata of plague appear to be explained by the rôle which the rat and the flea play in the dissemination of the disease, but many links are wanting before a satisfactory explanation of the recrudescence of plague is available.

#### ANCIENT ASSOCIATION OF THE RAT WITH PLAGUE EPIDEMICS.

The association between plague and rats is a very old observation. Apart from scriptural references there is evidence derived from some of the ancient monuments and coins of the connexion being known. Apollo and Æsculapius are each represented with the rat at their feet. There was the famous statue of Apollo by Skopias in which the god has a rat at his feet. Snakes are destroyers of rats, and in Asia Minor and elsewhere before the advent of the cat harmless snakes were kept in houses and in the temples doubtless for that purpose. This practice probably explains the accounts



so frequently given of snakes and serpents dying during epidemics of plague. Both the cat and the snake were venerated for their services to man.

There is an interesting coin brought to my notice by Dr. Sambon and which can be seen in the collection of colonial Roman coins in the British Museum (Fig. 1). It is a coin of the Emperor Lucius Verus struck at Pergamum in Asia Minor during a plague epidemic and represents Æsculapius with a rat at his feet and a small human figure standing by with his arms outstretched in the attitude of fear or worship. In the same collection there is a medallion of the Emperor Antoninus struck in commemoration of the erection of a temple to Æsculapius on the Tiberine Island at Rome. Plague was epidemic in Rome and a mission was sent to the temple of Æsculapius at Epidaurus to ask for advice. The advice given by the Æsculapian priests was apparently to destroy the rats, for on the reverse side of the coin is the return of the mission with a serpent, being welcomed by the river god (Fig. 2).

The dissemination of plague by domestic animals was formerly recognised even more than it is at the present day and very decided views were held, particularly regarding those animals in close association with man; not only rats but also dogs, fowls, and pigs were held to be agents in spreading the disease. When plague prevailed in Europe these animals were as much inmates of the house as the people themselves and it was observed, as it is in South-Western China to-day where the same conditions prevail, that during epidemics of plague the rats, fowls, pigs, and cattle sickened or died, which was attributed to plague. In the pandemic of 1348 it is recorded by numerous observers that dogs, cats, fowls, cattle, and rats died from the disease. Skeyne in 1568, in his work on the pest, states that "quhan the domestical foules become pestilential it is ane sign of maist dangerous pest to follow." The observations became so general that they formed a basis for certain orders in regard to the suppression of plague. Every European country has in its old orders concerning the checking of plague epidemics instructions to the inhabitants under certain penalties to kill domestic animals or to keep them confined to the house. Creighton mentions some of these orders as bearing on the regulations in England and Scotland against the spread of plague.



FIG. 1.



Coin of Emperor Lucius Verus commemorating plague epidemic.

FIG. 2.



Medallion commemorating erection of temple to Æsculapius by Emperor Antoninus.







In the regulations in London against the plague in the seventeenth century it is ordered that no hogs, dogs, pigeons, or conies shall be suffered to be kept within any part of the City. In Rouen on April 14th, 1407, it was ordered under penalty that no person of any condition or rank should keep pigs. When plague broke out again in 1498 a similar order was issued, and in 1566 the priests of the Madeleine and Commander of St. Antoine were forbidden to keep in their houses pigs, fowls, and rabbits. At Evereux in Normandy a police order was issued in 1561 that every one of whatever quality or rank should not keep pigeons, fowls, rabbits, and pigs under penalty of confiscation and a fine of ten livres, and anyone giving information would receive half the fine. The killing of dogs is in nearly every order. A photograph, kindly lent to me by Mr. Henry Wellcome, of a painting in the archives of Bologna representing a plague epidemic in that town is interesting, as it illustrates the actual killing of dogs during the epidemic. The picture shows the magistrate and his officers on duty. Some of them are removing the dead which are being lowered from the windows of the infected houses; priests are also to be seen administering the Sacrament. In the foreground are some men killing a dog and a little farther back there is a dog transfixed with an arrow. Similar measures for controlling plague were taken at Palermo in 1575. Ingrassia says, "an excellent measure was proposed and carried out. All dogs, cats, and other animals that might convey the plague from one house to another were to be destroyed." Not only were the dogs of the town destroyed but all those within a radius of at least four miles. Fiochetto, describing the measures that should be taken in the event of the discovery of an infected person in any house, says "fifthly, having killed all cats, dogs, fowls, and pigeons prepare arsenic for the rats." No mention is made of fleas on these animals but it is evident that experience had taught the authorities that these animals sometimes by contracting the disease and sometimes by carrying the infection on their coats, furs, and feathers, though not infected themselves, conveyed plague. In connexion with the conveyance of the infection by animals not suffering from the disease there is the observation made by the Austrian Commission in 1897 of plague bacilli appearing in the fæces of a dog fed with plague material.



## LECTURE II.

*Delivered on June 20th.*

## THE PRESENT PANDEMIC.

MR. PRESIDENT AND FELLOWS,—The present pandemic has no connexion with the plagues arising in Mesopotamia the chief features of which, as shown by Tholozan, were, during the latter part of the nineteenth century, those of comparative mildness, spontaneous cessation, and self limitation, irrespectively of preventive measures. It would appear that the strain of the Mesopotamian virus has become attenuated both in powers of attack and powers of diffusion and that it required a virus derived from a new source or from another endemic centre to produce a plague endowed with more virulent and diffusive qualities.

The Chinese endemic centre in Yunnan, from which the present pandemic is derived, is, like the endemic centres in Arabia and India, between 5000 and 7000 feet high, and in this respect differs from some of the older endemic centres which are low lying. Yunnan has been known as an endemic centre of plague since 1870 but there are Chinese records which seem to indicate that the disease probably existed there for over 100 years, for mention is made of a strange and fatal rat disease prevailing at the end of the eighteenth century which also infected the inhabitants. There are no records discovered which make the endemic centre older than this and there is no evidence to show that the Black Death of 1348 arose from Yunnan. It is not known exactly when the present pandemic overflowed its boundaries and invaded the adjoining provinces of Kwangtung and Kwangsi. Plague had passed over the boundary several times during the Mahomedan rebellion in Yunnan and in 1867 reached Pahhoi, a small seaport on the southern coast of China, but there appears to have been no very extensive epidemic. As far as can be ascertained it was about the year 1890 that the disease began to show unusual activity. At that time the annual recrudescences in Mentze, one of the principal trading towns in the south-east portion of the province, became more severe and there was



an extension of the disease to some of the towns situated on the West or Canton River and which have trade relations with Mentze and Canton. Gradually an extended area of the western parts of Kwangsi and Kwangtung became affected and in January, 1894, Canton was attacked. Canton is the chief port as well as the largest and most important city in Southern China. It is only 80 miles from Hong-Kong, which, situated at the mouth of the Pearl River, contains a population that is mainly Cantonese, and so great is the intercourse between them that Hong-Kong has been styled the suburb of Canton. Hong-Kong became infected in May, 1894. Recrudescences of plague have occurred more or less in Canton and Hong-Kong since. Canton and Hong-Kong are the great marts and distributing centres for the produce of Southern China and have trade connexions with the southern parts of China, the neighbouring islands of the Pacific, and with India, Australia, Japan, and America. They were accordingly favourably situated as distributors of plague to all those countries adjacent and distant with which they had commercial relations. Their ships carried infection to the seaports of other countries, and these in their turn infected other places. The course of the spread of plague has differed from all previous pandemics in that its distribution has been by sea routes, in contradistinction to former pandemics which spread by land routes and coasting vessels. With the exception of India and one or two places in South Africa and America the infected localities are mostly on the coast, and the history of their infection is importation of the disease from some infected port with which they carry on commercial relations. Any circumstance which increases to an unusual extent the transport of goods from infected ports increases the risk of importation of the disease. Thus, the war in South Africa, with its enormous shipments of grain and fodder from the Argentine and from India, whose ports were infected with plague, introduced the disease into Cape Town and Port Elizabeth, where the rats in the docks were the first to become infected. The Russo-Japanese war was, fortunately for Europe, out of the zone of any badly plague-infected district.

Many places have been infected in different parts of the world, but none outside India have hitherto given rise to any very serious epidemic. Still, notwithstanding its apparent inability to develop into an epidemic, yet the disease has in



many instances when imported into a locality shown a remarkable persistence as displayed by the annual recurrence of sporadic cases at the season of the year favourable to epidemic plague. The potentiality of plague becoming epidemic in such localities is there all the same and no country is safe while it retains infection.

#### THE EPIDEMIC IN INDIA.

At present, however, the chief interest of this pandemic lies in India. Imported into the city of Bombay in 1896 from Hong-Kong it broke out in epidemic form in September of that year, and by the end of April, 1897, when the first epidemic was over, it had caused 11,000 deaths. Every year there has been a recrudescence and the total number of deaths from plague in Bombay since its appearance till the end of 1906 is 150,000. From Bombay city it spread to the Bombay Presidency, chiefly by coasting boats and by the railways carrying fugitives infected with plague to their native villages. By December, 1897, 50,000 deaths had occurred in the Presidency, and a few deaths in some of the other provinces. It has continued ever since in this Presidency and has, up to the end of April, 1907, caused 1,500,000 deaths. Gradually the disease has spread to the other provinces of India, affecting some severely and some lightly, and the grand total of deaths from plague in India, as shown in the following statement of annual deaths, amounts to over 5,000,000 :—

#### *Total Recorded Annual Deaths from Plague in India.*

Years.	British Territory.	Native States.	Total.
Sept., 1896. } to end of 1897 }	57,000	—	57,000
1898	89,200	27,000	116,200
1899	102,300	36,600	138,900
1900	73,500	19,200	92,700
1901	234,600	46,100	280,700
1902	445,200	126,900	572,100
1903	701,800	179,000	880,800
1904	938,000	203,300	1,141,300
1905	940,800	128,300	1,069,100
1906	—	—	332,000
1907 (first 4 months)	—	—	641,000
			<hr/> 5,321,800



The population of British territory is 232,000,000 and that of the native states 62,000,000. The 5,000,000 deaths represent accordingly one death in every 60 of the inhabitants of India. The mortality during the later years is very much greater than in the earlier, the deaths in the last five years and four months reaching over 4,500,000.

The fact that India is an immense country with nearly 300,000,000 inhabitants has often been considered as minimising the gravity of the situation which 5,000,000 of deaths would otherwise represent, and the argument is employed that in such a large country it is impossible to deal with the disease. 1,000,000 deaths a year in a population of 300,000,000 is viewed only as 1 death in 300 of the inhabitants and from that point appears not to have much influence on the vast population. It is once more the fallacy of averages. There is the old story of the man who, assured that the average depth of a river was four feet, endeavoured to cross it and was drowned. He had not reckoned that it might be shallow in some parts and deep in others. Plague is not epidemic over the whole of India. But, even if it were, and admitting that India, including Burma, is greater by 12,000 square miles than the whole of Europe, excluding Russia, Poland, and Finland, most people will allow the mortality is serious. 5,000,000 deaths from plague in Europe would be considered on this side of the Red Sea appalling in whatever way it was distributed. And if it happened that many of the countries in Europe were more or less free from plague and that the disease concentrated itself on three or four countries, such as France, Italy, Austria, and Great Britain and Ireland, causing in these nearly 4,500,000 deaths out of the 5,000,000, the mortality would be viewed as a catastrophe of the first magnitude. But if in addition to the loss of the 4,500,000 of inhabitants there were, owing to the recurrence of the disease, a prospect of several more millions being destroyed in those places already attacked, and that there was the further danger as the pandemic developed of the other countries—such as Germany, Holland, Spain, Greece, and Turkey—being attacked in the same way, then the situation of Europe would be similar to that of India to-day. This will serve to give some conception of the tragedy which is going on in India at the present time and of the future perils of that unhappy country. It is a misconception,



fraught with the greatest danger, to suppose that in India the plague is only causing a death-rate of 3 per 1000, as was stated in the House of Commons during the debate on the Indian Budget. The figures giving the total number of deaths in the different provinces of India since September, 1896, exhibit a very different degree of incidence and severity in each. The Madras Presidency has escaped with a comparatively small number of deaths; so have most of the other provinces. Four provinces have hitherto borne the brunt of the epidemic in India out of the 15 presidencies, provinces, and States into which India is divided. These are the Bengal Presidency, with a little over 500,000 deaths; the Bombay Presidency, with a little over 1,500,000 deaths; the United Provinces, with nearly 1,000,000 deaths; and the Punjab, with over 1,750,000 deaths.

The annual returns for these provinces are approximately represented in the following figures:—

Year.	Bombay and Sindh, population 22,000,000.	Bengal, population 74,000,000.	United Provinces, population 47,000,000.	Punjab, population 25,000,000.
September, 1896, to } end of 1897... }	57,000	—	80	179
1898 ... ..	104,000	166	116	1,800
1899 ... ..	117,000	3,000	6	250
1900 ... ..	38,000	37,000	116	500
1901 ... ..	158,000	78,000	9,000	18,000
1902 ... ..	217,000	32,000	43,000	222,000
1903 ... ..	340,500	65,000	80,000	210,000
1904 ... ..	281,000	75,000	179,000	402,000
1905 ... ..	96,000	126,000	383,000	389,000
1906 ... ..	71,000	50,000	57,000	98,000
To May 11th, 1907...	52,000	50,000	223,000	432,000

#### THE EPIDEMIC IN THE PUNJAB.

The province of the Punjab which has lost nearly 1,750,000 of its inhabitants is in size less than one-twelfth the total area of India and it contains less than one-eleventh part of its population. It is slightly larger in area than Great Britain but is smaller than Great Britain and Ireland. Its population, including the Native States, is 25,000,000 without the Native States 20,000,000, against the 43,000,000 of Great



Britain and Ireland, so it is not a large province, and the loss of 1,750,000 out of 25,000,000 can only be viewed as an appalling disaster. If plague had destroyed 3,000,000 of the inhabitants of Great Britain and Ireland in ten years it would have represented proportionately what the Punjab has lost during that time with its smaller population. The plague began very slowly in the Punjab and took six years before causing 250,000 deaths. There were 179 deaths in 1897, 1871 in 1898, 253 in 1899, 525 in 1900, then, as reported by the Sanitary Commissioner for the Province, all restrictions were removed and a new policy was introduced; in 1901 there were 18,877 deaths and in 1902, 222,533 deaths. The great mortality has been during the past four and a half years and the greatest during 1907, when over 500,000 deaths occurred during the first five months, which is the epidemic season. 800,000 deaths from plague occurring in Great Britain and Ireland in five months would represent the intensity of the epidemic in the Punjab during the early months of this year. There is no comparison between 800,000 deaths and 54,000, which was the largest epidemic of cholera in England in 1854-55 and which was considered to be appalling in this country. During the week ending May 11th, when the climax of the present year's epidemic in the Punjab was reached, there were 60,000 deaths from plague in that province, which in the British Isles would be represented by 100,000 deaths in one week in an epidemic of the same intensity. The condition of affairs in this country with 100,000 deaths from plague taking place in one week in the British Isles as the climax of an epidemic which in the course of five months had destroyed 800,000 of its people would be similar to that now existing in the Punjab at the present time. The state of mind of the rest of the inhabitants of Great Britain and Ireland under such a catastrophe coming on the top of a devastation which had previously destroyed over 2,000,000 would not be one of calmness and contentment. In the first 12 weeks of the year there were 145,000 deaths from plague in the Punjab; in the next six weeks 286,700 deaths. During these six weeks the plague deaths were as follows:—

Week ending April 6th	...	...	...	...	34,651 deaths.
" " " 13th	...	...	...	...	39,084 "
" " " 20th	...	...	...	...	47,047 "
" " " 27th	...	...	...	...	54,24 "
" " May 4th	...	...	...	...	51,305 "
" " " 11th	...	...	...	...	60,400 "



These facts will dispel the view that the plague is a small thing in India scattered over a vast continent. The effect in the Punjab may be gathered from the following extract from the *Times of India* of June 1st, 1907 :—

A picture of some of the results of the terrible epidemic in the Punjab is given by the "Statesman's" Simla correspondent. To dismiss this epidemic (he writes) with the statement that the people of the Punjab have been dying from it for some time past at the rate of 50,000 a week gives but a faint idea of the deserted villages, the crops rotting upon the ground over wide areas for lack of men to reap them, and the breaking up of homes and family life inseparable from such a calamity. The people have learnt to quit their villages and to camp out in the open when the disease appears and the worst is now over for the year, since the hot winds of May invariably reduce the mortality. But the evil has attained such extraordinary magnitude that it is affecting the whole outlook of the people. In Simla carpenters have become difficult to procure, because the Jullundur district, where most of them lived, has suffered so terribly. The plague is an undoubted factor, though perhaps not the principal one, in connexion with the much-discussed unrest. It is also becoming important in changing the relations between population and sustenance, since the survivors inherit the property of those who succumb and grow less inclined in consequence to work for themselves.

In another extract from the same paper it is stated that "natives of Rawalpindi who have relations in the plague-infected villages will not go to tend their sick ; others have left the corpses or belongings of deceased relatives to the mercy of the village rather than risk plague. Firewood is not obtainable to burn the dead, so timber from the houses is being utilised and many Hindus are burying their dead." This last is against the religious views of the Hindus, but their necessity has brought it about.

The concentration in the Punjab does not mean an equal distribution of the disease over the whole province. The mortality falls with unequal intensity on the divisions and districts into which the province is divided.

Table I. gives the deaths registered in the rural circles of the Punjab with the death-rates of each from 1901 to 1905 inclusive. The statistics are not available for the great epidemic of 1907 or for the lesser one of 1906, but those which are available show the great incidence of plague on certain rural areas. In 1902 the district of Ludhiana was worst affected and had a death-rate from plague of over 70 per 1000. More than a fourth of the deaths in the rural circles occurred in this circle. Umballa came next with 30



TABLE SHOWING THE DEATHS REGISTERED FROM PLAGUE IN THE DISTRICTS (RURAL CIRCLES) OF THE PUNJAB FROM 1901 TO 1905; RETURN FROM REPORTS OF THE SANITARY COMMISSIONER FOR THE PUNJAB.

Rural circles.	Population according to census of 1901.	1901.		1902.		1903.		1904.		1905.		Total for five years, No. of deaths.
		No. of deaths.	Death-rate.	No. of deaths.	Death-rate.	No. of deaths.	Death-rate.	No. of deaths.	Death-rate.	No. of deaths.	Death-rate.	
<b>Delhi Division:</b>												
Hissar ... ..	693,044	—	—	—	—	229	0.33	1,688	2.44	13,595	19.62	15,512
Rohtak ... ..	576,415	—	—	—	—	187	0.32	2,859	4.96	30,336	52.63	33,382
Gurgaon ... ..	678,503	—	—	4	0.01	2,754	4.06	5,295	7.95	27,737	40.88	35,890
Delhi ... ..	457,658	—	—	—	—	—	—	590	1.29	6,116	13.36	6,706
Karnal ... ..	799,607	—	—	184	0.23	552	0.69	1,644	2.06	8,558	10.70	10,938
Umballa ... ..	698,479	153	0.22	21,152	30.28	4,537	6.50	17,839	25.54	16,510	23.64	60,191
Simla ... ..	21,449	—	—	5	0.23	—	—	5	0.23	—	—	10
<b>Total ... ..</b>	<b>3,925,155</b>											<b>162,629</b>
<b>Jullundur Division:</b>												
Kangra ... ..	751,945	—	—	5	0.01	—	—	33	0.04	23	0.03	61
Hoshiarpur ... ..	923,773	2,368	2.50	11,684	12.65	17,349	18.78	26,834	29.11	17,506	18.95	75,741
Jullundur ... ..	789,950	3,415	4.32	15,765	19.96	23,745	30.06	28,238	35.82	22,383	28.33	93,606
Ludhiana ... ..	586,569	427	0.73	41,282	70.38	7,357	12.54	31,522	45.91	20,066	34.21	100,654
Ferozepore ... ..	881,750	8	0.01	6,126	6.95	5,584	6.33	12,561	14.27	21,070	23.90	45,369
<b>Total ... ..</b>	<b>3,932,957</b>											<b>315,431</b>
<b>Lahore Division:</b>												
Montgomery ... ..	477,936	—	—	1	0.02	207	0.43	252	0.55	969	2.1	1,459
Lahore ... ..	906,019	174	0.19	11,071	12.22	21,965	24.27	22,440	24.77	26,897	29.69	82,567
Amritsar ... ..	842,818	1	0.001	3,668	4.35	25,593	30.37	20,929	24.83	28,649	33.99	78,840
Gurdaspur ... ..	871,990	4,325	4.96	14,100	16.17	5,195	5.96	40,806	46.80	19,260	22.09	83,686
Sialkot ... ..	994,914	3,478	3.50	26,707	26.84	13,678	13.75	48,347	48.69	11,497	11.56	103,707
Gujranwala ... ..	822,871	1	0.001	3,189	3.88	52,725	65.72	26,299	32.78	19,736	24.60	101,950
<b>Total ... ..</b>	<b>4,916,548</b>											<b>452,409</b>
<b>Rawalpindi Division:</b>												
Gujrat ... ..	709,017	—	—	353	0.50	2,535	3.58	29,478	41.58	13,917	19.63	46,283
Shahpur ... ..	471,933	—	—	5	0.01	731	1.55	35,381	74.97	4,196	8.90	40,313
Jhelum ... ..	565,297	1	0.001	—	—	21	0.04	10,388	21.98	134	0.23	10,544
Rawalpindi ... ..	819,219	—	—	—	—	118	0.14	613	1.31	816	1.74	1,547
Attock ... ..	—	—	—	—	—	—	—	13	0.03	45	0.10	58
<b>Total ... ..</b>	<b>2,565,471</b>											<b>98,745</b>
<b>Mooltan Division:</b>												
Mianwali ... ..	395,033	—	—	—	—	—	—	1	0.003	—	—	1
Jhang ... ..	954,602	—	—	135	0.14	2,175	2.28	3,639	3.81	517	1.15	6,467
Lyalpur ... ..	—	—	—	—	—	—	—	—	—	731	1.43	731
Mooltan ... ..	601,975	—	—	12	0.02	—	—	35	0.06	39	0.08	86
Muzaffargarh ... ..	393,253	—	—	—	—	—	—	—	—	—	—	—
Dera Ghazi Khan...	428,705	—	—	—	—	1	0.002	1	0.002	107	0.25	109
<b>Total ... ..</b>	<b>2,773,668</b>											<b>7,394</b>
<b>Total rural circles</b>	<b>18,114,729</b>	<b>14,291</b>	<b>0.79</b>	<b>155,449</b>	<b>8.53</b>	<b>187,258</b>	<b>10.35</b>	<b>357,980</b>	<b>20.34</b>	<b>311,430</b>	<b>17.22</b>	<b>1,036,408</b>





per 1000 and Sialkot with 26 per 1000; one-third of the circles were not infected. In 1903 Gujranwala was the worst infected circle and had a death-rate from plague of 65 per 1000; Amritsar and Jullundur came next with a mortality of 30 per 1000 each; seven circles still remained unattacked. In 1904 only one circle remained free from the disease. Shahpur had a death-rate from plague of 74 per 1000 of its inhabitants, Sialkot 48 per 1000, Gurdaspur 46 per 1000, Ludhiana 45 per 1000, Gujrat 41 per 1000, and Jullundur 35 per 1000. In 1905 the recurrence in the rural circles was not quite so severe as in 1904, still Rohtak had a death-rate from plague of 52 per 1000, Gurgaon 40 per 1000, and Ludhiana 34 per 1000. Similar rates are to be noted in the towns of the Punjab. For instance, in 1902 Rupa, a small town in the Umballa district, had a death-rate of 90 per 1000 of its population from plague. In Jamke, a small town in the Sialkot district, a death-rate of 116 per 1000 from plague was registered.

In 1902 the Sanitary Commissioner reports that in the minor towns of the Ludhiana district the ravages committed were fearful. Raikot and Machiwara were almost decimated. Jagraon lost 11 per cent. of its population and Khanna no less than 14 per cent. In 22 villages the death-rate from plague ranged from 20 to 40 per cent. of the population. These death-rates, or depopulation of villages, are similar to those which are recorded as having occurred in some of the villages of the Bombay Presidency. There some of the villages lost 33 per cent. of their inhabitants. As is always the case in plague, some places escape lightly in one year while others are almost depopulated.

Since 1903 special reports on plague in the Punjab have been discontinued and in that year the administration of plague was handed over to the Inspector-General of Civil Hospitals, an officer whose duties in ordinary times are always of an onerous character and who could have no time to devote to this extra work. Owing to these changes the information is henceforth scanty. In 1904, however, there can be gleaned from the few remarks made by the Sanitary Commissioner, when treating of the vital statistics of the province, the havoc which the plague caused in some localities. Thus he says: "As an instance of the fearful increase in the mortality caused by plague, it may be noted that the death-rate of the district of Shahpur in April when

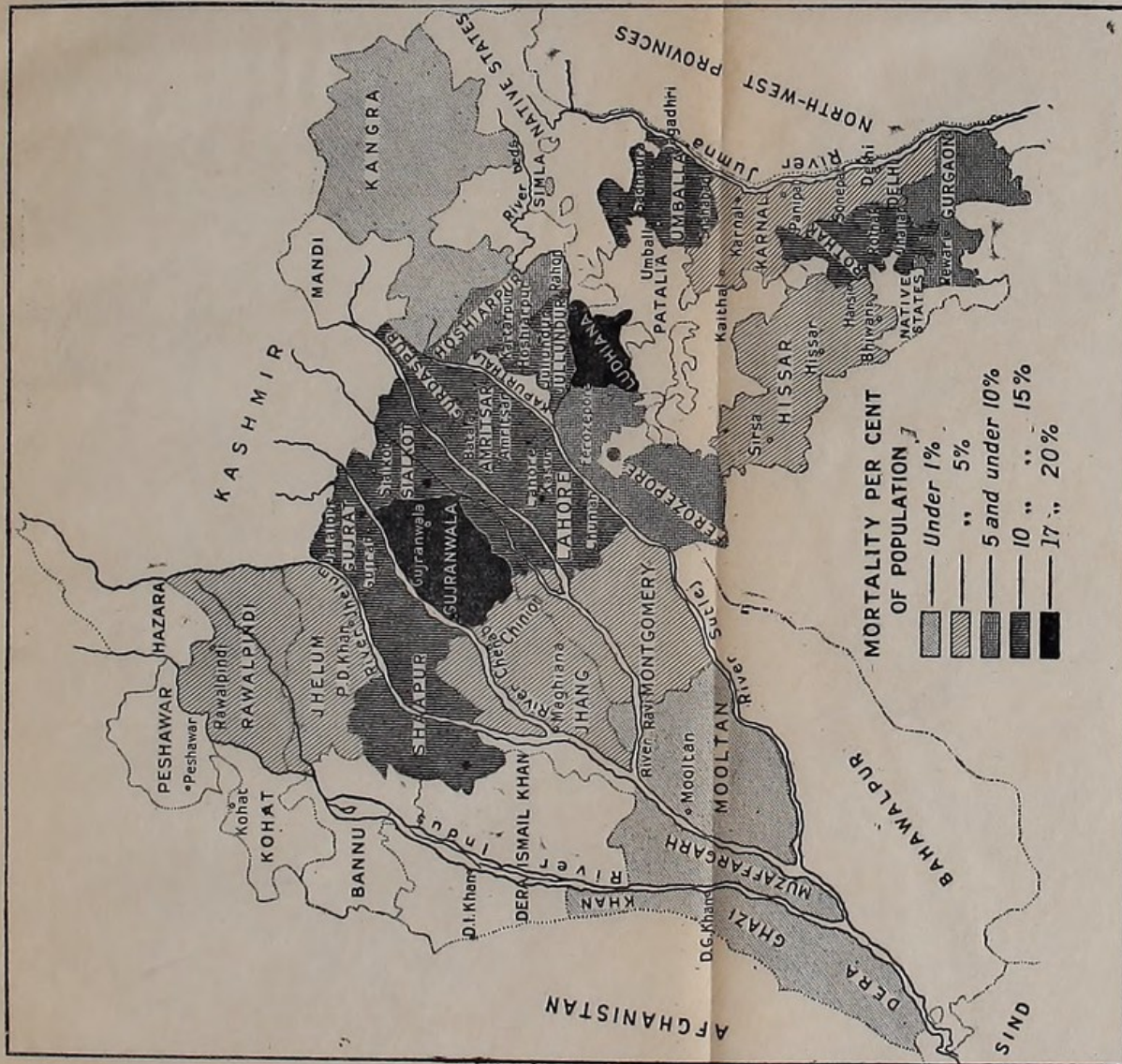


plague was most virulent was *twenty-three times* higher than in August, by which time the disease had entirely disappeared. The total number of deaths in April in that district was 17,889, of which no fewer than 17,012 were ascribed to plague, as against only 781 in August, including one death from plague. The death-rate for Shahpur for April was *415 per mille per annum*." With this rate in the district of Shahpur as a whole, it is safe to say that similar rates of 20 and 40 per cent. occurred in some of the villages as were recorded two years previously in the villages of Ludhiana. There was in 1904 an abnormal increase in the total urban death-rate which the Sanitary Commissioner states was accounted for by plague, and he mentions the high rate of 145 per 1000 in Hodal in the Gurgaon district and of 125 per 1000 in Miani in the Shahpur district, whose death-rate from plague was 100 per 1000 in each case.

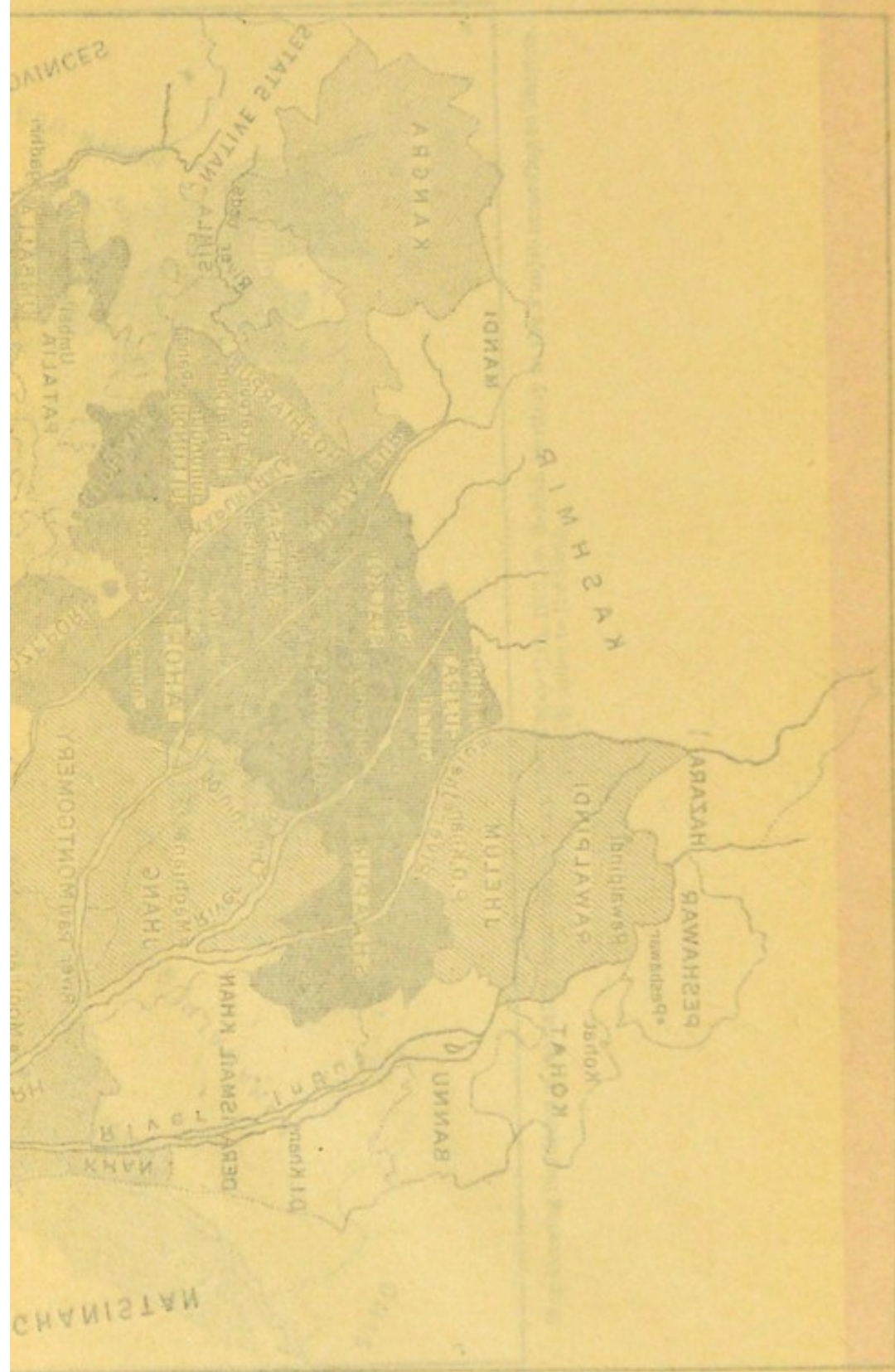
If the totals for the five years in the rural circles be taken it will be seen that the Ludhiana district lost 100,000 of its inhabitants out of 586,000, or more than 1 in 6. Sialkot lost 103,000 out of 994,000, or nearly 1 out of every 9. Gujranwala lost 101,000, or nearly 1 in 8 of its population. I have not been able to add to these losses in the rural districts those of 1906, which was a comparatively light year, and those of 1907, which has been worse than any of the previous years, but the figures as they stand demonstrate a devastation on an immense scale, and which with the losses of 1906 and 1907, together with what is to come, means a mortality comparable with even that of the Black Death.

Though not able to give the statistics of the rural circles for 1906 and the earlier months of 1907, I am able to give them for the divisions and districts of the Punjab as a whole from the year 1901 to May 11th, 1907. There are five divisions in the British territory of the Punjab Province. These divisions contain a population of 20,000,000. Since 1901 they have lost 1,500,000 of their inhabitants—i.e., more than one-fourteenth of their total population. The Jullundur and Lahore divisions have suffered the most. Jullundur has lost 441,000 of its inhabitants out of 4,260,000—i.e., more than one-tenth; and Lahore has lost 665,000 out of 5,550,000, or nearly one-eighth. In these two divisions the incidence on some of the districts was very heavy; thus the district of Ludhiana has lost 140,000 out of 673,000 of its inhabitants,











which is more than one-fifth of its population ; another district of Gujranwala has lost 156,000 of its inhabitants out of 890,000, or slightly less than one-fifth of its population.

There are 29 districts in the Punjab and eight districts have lost less than 1 per cent. of their population, seven districts under 5 per cent. of their population, three districts over 5 and under 10 per cent. of their population, nine districts over 10 and under 15 per cent. of their population, and two districts have lost 17 and 20 per cent. of their population. The map shows the distribution of this mortality and its incidence in percentages of the population. With the districts as a whole giving such figures it is certain, owing to the fact that plague is never evenly distributed, that some of the villages have lost half their population.

#### THE PREVENTION OF PLAGUE IN INDIA THE MOST IMPORTANT QUESTION FOR INDIA AND ENGLAND AT THE PRESENT TIME.

The disease attacks the able-bodied and the strong, the bread-winners and protectors of the family. It is the sturdy peasants of the Punjab, the sowers and tillers of the soil, the producers, that are dying in such enormous numbers, and if they continue to die the effect, as has been the case in all epidemics, will be a serious disorganisation of the social and economic conditions of the province. Already in 1903 the Lieutenant-Governor of the province recorded that there had been an increase of crime and although the effects of the plague had not been immediately apparent he anticipated that trade, agriculture, and education, recruiting and other interests were bound to suffer. These anticipations and more have happened and the state of the Punjab has become socially and politically a serious cause of anxiety. It has recently been announced in the *Times* that there is a deficit of 32 lacs of rupees in the Punjab revenues of last year and that in many places the crops are standing unreaped because there are no harvesters. The silence of those unharvested fields, together with the figures of mortality, should bring to everyone's imagination a very clear realisation of the awful devastation of the Punjab. Nor are the effects likely to be confined to the Punjab, for there can be no moral and material progress of India as a whole when one of its smaller



provinces is being more than decimated, and when there is danger of the disease attacking other provinces with a similar intensity.

It will be recognised from the foregoing facts that the dying millions in India present a problem of the greatest urgency and danger. The plague if left as it has been within recent years to take its own course bids fair in such circumstances to overwhelm not only India but also to be a danger to the world.

#### MODES OF DISSEMINATION AND CHANNELS OF INFECTION.

Turning to the preventive aspects of plague the question arises, Are the principal modes of dissemination and the channels of infection known? It is now accepted that the importation of plague into a healthy locality can be effected by an infected human being, or an infected rat, or infected clothes. Observations have been so numerous as regards these agencies as to remove all doubt on this point. Dr. E. E. Klein has further shown by some important experiments that infected grain may also be an agent in the importation of the disease. By feeding rats and guinea-pigs with grain which had been contaminated with old cultures of plague, and which was then dried, he was able to cause plague in those animals, so that grain which has been infected with infective material from plague rats or human beings may, on importation into a healthy seaport, give plague to healthy rats on shore which eat the contaminated portions of the grain. The association of corn ships with plague is a very old one. In recent years the association has been ascribed almost wholly to plague rats on board ship which have left the ship and infected healthy rats on shore, but now infected grain must be added as a likely agent.

Once imported, the dissemination of the disease is effected by similar agents as those bringing about importation. Rats, clothes, human agency, and food play their respective parts. It is now almost universally admitted that, except in pneumonic cases, rats are the principal agents in the dissemination of the disease, though personal contact, as in typhoid fever, also plays its part. They bring the infection into houses connected with their subterranean passages. In Hong-Kong one could trace many of the



subterranean passages with their infected rats and their connexion with the distribution of the disease in the houses. A systematic bacteriological examination of rats trapped and found dead proved that plague in the rats of the locality preceded plague in man. So constantly did this occur that as soon as plague-infected rats were discovered measures were introduced as in Cape Town but on a more extended and systematic basis, of treating the house or locality as plague infected. In other words, a policy of forestalling plague was adopted. The precedence of rat plague in relation to plague epidemics was observed in Bombay, the Punjab, Calcutta, South Africa, Australia, and Southern China. The value of the Hong-Kong observations lay in the direct evidence obtained by scientific and precise methods not only of the direct relationship which the precedence of rat plague bore to human plague but also of the important rôle which the rat plays in the spread of the disease from house to house and in groups of houses. Similar observations were made by Dr. J. Ashburton Thompson in Sydney, but under different conditions. The Sydney outbreaks are comparatively mild, the mortality being under 40 per cent., and consist mainly of bubonic cases with but few septicæmic cases. Probably the type in Sydney was the same as that met with in Cape Town, where one of the marked features was absence of cerebral symptoms and intestinal disorders, differing in this respect from the type met with in Poona in 1897, but which in 1907 seemed to me to have changed, presenting fewer nervous symptoms. The Hong-Kong outbreaks are exceptionally virulent, the mortality being over 80 and 90 per cent. and with a large percentage of septicæmic cases.

The problem of the dissemination of the disease by rats is not solved by simply proving that rats are infected with plague in a house or locality before human beings, or by the fact that if measures are taken to dispose of the infected rats human plague will not occur, and, *vice versa*, if no measures are taken plague will attack some of the inmates of the house. The question naturally arises, How is the infection of the rat transferred to man? There are two views and the upholders of each have a tendency to claim that theirs is the only way. The more that is learnt of plague the more it is evident that there is no only way.



## THE FLEA THEORY.

Dr. Ashburton Thompson had exceptional opportunities of studying the small outbreaks in Sydney and on that study he came to the conclusion that Simond's theory that the flea on the rat, leaving the rat dead from plague and then biting man, transfers plague from the rat to man, explained the phenomena connected with plague. That theory, of which Dr. Ashburton Thompson is the champion, has recently received very valuable support in its favour from the very important experiments made by the Indian Plague Commission and which are the outcome of certain researches by Captain W. G. Liston, I.M.S., to whom much credit is due for his excellent work in this direction. These experiments established first the accuracy of Simond's and Gauthier's and Raybaud's experiments as to the power of infected fleas from plague rats causing plague in healthy rats: 61 per cent. of the white rats, which are very susceptible to plague, and 52 per cent. of the Bombay rats experimented on contracted plague by the transference to healthy rats of fleas from infected rats. Similarly, guinea-pigs allowed to run free in plague houses in many instances attracted a large number of fleas, most of which were rat fleas, and 29 per cent. of the guinea-pigs contracted plague. Animals in cages protected from fleas by a layer of "tanglefoot" did not contract plague, while animals in cages not so protected developed plague to the extent of 24 per cent. Out of 247 fleas caught on the "tanglefoot," 60 per cent. were human, 34 per cent. were rat, and 6 per cent. were cat fleas. Plague-like bacilli were demonstrated in the stomach contents of one out of 85 human fleas dissected and of 23 out of 77 rat fleas. The commission carried the observations a stage further, and by the transference of infected fleas from guinea-pigs started an epidemic of plague among healthy guinea-pigs which was maintained by the introduction of fresh infected fleas.

That the flea is an important agent in spreading plague from rat to rat and in the maintenance of rat epizootic is evident from these experiments. The rat flea, variously named by different observers *Pulex cheopis*, *Pulex murinus*, and *Pulex pallidus*, and commonly found on the *Mus rattus*, was the active agent in the transfer of the disease from rat



to rat and from rat to guinea-pig. To the extent to which the *Pulex cheopis* is an agent in keeping up the epizootic in the rat, it will account for the epidemiology of plague, but it is not a necessary deduction from this that *Pulex cheopis* plays the same active part in the transfer of the disease from the rat to man as it does from rat to rat, though it may be credited with an indirect influence in the maintenance of the disease in man owing to its being an active agent in the dissemination of the disease in rats and possibly in other animals.

There is much in favour of *Pulex cheopis* playing an active part in the transfer of plague from the rat to man. There can be no doubt that *Pulex cheopis*, unlike *Pulex fasciatus*, another common rat flea, bites man. *Pulex cheopis* is only found occasionally in ordinary circumstances on man. As a rule, it is either the human flea or *Pulex canis* that is usually found on man. Hilger identified 59 per cent. of over 2000 fleas which he found on man as being *Pulex canis*, and it may possibly have been this flea which, owing to its wide distribution on rats, dogs, cats, and man, gave rise to the older views that dogs, cats, and fowls from infected houses spread plague even when these animals were unaffected. In certain circumstances *Pulex cheopis* may be found in numbers on man, such as the instance given by Liston, in which 46 per cent. of the fleas found on the persons of inmates in an infected house proved to be *Pulex cheopis*.

In Hong-Kong in 1902 I was able to infect two monkeys by placing rats which had died from plague and which were covered with fleas in the same cages as the monkeys but in compartments which prevented any possible contact between rat and monkey but which allowed of a free passage of fleas from rat to monkey. Both monkeys fell ill but recovered. The Indian Plague Commission has in a similar fashion on two occasions succeeded in transferring the plague of the rat to monkeys by the agency of fleas. As it is in the monkey so probably it is the case in man. No direct experiments can be made to prove this, but the accidental infection in man caused by the handling of rats dead from plague and on which Simond's first founded his theory would appear to bear the interpretation given them by the laboratory experiments.

On the other hand, taking the most liberal interpretation



of the flea theory based on the experiments mentioned, it is doubtful whether the flea theory will account for more than a certain percentage of the fatal bubonic cases which may vary in different circumstances in different localities. Out of ten experiments with monkeys by the Indian Plague Commission eight failed and in my own experiments the monkeys recovered. Moreover, the fact that infants under one year of age are more or less immune to plague militates against the flea being as important an agent in the causation of human plague as of rat plague. The incidence on infants is very small. This has been shown by Lieutenant-Colonel C. J. Bamber, I.M.S., in the different Punjab epidemics. This immunity is shared with the aged. Fleas probably are not attracted to old people but the same cannot be said with reference to infants who sit, lie on, and crawl about the floor. The food of infants fed as a rule at the breast of the mother differs from that of the adults in that it is pure and not subject to contamination with plague virus and herein probably lies the explanation of the immunity of the infant.

#### THE FOOD THEORY.

The difference in the type of the disease in Sydney as contrasted with Poona and Hong-Kong has already been mentioned. More post-mortem examinations are made on plague cases in Hong-Kong than in any other part of the world, and it is on the observations there both on man and animals that the theory has been formulated that the ingestion of food contaminated with the plague virus is the cause of septicæmic cases of plague.

Wilm in 1896 found that in 20 per cent. out of 150 necropsies the mucous membrane of the stomach or intestines showed lesions with hæmorrhages, and he was successful in causing plague in fowls by feeding them with plague material and with pure cultures of the plague bacillus. He also succeeded in infecting a pig fed with the spleen of a man who had died from plague. In 1897 the German Commission in Bombay was successful in causing plague in rats, a mongoose, a squirrel, and monkeys by feeding experiments, but failed with mice, guinea-pigs, dogs, and pigs. The Austrian Commission was successful in similar experiments with guinea-



pigs, rats, mice, and cats, but failed with dogs, pigeons, hens, and a mongoose.

In 1902 I had the opportunity of seeing with Dr. W. Hunter a large number of necropsies on plague cases in Hong-Kong and we were able to confirm the great frequency with which the intestines are the seat of primary hæmorrhagic lesions and the mesenteric glands swollen and hæmorrhagic. Later Dr. Hunter has given a detailed description of the pathological changes which are observed in the alimentary canal and which are practically present in all the septicæmic cases of plague. The stomach shows well-marked congestions and hæmorrhages; some of the hæmorrhages may occasionally be of the size of a dollar piece. The changes met with in the small intestines are even more severe than those in the stomach. Petechial hæmorrhages and blood extravasations with necroses, forming not infrequently superficial ulcers, are common. Peyer's patches and the solitary follicles are swollen and may be hæmorrhagic, and in some parts inflammatory changes extend through the walls of the intestine. The mesentery is frequently affected by extensive hæmorrhages and the contained lymphatic glands are enlarged and hæmorrhagic. The lymphatic glands standing in relation to the ileum and cæcum are almost always affected. They are frequently double their ordinary size and on section are œdematous, with minute blood extravasations into their parenchyma. With Dr. Hunter and Dr. Matsuda, a Japanese medical man lent to the Government of Hong-Kong by Japan, I was able to carry out a series of feeding experiments which established that poultry, calves, pigs, sheep, rats, and a monkey contracted plague by feeding. We failed to cause plague in dogs by feeding. These observations on men and on animals led me to the conclusion that septicæmic plague is in most cases contracted by the alimentary canal; an additional fact which lends support to this view is the frequency of abrasions and denudations of the alimentary canal in Asiatics. Dr. H. Fraser, who is engaged in a research on the condition of the intestines, showed me in his laboratory at Kuala Lumpur in the Malay States microscopical specimens of the intestines of Chinese and Indians in which he had found over 50 per cent. with abrasions or ulcers. Dr. Hunter has also shown that when premonitory symptoms of plague do manifest themselves the



patients frequently suffer from gastric and intestinal disorders with diarrhoea and in these cases examination of the blood shows a septicæmic infection.

More decisive than even the foregoing experiments on animals are those made by Dr. Klein in this country because of the convincing histological work which he has associated with them. He has proved beyond all question of dispute that the plague bacilli taken in contaminated food multiply while the food is in the intestines, enter through the lymph channels or lacteals of the intestines, and invade the blood in swarms. The only qualification is that the microbes shall be so protected as not to be affected by the gastric juice.



## LECTURE III.

*Delivered on June 25th.*

## IMMUNISATION AGAINST DISEASE.

MR. PRESIDENT AND FELLOWS,—The next question from a preventive aspect is whether there is a prophylactic against plague similar to that of vaccination against small-pox, and if so what is its value. The question naturally leads to a consideration of Haffkine's prophylactic against plague and of methods of artificial immunisation. Jenner's great discovery lay in the fact that he ascertained that the passage of the small-pox virus through the cow fixed its properties in such a manner that the immunising effects of the small-pox virus were retained while its power of producing the disease was destroyed. The defects of inoculation with the small-pox virus consisted in the danger to the inoculated which sometimes attended the operation and in the risk of infection which sometimes spread from the inoculated to other persons. Notwithstanding these disadvantages inoculation was practised as the lesser evil because in the majority of cases its effects were comparatively mild and it conferred a very high protection. Inoculation against disease is thus a very old method of protection. In some of the ancient shastras written contemporaneously with the works of Menoo inoculation is mentioned as being practised as a preventive or modifier of small-pox. Even inoculation against plague has been practised among the Turks.

The Brahmins who performed the inoculations against small-pox in India instituted certain procedures to avoid the defects as much as possible. They made it a point to inoculate if possible all the children in the village at the same time so as to prevent natural infection; they selected the virus from a discrete case and they usually kept it several days before inoculating it into individuals, for they found by experience that it produced a milder disease when thus kept than when directly transmitted from person to person. In



later times such precautions were often relaxed with results not nearly so satisfactory. In China the inoculations against small-pox were often practised by ignorant men and instead of the small-pox virus being inoculated through the skin, which generally gives a mild attack, it was not infrequently placed in the nostrils and a very severe attack of the disease usually followed. When in China I came across an instance of this kind where some 17 persons had been inoculated in this manner and where the results were serious.

The older methods of inoculation, whether for small-pox or plague, depended on the employment of crude material containing the living germs of the disease and over these there was little or no control. Sometimes the material was efficacious and harmless, at other times it was dangerous. There was also risk of the method, while protecting the individual inoculated, spreading the disease to healthy persons. The discoveries of Jenner, Pasteur, and Haffkine have introduced new methods by which the material employed is fixed in strength, protective and harmless to the individual, does not spread the disease, and is fully under control.

#### HAFKINE'S CHOLERA VACCINATION.

There is a difference between the cholera and plague inoculations introduced by Haffkine. In cholera a living vaccine is employed; in plague a devitalised or chemical vaccine is used. The cholera vaccine needs to be fixed in its strength in order that the microbe shall behave constantly in the same manner when injected alive into man. It was the non-recognition of this fundamental principle which led to Ferran's failure in Spain. He practised inoculation against cholera on the same principle as the old inoculations against small-pox. The crude microbe isolated from a cholera patient was employed without fixing its strength. In Haffkine's method of inoculation against cholera there are two vaccines. The cholera microbe is first fixed at a high stage of virulence by passing through animals and is maintained at its high strength by the same process. It is necessary to mention that the cholera microbe requires air for its life and accordingly in the process of passing it through a succession of animals it is necessary to alternate



this procedure with aeration of the microbe for some hours, otherwise it will die. It is in this way that the strong vaccine is obtained. But as this vaccine when injected under the skin of animals is apt to produce a slough, an attenuated microbe is used as a first vaccine. The attenuation is attained by a prolonged aeration and exposure to a continuous high temperature.

The advantage derived from using a living vaccine is that the immunity is higher and of longer duration. The disadvantage is that it has always to be prepared afresh by a bacteriologist and consequently difficulties arise in its preparation and distribution over large and numerous areas, whereas a devitalised or chemical vaccine can be preserved for a considerable time and sent out to great distances and administered by any physician who knows how to employ it aseptically.

Toussaint was the first to introduce chemical vaccines. He employed a vaccine of this kind against anthrax prepared from the heated defibrinated blood of dead animals. The method worked well as long as there were no spores in the blood. The heat to which the blood could be subjected without being coagulated—viz., 57° C.—would not destroy spores, so that if these were present and animals were inoculated the result was the death of the animals and the danger of spread of anthrax to other animals.

Many experiments were tried on similar lines by others with different kinds of microbes and on different animals, but the immunity obtained by such chemical vaccines was so short-lived that the methods could not be used for practical purposes, and so it happened that up to the time of the cholera inoculations inclusive all vaccinations were done with living vaccines.

#### HAFFKINE'S PLAGUE INOCULATION.

When the problem of preparing a vaccine against plague presented itself Haffkine with his experience of the cholera vaccine quickly realised the importance of endeavouring to discover a chemical preparation of practical utility. The reason for this was the distribution of the plague in numerous villages and small towns and the impossibility of obtaining a sufficiently large number of bacteriologists to prepare and



use a living vaccine. With these facts in front of him Haffkine pursued several lines of research. One of these was to vary the microbial preparation and to study the effect on each of them of different processes of sterilisation. Artificial cultures of the microbe, the blood and exudation of animals dead from plague, and the pulp of their different organs were taken and subjected to heating, drying, chloroform, carbolic acid, lactic acid, or essential oils.

Inoculation with the dried powder of pulverised organs and blood of animals dead from plague was found to be by far the most effective. A few years ago Dr. Klein made a very careful investigation in this direction and was successful in preparing a powder possessing very high immunising properties. In India, however, dying animals are rapidly invaded with intestinal vibrios and bacilli and the heating and drying which were employed to devitalise the plague microbe were not sufficient to kill the spores of these extraneous microbes, so that the same difficulty met with by Toussaint recurred here in another form. Sometimes also the powder appeared sterile in culture but when injected into an animal killed it, plague bacilli being present in its blood; at other times the animal died apparently from toxins, no microbes being found. When the animal did survive it was very thoroughly vaccinated but for the reasons mentioned this method was set aside.

The most practical method of preparation was to use artificial cultures and sterilise them by heat, but it was found that the animals naturally susceptible to plague, such as rats, guinea-pigs, and monkeys, could not be vaccinated by this preparation or required many injections extending over several weeks before any immunity was established. Experiments, however, showed that an animal not naturally susceptible to plague—viz., the rabbit, which possesses a relatively high degree of resistance even to injected plague—could be rendered immune with this chemical vaccine. Influenced by this circumstance and not deterred by the other Haffkine determined to ascertain whether man could not be immunised in a similar way to the rabbit.

On *a priori* reasoning it seemed improbable but the experiment first made in the outbreak of plague in His Majesty's House of Correction at Byculla in Bombay proved the possibility of such immunisation. This epidemic only lasted



a week after the inoculations but still it seemed to show that during that short time benefit had accrued from the use of the prophylactic. The result obtained at the Byculla jail was subsequently confirmed by many experiments made under varied conditions and on a larger scale, and finally, it has been established that the immunity in man is not only real and of a satisfactorily high degree but lasts for a considerable time.

These two circumstances demonstrated for the first time the practicability of immunisation by a chemical vaccine. The success of the method encouraged a trial of immunisation on similar lines against typhoid fever, and this also appears to have been attended with successful results.

Experience of the effect produced by the cholera vaccines in India from 1893 to 1896 demonstrated that immunity was obtained against attacks of cholera, but when the inoculation failed and the person inoculated was subsequently attacked the fatality was practically the same as among those not inoculated. This result pointed to antimicrobial immunity being obtained but not to antitoxic immunity, and appeared to be related to the fact that the cholera vaccine consisted of the bodies of living bacilli obtained by cultivation on solid media. Haffkine realised that the defect attaching to the cholera vaccines should, if possible, be remedied in the production of the plague prophylactic and endeavoured to prepare a material which would give, not only an immunity against attack, but also at the same time diminish fatality when an attack occurred.

In the case of microbes producing extra cellular toxins, such as diphtheria, antitoxic properties are obtained in animals by injection of the toxins. Plague cultures in fluid media do not show the presence of any appreciable toxins in the filtrate, but Haffkine observed that when he injected into animals sterilised old fluid cultures of the plague bacillus he obtained a reaction which he could not obtain to the same extent when using the microbes and the filtrate separately. This appeared to indicate that the fluid possessed properties of its own. It encouraged him to try the combination of the microbes and the fluid which later was proved to be a success. The method adopted was to use old cultures rich in bacilli and their secretions. A suitable medium for obtaining such cultures was peptone broth to which were added a few drops of butter or oil. By the end of



six weeks the culture is ripe for use and its purity is ascertained by drawing off a small quantity and subjecting it to the tests already described in the first lecture. The culture is then heated at from  $55^{\circ}$  to  $60^{\circ}$  C. for 20 minutes, with the result that the microbe is devitalised. The prophylactic then becomes a chemical drug with fixed properties and can be used in measured doses like other drugs. The preliminary fixation of the biological and pathogenic properties of the microbe is under such conditions not an essential process as in the case of cholera and small-pox, where living vaccines are introduced into the system.

The dosage of the prophylactic was determined by careful observation of its effects on man, which led to the adoption of the principle gathered from the study of the results of the cholera inoculations in India. This principle consists in regulating the dose with the view of producing an average temperature of  $101^{\circ}$  F. The same dose in different individuals gives rise to different ranges of temperature. Following the above standard it is generally observed that in one-third of the inoculated the temperature may rise to  $102^{\circ}$  F. and above. This proportion should not be exceeded. The thermometer is thus used as the indicator of the reaction. There is no testing of the blood in plague or cholera inoculation for the purpose of ascertaining what dose shall be given. The information obtained by the thermometer has been found to be a reliable guide and supplies a very simple and practical method of regulating the dose. It is a notable fact that in cholera and plague inoculations no instance has been observed of the inoculated groups having been rendered by the inoculation at any time more susceptible to these diseases than the uninoculated.

#### THE RESULTS OF THE USE OF THE PROPHYLACTIC.

The harmlessness of the prophylactic was first established by the inoculation of several hundred volunteers, European and Indian. Then its protective effect was ascertained for the first time at the height of an outbreak of plague at the Byculla jail and certain facts were observed by Haffkine which enabled him to arrive at some very important conclusions. These were: (1) that one injection of three cubic centimetres of the prophylactic was sufficient to protect



during an existing epidemic; (2) that inoculation was powerless to arrest the disease in those in whom the symptoms have already appeared or develop in a few hours after inoculation; (3) that the inoculation mitigated or aborted the disease in those who were in the incubation stage and had been infected three or four days previously; and (4) that the prophylactic, unlike the vaccines for cholera, rabies, anthrax, or small-pox, exercised its protective effect in less than 24 hours, acting in this respect with a rapidity which was only known in antitoxic sera.

Of these deductions that relating to the effect of the vaccine on individuals in the incubation stage and its power of arresting the development of infection or mitigating the disease appears to be the most incredible, particularly in view of the shortness of the incubation period in plague. Calmette and his co-workers as well as other bacteriologists asserted that an individual inoculated not only in the incubation period but also a short time before infection would succumb to the disease and recommended that no "contacts" or persons exposed to infection should be inoculated. The Indian Plague Commission of 1889, though not endorsing this view, was of opinion that inoculation was not likely to effect any protection for the first five days and was against Haffkine's conclusion as to the benefit of the inoculation in the incubation period. Subsequent study of the subject, however, induced Sir Almroth E. Wright to adopt Haffkine's views, and it is in conformity with the results obtained by Haffkine's inoculation in the incubation stage of plague that he based his method of treating with vaccines patients suffering from furunculosis, sycosis, acne, and other bacterial infections. The fact of the prophylactic immunising so rapidly and being beneficial in the incubation stage not only excludes the danger that was feared but allows of the application of the prophylactic in infected houses and localities, and generally during the prevalence of an epidemic.

Later observations have fully confirmed Haffkine's conclusions which stand to-day without modification. It is not from observations on animals but from observations on man that the question as to the action of Haffkine's prophylactic has to be worked out and has to be judged. This test has now been applied in many places and under various conditions and always with the same successful result. The



observations are divisible into two classes—viz., those that have been made on a small scale in restricted communities living under special administrative and medical control, and those made on a large scale. Owing to the circumstances in which the first class, conducted on a small scale, were carried out and which permitted of the results being carefully watched and thoroughly checked, they possess a special value on account of their exactness and precision.

Table A shows the incidence of plague cases and plague deaths in some 18 small communities under careful control where a part of the inhabitants were inoculated and a part remained not inoculated; most of them are taken from the reports of Haffkine and Indian medical men collected by Colonel W. B. Bannerman, I.M.S. The table shows their comparative liability to attack and death and the percentage of saving in cases and deaths among the inoculated as compared with the not inoculated.

In the Byculla jail, out of 172 not inoculated there were 12 cases of plague, six of which proved fatal, while among 147 inoculated there were only two cases and no deaths—that is, among the non-inoculated 7 per cent. of the population were attacked and 3·5 per cent. of the population died, and the proportion of deaths to cases was 50 per cent., whereas among the inoculated only 1·4 per cent. of the population were attacked and there were no deaths. The percentage of saving in cases was accordingly 80 per cent. and in deaths 100 per cent.

Again, in Umerkhadi jail, out of 127 persons not inoculated there were ten cases with six deaths, whereas among the inoculated there were three cases and no deaths—that is, among the non-inoculated 7·9 per cent. of the population were attacked and 4·7 per cent. of the population died, with the proportion of deaths to cases of 60 per cent., whereas among the inoculated there were only 2 per cent. of the population attacked and none died. The percentage of saving in cases amounted to 74 per cent. and in deaths to 100 per cent.

The results given in these first two practically represent the results in the others; for instance, if the employees of the Southern Maratha railway be taken it will be observed that out of 760 not inoculated 35 cases occurred with 21 deaths, whereas out of 1260 inoculated 11 cases occurred with two deaths—that is, among the non-inoculated 4·6 per



CLASS I.—TABLE A.  
OBSERVATIONS ON THE WORKING OF HAFKINE'S SYSTEM ON A SMALL SCALE, SPECIAL OBSERVATIONS BEING CARRIED OUT ON RESTRICTED COMMUNITIES.

Name of locality.	Non-inoculated.						Inoculated.					
	Non-inoculated.	Cases.	Percentage of cases to population.	Deaths.	Percentage of deaths to population.	Proportion per cent. of deaths to cases.	Inoculated.	Cases.	Percentage of cases to population.	Deaths.	Percentage of deaths to population.	Proportion per cent. of deaths to cases.
1. Byculia jail ... ..	172	12	7.0	6	3.5	50.0	147	2	1.4	—	0	0
2. Umerkadi jail, ... ..	127	10	7.9	6	4.7	60.0	147	3	2.0	—	0	0
3. Undhara village (plague infected houses) ... ..	64	27	42.2	26	40.6	96.3	71	8	11.3	3	4.2	37.5
4. Hobli (mill) ... ..	75	—	—	20	26.66	—	1098	—	—	30	2.7	—
5. Hobli (employees of Southern Maratha Railway) ... ..	760	35	4.6	21	2.7	60.0	1260	11	0.9	2	0.2	18.2
6. Dharwar jail * ... ..	—	—	—	—	—	—	374	—	—	—	—	0
7. Broach (Parsee population) ... ..	763	9	1.2	5	0.6	55.6	1080	2	0.2	1	0.1	50
8. Broach (tailors' camp) ... ..	135	10	7.4	6	4.4	60.0	90	—	—	—	—	0
9. Belgaum (49th Battery R.F.A. Native followers) ... ..	—	—	—	—	—	—	—	—	—	—	—	—
10. Belgaum (Army Hospital Corps, 1897) ... ..	3	2	66.7	2	66.7	100.0	80	—	—	—	—	0
Ditto, 1899 ... ..	5	1	20.0	1	20.0	100.0	79	2	2.5	2	2.5	100.0
11. Major Forman's servants ... ..	2	1	50.0	1	50.0	100.0	28	—	—	—	—	0
12. Bulsar Shanchis (oil pressers) ... ..	35	4	11.4	4	11.4	100.0	261	7	2.7	4	1.5	57.1
13. Golaba ward (Chawl), Bombay ... ..	32	19	59.4	12	37.5	63.2	21	1	4.8	—	0	0
14. Poona, Yerowda jail.† ... ..	—	—	—	—	—	—	—	1	0.06	0	0	0
15. Aden—Jewish community. (31 households infected.) ... ..	179	44	24.6	29	16.2	65.9	246	19	7.7	8	3.3	31.2
16. Aden (special prison)§ ... ..	2	2	100.0	1	50.0	50.0	—	0	0	—	0	0
17. Aden (Orater Plague Hospital) ... ..	—	263†	—	163	—	61.9	—	21†	7.0	—	33.3	—
18. Kirkee, near Poona, 1905 ... ..	12	6	50.0	3	25.0	50.0	1300	5	0.4	1	0.1	20.0

\* Four deaths occurred among the prisoners before inoculation. The entire population was inoculated. One case occurred two days after inoculation, which recovered.

† Population 334. Plague continued for 37 days and 23 cases and 17 deaths occurred. Gradually the whole population was inoculated and none of those inoculated were attacked.

‡ Population 1631. Plague continued for 13 days and three cases and three deaths occurred in those who had not been inoculated. 1638 were inoculated by the thirteenth day; of these one was attacked but recovered. There were no further cases.

§ All the prisoners were inoculated excepting two; these two were attacked, one of whom recovered. When inoculation completed no cases, although rats were dying from plague.

These observations were made in places where non-inoculated people had between 1.2 and 100 per cent. of cases and between 0.6 and 66.7 per cent. of deaths, with a proportion of deaths to cases varying between 50 and 100 per cent. The inoculated people of the same places had between 0 and 11.3 per cent. of cases and between 0 and 4.2 per cent. of deaths, with a proportion of deaths to cases varying between 0 and 57.1 per cent. The number of cases among the inoculated was reduced by between 68.3 and 100 per cent., and the number of deaths by between 79.5 and 100 per cent., as compared to the incidence of attacks and deaths among the non-inoculated people of the same place.



CLASS II.—TABLE B. **Table of the same type.**

The number of cases through the interval also are listed by means of the interval, and the number of cases through the interval also are listed by means of the interval.

Name of locality.	Non-inoculated.					Inoculated.								
	Non-inoculated.	Cases.	Percentage of cases to population.	Deaths.	Percentage of deaths to population.	Proportion per cent. of deaths to cases.	Inoculated.	Cases.	Percentage.	Deaths.	Percentage.	Proportion per cent. of deaths to cases.	Percentage of saving in cases.	Percentage of saving in deaths.
Mora ... ..	580 (about)	26	4.5 (about)	24	4.1 (about)	92.3	419	7	1.7	—	0	0	62.7 (abt)	100.0
Damaun ... ..	6,033 (about)	—	—	1482	24.6	—	2,197	—	—	36	1.6	—	—	93.4 (abt)
Lanowil ... ..	377	78	20.7	57	15.1	73.1	323	14	4.3	7	2.2	50.0	79.1	85.7
Kirkee, in 1897 ... ..	859	143	16.6	98	11.4	63.5	671	32	4.8	17	2.5	53.1	71.4	77.9
Undhera village, whole population...	437	27	6.2	26	5.9	96.3	513	8	1.6	3	0.6	37.5	74.8	90.2
Khoja community in Bombay, 1898	9,516 (about)	—	—	77	0.8 (about)	—	3,814	—	—	3	0.08	—	—	90.3 (abt)
Habli ... ..	17,788	—	—	2,348	13.2	—	24,631	—	—	338	1.3	—	—	89.6
Dharwar (town) ... ..	16,843	1,100	6.5	889	5.3	80.8	4,231	129	3.04	54	1.3	41.8	52.2	75.7
Gadag (town) ... ..	4,163	278	6.6	216	5.2	77.7	13,004	193	1.5	83	0.6	43.0	77.7	87.6
Belgaum (cantonnement) ... ..	4,558	506	11.1	346	7.59	68.4	4,842	78	1.6	40	0.83	51.3	83.8	89.1
Ahmednager (district) ... ..	8,794	563	6.4	415	4.7	78.7	2,493	70	2.8	31	1.2	44.3	56.2	77.0
Aden (Jewish community) ... ..	932	183	8.4	165	6.6	78.3	1,190	23	1.9	8	0.6	34.7	77.0	89.7
The Punjab:														
1897-1900 ... ..	—	—	—	—	—	60.99	366,730	—	—	—	—	36.55	—	—
1900-1901 ... ..	—	—	—	—	—	60.59	197,278	—	—	—	—	36.50	—	—
1901-1902 ... ..	3,909,326	266,700	6.8	173,732	4.4	65.14	235,776	881	0.4	209	0.1	35.07	94.5	97.1
1902-1903 ... ..	—	—	—	—	—	60.1	505,849	—	—	—	—	30.47	—	—
Part portion of the inoculated in 1902-03 ... ..	639,630	49,433	7.7	29,723	4.6	60.1	186,797	3399	1.8	817	0.7	23.9	76.5	90.6
Aden, 1905... ..	1052	368	34.9	194	27.9	78.6	898	37	4.1	14	1.6	37.8	88.2	94.4

\* Besides 32,798 in Punjab native states.



cent. of the population were attacked and 2·7 per cent. of the population died with the proportion of 60 per cent. of deaths to cases, whereas among the inoculated there was 0·9 per cent. of cases to the inoculated population and 0·2 per cent. of deaths with a proportion of deaths to cases of 18·2 per cent. The percentage of saving in cases amounted to 81·03 per cent. and of saving in deaths to 94·1 per cent.

Among these 18 observations there are several where the whole community was inoculated with the result that the plague was arrested. Thus in the Yerowda Jail, Poona, plague appeared and in 13 days caused three cases which were fatal. By the thirteenth day the whole of the jail consisting of 1658 persons were inoculated, one of whom was attacked, but recovered, and there were no further cases. In the Aden Prison all the prisoners were inoculated except two; these two were attacked with plague and one recovered. When inoculation was completed no cases occurred although rats were dying from plague.

Summing up these experiments as a whole, they were made in places where the *non-inoculated* people had between 1·2 and 100 per cent. of cases and between 0·6 and 66·7 per cent. of deaths, with a proportion of deaths to cases varying between 50 and 100 per cent. The *inoculated* people of the same places had between 0 and 11·3 per cent. of cases and between 0 and 4·2 per cent. of deaths, with a proportion of deaths to cases varying between 0 and 57 per cent. The number of cases among the inoculated was reduced by between 68·3 and 100 per cent. and the number of deaths among the inoculated was reduced by between 79·5 and 100 per cent., as compared to the incidence of attack and deaths among the non-inoculated people of the same places.

The conclusions derived from these observations will be more clearly followed if the comparative results are given in a graphic form and the smaller numbers excluded.

[Professor Simpson here showed upon the screen several diagrams dealing graphically with these figures. In Diagram I. A the most instructive epidemics had been taken which illustrated different degrees of severity on the population, the incidence of plague varying from 1·2 to 59·4 per cent. of the population. The columns were formed on the principle of each column representing 100 inhabitants inoculated or not inoculated.



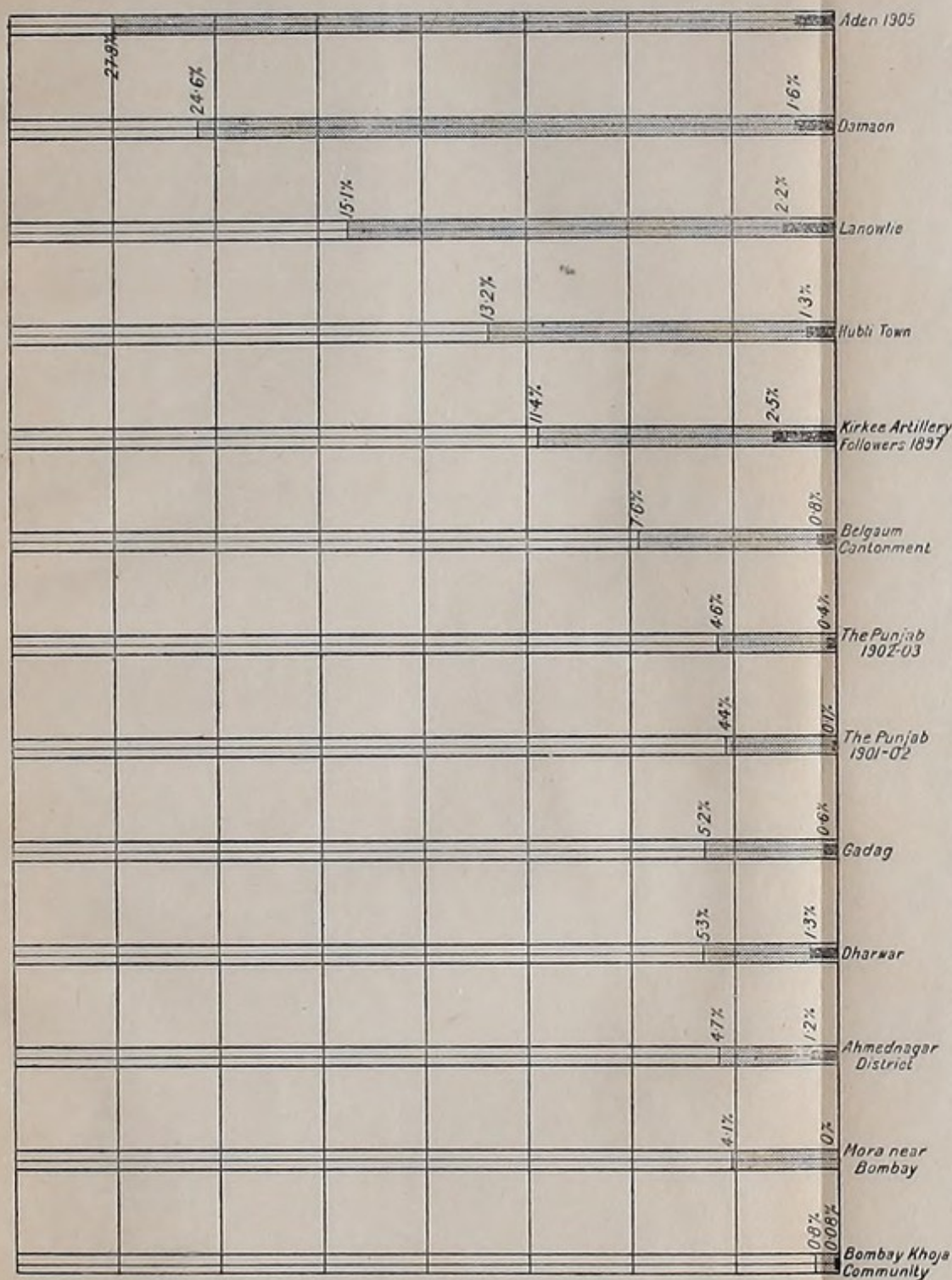
*Diagram I. A* showed that the observations were made in epidemics in which the incidence of *attack* in the non-inoculated varied from 1·2 to 59·4. The incidence of attack among the inoculated varied from 0 to 11·3. In general the incidence of attack on the inoculated corresponds to the severity of the epidemic, but this is not uniformly the case, for in a few the inoculated show a striking immunity in the midst of very severe epidemics.

*Diagram I. D* represented the percentages of plague attacks averted by inoculation. Each column represented 100 attacks which occurred among the uninoculated population; the upper shaded portion of the columns represented the number of attacks which occurred in an equal number of the inoculated population. The remaining blank portion of the column shows the percentage of attacks averted by inoculation; the saving in attacks varies from 58·3 to 100 per cent. In the Jewish community in Aden against each 100 attacks among the non-inoculated there were 31·7 in the inoculated and the saving in cases was 68·3, whereas in the tailors' camp at Broach the inoculated escaped attack altogether and the saving was 100 per cent.

The second class of observations, which represented observations of the working of the system on a large scale, furnished results similar to those obtained on the smaller scale. Table B gave those results. Of these Professor Simpson specially referred to the observations at Kirkee in 1897, because he had the opportunity, along with Haffkine, of checking the results on the spot. Of the community on which the experiment was made, 859 were not inoculated and 671 were inoculated. Out of the 859 not inoculated there occurred 143 cases with 98 deaths, and the proportion of deaths to cases was 68·5 per cent. Out of 671 inoculated there were 32 cases with 17 deaths and the proportion of deaths to cases was 53·1 per cent. Thus the incidence of attack on the not inoculated was 16·6 per cent. and of deaths 11·4 per cent., whereas the incidence of attack on the inoculated was 4·8 per cent. and of deaths 2·2 per cent. Or, in other words, there was among the inoculated a percentage of saving in cases of 71·4 and of deaths of 77·9, as compared with the not inoculated.] He went on to say:—

Undhera village may also be taken as another example.





Inoculation on a large scale. Percentage of plague deaths to population. The stippled portions of the columns represent the percentage of deaths in the non-inoculated. The black portions represent the percentage of deaths among the same number of inoculated.







In this village more than half the population was inoculated, 513 being inoculated and 437 not being inoculated. Out of the 437 not inoculated there were 27 cases of plague with 26 deaths, the proportion of deaths to cases being 96·5 per cent. Out of the 513 inoculated there were eight cases with three deaths, the proportion of deaths to cases being 37·5 per cent. The incidence of attack among the not inoculated was 6·2 per cent. and of deaths 5·2 per cent., while among the inoculated the incidence of attack was 1·6 per cent. and of deaths 0·6 per cent. So that among the inoculated the percentage of saving in cases was 74·8 and in deaths 90·2, as compared with the not inoculated.

Considering the observations as a whole in the different places recorded the results show that the non-inoculated part of the population had between 4·3 and 34·9 per cent. of cases and between 0·8 and 27·9 per cent. of deaths, with a proportion of deaths to cases varying between 60·1 and 96·3 per cent., while the inoculated part of the population had been 0·4 and 4·8 per cent. of cases and between 0 and 2·5 per cent. of deaths, with a proportion of deaths to cases varying between 0 and 53·1 per cent. The number of cases among those inoculated was reduced by between 52·2 and 94 per cent., and the number of deaths between 75·7 and 100 per cent., as compared to the incidence of attacks and deaths among the non-inoculated inhabitants of the same localities.

The following diagrams refer to the observations on large communities and they are constructed on the same principle as those relating to the smaller communities.

*Diagram II. B* (a copy of which is printed) illustrates epidemics of different degrees of severity and the relative incidence of the disease among the not inoculated and the inoculated. The whole column represents 100 inhabitants inoculated or not inoculated, the shaded portion shows the percentage of deaths among the not inoculated, and among the inoculated. The incidence of deaths in the non-inoculated population varied between 0·8 and 27·9 per cent., whereas among the inoculated it varied between 0 and 2·5 per cent.

[*Diagram II. E* showed the saving in the number of deaths among the inoculated compared to the non-inoculated. Each



column represented 100 deaths which occurred among the uninoculated population. The shaded portion of the column represented the number of deaths which occurred in an equal number of the inoculated population. The remaining blank portion of the column showed the percentage of deaths averted by inoculation. The saving in the number of deaths effected by the inoculations varied between 75·7 and 100 per cent.]

These diagrams bring out in a very clear manner the great value of the inoculation. Stated generally, the average reduction amounts to three times fewer attacks among the inoculated and should the inoculated take plague the chances of death are reduced at least twice. Accordingly, the chances of escape from death are 6 to 1 in favour of the inoculated compared to the uninoculated. In many cases they are at least 10 to 1 in favour of the inoculated—that is, out of 1,000,000 deaths among a non-inoculated population, if that population had been inoculated and exposed to the same infection, 900,000 lives would have been saved.

There are numerous other observations that might be quoted showing the value of Haffkine's prophylactic as a protective against plague. I shall content myself, however, by giving two further examples, one recorded by Dr. J. A. Turner, health officer of Bombay, and the other by Lieutenant-Colonel J. A. Cunningham, I.M.S. The first relates to the municipal employees under Dr. Turner. 7182 were inoculated and 418 were not inoculated. Out of the 7182 inoculated there were 14 attacked with plague and 13 died, being a percentage of 0·19 of attacks and 0·18 of deaths, whereas among the 418 not inoculated there were 28 attacked and 26 deaths, equal to a percentage of 6·7 attacks and 6·2 deaths. If the inoculated had suffered to the same extent as the non-inoculated they would have furnished 481 attacks with 446 deaths, instead of 14 and 13 respectively. The second refers to a small plague-stricken village in the Umballa district of the Punjab, where Lieutenant-Colonel Cunningham inoculated nearly half the population. Lieutenant-Colonel Cunningham describes the circumstances connected with the inoculations as follows :—

The village is Chamaru, about nine miles from Umballa city, situated in Thana Ganour in the Patiala State, the population of which was 783 souls. Narain Singh, a Lambardar of the village, brought in batches



to the civil hospital, Umballa, between 21st and 27th March, 1907, 312 people, comprising men, women, and children of all classes, and these were inoculated with plague prophylactic serum by Captain Ross, I.M.S., assistant plague medical officer. The Lambardar, to whom great praise is due, took this action because rats were dying of plague in the village. On the 22nd March, the day following the first batch of inoculations, cases of plague were observed amongst the people of the village, and between this date and the 14th May 64 people contracted the disease, 38 dying.

We can now compare the results (which I had carefully verified on the spot by a medical officer) between the 312 inoculated people and the 471 uninoculated similarly situated in all respects, except for the difference in inoculation. Out of 312 inoculated, 13 contracted plague and four died, whilst amongst 471 uninoculated people 51 got plague and 34 died. The percentage works out for inoculated, attacks 4.13 per cent. and deaths 1.25 per cent.; whereas for uninoculated the figures are: attacks 10.8 per cent. and deaths 7.2 per cent.

For comparison I had the results ascertained in another village, Rampur, population 484, situated two miles from Chamaru in the Patiala State, where no inoculation had taken place. Here there were 74 attacks and 32 deaths, the disease occurring simultaneously with that at Chamaru between 14th March and 14th May; the percentages here are: attacks about 15.2 per cent. and deaths 6.6 per cent. of the population. Of the four who died in Chamaru amongst the inoculated two of them showed signs of the disease the day following the inoculation, and in their case it is safe to assume that their fate was sealed by previous infection before the protective effect of the inoculation came into operation.

It is, I think, a fair assumption that the inoculation of these 312 people saved the lives of 19 and saved 21 others from an attack of a very serious disease. If we could conceive a relative amount of immunity from death and plague throughout the Punjab, what a difference it would make in the experience of thousands of families, and in the population of the province. Even if this Umballa district, with its population of about 763,250 had been thoroughly inoculated, these figures show that about 20,000 of the 28,551 deaths from plague this season might have been averted. This and previous experience would justify the revival of an extensive inoculation campaign throughout the country.

#### DURATION OF IMMUNITY.

Observations in Hubli, Dharwar, and Gadag, three towns in the Southern Mahratta country where a large number of inoculations were done in 1898, tend to show that the effects lasted for several years (weekly reports of collector of Dharwar). The annual reports of the Parsee community in Bombay and the general report issued by them in 1902 seem to indicate that the effect of the inoculations lasted four or five years, though gradually it diminishes. Certain indications in a similar direction were obtained in the Punjab in observations made in 20 villages.



## THE MULKOWAL ACCIDENT.

The inoculations have been going on for ten years in India, and several millions of people have undergone the operation. In these ten years there has been only one serious accident, and this was due to a departure from the technique or rules prescribed by the laboratory when opening a bottle of prophylactic in a village in the Punjab in 1902, in other words, to a faulty application of the prophylactic and not to a fault in its preparation. This accident is an important event in the history of plague operations and as the inquiry into it is of great scientific interest it is desirable briefly to record the salient facts connected with it. These facts have been gathered by a special commission of inquiry in India. Briefly, they are that the bottle was one of five filled from the same cultivation flask, and four were used without any ill effects, proving that the laboratory flask was not contaminated; further the bottle had been issued from the laboratory 26 days before being opened and when opened had no smell. This absence of smell is proof that no culture, even of a few days old, of the tetanus bacillus was present. A number of other facts confirm this conclusion. Thus the period of incubation and the duration of the disease were prolonged, which would not have been the case with an injection of a ready-made culture and toxin. It was found that the Mulkowal tetanus bacillus when experimentally introduced into a bottle of water agar prophylactic for a few days produced a very rich and extraordinarily toxic culture;  $1\frac{1}{2}$  cubic centimetres of this mixture of toxins and microbes would represent an infection such as never occurs in nature. The disease should therefore have been of the most fulminating character ever observed clinically; whereas, on the contrary, it was of an average character with a relatively long incubation period and duration of the disease. The syringe, moreover, with which the injections were made did not convey tetanus to those inoculated from other bottles which would have been the case if it had been infected with a rich culture of tetanus, notwithstanding a soakage for a few minutes in a carbolic solution of 1 in 20. The dregs of the bottle showed some aerobic microbes and only a poor and weak culture of tetanus such as would develop under aerobic conditions, subsequently to



the emptying of the bottle. The actual contamination of the bottle was rendered possible by the local authorities having abolished the laboratory instructions of sterilisation by heat and having substituted for them momentary dipping in carbolic acid. In the opening of the bottle the cork and neck were not sterilised by passing through the flame and for withdrawing the cork soiled forceps were used which had fallen to the ground and were applied to the mouth of the bottle without sterilisation. The fact that no accident occurred while the proper technique was unaltered proves the high degree of safety with which operations on a large scale can be carried out in India.



## LECTURE IV.

*Delivered on June 27th.*

## NO SPECIFIC TREATMENT FOR PLAGUE.

MR. PRESIDENT AND FELLOWS,—I shall not touch on the specific treatment of plague. Great expectations were raised on the introduction of Yersin's serum but they have not been realised and a serum has yet to be discovered which, while being germicidal in its action, also possesses antitoxic properties. The researches of the late Dr. Allan Macfadyen were directed to the preparation of a serum with these double properties, but his untimely death at a moment when he appeared to be on the verge of success has postponed an early solution of this problem, though the researches have, I think, shown the direction in which the solution lies.

## CONSIDERATIONS RELATING TO PREVENTIVE MEASURES IN THE PAST.

From the historical part of these lectures it will have been gathered that the discovery of a prophylactic by Haffkine gives the only measure of defence against plague that has not been employed more or less by some authorities in the older epidemics. Isolation of the sick, evacuation of the infected house, and segregation of contacts, disinfection, destruction of animals, and *cordons sanitaires* were employed. Quarantine of ships from infected ports and purification of merchandise according to the methods known at the time were also put into force. How frequently they were successful there are no means of knowing, but the numerous epidemics with the large mortality recorded are evidences of their failure in a large number of instances. The failure was caused mainly by the uncertainty of diagnosis with its attendant delays until the epidemic had become established and by the employment of an improvised



and untrained service to deal with the disease. Deficiencies in organisation were attempted to be made up for by stringency and severity in rules. Thus at Windsor in the time of Queen Elizabeth, in order to protect the Court, a gallows was erected in the market place to hang everyone who came from London or brought wares from there during the epidemic of plague. In 1585 three gibbets were erected in different parts of Aberdeen "in case any infected person arrive or repair by sea or land to this burgh, or in case any indweller of this burgh receive, house or harbour, or give meat or drink to the infected person or persons the man be hangit and the woman drownit." These are echoes of the stringent measures taken by Count Barnabo in the fourteenth century to prevent people from plague-stricken places entering his territories. In Europe when plague prevailed the services of medical men as advisers and attendants on the sick were understood and taken full advantage of, but their services as sanitarians, directing and controlling with special knowledge and machinery the fight against epidemic disease, were not known. The idea is a product of the Victorian era, and it is not to be forgotten that the impetus for modern preventive work in medicine both for Europe and for India owes its source to England. In India the idea has developed more slowly than in Europe, the conditions there being less favourable to rapid progress. It began in the appointment of sanitary commissioners to provinces, a sanitary commissioner for the Government of India, and health officers to large towns such as Calcutta and Bombay, and the making of the civil surgeons *ex-officio* health officers of the station and district to which they were attached.

The Indian Medical Service, which does magnificent work in India, is very limited in numbers and being spread over the whole of India has a very scattered distribution. Duties military and civil have been assigned to it, and among the civil are attendance on Government officials, on the civil population, on the prisoners in the jails, on the inmates of the asylums, and on the patients in the local hospitals. Besides these duties the civil surgeon is expected to deal with vaccination and sanitation. There is also a small group of officers attached to the laboratories that are springing up in India. The Indian Medical Service being small and not having been increased proportionately to the increased duties which have



been laid upon it by the authorities forgetful of the incident of the last straw on the camel's back, it is impossible, even if its strength were doubled and devoted wholly to preventive medicine, for such an establishment to deal with plague without being supplemented by a large and well-trained native service. There are 145 small towns in the Punjab alone.

It has been recognised for many years past by medical men in India who have paid attention to the subject that the sanitary organisation does not meet the wants of India and that great and fundamental changes are needed. The subject was publicly discussed on a paper read by me at the first medical congress in India held at Calcutta in 1894—i.e., nearly 13 years ago—and as a result of that discussion a deputation from the congress, headed by Surgeon-General R. Harvey, late director of the Indian Medical Service, who was a Fellow of this College, waited on the Government of India and pointed out the urgency and importance of providing a special sanitary service for India which should consist mainly of medical persons specially trained at the medical colleges of India in preventive medicine and which would open up an honourable and useful career in Government service for a number of the more ambitious and well-educated medical students attending the colleges in India. It was felt that just as there are a police service and a medical service there should be a separate and distinct sanitary service which should have its own budget. This was nearly two years before plague reached India, and the recommendation was based on the powerlessness of the system then existing to deal with preventable disease in India. The diseases then in view were cholera, malarial fever, and kala-azar. The appearance of plague in India accentuated the necessity for such a service and to its absence and the employment of improvised agencies consisting mostly of laymen may be partly ascribed a portion of the hostile attitude of the people and of the failure to deal with the disease.

In Europe in former times, in addition to the absence of any specially organised staff to deal with plague and the difficulty relating to diagnosis, there was also, as there always must be in every large epidemic, the difficulty of providing sufficient hospital accommodation for the sick and camps for those who had been in contact with the sick. Under stress



of circumstances the fact which had been recognised at an earlier period that it was dangerous to shut up the sick with the healthy in an infected house was lost sight of and the practice came into vogue during the great epidemic in London to quarantine the house and household in an infected house. It was against this practice that in 1720 Dr. Richard Mead, a distinguished Fellow of this College, wrote when Europe had become alarmed by the severe epidemic of plague in Marseilles in that year. Dr. Mead advocated a return to the system which had been practised in Venice and Scotland since the sixteenth century—viz., the evacuation of infected houses, the sick being removed to hospital and the sound to special airy buildings outside the town. He recognised, however, that a time might come when the epidemic had increased to such an extent that this policy was impossible to carry out and that then, beyond fumigation of the house and attention to personal health, there was little to be done except forbidding convalescents to leave the house until a certain time had elapsed. To prevent infection being carried from an infected town to a healthy one he advocated the abolition of *cordons sanitaires* which the Marseilles authorities had adopted and which, owing to the food-supply being thus cut off, added greatly to the miseries of the population without any corresponding advantages. He proposed the substitution of a passport system after the person who came from the infected town had undergone quarantine or observation for a certain time and disinfection of goods.

#### MEASURES SOLELY DIRECTED AGAINST INFECTED PERSONS AND THINGS WILL NOT CHECK AN EPIDEMIC.

Writing against a system which favoured the spread of the disease from the sick to the healthy, Dr. Mead's proposals dealt only with infected persons and infected goods and did not include Fiochetto's recommendation that arsenic should be prepared for the rats after the cats, dogs, fowls, and pigeons in an infected house were killed. It is obvious that if the lower animals, and particularly rats, suffer from plague and spread the infection to men, measures directed solely to infected persons and infected goods will not stay an epidemic. The very slow recognition of this fact has contributed more than any other



cause to the spread of plague once the infection has been imported into a new locality and has become established there.

For many years before plague appeared in India my thoughts had been directed to the possibility of preventing disease in man by dealing with the allied disease in animals before it reached man. It was partly with this view that I had carried on for years researches as to the relationship of small-pox in man with certain diseases in animals. When several cases of plague occurred in Calcutta and rats were dying in several houses in a particular quarter of the town an opportunity came in an unexpected manner of putting this view into practice, for it had been observed in Bombay that the mortality of rats preceded plague mortality in man. Steps were accordingly taken to have the rats destroyed in the few houses in which they were observed to be dying with the object of preventing the spread of the disease. The measure met with success and the sickness and mortality among rats were arrested. I left Calcutta in 1897 and it was not until April of 1898 that rats were found again to be dying in the sheds connected with the shipping and with the railways, evidently a fresh importation; and with the mortality came the first outbreak of plague in Calcutta.

In Cape Town, after much delay and experimenting, large quantities of Danysz's virus were used with the object of destroying rats in infected quarters, and it is remarkable that no recrudescence of plague has ever occurred in this town. In Hong-Kong a similar policy of dealing with the dissemination of the disease by rats was carried out and with comparative success, notwithstanding continual importation of the disease from Canton. Even this measure has its limits and unless directed with intelligence it is not likely to be successful. It is impossible to destroy all rats in a country and any measure having in view this object is destined to fail. General destruction of rats is good in itself and if the inhabitants of a town or village can be induced to join in a general campaign against rats it is a matter for congratulation. The main point, however, is to deal with the infected rats and for this it is necessary to provide an agency to ascertain where they are and to concentrate energy on infected localities.



## PREVENTIVE MEASURES ADOPTED IN INDIA.

With reference to the plague in India the fullest recognition and credit must be accorded to the Government of India for its energetic efforts to prevent the spread of the disease with the agency at its disposal. There can be no question regarding the anxious and strenuous efforts at first made to check and to control the disease. The Government of India did its utmost to encourage the Government of Bombay to pursue an active policy in combating the plague and Bombay did its best. Very large sums were spent for this purpose amounting to at least £500,000 sterling from 1897 to 1900, and another £300,000 for the protection of the other provinces. But the measures were based, with few exceptions, on the view that plague is disseminated wholly by infected persons and infected clothing.

The failure which followed these measures in a country where the sanitary organisation was small and ineffective and where the habits and dwellings of the people favoured the spread of the disease was facilitated by other circumstances. These were the apathetic attitude of the people; the suspicions and alarms aroused by inspection of huts and houses; the opposition, sometimes merging into open hostility, to the removal of patients from their houses; and then, as the disease increased, the panic and flight that followed, with the scattering of the infection far and wide. The difficulties thus met with were immense and a time arrived when it appeared to the authorities that the continuance of active measures for the prevention of the disease was not only hopeless but would raise trouble by exciting generally the hostility of the usually docile and peaceful inhabitants. A general relaxation of measures was accordingly encouraged and the adoption of plague measures was left to the option of the people themselves. In thus avoiding Scylla the authorities do not appear to have been aware of Charybdis. The plague, unchecked, and taking no heed of politics, has gradually shot ahead. Year after year it is gaining ground and the mortality is now producing just those results which were feared would arise from a policy of activity. The disorders and excitability of the inhabitants of the Punjab have come to most people as a shock and a surprise, but they are what history teaches to be inevitable



where whole families are swept away and where the people of a country are dying in immense numbers.

The result of a relaxation of efforts proved in the case of the Punjab most disastrous and this has been the case also in other parts of India. For instance, in Berar, a province of nearly 3,000,000 of people, plague was kept well under control for six years. There was no quarantine but notification and surveillance of people coming from infected villages to healthy places and the immediate adoption of preventive measures when a case of plague occurred consisting mostly of evacuation of the infected house and camping out on the outskirts of the village or town. The policy met with remarkable success, notwithstanding constant importation of disease from the Bombay Presidency, Central Provinces, and Hyderabad State, and it was accepted by the people in good spirit so long as the system was believed in by the authorities. But latterly the measures were considered irksome and accordingly they were relaxed. The next season the disease began to spread unchecked and Khamgaon, with a population of 26,000, lost 5000 of its inhabitants in 12 months, and by the end of 1903 and the beginning of 1904 nearly the whole of the province of Berar was infected. In many of the villages the villagers adopted on their own initiative precautions—i.e., vacating their village and camping out at once on the first appearance of a case of plague, or of dead rats, and so escaped an epidemic, while in other villages the villagers were too ignorant or too lazy to take the initiative and adopt precautions and camp out on the first appearance of plague. These almost invariably suffered severely.

There were practically no precautions in force in the city of Nagpur against plague when the second epidemic of plague broke out there in 1903-04 and in five months from November to March there was a mortality of 15,000 in a population of 130,000. Many of the inhabitants took the initiative, vacating the city and camping out, and they escaped, the mortality being among those who remained in the city and who did not vacate their houses.

During the whole ten years one presidency stands out conspicuously as having steadfastly pursued an active policy and of not leaving preventive measures to the option of the people, and this is Madras. The local Government placed full reliance on its experienced sanitary commissioner and its



confidence has been amply justified. Under the strong and able direction and administration of Colonel King, I.M.S., assisted with very inferior material as a staff, the plague has been kept under control, notwithstanding the fact that large numbers of infected persons are constantly passing into the Presidency from the neighbouring States.

#### IS IT POSSIBLE TO DEAL WITH PLAGUE AS IT NOW EXISTS IN INDIA?

Seeing that plague has reached the proportions it has now attained in India the question arises, Are there any measures likely to be useful in checking the epidemic which, while effective against the disease, are applicable to Hindus and Mahomedans and their mode of life? The answer is yes, but in considering this question the sanitary condition of India and the habits, prejudices, and religious scruples of the people have to be recognised. The sanitary conditions of India, however deplorable they are, have to be taken as they exist. They are similar to those in Europe in the fifteenth century. It is not possible when an epidemic prevails to transform a town or a country into a condition which will supply it with light and well-ventilated houses and which will render it free from rats, fleas, and other agents which play a part in the spread of the disease. Measures which may be desirable but which are impossible have to be distinguished from those that are possible. Under the impossible may be grouped any attempt suddenly to change the thoughts and habits of the people or the condition of their dwellings, or their dislike and hostility to wholesale removal of their sick to hospitals, or any measures based on the supposition that the communities in India can defend themselves against plague without the intervention of the Government.

It has been seriously advocated as a justification of the removal of all plague restrictions that the people, seeing the havoc that plague causes, would be willing to adopt for their own preservation European methods. The havoc has come but not the change in thought or habits of the people. Next comes the advocacy of rebuilding the huts and houses in the infected villages and towns of India, because it has been observed that the incidence was greater in dark, badly



ventilated and rat-ridden mud huts than in others and particularly when they were grouped together in such a manner as to form a common tenement for large numbers of families. The scheme is a good one, which will be supported in principle by all sanitarians, but it is obvious that on a large scale the cost is prohibitive and even if the money were forthcoming could only be brought about after the lapse of very many years. In the meantime the people are dying.

The reluctance to be removed to hospital for purposes of segregation is a general one in every country but it is accentuated in the East by the fact that in consequence of the great mortality from plague very few patients taken to the hospital return to their homes. It is necessary to consider the dislike to removal to hospital from the standpoint of the patient and the patient's friends. I remember the difficulty as a rule encountered in getting either Hindu or Mahomedan to be removed to hospital when suffering from small-pox, which is not nearly so fatal a disease as plague. The compromise which had often to be made was to vaccinate everyone in the house and as far as possible in the adjoining houses, leaving the patient to be treated at home, and after death or recovery of the patient the disinfection of the house. A similar procedure is feasible in plague, except, as I shall show afterwards, the house should be disinfected at once. The impossibility of destroying during an epidemic all rats and fleas in a town or province has already been mentioned and measures have to be devised to concentrate the destruction where it will be most useful; liquid chemicals, except perhaps in the case of latrines and also for washing one's hands, are valueless and a waste of money. Possibly an exception may have to be made to this statement regarding pesterine, a preparation of petroleum employed by Dr. J. A. Turner, the health officer of Bombay, and which he has found useful for the destruction of fleas in rooms.

#### IT IS IMPOSSIBLE FOR THE PEOPLE THEMSELVES ON THEIR OWN INITIATIVE TO COMBAT PLAGUE.

Moreover, it is a fundamental point in any preventive measures in India to recognise the fact that it is impossible for the people themselves on their own initiative to defend themselves against the ravages of plague. One might as



reasonably expect each village and town on its own initiative to defend itself against a powerful invading army. With the exception of a few large towns, such as Bombay and Calcutta, the general conditions prevailing in India and the relations of the Government to the people, which are of a paternal and patriarchal character, are opposed to any initiation or carrying out of measures by the people themselves without direction, supervision, and control by the Government. In 1902 the Gujrat district inhabited by Mahomedan agriculturists was seriously affected with plague. The Deputy Commissioner writes: "As a rule the people were extraordinarily patient while the disease was epidemic in the village. Their attitude was entirely that of quiescence. They were willing to take almost any steps they were advised to take so long as someone in authority was present to see it carried out, but if no one was there to see it carried out they let things go as they were before and did nothing." This may be stated to be the general attitude of the peasants and poorer people in India. For centuries the Sircar or Government has been looked up to for guidance and to be told to rely on themselves or anyone else besides the Sircar is not understood.

In 1903 Mr. Maynard, a Deputy Commissioner, in his report on plague operations in the Punjab says: "The measures authorised by the Government are now in some respects behind rather than in advance of what general opinion would approve. It must be realised that the people cannot altogether protect themselves. A community that is not completely organised for self-government hardly knows what it wants and certainly cannot enforce its will without external help. It is not fair that it should be at the mercy of selfish or reckless individuals."

The resolution of March 9th, 1904, of the Government of the Punjab points out the unfriendly attitude of the inhabitants of infected villages as among the reasons for leaving measures to the people themselves. With reference to evacuation of infected houses it says: "It is by adopting this measure that the people can help themselves best. They must not, however, look to Government for assistance and establishment. It is out of the question to provide huts or extra police." And on the subject of killing rats it goes on to say: "It has now been decided that it is undesirable to incur any further expenditure on further experiments." This



policy was reversed in April, 1907, in the adjoining province of the United Provinces when it was announced in the Legislative Council that the Government had determined to depart from the old policy and to provide shelters for the plague-stricken people who evacuate their homes, £2000 being devoted to that purpose and a special plague committee being appointed to advise as to the methods for fighting the disease and spending the sum mentioned.

It may be taken as an axiom that without a specially trained agency to direct and control the plague measures the essentials in regard to the prevention of the disease are forgotten or misapplied and often useless measures are adopted. Without this agency it is a matter of the blind leading the blind. It is pitiable to read some of the suggestions which are made to deal with plague and which are accepted and carried out in good faith as being likely to check the epidemic. Here an inspector is added to the conservancy staff, there it is a few bheesties or water-carriers, and elsewhere a native surgeon. They are all doubtless useful in their way but as regards influencing the plague the money spent on them is thrown away. Similarly when I was in Poona last year I learnt from the health officer that a sanitary engineer had visited the town with the object of drawing up a drainage scheme, which was an excellent thing in itself and which would cost much money, but it would have no effect on plague, which is the most serious illness from which Poona is suffering.

#### THE STATE OF POONA IN SEPTEMBER, 1906.

I consider the keynote of success to the prevention of plague is the provision of money and machinery and of a special plague organisation to direct, to supervise, and, if necessary, to carry out the requisite measures. With such a trained organisation, having yearly conferences to compare notes between the heads of departments, it would be possible to sustain and to carry out a settled policy modified only by scientific research and experience. This is what is needed for India and I shall illustrate the necessity for it by an instance which recently came under my observation when I was in India in September, 1906. At that time plague prevailed in Poona, a town of not more than 120,000 inhabitants.



At the last census it numbered 110,000 persons. The town had already in its previous epidemics lost over 30,000 of its inhabitants. This fresh epidemic began with one death from plague in June, followed by 107 deaths in July, 1166 deaths in August, and 1173 deaths in the first 13 days of September. On the day I inspected the registers 90 deaths from plague had occurred before noon. By the time this epidemic was over another 8000 deaths were added, bringing up the total of all the epidemics to at least 40,000 deaths.

Under the guidance of Dr. Satpute, the municipal health officer, I visited the plague-stricken quarters of the town, and I shall never forget the painful impression produced on my mind by the heartrending scenes of distress, despair, and desolation which met me on every side. The town had the appearance of a deserted city. The streets were silent, some of them had scarcely an inhabitant visible in them; the only sounds which occasionally broke the silence as we passed through street after street were the noise and clang of the funeral processions and the wail and cries of the mourners at houses in which a death had recently occurred. In whole streets the shops and houses were closed and in those quarters where shops were open they were served by men who only remained in them during the day and left the city for the night. I visited house after house where deaths from plague had occurred and where plague cases were being treated by one or other of the two hospital assistants under the health officer. The patients lay in rooms and passages which were often so dark that it was with difficulty they could be seen. In the house where plague first broke out in 1906 the owner had lost his seven sons during the seven epidemics from which Poona has suffered. Similar tragedies belonged to other houses. These seven epidemics have impoverished the municipality, have destroyed an enormous number of people, have brought ruin and beggary to many families, and have increased the price and scarcity of labour. Falling on the adult population, the labourers have been chiefly affected. The ravages of the plague have, however, not confined themselves to these classes, for the Brahmins have also suffered heavily. Large numbers of women and girls in all classes have been left husbandless and young girls betrothed to young men have been made widows with no possibility of remarriage but with all the drawbacks before them of an Indian widow's life. The devastation produced



by plague is not a mere question of so many deaths but the sickness and suffering, the despair and the losses, and the evils entailed thereby engender other evils and a discontent which it is difficult for any Government to meet, however anxious it may be for the welfare of its subjects.

I shall now pass on to the measures which I found in force to deal with this great epidemic. The staff consisted of Dr. Satpute and three hospital assistants. One of these hospital assistants was employed in disinfecting houses so far as possible and the other two in treating patients at their own homes. Good work had been done so far as such a staff was able to do it but it was a microscopic staff attempting a herculean work: 1200 people had been inoculated since the middle of July—i.e., in the course of two months. The Government granted 8 annas to all the servants who were inoculated and the municipality 4 annas to others. Some 2000 persons had gone out to the municipal health camps which were available for those whose income was less than 16 rupees a month. Some 7000 people had made health camps for themselves on the outskirts of the town. The rich had gone to their country houses and the remainder of the 60,000 had taken to flight. About 20 out of every 100 patients were removed to the plague hospital.  $2\frac{1}{2}$  annas daily, with medicine, milk, sago, and sugar, were supplied by the municipality to the poorer patients attended by the two municipal medical officers. Four native medical men were fighting against an epidemic which had reached the proportions I have stated and their energies were devoted mainly to tending the sick. With a trained service available Poona could have immediately had the necessary assistance to deal effectively with this epidemic.

#### FOR COMBATING PLAGUE IN INDIA AN ORGANISED STAFF AND A POLICY ARE THE FIRST ESSENTIALS REQUIRED.

Having considered what is impossible and useless to attempt in India I now come to that which is possible. But before doing so it is necessary to look at the financial position of India, for if there are no funds available to provide money and an adequate machinery then the only policy possible is that which has already been followed with the results mentioned. In any circumstances, when the plague becomes a terror to everyone it is questionable whether



attributing the scourge to the hand of God, as was recently done by the Under Secretary of State for India, is the best way out of the difficulty. Evidently Lord Palmerston's rebuke to those who wished to place the blame of the cholera epidemic in England on Providence was forgotten.

As regards finances, with the exception of 1896-97, when nearly £1,500,000 were spent on famine relief, and 1897-98, when over £3,250,000 were similarly spent, there have been large surpluses in the revenues of India during the past ten years. This is not due to money not being devoted to famine purposes, for in 1899-1900 over £2,000,000 were spent in this direction and £1,000,000 have been annually devoted to famine purposes and famine insurance ever since. The figures indicate the liberal, magnificent, and statesmanlike policy carried out in India for the prevention and mitigation of the effects of famine. Hundreds of thousands of lives have in this way been saved.

A similar policy is required in regard to plague prevention, which destroys more lives even than famine. Since 1896 some £17,000,000 sterling have been spent on famine, nearly £1,500,000 on plague, and in spite of this there have been surpluses amounting in the same number of years to over £20,000,000. Of the £1,500,000 spent on plague since 1906 a little over £200,000 have been spent on the Punjab where nearly 2,000,000 people have died. During the years 1905-06, which is the last account available, the Imperial Government of India spent for the plague in the Punjab the sum of £2423 and in Madras £34,603.

The following are the annual amounts spent by the Government on plague in the Punjab and the Madras Presidency since 1897:—

		Madras				Madras.	
Punjab.		Presidency.		Punjab.		Presidency.	
£		£		£		£	
1897-98	... 8,877	... ..	4,234	1902-03	... 51,772	... ..	24,591
1898-99	... 19,674	... ..	46,382	1903-04	... 28,980	... ..	37,277
1899-1900	... 11,560	... ..	39,319	1904-05	... 19,526	... ..	52,128
1900-01	... 21,045	... ..	13,880	1905-06	... 2,423	... ..	34,603
1901-02	... 34,532	... ..	14,592				

With money available there is no difficulty in providing a special plague organisation for plague work and for supplying it with the requisite material for carrying on an anti-plague campaign. Such a campaign must, however, be based



on a well-defined, fixed, and steadfast policy which shall be well known and readily applied. This would not debar modifications being made in the application of the measures according to local circumstances and the discoveries of science. The principles guiding such a policy would be first the discarding of measures which are inapplicable to India and which on that account are bound to be unsuccessful; also of measures which, though useful from a health point of view, have no influence on plague; and; secondly, the steady application of measures known to be of value; for instance, the passport system, inoculation, evacuation, destruction of rats in infected localities, and the disinfection in its widest sense of infected houses. These have all been recommended and tried more or less at one time or another in several places—i.e., locally; but their success depends on their adoption in every province and on the agency and regularity and thoroughness with which they are carried out. With a special organisation provided such measures are possible and without it the attempt to deal with the epidemic is hopeless.

#### MEASURES TO PROTECT HEALTHY DISTRICTS.

Differentiation is required in the treatment of areas in which the disease is endemic and in which it is not. Healthy districts should in every circumstance be kept free from plague. This can be effected as it has been done in the Madras Presidency by a passport system and surveillance and immediate action on the occurrence of a case of plague. No relaxation on any account should be allowed. This should be an imperial policy admitting of no modifications. It is to the interest of the locality concerned and to the interests of adjoining localities which are unaffected. Examples have already been given of the alarming results following relaxation in this respect. A careful inspection of crates filled with goods from infected localities should also be arranged for in order that any dead or sick rats may be immediately discovered and disposed of in a safe manner and the contaminated portion of the goods disinfected; for the same reason an inspection of fodder and loads of grain from infected localities is necessary. The warehouses attached to railways and docks require to be specially watched, also granaries,



stables, slaughter-houses, and markets, where rats from infected localities are likely to be imported and spread infection among indigenous rats or where contaminated goods infect healthy rats.

#### MEASURES IN INFECTED LOCALITIES.

With regard to infected areas the only measures on a large scale available are inoculation, evacuation, and disinfection of infected houses and destruction of rats. Of these inoculation is by far the most powerful and effective. The feasibility of inoculation in the infected districts and houses, if a suitable agency is employed, is demonstrated by the success of the inoculation campaign undertaken in 1902 in a portion of the Punjab. The scheme as originally planned was to inoculate 7,000,000 of the people at a cost of a little over £50,000. It was a splendid conception and if the time and planning devoted to its realisation had been more liberal and less hurried the organisation would have been on a larger and more complete scale and more adequate for the occasion. Half a million of people, however, were inoculated and an investigation carried out by the Government of the Punjab showed that the mortality from plague among the inoculated was reduced to one-twelfth of that which occurred among the non-inoculated, so that it is estimated that 13,000 lives were saved by inoculation during that season.

The Mulkowal accident which occurred at the commencement of the campaign unfortunately shook the confidence of the Government in the prophylactic supplied and, as I have shown, the laboratory was wrongly held responsible for an accident which was actually due to defective organisation which admitted of faulty technique in the application of the prophylactic at the time of the inoculations. The people themselves, however, appear to have understood that the tetanus was an unfortunate accident and were not in the least deterred from availing themselves of the inoculations any more than people are deterred from railway travelling because an express train has met with an accident. This is apparent from the fact that whereas before the accident happened over 100,000 persons came forward to be inoculated, during the season subsequent to the accident nearly 400,000 were inoculated. Major S. Browning Smith of the



Indian Medical Service, who took an active part in the inoculations, describes the attitude of the villagers in this respect. When he began to give the Amritsar people an account of the Mulkowal accident they said that they had seen for themselves the good effect of the inoculations and the sooner he stopped talking and began working the better they would be pleased. He soon finished the few doses he had with him and he remarks: "The genuineness of their feelings was evidenced by the reproaches of those who had to go away unsatisfied, the reproaches of some of the women taking the form of an abuse which was evidently heart-felt." However, with the Government averse to continuing any sustained effort, little or no further progress was made, and in 1904, when the plague was causing enormous ravages, only 49,000 persons were inoculated in the Punjab. It is stated in the report of the Inspector General of Civil Hospitals, who was in charge of the plague operations, that "no special measures were taken for inducing the people to submit to inoculation and the operation was performed almost solely in response to the spontaneous demands of the people." An attitude of this kind in a grave crisis is unjustifiable. In no country of the world can the peasant population be expected to form an opinion on the merits or utility of a scientific method, and even if its utility were appreciated by them, as appears to have been the case with the 49,000, the initiative and organisation required for providing that the full benefit of the measure shall be secured devolve upon the Government. There is no reason that Haffkine's great discovery should not again be made use of on a larger scale. If it finds favour with the Government to-day it will be in favour with the people to-morrow, but the organisation must be such that in its application in the villages there is not the slightest chance of another accident. I believe a pronouncement exonerating the laboratory would, in the circumstances in which it has been mistakenly blamed, have an excellent effect in reinstating the enthusiasm for inoculation.

There is no reason, moreover, that systematic endeavours should not be made whenever a case of plague occurs in a house to get the inmates of the house, and possibly those of the adjoining houses, to be inoculated, and if the benefits are thoroughly explained to them in their own language and tactfully Indians, like other people, are not averse to avail



themselves of anything that is likely to be to their advantage so long as they believe in the honesty of those who are dealing with them. Necessarily, one comes across exceptions who will have none of it, but these sort of people are not confined to India. Inoculation is the cheapest mode of protection. The cost of vaccines, establishment, and equipment works out to less than 6 annas per person inoculated, which is not an excessive expenditure. Owing to the original Punjab scheme being abandoned the cost was slightly over 1 rupee a head on the 500,000 inoculated, but if the numbers contemplated—viz., 7,000,000—had been inoculated it would have cost about  $1\frac{1}{2}$  annas, or about  $1\frac{1}{2}d.$ , per head. The margin of 6 annas per head will therefore be seen to be liberal.

Evacuation of an infected locality and inoculation promptly carried out will stop any epidemic. In Cape Town plague was becoming serious among the Kaffirs. It was decided to remove them from their dwellings where they were crowded together under most insanitary conditions as bad as, if not worse than, any in India. In the course of a week from 7000 to 8000 were removed to a small village prepared for them and all were inoculated. The epidemic ceased among them and although after two or three days' rest in order that they should recover from the malaise caused by the inoculation they came in regularly to Cape Town and often worked in infected portions of the town they remained free from the disease.

In an infected area the measures to be adopted are controlled to some extent by circumstances. In some localities all the measures mentioned can be brought to bear and of course these are the best conditions for success. But if plague is in a village where there are no means of disinfecting the huts and destroying the rats during the process of disinfection, then evacuation and inoculation are the only measures that can be practised, and if inoculation is carried out the evacuation need only be as long as is necessary to allow of time for the inoculations. Exposure of the grain to the sun, boiling the infected clothes, general destruction of rats, and a general use of pesterine, as advocated by Dr. J. A. Turner, the health officer of Bombay, should also be carried out. In towns where it is possible to carry out disinfection the complicated and unsatisfactory methods belonging to the systems now in vogue should



be abolished. When dealing with an epidemic I know of nothing which is more irritating to householders, rich or poor, and which contributes in a greater degree to the hostility met with in disinfecting many houses and to the fostering of surreptitious removal of infected clothing than the fact that everything suspected has to be removed to a central station for disinfection by steam, that the furniture and house have to be sprayed and washed with disinfectants, and that the inmates of the house are turned out for nearly a fortnight before they can get back again. It is exceptional if during the several procedures some articles are not lost or spoilt. At the end of the disinfection, even with careful work, insects will often be seen in the tropics to survive, while the process has no effect on the rats or the rat runs. For these reasons I would abandon all disinfection of this kind and substitute a system of fumigation by a gas which shall disinfect everything *in situ*, which shall, in addition to destroying the germs of the disease, kill the fleas, bugs, other insects, and rats, and which shall disinfect the rat runs in the house.

The Clayton method of disinfection, which consists in the pumping of sulphurous acid gas with sulphuric anhydride into the house, destroys not only the plague germ but all rats, fleas, bugs, and other insects in the house, and it can be applied to thatched huts with the same effect. The gas is generated by burning sulphur at a high temperature in a specially constructed portable apparatus which is brought to the front or back of the house and which is not unlike the vacuum carpet cleaners. One pipe from the apparatus conveys the sulphurous acid gas previously cooled down to a normal temperature into the house, and another pipe also connected with the apparatus draws the air out of the house and through the furnace. Gradually the air in the house becomes saturated with sulphurous acid gas and it has been established that a few hours' exposure to a 2 per cent. gas in the different rooms is destructive to insects, rats, and the plague germs. Not more than seven hours would be required for each operation. The advantages of this method of disinfection are that no occupant of a house need evacuate the house for more than 24 hours at the most, that no furniture, bedding, nor clothes require to be removed from the house, so that there is no risk of the articles being mislaid or stolen. Everything is disinfected



*in situ*; the only articles that require to be removed are such foodstuffs as flour, fresh fruits, fish, and meat. Rice and grain need not be removed and would be disinfected along with the other contents of the house. As rice and grain are the most common foodstuffs and the most liable to be contaminated by infection their disinfection is most important. Any discolouration of exposed metal or silk-stuffs can be immediately removed by a weak solution of ammonia without any damage whatever, and a very important fact in connexion with this mode of disinfection is that even such things as become tarnished by direct exposure to the gas are unaffected when they are covered with cloths or are in closed boxes and yet they are disinfected. The gas also has a certain penetrative power into the soil. As stated previously, the disinfection is as applicable to huts with thatched roofs as to houses and more than one series of pipes can be attached to one machine and blocks of houses can be disinfected with several machines in such a manner that the rats, old and young, are prevented from migrating from these blocks and so get destroyed and the infected rat runs are also disinfected. In the case of a plague patient being in the house and objections being raised to removal to hospital the patient can be made comfortable in a tent during the fumigation and be removed back to the house after 24 hours, for with the rats and insects destroyed there would be little danger of the spread of the disease. After the patient had recovered or died the house could be again disinfected.

#### HOW TO PREVENT RECRUDESCENCE AT POONA.

From a practical point of view it might be asked what can be done with Poona, which has had 40,000 of its inhabitants die from plague since 1896 and which suffers from plague nearly every year. The town is being ruined and is there nothing that can be done to save it? I believe that if measures were taken on a sufficiently large scale and on an organised plan it is possible to rid Poona of its recrudescence plague, and when this is done then imported plague might with care be kept fully under control. For this purpose it would be necessary not only to carry on a campaign against the rats by poison and by Danysz's virus



but to disinfect every house, block by block, in the town in such a manner that the rats, fleas, and plague bacilli in the houses and rat runs were destroyed. It is possible to disinfect by Clayton's machines every house in Poona in the course of six months at an approximate cost of £1 a house, exclusive of the plant. I have not been able to ascertain exactly the number of houses in Poona but there are certainly not more than 20,000. After the disinfection the plant, with the exception of two machines, could be used for other towns or districts. The two machines left would be sufficient, with the other precautions, to prevent the disease when imported from spreading and assuming epidemic proportions.

#### CONCLUSION.

It will be noted that my whole thesis in this lecture is based on the necessity of the formation of a special and trained plague service for the prevention and mitigation of plague in India. If this service is organised on proper lines and on a liberal basis the rest will follow. But steps must be taken for it to be done quickly if more stupendous disasters than those of the present year are not to follow and if the great danger to the people of India is to be averted.













