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THE PREVENTION OF INFECTIOUS DISEASES

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THE PREVENTION OF INFECTIOUS DISEASES

BEING

THE LANE LECTURES
DELIVERED AT COOPER MEDICAL COLLEGE
SAN FRANCISCO, IN AUGUST, 1906, AND
REVISED FOR PUBLICATION

BY

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PREFACE

THIS is not a treatise on Infectious Diseases, but only a course of lectures about their prevention and control. The purpose of the course was to give to an audience of medical men and medical students in California, some account of the administrative methods adopted in Britain in preventing the spread of such diseases. The lectures have been revised for publication; they are not printed in the exact order of delivery. They are limited to the ordinary list of infectious diseases whose control is more or less thoroughly attempted by Public Health Authorities. Whooping cough is not included because it hardly yet comes within that category. There is no pretence at originality, but the examples of methods of control of most of the diseases are nearly all from the author's own experience. References to ordinary sanitary and preventive measures—to reception houses, hospitals, school hygiene, disinfection, and the like—are introduced incidentally in their relation to particular diseases. The notes on bacteriology have been very kindly revised by Dr. R. M. Buchanan, Bacteriologist to the Corporation of Glasgow, and the plates of bacteria are from preparations made by him. The fine collection of lantern slides in Professor Glaister's Laboratory at Glasgow University, and other collections belonging to Dr. Kerr of the London County Council's Education Department, Dr. Robertson, Medical Officer of Health of Birmingham, the chiefs of various departments of the Glasgow Corporation, and others, were freely lent for illustration of the lectures, though not reproduced here. The author's thanks are due to Dr. J. R. Currie for preparation of the Index and Table of Contents.

GLASGOW, *September*, 1907.

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NOTE.

The Lane Medical Lectureship of Cooper Medical College, San Francisco, was founded in 1896 by the late Dr. Levi Cooper Lane. The course consists of not less than ten lectures, delivered at the beginning of the College Session in August. The lecturers and subjects of previous courses have been as follows :—

1896. Prof. Sir William Macewen, Glasgow University, " The Surgery of the Brain."
1897. Prof. Christopher Heath, University College, London, " Diseases of the Jaws, Aneurisms, and Congenital Deformities."
1898. Prof. Clifford Allbutt, Cambridge University, " Diseases of the Heart."
1899. Prof. Nicholas Senn, Rush Medical College, Chicago, " Gunshot Wounds."
1900. Prof. Sir Michael Foster, Cambridge University, " The History of Physiology."
1901. Mr. Malcolm Morris, St. Mary's Hospital, London, " The Social Aspects of Dermatology."
1902. Prof. C. B. Ball, Dublin University, " Diseases of the Rectum."
1903. Mr. Oscar H. Allis, Philadelphia, " Dislocations of and Fractures involving or near the Major Joints."
1904. Prof. Wm. H. Welch, Johns Hopkins University, Baltimore, " Infection and Immunity."
1905. Prof. Sir Patrick Manson, London School of Tropical Medicine, " Tropical Diseases."

LECTURE I

PUBLIC HEALTH ORGANISATION IN BRITAIN

It is impossible to begin this course of lectures without making reference to the unique circumstances under which they are to be delivered. When the great catastrophe of earthquake and fire overwhelmed San Francisco, the world stood appalled at the extent of the disaster, and the heart of every civilised nation went out in deep sympathy to the victims of the calamity. But while sympathy was not diminished, it was very soon accompanied by other feelings—feelings of astonishment and admiration at the unconquerable pluck and resource of the citizens in fighting and ultimately overcoming the fire under conditions of unparalleled difficulty; in controlling the measure of lawlessness which was an inevitable accompaniment of the public disorder; in making, with the aid of the other States of the Union—an aid which would have been gladly shared by all the rest of the nations had opportunity been given them—provision for the hungry and homeless; and in immediately setting to work to rebuild the city, and to establish it again as one of the great centres of the world's trade and commerce. The splendid recovery which is being made from the effects of the convulsion of nature cannot fail to obtain for the City of the Golden Gate even a higher place among the communities of the world than has already been procured for it by the energy and enterprise of its inhabitants, and by its wonderfully favourable situation, with the United States behind it, and the ocean highway to Australia, and China, and Japan, and the Philippines in front.

Among the minor and incidental evidences of the kind of people the San Franciscans are, is the fact that the authorities of Cooper Medical College have not intermitted their ordinary curriculum, including the Lane Lectures, even in this year 1906. When the news came of the city's terrible plight, I confess I looked on the arrangement for the course of lectures as being at an end, and Dr. Ellinwood's cablegram to proceed reached me as a genuine surprise. But here I am, and my first duty is to thank the President and Council of the College for asking me to give this year's course of Lane Lectures. It is a great honour, and at the same time a great responsibility, to follow the distinguished lecturers of past years—men of world-wide reputation like Sir William Macewen, who gave the first course in 1896, and Sir Patrick Manson, who lectured to you last year on the important subject of tropical diseases.

The present course, it was arranged, should be devoted to some subject within the wide domain of Hygiene. America in modern times has so valuably contributed to that science as to make me doubtful whether, after all, the old land across the sea has much to teach to its energetic offspring who have taken possession of the Western Hemisphere. In consulting with your President as to the particular department of Hygiene which should be dealt with in the lectures, I was advised that Prevention and Control of Infectious Diseases would be the most suitable, and that the great sanitary agencies which have so much to do with such prevention could be spoken of incidentally in their bearing on individual maladies.

In adopting this suggestion it is necessary to make one point perfectly clear. There is in the public mind a rooted conviction that sanitation is restricted to the prevention of infectious diseases, but that it is at the same time very effective in preventing all diseases

Sanitation.

of this class. That is in two directions a most serious mistake. On the one hand, sanitation is useful quite outside the regions of epidemic infection. The term is of course capable of different definitions, but in so far as it includes improved housing, air, water, and food, and greater cleanliness of person and abode, of village, town, and nation, it has a good influence on all the ills that affect the human frame, and it serves to prolong life quite independently of checking the prevalence of infectious diseases. On the other hand, apart from and in addition to the measures embraced in the general term "sanitation," nearly every preventable disease requires its own special preventive agency or agencies, duly related to its own special causes; and where such agencies are not yet discovered, or are not sufficiently employed, I shall have occasion to show you that sanitation has not been very successful in controlling the spread of the disease. Indeed, it must be admitted that some members of the group usually known as preventable have been little, if at all, diminished in prevalence by reforms in housing, water supply, drainage, and the like. But the general health of the community has been much benefited by such reforms, and it is owing to a combination of diminutions, made up partly of infective and partly of non-infective maladies, that the modern death-rates of civilised nations have been so greatly reduced.

Sanitary Organisation in Britain.

In ten lectures it is obvious that even the prevention of infectious disease can be only very incompletely discussed. For an American audience the subject can, perhaps, be most conveniently approached by speaking of the origin and organisation of the sanitary service in Britain. That great machine which has for its functions the conservation of health and the prolongation of life has been built up very gradually. It did not spring complete from any creative brain. Neither is it the result of high altruistic conceptions of individual or public duty. Men filled with such conceptions and giving utterance to them were like voices crying in the wilderness until other influences came into play. Modern sanitation, indeed, is a product of stern necessity. It is a natural consequence of the conditions of urban life. The crowding together of great masses of human beings into the limited space of towns and cities gave rise to health problems which demanded solution. In the days of feudalism there were few artisans. After the end of the Jacobite rising of 1745 in Scotland, feudalism as represented by the clan system in the Highlands was finally suppressed, and its suppression was followed by a rapid growth of the class of skilled workmen who plied their trades in small workshops, or even in their own dwellings, in little rural villages and towns. But about the end of the eighteenth century great hosts of these artisans were drawn from their scattered workshops in country hamlets into huge factories for the purposes of industrial co-operative production, and this resulted in the rapid growth of town populations. Such aggregation of human beings is a root factor of ill health, with all its moral and economic evils, and has been the main influence behind the efforts at amendment. It cannot, indeed, be too clearly realised that under ordinary circumstances health is very specially a question of density of population. Fresh air in the promotion of health stands high above all other agencies. A man will die within a minute or two from deprivation of air, but will resist death for days without water and for weeks without food. Similarly, for a healthy life, purity of air is of more consequence than purity of food or water.

In England and Scotland the factory system took quite exceptional hold, and developed fast. Coincidently, villages grew into towns and towns into cities, and so in Britain the need for municipal sanitation first asserted itself. At the same time Britain contained a population which, as compared with that of most other countries, was fairly well off, fairly educated and intelligent, possessed of a public conscience, and very largely self-governing. These are broad statements, as to which it would be easy to urge exceptions of detail—and my presentation of facts is necessarily incomplete—but they sufficiently indicate how it has come to pass that Britain has been a pioneer of modern sanitation.

Yet modern sanitation did not entirely owe its origin to any general public recognition of the evils of filth and overcrowding as illustrated by high death-rates or sick-rates. England, up to the year 1838, and Scotland up to 1855, had only a very incomplete statistical stimulus to improvement. There was no systematic registration of births and deaths, so that the national birth-rates and death-rates were unknown, though in large towns like London and Glasgow and Edinburgh the burial registers were utilised for statistical purposes. It is surprising in this connection that for the United States as a whole statistics are still wanting, though individual States publish their own figures.

As pointed out by the late Dr. Russell, of Glasgow, the real stimulus to sanitary organisation consisted in the terrible visitations of epidemic disease which time after time spread panic and despair throughout crowded towns and cities, and often invaded rural districts also. Cholera and typhus were the school-masters whose teaching, though expensive, was effectual. Where figures and arguments had failed, the appalling ravages of pestilence, the black flags unfurled over fever-stricken areas, the constant passing of the death carts to and from the crowded graveyards, succeeded in awakening the nation to the need for reform. Parliamentary Commissions were appointed, public inquiries were instituted, and owing specially to fear of cholera, a national Board of Health was created in 1831. I shall not attempt to trace step by step the progress which began in this way, but will only tell you very briefly what are the main features of the system as at present existing, and what are the essentials of the best kind of administration.

Each of the three kingdoms has a central health authority, and numerous local health authorities. The former, the Local Government Board, exercises general supervision over the latter.

In England the Local Government Board has a President, who is a member of the Government for the time being, and a staff of permanent officials, including a medical department, with a principal medical officer, assistant medical officers, and medical inspectors, who travel all over the country, investigating public health questions and superintending the administration of the Vaccination Acts. In Scotland the Local Government Board is differently constituted. Its head is the Secretary for Scotland, and the Solicitor General is also a member, both of these belonging to the Government of the day. But in addition there are a vice-president, a legal member, and a medical member, who on the one hand are not merely officials, but have a seat on the Board, and who on the other hand do not pass out of power or position with any change of Government. These central authorities in both countries also superintend the administration of the poor law. The country is divided into sanitary districts, urban and rural, each in charge of a locally elected board. For burghs in Scotland, and boroughs [1] in England, the sanitary authority is the town council. In Scotland, for all the rest of the country, the authorities are county councils and their district committees. The smaller counties are not divided into districts, but where district committees exist, it is they who are entrusted with the administration of all the statutes or parts of statutes relating to public health—the Public Health Acts, Housing Acts, Infectious Disease (Notification) Act, Food and Drugs Acts, Rivers Pollution Prevention Acts, parts of the Factory and Workshops Act, and of the Contagious Diseases (Animals) Acts, and so forth.

For the most successful kind of administration the outstanding requirements are as follows:—Sufficiently large sanitary areas; whole-time health officials; security of tenure of such officials; the possession of diplomas in public health by medical officers; and sufficient control of the inspectorial staff by the medical officer. I do not say that no success is obtainable where some of these con-

[1] The word is differently spelt in the two countries.

ditions are absent, or that the greatest success is invariably achieved where all these conditions are present, but I do say that, taking a broad view of the facts, these are the conditions best calculated to yield the best results.

A strong point in the Scottish system is that the non-burghal or landward sanitary authorities have fairly large areas to control. The population of Scottish counties differs greatly, but two or three smaller counties usually combine in appointing one medical officer, and the average non-burghal population which a whole-time officer has charge of, with or without assistance, is not far short of 100,000. The districts into which the landward parts of all but the smallest counties are divided vary considerably in size, the larger having populations of 20,000 to 40,000 or more. These districts are mainly, but by no means entirely, rural. They may contain non-burghal towns with populations up to 10,000 or 15,000, though most towns of such size are burghs, with their own local government. Wherever the units of sanitary administration are very small, inefficiency may result. Petty local influences tend to prevent activity in removal of nuisances, and in closing uninhabitable houses. Satisfactory schemes of water supply, drainage, and hospital accommodation are often very difficult and expensive to carry out for small populations, whilst attempts at combination for such objects are notoriously apt to end in failure. Whole-time health officials cannot be employed in small areas, so that the doctor who acts as medical officer of health is at the same time engaged in general practice, which is usually of much more importance to him, and he is liable to be hampered in his public health work by his relationship as medical attendant to persons who are responsible for the existence of insanitary conditions. Similarly, small areas cannot afford to employ laymen to devote all their time to the duties of sanitary inspection, so that other functions have to be imposed on inspectors. In small burghs such a combination of municipal offices can usually be made as will keep a man wholly employed in the service of the

Large Administrative Areas.

town council, as road surveyor, sanitary inspector, cleansing inspector, master of works, and so forth. But he has security of tenure only as sanitary inspector and cleansing inspector.

In Scotland and in London no one can be elected Medical Officer of Health, unless he possesses, in addition to his ordinary medical qualifications, a special diploma in public health. I am told that diplomas in public health are not granted by American universities. As they have been found so valuable in the old country, in providing a class of men specially educated and trained in sanitary science, it may be useful for you to know the course of study and the standard of knowledge required of candidates. The diploma granted by the University of Cambridge is the longest established and best known, and its regulations are appended to this lecture.

Diplomas in Public Health.

It has been suggested to me by Dr. Freeland Snow, of Stanford University, that diplomas in public health by American universities and colleges would tend to advance and secure the other great reform needed to give a sound foundation for a public health service in the United States, namely, security of tenure of officials. Dr. Snow thinks that a medical man possessed of a special qualification in sanitary science would not readily be dismissed, and an unqualified substitute appointed in his place, as the result of any political changes. Such dismissal would be so obviously contrary to the public interest that the public conscience would not permit it. I am glad to see that attention is being drawn to this important matter by American authorities in public health. Professor Sedgwick, of Boston, writes as follows in *American Medicine*:—'Politics must also be wholly eliminated from our boards of health, both state and municipal. There is no Republican method of vaccination, and no Democratic method of street cleaning. And places on boards of health must not be used as rewards of political activity. The time—if it ever existed—has gone by when

Security of Tenure.

a proper board of health can be made up of a political doctor, a political saloon-keeper, and a political nobody; for no well-trained and self-respecting expert in hygiene or sanitation can or will remain in the dubious and uncertain service of such weak, incompetent, or shifty characters.'

In Scotland and in London, no health official, lay or medical, can be dismissed from office by the local authority who appointed him, excepting with the approval of the Local Government Board. Nor, at least in Scotland, can salaries be reduced without such approval, lowering of salaries being regarded as an indirect effort at dismissal. Moreover, the officials of the Local Government Board cannot themselves be dismissed, excepting for grave dereliction of duty; changes of Government make no difference to them. This central and local fixity of tenure is invaluable. It helps the officer to perform his frequently unpleasant duties without fear or favour. Members of local authorities who are charged with control of sanitation may themselves be the greatest sinners against sanitation. Sometimes a jerry-builder gets himself elected to a local board for the very purpose of protecting his own nefarious business, and it would be subversive of all good government if such men had it in their power to dismiss a public servant, not for failure to do his duty, but for zeal and independence in its performance.

The provinces of England are by no means so well off in respect of sanitary government as are London and Scotland. A diploma in public health is not essential for a medical officer, nor is security of tenure of health officials provided for by law. And outside of the large towns the areas of administration are often much too small for efficiency. As regards officials, it is true that a number of adjoining local authorities may combine in the appointment of a whole-time medical officer, and so secure a certain degree of uniformity of procedure; but in such a union each small local body has still entire control within its own boundaries, and the combination is not binding, even for the very purpose for which it was organised, so that any single authority, perhaps offended by the activity of its officer, may retire from the agreement, and break up the whole union, and in effect dismiss the medical officer from his employment. This does not occur very often, but even the risk of it is obviously apt to make men hesitate to apply for such offices, and to fret and annoy them when appointed. Efforts are being made to remove these defects in sanitary organisation, but Parliament has very many duties, and measures for which there is no loud public outcry are usually long deferred.

Duties of a Medical Officer of Health.

The duties of a medical officer of health are administrative. After appointment to any large area he has no time for laboratory research, but he requires to keep himself acquainted with the results of research, and to apply them in his daily work. He need not himself be a professional chemist, but he must know chemistry, so as to interpret reports of chemical analyses of samples of water, air, food, and sewage, and to appraise the value of the ascertained facts. He need not be a bacteriologist, but he must understand the science of bacteriology; he must know how to use it in the diagnosis of infectious disease, in determining the safety of water and milk supplies, in testing the purity of air, in judging the value of rival methods of disinfection, and in the treatment of sewage, whether by artificial or by natural means. Some medical officers have as part of their department a chemical and bacteriological laboratory, with assistants wholly occupied therein. Others have a working arrangement with laboratories at universities or hospitals, or elsewhere. The medical officer need not be an engineer, but he must know enough engineering to enable him to advise his local authority as to the strong and weak points in reports on schemes for water supply and sewerage, and for the treatment and disposal of sewage. He need not be an architect, but he must be prepared to examine and check sanitary defects in plans of dwelling-houses, hospitals, and schools. So it is likewise with the practical applications to public health problems of the sciences of geology and meteorology and climatology.

Also, he is likely to be not infrequently called on by the medical practitioners of his district to aid them in the diagnosis of doubtful cases of infectious disease—to help to distinguish between smallpox and chickenpox, between German measles and measles or scarlet fever, between cerebro-spinal fever and other forms of acute meningitis, and so forth. There is no statutory obligation for him to do such work, and it is not mentioned in any regulations, but he will find his position much strengthened by the possession of a sound knowledge of such diseases, and by willingness to aid his medical brethren. A year or two's residence in a fever hospital is almost essential as part of his training. Indeed, besides this, a medical officer would be the better to have a short time of general practice, to accustom him to the difficulties of the practitioner, and to enable him to look at public health administration from the visiting doctor's point of view. But nowadays in Britain it is seldom that a man can get into the public health service once he has fairly entered on private practice, and this special qualification, therefore, is not often obtainable. In its absence, the health officer must be very careful to act with due consideration for his professional brother. Though a mistake in diagnosis is made, and a case is sent in to hospital as suffering from smallpox when the disease is only measles, or as having enteric fever when the real trouble is pneumonia, that is no reason for the health officer or hospital physician adopting the attitude of a superior. It is much easier to diagnose typhus in the bright, clean ward of an hospital, with all the dirt removed from the patient's skin, and all the filthy clothing put away, than in the dark and dismal dwellings of the very poor. And if a case turns out to be, say, not enteric fever, but pneumonia, there is no need for advertising the mistake throughout the parish by ostentatiously sending the patient home again the next day after his admission. The pneumonia case will be better treated in the hospital than in a labourer's house, and can be dismissed in the end without any needless fuss. The interests of the patient must always be the first consideration, but these seldom clash with due regard for the doctor. If under such circumstances the doctor is not considerately treated, then the next time he has enteric fever to deal with, he may wait before notifying until the infection has had time to spread, and when expostulated with, he may reply that as his last case, which he had intimated early to aid in preventing spread of infection, had been immediately sent home again, he had determined to take no such risks in the future, but to wait until every case had become quite unmistakable.

In short, the medical officer of health, in order to be successful, must work in co-operation with the doctors in his district, and must treat them with all courtesy and regard consistent with the public interest. If he follows this policy, then when a case occurs in which, as a matter of duty, he has to criticise or recommend action against a medical man, say for delay or neglect of notification of dangerous infectious disease, his ordinary attitude in such matters will prevent his being suspected of high-handed procedure or official tyranny.

It will be convenient, for the information of American readers, to add, as an appendix, not only the Cambridge University regulations for its diploma in public health, but also an example of regulations made by a sanitary authority, with approval of the Local Government Board, for a medical officer of health, and for this purpose I have taken the regulations in force in one of the county districts of which I have charge.

A copy of the Local Government Board's regulations for annual reports by medical officers is also appended.

The Dividend.

In suggesting for the consideration of Americans that the sanitary organisation of Britain, and especially of the counties of Scotland, includes points well worthy of imitation, I may be asked what, after all, is the direct profit of this system as indicated in the death-rates and sick-rates. In criticism of what

I have been saying, it may be argued that already, both in Britain and in America, there is too much officialdom, and that no evidence has been submitted that the systems I advocate are at all efficient in improvement of the public health. In the course of these lectures I shall hope to show in some detail that, in the best sense, great profit has accrued from sanitary organisation in Britain, but it may be convenient here to give a concrete illustration of the results of public health government in Scottish counties. The system of control which I have described as belonging to them dates only from the year 1890, when a new Local Government Act passed in 1889 came into force. County councils and their district committees, with medical officers and sanitary inspectors, were appointed mostly in the year 1891. Additional statutory powers were obtained by Acts passed in 1894 and 1897. Hospital construction, housing, water supply, drainage, scavenging and cleansing, and other such details of sanitary administration, were heartily entered on, and it is now possible to gain some conception of the outcome of this activity and expenditure during the last fifteen years.

It would not only be of curious interest, but it would also be of great practical utility, if it were possible from period to period to correlate accurately the outcome of sanitary enterprise with its cost. In economic or industrial undertakings, whether on a large scale or on a small, the criterion of merit is well known. It may be described as an adequate excess of income over outlay, which it is customary to state as a percentage on the stock or capital involved. The criterion, in brief, is a dividend, a simple numerical expression whose relation to capital and outlay forms a ready index of commercial soundness. Those who bear the cost receive the profit. Expenditure and outcome are expressed in identical terms, in dollars or pounds sterling as the case may be. Expenditure and outcome in such cases are obviously and easily comparable. But in the case of sanitary enterprises there is no such simple relation between capital or incidental outlay on the one hand, and benefit received on the other. In certain instances those who receive the profit do not bear the cost. For example, when improvements in housing are required in the public interest by the local authority, the work is effected at the landlord's expense. The outlay is a private charge; the profit is to the community. It would be difficult to express this compulsory altruism in commercial phrase. Where money is borrowed by a local authority for expenditure on schemes of water supply, sewerage, and the like, the original loan is repayable by annual instalments over a period of thirty years. The relationship between capital and profit in such cases varies continuously from year to year, and an annual comparison could not readily be effected.

But even if it were practicable to reduce all expenditure on public health to an expression which would embody all its forms and sources, another problem would remain, the problem which is presented by the discrepancy in terminology between outlay and profit. The outlay appears in the public estimates as a monetary statement; the profit, as interpreted from the medical officer's returns, is in a loftier currency, whose standards are the life and happiness of human beings. When lives are saved to a community, as is indicated by a falling death-rate; or when interference with the business of a district is diminished, as is suggested by a reduced attack-rate of infectious disease, the economic value of the results is capable only of a conjectural estimate; and there is no economic expression for the absence of suffering and suspense, or for the presence of brightness and good cheer in dwellings unvisited by disease.

These difficulties, however, are not of primary importance. They neither impair nor destroy the teaching of public health reports.

In submitting an illustration of the benefits derived from fifteen years' sanitary activity, I have selected the statistics of the counties of Stirling and Dunbarton, of which I have charge, not because they are one whit better than those of other counties, but because I naturally am better acquainted with the facts and figures. A similar statement could be made with reference to any well-governed county in Scotland.

In the tables which follow are presented the combined statistics of the counties of Stirling and Dunbarton during the period of fifteen years from 1891 to 1905 inclusive. In addition to giving the figures for individual years, I have grouped these, so far as death-rates are concerned, into three periods of five years each. In the case of attack-rates, however, this was not wholly practicable, for the Infectious Disease (Notification) Act was not in force in all parts of both counties till 1893. With respect to attack-rates, therefore, the first period embraces three years only, but the second and third periods correspond with those for which death-rates also are given.

Sanitary measures are more or less useful against nearly all diseases, infectious and non-infectious; and their influence on notifiable infectious diseases as a whole is shown in two tables, of which one has reference to the death-rate and the other to the attack-rate of this class of disease. The diseases, however, to which sanitary and hospital control in the two counties has been mainly directed are enteric fever and scarlet fever, and each of these diseases also is considered in two tables, of which one is devoted to the death-rate, while the attack-rate is treated in the other. A statement of the phthisis death-rate for the selected period is likewise presented, because that disease is largely affected by sanitary conditions.

The statistical illustration has thus eight sections:

(1) Death-Rates from All Causes,
(2) Death-Rates from principal Infectious Diseases,
(3) Death-Rates from Enteric Fever,
(4) Death-Rates from Scarlet Fever,
(5) Notifications of Infectious Diseases,
(6) Notifications of Enteric Fever,
(7) Notifications of Scarlet Fever,
(8) Death-Rates from Phthisis.

Statements regarding death-rates are calculated on the total landward or non-burghal population of the united counties exclusive of institutions. 123,450 is the mean population of the last quinquennium for the purposes of Tables I., II., III., IV., and VIII.

Statements regarding notifications are calculated on the total landward population of the united counties, institutions included. 125,688 is the mean population of the last quinquennium for the purposes of Tables V., VI., and VII.

TABLE I.

Death-Rates per 1000 of Population from all Causes, Stirlingshire and Dunbartonshire Combined.

1891-1895

1891	1892	1893	1894	1895
19.745	15.204	18.477	15.720	16.830
		17.195		

1896-1900

1896	1897	1898	1899	1900
14.352	16.750	15.936	15.488	16.492
		15.803		

1901-1905

1901	1902	1903	1904	1905
16.371	14.184	14.202	14.606	14.177
		14.708		

Annual Death-Rates from All Causes.—These figures show a very steady and very appreciable diminution in the total death-rates. The difference may be stated thus—Taking the population of each quinquennium as represented by that of the central year of the quinquennium, then the mean landward population of the first quinquennium was 114,524 (1893), and of the last quinquennium 123,450 (1903). In a population of 123,450 a death-rate of 17.195 means 2122 deaths in one year. In the same population a death-rate of 14.708 means 1815 deaths in a year. Therefore during the last quinquennium there have been in each year of the five 307 fewer deaths than if the original death-rate of 17.195 had continued. This is for the five years a diminution of 1535 deaths.

TABLE II.

Death-Rates from Principal Infectious Diseases.—The term principal infectious disease, as used in this table, refers to smallpox, diphtheria, scarlet fever, typhus fever, enteric, and other or doubtful fevers, measles, whooping-cough, and diarrhœa. The death-rates from these diseases were as follows:

Death-Rates from Principal Infectious Diseases per 1000 of Population, Stirlingshire and Dunbartonshire Combined.

1891-1895

1891	1892	1893	1894	1895
2.183	1.150	3.182	1.946	1.822
		2.056		

1896-1900

1896	1897	1898	1899	1900
1.536	1.517	2.428	1.984	1.969
		1.887		

1901-1905

1901	1902	1903	1904	1905
2.272	1.131	.810	1.456	1.501
		1.434		

The diminution here is much more notable than in the death-rates from all causes. In every 10,000 of the population 20 deaths occurred annually from these diseases in the first quinquennium and only 14 in the last quinquennium. In a population of 123,450 (1903) a death-rate of 2.056 means 253 deaths annually, or 1265 in five years. In the same population a death-rate of 1.434 means 177 deaths annually, or 885 in the five years. The difference in the five years represents a saving of 380 lives.

TABLE III

Death-Rates from Enteric Fever.—The following are the figures for the fifteen years:

DEATH-RATES FROM ENTERIC FEVER PER 1000 OF POPULATION, STIRLINGSHIRE AND DUNBARTONSHIRE COMBINED.

1891-1895

1891	1892	1893	1894	1895
.196	.208	.220	.228	.134

.196

1896-1900

1896	1897	1898	1899	1900
.130	.080	.230	.173	.218

.166

1901-1905

1901	1902	1903	1904	1905
.230	.056	.063	.110	.069

.105

Here again there is a notable diminution. For every 19 deaths that occurred in the first period only 10 occurred in the last. In a population of 123,450 (1903) a death-rate of .196 means 24 deaths annually, or 120 in five years. In the same population a death-rate of .105 means 13 deaths annually, or 65 in the five years. The difference in the five years represents a saving of 55 lives. I fully expect that the saving will be greater when certain new water supply systems at present under construction are completed and in operation.

TABLE IV.

Death-Rates from Scarlet Fever.—The death-rates from this disease were as follows:

DEATH-RATES FROM SCARLET FEVER PER 1000 OF POPULATION, STIRLINGSHIRE AND DUNBARTONSHIRE COMBINED.

1891-1895

1891	1892	1893	1894	1895
.134	.178	.339	.293	.248

.238

1896-1900

1896	1897	1898	1899	1900
.178	.089	.119	.204	.132

$\underbrace{\qquad\qquad\qquad\qquad}_{.144}$

1901-1905

1901	1902	1903	1904	1905
.041	.032	.032	.023	.045

$\underbrace{\qquad\qquad\qquad\qquad}_{.034}$

In a population of 123,450 (1903) a death-rate of .238 means 29 deaths annually, or 145 in five years. In the same population a death-rate of .034 means 4 deaths annually, or 20 in the five years. The difference in the five years is 125.

With regard to this remarkable diminution I shall have more to say in the lecture on scarlet fever.

TABLE V.

Notifications of Infectious Diseases.—The figures of Table V. refer to the total notifications of infectious diseases, the diseases on the list being smallpox, cholera, diphtheria and membranous croup, erysipelas, scarlet fever, typhus fever, enteric fever, relapsing fever, continued fever, and puerperal fever. It will be observed that this list is not identical with that of Table II., measles and whooping-cough not being notifiable in these counties.

Notifications of Infectious Diseases per 1000 of Population, Stirlingshire and Dunbartonshire Combined.

1893-1895

1893	1894	1895
13.226	12.720	10.450

$\underbrace{\qquad\qquad\qquad\qquad}_{12.132}$

1896-1900

1896	1897	1898	1899	1900
6.70	8.17	7.85	10.96	11.17

$\underbrace{\qquad\qquad\qquad\qquad}_{8.97}$

1901-1905

1901	1902	1903	1904	1905
9.24	5.72	4.96	4.81	4.53

$\underbrace{\qquad\qquad}_{5.85}$

Taking the mean landward population of the two counties in the last period as 125,688, if among this population there had been 12.132 notifications per 1000 per annum, the total annual number would have been 1524, and the total for the five years would have been 7620. But the fact is that in these five years, the rate being only 5.85 per 1000 per annum, the total annual average was 735, which gives for the five years 3675. There have therefore been 3945 fewer notifications in the five years than if the old rates of prevalence had continued.

TABLE VI.

Notifications of Enteric Fever.—The mean landward population of the two counties in the last period was 125,688. If among this population there had been 2.240 notifications of enteric fever per 1000 per annum the total annual number would have been 281, and the total for the five years would have been 1405. During these five years, however, the rate being only .973 per 1000 per annum, the total annual average was 122, or 610 in the five years. There have therefore been 795 fewer notifications during the last quinquennium than if the old rates had persisted.

NOTIFICATIONS OF ENTERIC FEVER PER 1000 OF POPULATION, STIRLINGSHIRE AND DUNBARTONSHIRE COMBINED.

1893-1895

1893	1894	1895
3.156	1.759	1.805

$\underbrace{\qquad\qquad}_{2.240}$

1896-1900

1896	1897	1898	1899	1900
.967	.919	1.595	1.645	.937

$\underbrace{\qquad\qquad}_{1.212}$

1901-1905

1901	1902	1903	1904	1905
1.381	.862	.704	.985	.932

·973

TABLE VII.

Notifications of Scarlet Fever.—This table has interest for comparison with Table IV., which shows the death-rates from the same disease. The subject matter of Table VII. will be discussed later, meantime these points may be noted:

NOTIFICATIONS OF SCARLET FEVER PER 1000 OF POPULATION, STIRLINGSHIRE AND DUNBARTONSHIRE COMBINED.

1893-1895

1893	1894	1895
7.800	7.804	5.879

7.161

1896-1900

1896	1897	1898	1899	1900
4.049	5.278	4.587	7.629	8.726

6.054

1901-1905

1901	1902	1903	1904	1905
5.886	2.669	2.448	1.675	1.519

2.839

The mean landward population of the two counties in the last quinquennium was 125,688. Had there been among this population 7.161 notifications of scarlet fever per 1000 per annum, the total annual number would have been 900, and the total for the five years would have attained 4500. It is the fact, however, that in these five years, the rate being only 2.839 per 1000 per annum, the total annual average was 357, or 1785 notifications in the five years. There have therefore been 2715 fewer notifications in the five years than if the old rates of prevalence had continued.

TABLE VIII.

Death-Rates from Phthisis.—The beneficial influence of improved sanitation, even on diseases against which it is not specifically aimed, is evident from the figures of Table VIII., which indicate that the death-rate from phthisis in the two counties fell progressively during the three quinquennia of the selected period from 1.475 in the first quinquennium, to 1.404 in the second, and 1.228 in the third.

DEATH-RATES FROM PHTHISIS PER 1000 OF POPULATION, STIRLINGSHIRE AND DUNBARTONSHIRE COMBINED.

1891-1895

1891	1892	1893	1894	1895
1.752	1.104	1.405	1.456	1.658

1.475

1896-1900

1896	1897	1898	1899	1900
1.534	1.309	1.367	1.434	1.378

1.404

1901-1905

1901	1902	1903	1904	1905
1.290	1.278	1.166	1.312	1.096

1.228

In a population of 123,450 a death-rate of 1.475 means 182 deaths annually, or 910 in five years. In the same population a death-rate of 1.228 means 152 deaths annually, or 760 in the five years. The lives saved in the five years thus number 150.

By this series of tables it is my design, as I indicated above, to show that good has accrued to the areas dealt with during fifteen years of sanitary guidance. The fifteen years in question constitute a period when public health control was synchronous with a fall in the death-rate from all causes, and in particular with a diminution in the incidence and death-rate of those diseases against which administrative measures were specially directed. The correspondence in time is not a coincidence; inquiry into detail will make it clear that a causal relationship has existed.

And if it be a result of sanitary government that children born during the third quinquennium have a greater chance of eluding the clutch of disease than children born during the first; if, when sickness does fall upon them, they have a better prospect of passing safely through the ordeal; in brief, if they have at their birth a gift, not only of longer but of happier days than children had who were born during the first five years of the period, it will not be too much to claim that good has resulted from sanitary government. From such tables it is even possible to count the number of lives preserved, to estimate the years that are added to the life-time of the people, and to tell with precision the tale of those who have been spared the sufferings of disease.

Such is the significance of the figures presented. They show the dividend which has been earned on sanitary expenditure. They show, too, that cleanliness which is next to godliness resembles godliness in being great gain.

APPENDIX I.

REGULATIONS FOR THE EXAMINATION IN SANITARY SCIENCE CONDUCTED BY THE STATE MEDICINE SYNDICATE OF THE UNIVERSITY OF CAMBRIDGE.

Two Examinations will be held during the year 1907; one in April, and one in October. At the April Examination Part I. will begin on Wednesday, April 3, and Part II. on Monday, April 8. At the October Examination Part I. will begin on Wednesday, October 2, and Part II. on Monday, October 7.

Any person whose name is on the *Medical Register* is admissible as a Candidate to this examination provided that

(I.) a period of not less than twelve months has elapsed between the attainment of a registrable Qualification in Medicine, Surgery, and Midwifery, and the admission of the Candidate to either part of the examination;

(II.) he produce evidence that, after obtaining a registrable qualification, he has attended during three months the practice of a hospital for infectious diseases at which opportunities are afforded for the study of Methods of Administration, including therein the methods of dealing with patients at their admission and discharge as well as in the wards, and the medical superintendence of the hospital generally;

(III.) he produce evidence that, after obtaining a registrable qualification, he has attended during a period of six months one or more courses, approved by the Syndicate, of Practical Laboratory Instruction in Chemistry, Bacteriology, and the Pathology of those Diseases of Animals that are transmissible to Man;

(IV.) he produce evidence that, after obtaining a registrable qualification, he has during six months * (of which at least three months shall be distinct and separate from the period of Laboratory Instruction required under paragraph III.) been diligently engaged in acquiring a practical knowledge of the duties, routine and special, of Public Health Administration, under the supervision of

(*a*) in England and Wales, either the Medical Officer of Health of a County or of a single Sanitary District having a population of not less than 50,000, or a Medical Officer of Health devoting his whole time to Public Health work; or

(*b*) in Scotland, the Medical Officer of Health of a County or Counties, or of one or more Sanitary Districts having a population of not less than 30,000; or

(*c*) in Ireland, the Medical Superintendent Officer of Health of a District or Districts having a population of not less than 30,000; or

(*d*) in the British Dominions outside the United Kingdom, a Medical Officer of Health of a Sanitary District having a population of not less than 30,000, who himself holds a registrable Diploma in Public Health; or

(*e*) a Medical Officer of Health who is also a Teacher in the Department of Public Health of a recognised Medical School; or

(*f*) a Sanitary Staff Officer of the Royal Army Medical Corps having charge of an Army Corps, District, or Command, recognised for this purpose by the General Medical Council.

The Certificate of an Assistant Officer of Health of a County or of a single Sanitary District having a population of not less than 50,000 may be accepted as evidence under paragraph IV.,

* This period of six months may he reduced to a period of three months (which must be distinct and separate from the period of Laboratory Instruction required under paragraph III.) in the case of any Candidate who produces evidence that, after obtaining a registrable qualification, he has during three months attended a course or courses of instruction in sanitary law, sanitary engineering, vital statistics, and other subjects bearing on Public Health Administration, given by a Teacher or Teachers in the Department of Public Health of a recognised Medical School.

provided the Medical Officer of Health of the County or District in question permits the Assistant Officer to give the necessary instruction and to issue certificates.

*** A candidate who produces evidence that he has himself held for a period of not less than three years an appointment as Medical Officer of Health of a Sanitary District within the British Dominions, and having a population of not less than 15,000, shall be exempt from the provisions of paragraph IV. The provisions as to previous study, paragraphs II., III., IV., shall not apply to Medical Practitioners registered, or entitled to be registered, on or before January 1, 1890. A candidate, who previous to January 1902 was admitted or was qualified for admission to the examination, or who had already entered on the course of study prescribed by the Regulations in force before that date, will continue to be admissible on presenting the certificates required under the old Regulations.

The First Part of the Examination will have reference to the General Principles of Sanitary Science, and will comprise the following subjects :

The elements of chemistry and physics : methods of chemical analysis, and in particular the analysis of air and water. The laws of heat and the elements of pneumatics, hydrostatics, and hydraulics, in their application to warming, ventilation, water-supply, and drainage. The geological and other conditions determining the healthiness of sites for dwellings. Sources, storage, and purification of water-supply. The elements of meteorology in relation to health. Principles of building-construction in their application to dwellings, hospitals, and schools. The disposal of sewage and refuse, and the general principles of sanitary engineering. Disinfectants, their chemistry and use. The chemical and microscopical examination of foods, and the detection of the commoner forms of contamination. The methods of bacteriological investigation and analysis. The bacteriology of air, water, food, and soil. The general pathology of infection, and of the diseases of animals that are transmissible to man.

The Second Part of the Examination will have reference to State Medicine and to the applications of Pathology and Sanitary Science, and will comprise the following subjects.

Laws and Statutes relating to Public Health.* The model Bye-laws of the Local Government Board. Sanitation of dwellings, schools, factories, and workshops, and of villages and towns. Inspection of slaughter-houses, cow-sheds, etc. Inspection of meat and other articles of food. General Epidemiology, with special reference to

* All candidates will be examined in the provisions of the English Statutes relating to Public Health, but any candidate will be given an opportunity of showing a special knowledge of other Sanitary Laws in operation within the British Empire, provided that, *when applying for admission to the Examination, he give notice* of his desire and indicate the Special Law he proposes to offer.

the origin, pathology, symptoms, propagation, geographical distribution, and prevention of the epidemic, endemic, and other infective diseases both of temperate and of tropical climates. The methods applicable to the medical investigation of epidemics. Effects on health of overcrowding, vitiated air, impure water, polluted soils, and bad or insufficient food. Unwholesome trades and occupations, and the diseases to which they give rise. Nuisances injurious or dangerous to health. The effects on health of season and climate. The principles and methods of Vital Statistics in relation to Public Health.

N.B. The foregoing schedule is not to be understood as limiting the scope of the examination, which will include every branch of Sanitary Science. No candidate will be approved by the Examiners who does not shew a high proficiency in all the branches of study, scientific and practical, which bear upon the duties of Medical Officers of Health.

The examination in both parts will be oral and practical as well as in writing. One day at least will be devoted to practical laboratory work, and one day to oral and practical examination in, and reporting on, subjects connected with out-door sanitary work.

Candidates may present themselves for either part separately or for both together at their option; but the result of the examination in the case of any candidate will not be published until he has passed to the satisfaction of the Examiners in both parts.

Every candidate will be required to pay a fee of six guineas before admission or re-admission to *either part* of the examination, but candidates, who have presented themselves before the year 1896, will be re-admitted to either part on payment of a fee of five guineas.

Every candidate who has passed both parts of the examination to the satisfaction of the Examiners will receive a Diploma testifying to his competent knowledge of what is required for the duties of a Medical Officer of Health.

All applications for information respecting this examination should be addressed to Dr. Anningson, Walt-ham-sal, Cambridge, Secretary to the State Medicine Syndicate.

Candidates must before admission to either part of the examination produce evidence of having satisfied provisions I., II., and III., and before admission to Part II. evidence of having satisfied provision IV., above mentioned.

APPENDIX II.

REGULATIONS FOR A MEDICAL OFFICER OF HEALTH, MADE UNDER SECTION 15 OF THE PUBLIC HEALTH (SCOTLAND) ACT, 1897.

1. Subject to the control of the Local Authority the Medical Officer of Health shall be head of the Public Health Department,

and shall exercise general superintendence and direction over the Sanitary Staff.

2. The Medical Officer of Health shall perform all the duties lawfully imposed upon him by any bye-laws and regulations of the Local Authority; and he shall further observe and execute, so far as the circumstances of his district may require, the instructions of the Local Authority.

3. The Medical Officer of Health shall attend all Meetings of the Local Authority and Committees thereof, when so required.

4. The Medical Officer of Health shall inform himself as far as practicable respecting all influences affecting or threatening to affect injuriously the public health within his district.

5. The Medical Officer of Health shall inquire into and ascertain by such means as are at his disposal the causes, origin, and distribution of diseases within his district, and ascertain to what extent the same have resulted from or may depend on conditions capable of removal or mitigation.

6. The Medical Officer of Health shall, by inspection of his district, systematically, and as occasion may require, keep himself informed of the conditions injurious or dangerous to health existing therein.

7. The Medical Officer of Health shall advise the Local Authority on all matters affecting the health of his district, and on all sanitary points involved in the action of the Local Authority; and he shall, previous to and as a basis for the issue of any notice under section 20 of the Public Health (Scotland) Act, 1897, certify as to any nuisance or complaint regarding which intimation made by the Sanitary Inspector under Section 19 of the said Act has not been followed by abatement of the nuisance or cause of complaint; and in cases requiring it he shall certify, for the guidance of the Local Authority or the Sheriff or any Magistrate or Justice, as to any matter in respect of which the certificate of a Medical Officer of Health or a Medical Practitioner is required as the basis or in aid of sanitary action.

8. The Medical Officer of Health shall advise the Local Authority on any question relating to health involved in the framing and subsequent working of such bye-laws and regulations as they may have power to make.

9. When a Certificate has been received from a Medical Practitioner or a Notice from the head of a family in terms of Section 3 (1) (*a*) and (*b*) of the Infectious Disease (Notification) Act, or otherwise the existence of a case of infectious disease has come to his knowledge, the Medical Officer of Health shall instruct the Sanitary Inspector or other competent officer to make the necessary inquiries and to forthwith submit to him a Report on the case, and to take such measures as are necessary for preventing the spread of the disease. Forms for Reports under this Regulation shall be prepared by the Medical Officer of Health and supplied as required to the Sanitary Inspector.

10. It shall be the duty of the Medical Officer of Health to file or cause to be filed both the Certificates and Notices and the Reports, and the files shall be kept in the offices of the Local Authority. The Medical Officer of Health shall bring with him to each ordinary monthly meeting of the Local Authority the Reports under Regulation 9 made to him during the previous month.

11. The Medical Officer of Health shall also keep any other books or forms in connection with the Infectious Disease (Notification) Act which the Local Government Board or the Local Authority may from time to time consider necessary.

12. On receiving information of the outbreak of any dangerous infectious disease within his district, the Medical Officer of Health shall visit without delay the place where the outbreak has occurred, and inquire into the causes and circumstances of such outbreak, and in case he is not satisfied that all due precautions are being taken, he shall advise the persons competent to act as to the measures which may appear to him to be required to prevent the extension of the disease, and shall take such measures for the prevention of disease as he is legally authorised to take under any Statute in force in the district or by any Resolution of the Local Authority.

13. When in his opinion any infectious disease threatens to become dangerous or epidemic within the district, the Medical Officer of Health shall forthwith report the same to the Local Government Board and to the Local Authority, stating the extent of the outbreak, its supposed origin, and the measures adopted for the prevention of the spread of the disease, and for the isolation and treatment of those affected.

14. When the Medical Officer of Health becomes aware that any infectious disease, within the meaning of the Infectious Disease (Notification) Act, exists at any dairy within the meaning of the Public Health (Scotland) Act, 1897, or in the household of any person registered under the Dairies, Cowsheds, and Milkshops Order, and that milk is supplied from such dairy or by such person without the district, he shall forthwith report the same to the Local Government Board and to the Local Authority, specifying the name and address of such dairy or person, and of the person to whom such milk is consigned, or the district within which it is supplied, and the measures adopted to prevent the spread of the disease.

15. The Medical Officer of Health shall report to the Local Government Board and to the Local Authority every case of Small-pox in the district as soon as it comes to his knowledge.

16. When the Medical Officer of Health becomes aware that any infectious disease exists in any house in which children of school age reside, he shall cause intimation thereof to be made to the Clerk of the School Board and to the headmaster of any school which such children or any of them may be attending.

17. The Medical Officer of Health shall from time to time visit and inspect any Hospital for Infectious Diseases to which the Local

Authority is entitled to send patients, and shall as often as need be report to the Local Authority on the condition and adequacy of such Hospital and of the apparatus provided therein for disinfection.

18. Whenever the Local Government Board shall make regulations for all or any of the purposes specified in Section 79 of the Public Health (Scotland) Act, 1897, and shall declare the regulations so made to be in force within his district or any part thereof, the Medical Officer of Health shall observe such regulations, so far as the same relate to or concern his office.

19. The Medical Officer of Health shall direct or superintend the work of the Sanitary Inspector or Sanitary Inspectors in the way and to the extent that the Local Authority shall approve, and on receiving information from any Sanitary Inspector that his intervention is required in connection with any nuisance, he shall, as early as practicable, take such steps as he is legally authorised to take under any Statute in force in the district, or by any Resolution of the Local Authority, as the circumstances of the case may justify and require.

20. The Medical Officer of Health shall in any case when required by the Local Authority or when it appears to him to be necessary or advisable, exercise the powers conferred on him by Section 43 of the Public Health (Scotland) Act, 1897. In the case of any proceeding with regard to a living animal, he shall call upon the Veterinary Surgeon approved by the Local Authority to accompany him.

21. The Medical Officer of Health shall inquire into any offensive process of trade carried on within his district, and report on the appropriate means for the prevention of any nuisance or injury to health therefrom.

22. The Medical Officer of Health shall from time to time inspect any bakehouses which are workshops, and are situate within his district, and he shall thereupon report to the Local Authority whether any steps are necessary to be taken for the purpose of enforcing, as respects such bakehouses, the provisions of the Factory and Workshop Acts.

23. The Medical Officer of Health shall from time to time report in writing to the Local Authority his proceedings, and the measures which may require to be adopted for the improvement or protection of the public health in his district. He shall in like manner report with respect to the sickness occurring within his district, so far as he is able to ascertain the same, and with respect to the mortality thereof.

24. The Medical Officer of Health shall also from time to time make such special reports and returns as may be called for by the Local Authority or the Local Government Board.

25. The Medical Officer of Health shall keep a book or books in which he shall make any entry of his visits, inspections, and other proceedings, and shall produce such book or books, whenever required, to the Local Authority.

26. The Medical Officer of Health shall examine and report on all plans submitted to him by the Local Authority.

27. The Medical Officer of Health shall be entitled to a month's holiday in the year at such time as may be approved by the Local Authority; he shall name a substitute legally qualified to discharge the duties of a Medical Officer of Health, to act in case of need in his absence, and for whom he shall be responsible. The Medical Officer of Health may in the absence through illness or incapacity or otherwise of the Sanitary Inspectors, exercise any of the powers of a Sanitary Inspector under the Public Health Act.

APPENDIX III.

ANNUAL REPORT BY MEDICAL OFFICER OF HEALTH.—SCOTTISH LOCAL GOVERNMENT BOARD'S INSTRUCTIONS.

The instructions as to the Annual Report by the Medical Officer of Health remain as stated in the Board's Circular of 13th December, 1905, viz. :—

The Board, in virtue of their powers under Section 15 of the Public Health (Scotland) Act, 1897, hereby call upon every Medical Officer of Health of a District of a County, or of any part thereof, to prepare annually a Report with regard to his district for the year ending 31st December, which Report shall contain—

a. A general account of influences and conditions injurious or dangerous to the health of the district, and of the measures that in his opinion should be adopted for its improvement.

b. A statement of the general enquiries he has made during the year, and of any special enquiries as to sanitary matters.

c. A general statement of any matters as to which he has given advice or granted certificates, including any action as to offensive trades.

d. A specific account of the administration of the Factory and Workshop Act, 1901, in workshops and workplaces, in terms of Section 132 of that Act, together with a tabular statement in the form issued by the Home Office.

e. An account of the house accommodation of the labouring classes in the district, and of any proceedings under the Housing of the Working Classes Acts, or otherwise.

f. An account of any action taken under the Rivers Pollution Prevention Acts.

g. An account of the hospital accommodation available for persons suffering from infectious disease (including the means provided for the conveyance of such persons), and of the houses of reception, with observations on the furnishing, maintenance, administration, and adequacy of such accommodation, etc.

h. An account of the premises with necessary apparatus and attendance available for the destruction or disinfection of infected articles (including the means for the conveyance of such articles), also of other processes of disinfection in use, with observations on the adequacy of such arrangements and processes.

i. An account of the action taken to prevent the outbreak and spread of infectious disease.

j. A statement as to the causes, origin, and distribution of diseases within the district, and the extent to which the same have depended on or been influenced by conditions capable of removal or mitigation.

k. A tabular statement, in such form as the Local Government Board may from time to time direct, of the sickness and mortality within the district.

The Medical Officer of Health shall transmit a copy of the aforesaid Report to the Local Government Board and to the Local Authority not later than the 31st March immediately following the year to which such Report refers.

Where in any district there is a chief Medical Officer of Health with one or more assistants or subordinates, it will not be necessary for each assistant or subordinate Medical Officer of Health to furnish a Report to the Board. Each will report to the chief Medical Officer of Health, who will report on the whole district.

Where the County Medical Officer is Medical Officer of Health for each of the districts in the county, the Board will hold the foregoing instructions to be complied with if the County Medical Officer furnishes a Report for the whole county, provided that in such Report each district is separately dealt with.

LECTURE II

THE PREVENTION OF TYPHUS FEVER

When it is understood how modern sanitation in Britain has so largely owed its origin to epidemics of infectious disease, it will be seen how appropriate it is that, as advised by the President of the College, these lectures should in the main be devoted to discussion of the methods of prevention and control of these diseases. And it seems best to begin with one of two which above all others were influential in awakening the public to the necessity for sanitary reform. The two were cholera and typhus fever. These differ from each other in one essential respect. So far as Great Britain and America are concerned, cholera is merely an exotic disease. Its home is away in India, far from our shores, which it only invades at rare intervals, and from which it has been successfully beaten back for forty years. Typhus is in a different position. Its habitat is not in tropical countries but in the temperate zone. For many a long year Ireland was a centre of its operations, and from this centre at frequent intervals it spread into England and Scotland, and committed appalling ravages.

Typhus has been fostered through all its natural history by conditions of low vitality, and by surroundings of human overcrowding and foul air. Consequently it has often been associated with war, famine, and misery. Under various names it has been known for perhaps a thousand years. In Italy in the sixteenth century, on the continent of Europe during the Seven Years' War, in England in times of civil warfare, in France during the wars of the Revolution and in those of Napoleon, for about a quarter of a century, from 1790 onwards, typhus accompanied and resulted from the operations of great armies. In the nineteenth century it has been less prevalent than ever before; but it was imported into Britain by the Crimean War, and its last considerable visitation of the three kingdoms was in the sixties.

In the United States it appears never to have been of great importance. Indeed, so far as I can learn, the Western States have seldom been invaded, while in the East it has chiefly been due to Irish immigration.

Though it has frequently followed the trail of war, yet warfare has no necessary relation to typhus. Famine is a condition which has often been its accompaniment. This was the case in Ireland at the end of the eighteenth and the beginning of the nineteenth century, and the experience has frequently been met with elsewhere. Yet in Ireland it has sometimes occurred when there was no famine.

Soil and Seed.

Typhus is very particularly associated with insanitary conditions of dwellings. In all infectious diseases soil and seed have both to be taken into consideration. The seed of typhus is favoured and fostered by foul air within and around human abodes. The air in a dwelling-house is capable of defilement by causes either within or without the house, or by both. It is the condition of the air within the house which is of special importance in typhus. Filth, overcrowding, and defective ventilation produce the exact conditions in which the disease breeds. Famine and privation, on the other hand, fit the soil for reception of the seed. They lower the health of the individual, and make him a ready prey to infection. It is therefore apparent why war has been so frequently a cause of typhus. Overcrowding in besieged cities, and even in the camps of besiegers; privations, both of armies and of peoples, readily produced conditions favouring epidemics of the disease. Once originated in this way typhus was readily carried throughout invaded countries, and also into countries to which armies returned after the end of a war. Infection thus established continued to spread in circumstances which, though not themselves so insanitary as to be capable of giving birth to it, were yet sufficient to propagate the disease.

As is well known, typhus outbreaks have often occurred within limited populations. Overcrowded prisons, workhouses, and ships have often suffered from it, and prisoners brought for trial from foul cells have infected their judges and the audience in the court-rooms. Once again, therefore, it will be noted that the environment which specially favours its spread consists of limited and befouled spaces with infrequent change of air. So also outbreaks have occasionally occurred among navvies occupied on great public undertakings like railway construction, such navvies being housed in temporary structures often both overcrowded and filthy.

But it is obvious that a disease of this sort must to some extent be under conditions outside the dwelling-house.

Outside Conditions.

The maximum purity of the air inside a house can be no greater than that of the outside air from which it is supplied. In practice house air is invariably less pure than outside air, whether in a mansion in the country or in a slum dwelling in a town. If, therefore, in any given population there are small, dirty, and ill-ventilated houses, and if these themselves abut on narrow and filthy lanes where refuse of every kind is allowed to accumulate, then typhus, once finding entrance, will flourish and spread and become endemic rather than epidemic.

It was exactly these conditions which existed in the cities of Britain a century ago, and it was the appearance

Glasgow a Century ago.

and persistence of typhus which awakened the public to the unhealthy surroundings in which they lived. Here is a description by the Professor of Botany in the Glasgow University of the most thickly-populated part of the city of Glasgow in 1818:

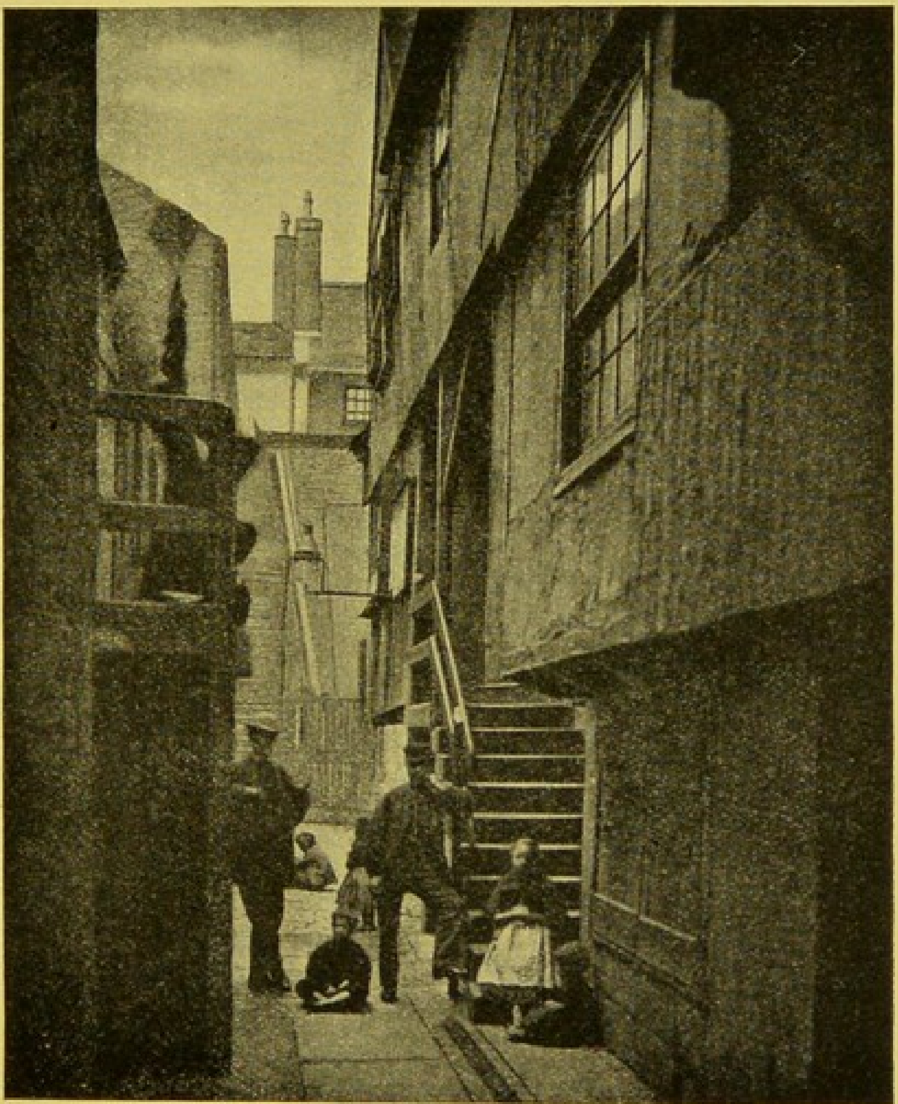
'If any man wonders at the prevalence of continued fever among the lower classes in Glasgow, or at its spreading from their habitations, let him take the walk which I did to-day with Mr. Angus, one of the district surgeons. Let him pick his steps among every species of disgusting filth, through a long alley, from four to five feet wide, flanked by houses five floors high, with here and there an opening for a pool of water, from which there is no drain, and in which all the nuisances of the neighbourhood are deposited in endless succession, to float and putrefy and waste away in noxious gases. Let him look as he goes along into the cellars which open into this lane, and he will probably find lodged, in alternate habitations, which are no way distinguished in their exterior, and very little by the furniture which is within them, pigs, cows, and human beings which can scarcely be recognised till brought into the light, or till the eyes of the visitant get accustomed to the smoke and gloom of the cellar in which they live. I have been to-day in several dens of the kind, where I did not see persons lying on the floor near me till Mr. Angus, whom a previous visit had taught where to find them, inquired after their health. I was in one closet, measuring twelve feet by less than five, on the floor of which he told me six people had lain, affected with fever, within these two days, and where I saw the seventh inhabitant now confined. We found in one lodging-house, fifteen feet long by nine feet from the front of the beds to the opposite wall, that fifteen people were sometimes accommodated; and when we expressed horror at the situation in which they were placed, the woman of the house, somewhat offended, and, I believe, a little alarmed lest we should cause some enquiry to be made by the police, said in support of the character of her establishment, that each family was provided with a bed, and that she very seldom had anybody lying on the floor. I shall only mention one other instance of misery. In a lodging-house consisting of two rooms, separated by boards, the first thirteen feet by eleven, the other fifteen by eight, twenty-three of the lowest class of Irish were lately lodged. To-day there are fourteen, of whom two are confined with fever, three are convalescent, and one only has hitherto escaped. There are only three beds in this house (denominated, with that facetiousness which enables an Irishman to joke with his own misery, Flea Barracks), one of them in a press half-way up the wall, the others wooden frames, on which are laid some shavings of wood, scantily covered with dirty rags. Most of the patients were lying on the floor. A man, two sons, and an adult daughter were lying side by side on the floor of the first room, their bedding of the same materials with the others, and the boys being destitute of shirts. Could imagination feign a combination of circumstances more horribly conducive to disease and immorality?'

Twenty years later, in 1838, a Government Commissioner reported as follows about the slums of Glasgow:

'The wynds consist of long lanes, so narrow that a cart could with difficulty pass along them; out of these open the "closes," which are courts about fifteen or twenty feet square, round which the houses, mostly of three storeys high, are built; the centre of the court is the dunghill, which probably is the most lucrative part of the estate to the laird in most instances, and which it would consequently be esteemed an invasion of the rights of property to remove. . . . In the lower lodging-houses, ten, twelve, and sometimes twenty persons, of both sexes and all ages, sleep promiscuously on the floor in different degrees of nakedness. These places are generally, as regards dirt, damp, and decay, such as no person of common humanity would stable his horse in.'

In 1840 Dr. Neill Arnott reported thus to the Poor Law Commissioners:

'We entered a dirty, low passage like a house door, which led from the street through the first house to a square court immediately behind, which court, with the exception of a narrow path around it leading to another long passage through a second house, was occupied entirely as a dung-receptacle of the most disgusting kind. Beyond this court the second passage led to a second square court, occupied in the same way by its dunghill; and from this court there was yet a third passage leading to a third court and third dung-heap. There were no privies or drains there, and the dung-heaps received all

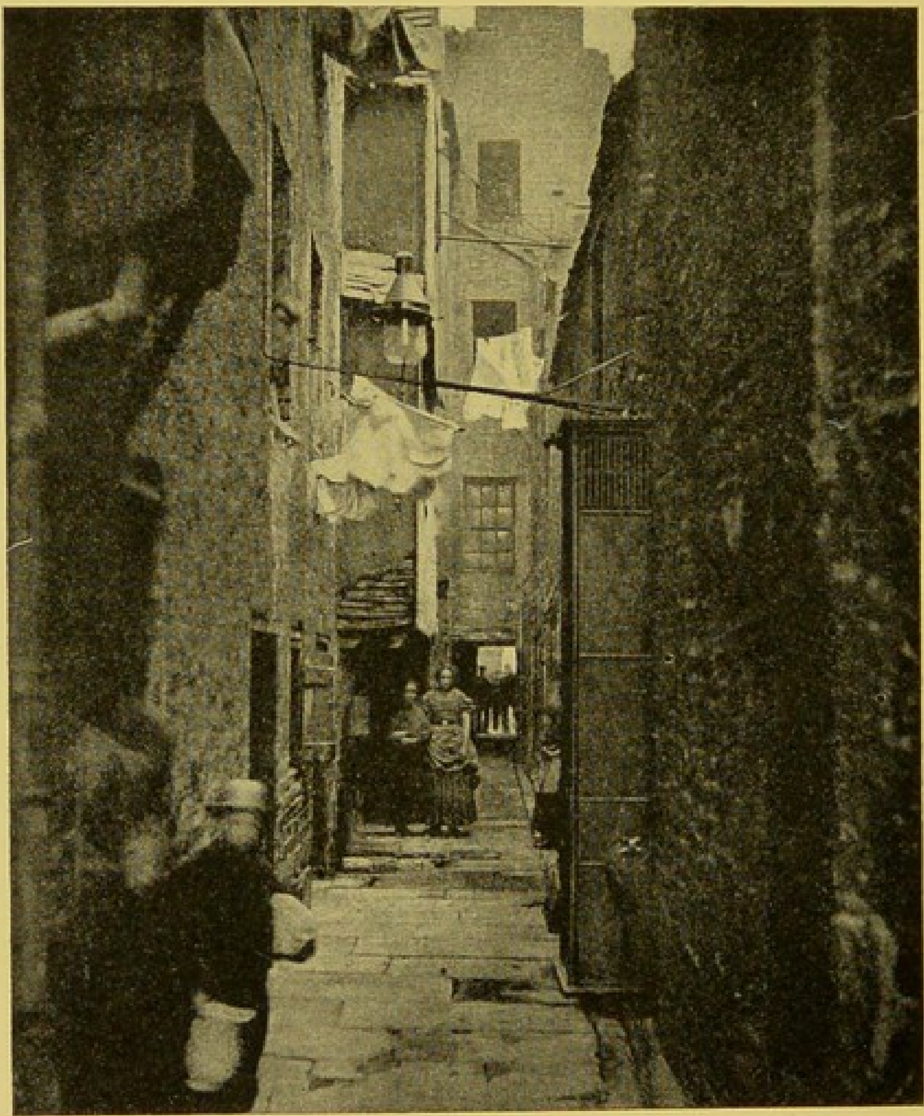


CLOSE, NO. 28 SALTMARKET, 1868.

filth which the swarm of wretched inhabitants could give; and we learned that a considerable part of the rent of the houses was paid by the produce of the dung-heaps. Thus, worse off than wild animals, many of which withdraw to a distance and conceal their ordure, the dwellers in these courts had converted their shame into a kind of money by which their lodging was to be paid.'

And so late as 1849 Dr. Sutherland, in reporting on the measures adopted in Glasgow for the relief of cholera, said:

'The interior of the houses is in perfect keeping with their exterior. The approaches are generally in a state of filthiness beyond belief. The common stairs and

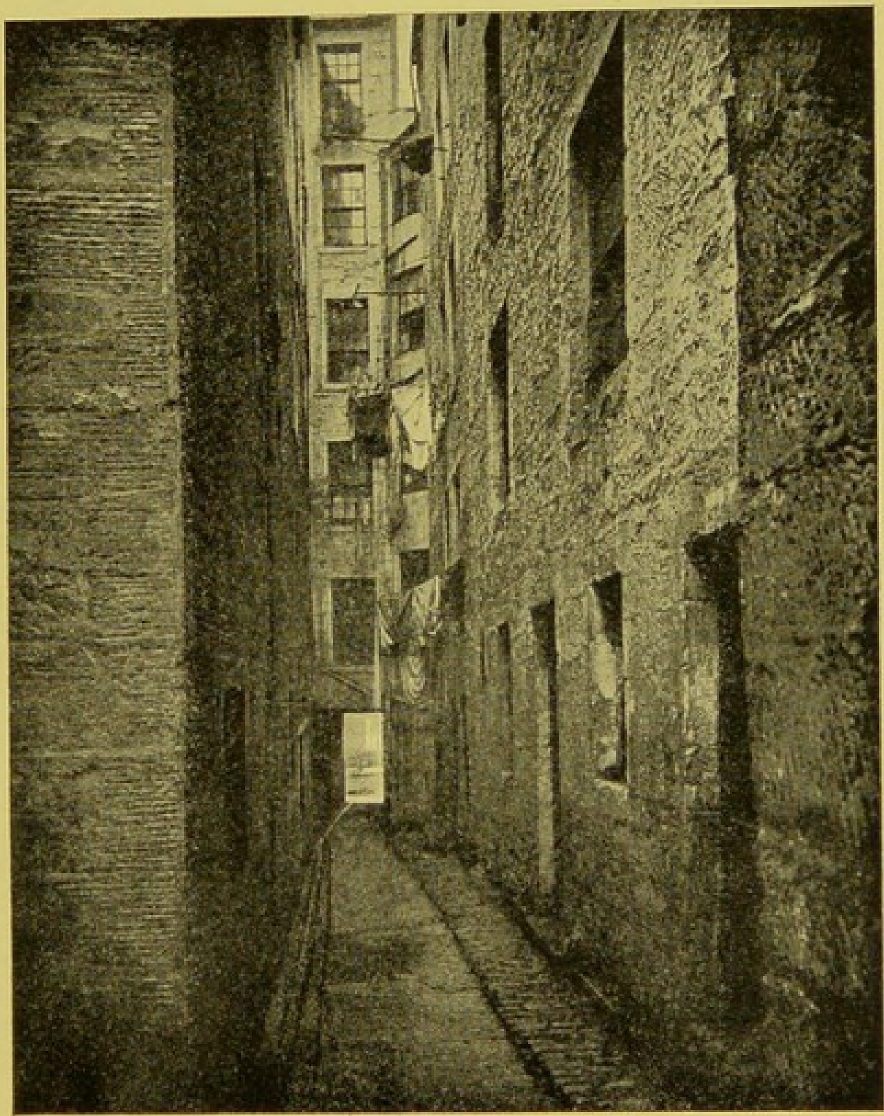


CLOSE, NO. 37 HIGH STREET, 1868.[1]

passages are often the receptacles of the most disgusting nuisances. The houses themselves are dark, and without the means of ventilation. The walls dilapidated and filthy, and in many cases ruinous. There are no domestic conveniences, even in the loftiest tenements, where they

[1] The method of clothes drying or "airing" is indicated in this and the next two plates.

are most needed, except a kind of wooden sink placed outside some stair window, and communicating by a square wooden pipe with the surface of the close or court beneath. Down this contrivance, where it does exist, is poured the entire filth of the household or flat to which it belongs, and the solid refuse not unfrequently takes the same direction, till the tube becomes obstructed.'[1]

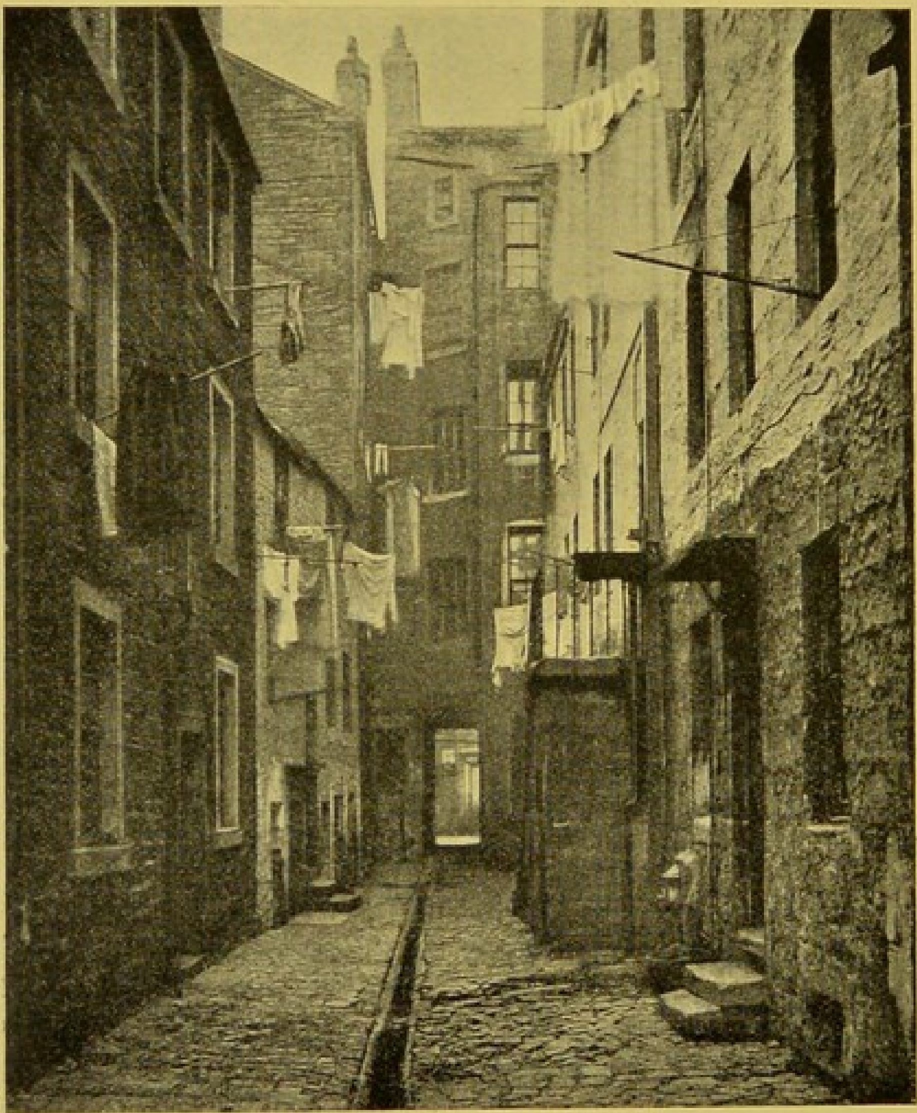


CLOSE, NO. 148 HIGH STREET, 1868.

It is impossible now to depict to the eye the lanes of Glasgow as they existed in 1818. Fifty years later the conditions which gave rise to the Zolaesque descriptions from which I have read these extracts had largely dis-

[1] These and other reports are quoted in papers by the late Dr. Russell, and are reproduced in *Public Health Administration in Glasgow*, published by James MacLehose & Sons, 1905.

appeared, and typhus had gone down correspondingly. But it had by no means altogether departed, and in 1866 the city obtained Parliamentary powers to sweep away a great part of what remained of the buildings which had harboured the disease. By this time photography had become available for sending down to posterity a pictorial



CLOSE, NO. 75 HIGH STREET, 1868.

representation of such Glasgow wynds and closes as still existed, and fortunately, before the clearing away process was entered on, pictures were taken of many of the worst parts of the town. Four of these pictures are reproduced here.*

The causes of these amazing conditions in Glasgow

* Many more were shown at the lecture.

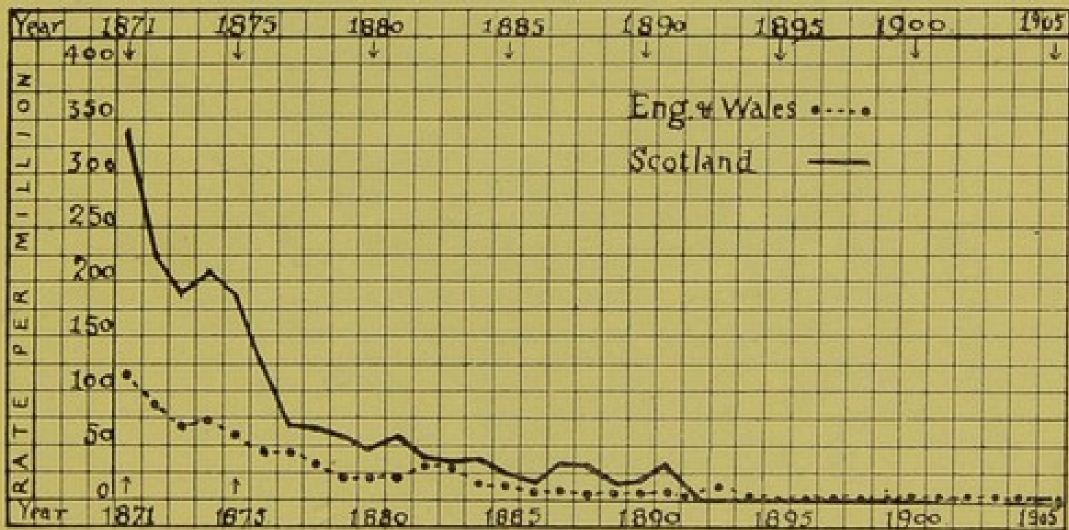
were the rapid growth of the city, and the entire absence of sanitary organisation or supervision. I have told you that modern sanitation is the offspring of modern city life, but at that time the birth had not taken place.

The population of Glasgow at each decennial census between 1801 and 1851 was as follows:

1801,	83,805	1831,	202,426
1811,	110,460	1841,	280,602
1821,	147,043	1851,	347,001

Glasgow Epidemics.

Into this city there was constant immigration from Ireland, the home of typhus. In 1818 there was an epidemic, but the number of deaths is unknown. In 1837 there were 2180 deaths, and the general death-rate was 41 per 1000 per annum of the population. In 1847 the deaths from

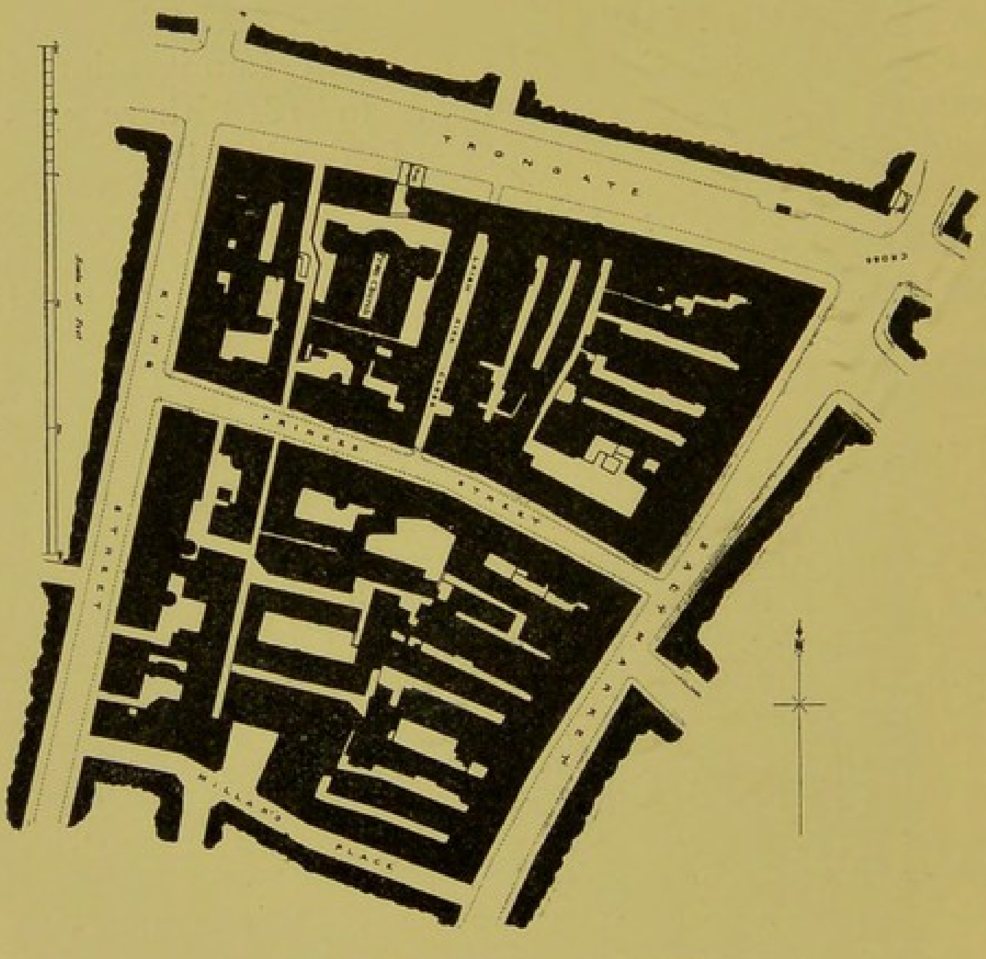


TYPHUS—DEATH RATE PER MILLION 1871 TO 1905.
ENGLAND AND WALES, SCOTLAND.

typhus were 4346, and the total death-rate reached the very high figure of 56 per 1000 of the population from all causes.

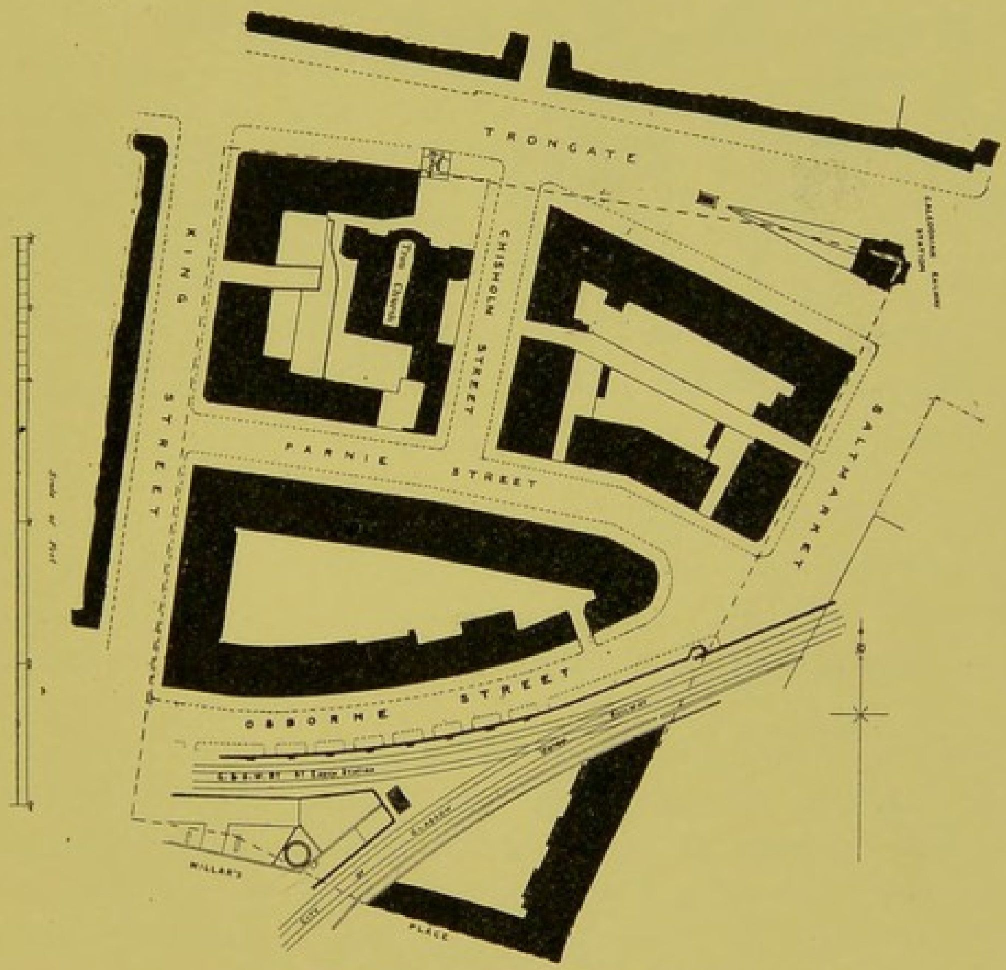
Typhus has now practically disappeared from Glasgow, and from England and Scotland as a whole. A chart is given above to show the death-rates for England and Wales, and for Scotland, from which it is seen that there has been almost no typhus during the last twenty years.

Typhus has gone from Glasgow owing to removal of the conditions which favoured its continuance. Cleanliness has been made easy for the people. The city has been supplied with water by tapping a great loch in the Highlands, and by constructing huge culverts and viaducts, to appearance almost as enduring as the lonely hills and glens through which they pass on their way to a reservoir, whence the water is piped into every house. Drainage and sewerage have accompanied water supply.



CITY OF GLASGOW IMPROVEMENTS.
Plan shewing the area bounded by Trongate, Saltmarket, Millar's Place, and King Street *before* the Improvements were carried out.

Refuse removal is systematic and frequent and thorough. The nuisance inspector has been at work, and dirt and overcrowding are less common than ever before. The wynds and lanes have been cleared away, and much wider streets have been formed in their stead. The old houses have been replaced by better dwellings. These are constructed only in accordance with regulations made by the public authorities, and though in many cases much is left to be desired, the improvement as compared with that old time is unspeakably great. Though enough has been done to abolish typhus practically, even now the housing reformation is far from complete, one area being dealt with after another, and each scheme being better than its predecessor. Here are two plans, one showing a scheduled area as it existed less than twenty years ago,



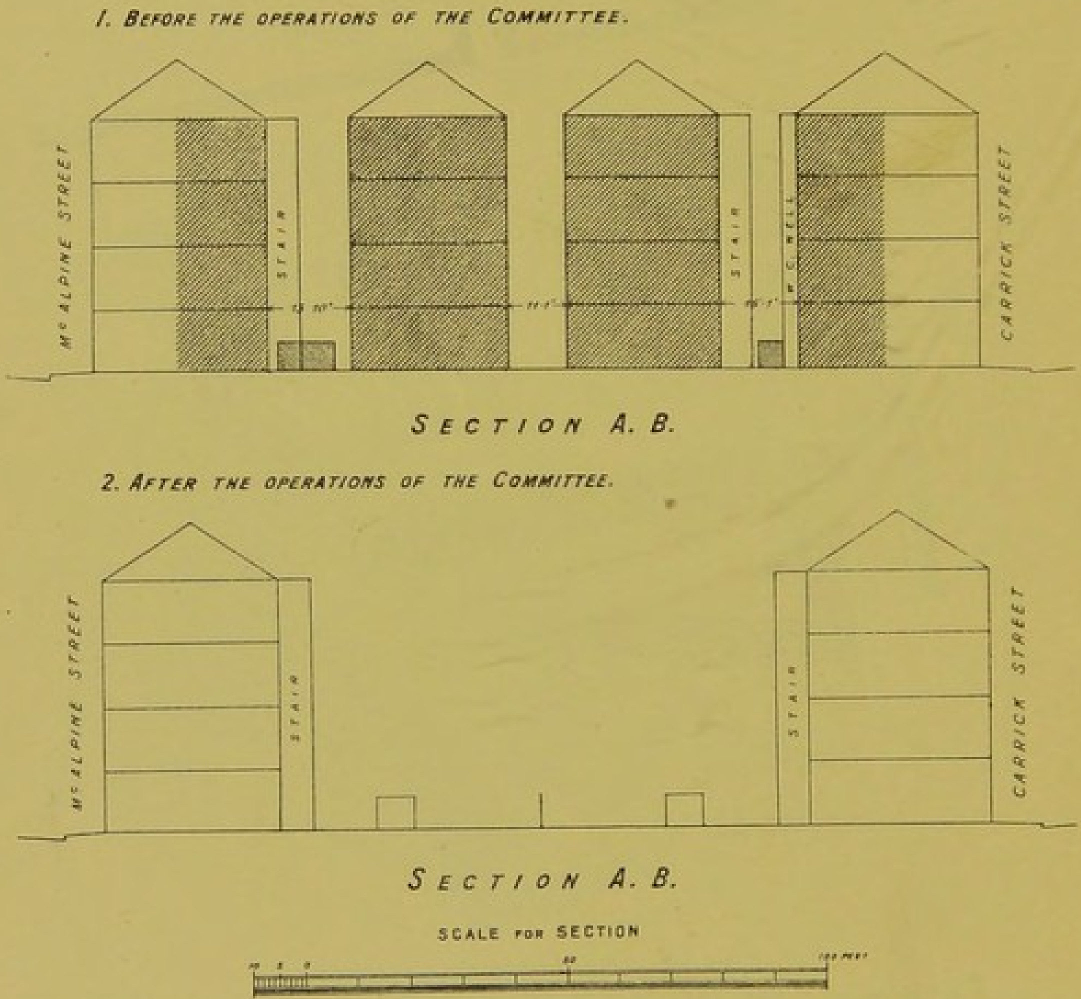
CITY OF GLASGOW IMPROVEMENTS.
Plan shewing the area bounded by Trongate, Saltmarket, Millar's Place, and King Street *after* the Improvements were carried out.

and the other the same area as now built over. What are called 'back lands' are still too numerous. They consist of tenement buildings of two or three flats, each containing multiple small dwelling-houses, situated on what ought to be unbuilt areas behind streets of houses. An extreme example, only recently removed, is shown here.

It is mainly in such houses that what is still left of typhus in Glasgow is to be found.

Hospital Isolation.

In addition to all these agencies there has been the increasing habit of removal to hospital of cases of infectious disease. In the old times no practicable hospital could have held all the infected, and it hardly occurred to town councils to provide accommodation for isolation of cases.



GLASGOW—WORK OF THE SUB-COMMITTEE ON UNINHABITABLE HOUSES, 1906. 14 M'ALPINE STREET AND 9 CARRICK STREET.

Such provision as existed was due not so much to any regard for the public health, as to the fact that many persons were already so near the poverty line that they became paupers when attacked by typhus, and as paupers the poor law authorities had to take charge of them. It was not until about forty years ago that local authorities were empowered to provide isolation hospitals out of the rates. Such provision has been made gradually, and resort to hospital isolation has also been gradual. In later years, however, isolation has played an increasing part in aiding the practical disappearance of typhus—in sweeping up what still remains of the disease.

Along with the provision of isolation hospitals, a most important advance in medical knowledge made it easier than ever before to utilise hospitals for typhus. In the first half of the nineteenth century, typhus fever was constantly confused with typhoid or enteric fever. The distinction of these two diseases from each other was a result of the work of several investigators, including Dr. Perry, one of the physicians of the Glasgow Royal Infirmary. But the discoveries of hospital clinicians do not at once reach the medical profession whose members are already in practice and have ceased to attend the medical schools. By the time, however, that local authorities were empowered to provide isolation hospitals, typhus had come to be well separated from typhoid, and the coincidence was no doubt of much value. In the Scottish Registrar General's returns the diseases have been separated since 1870.

Typhoid and Typhus.

One feature in the history of typhus control is notable. The disease has been nearly extinguished without any knowledge having been obtained of its microbic cause. Reasoning by analogy a microbe may safely be assumed. Diplococci were found associated with it in 1892 by Lewaschew, and again more recently by Balfour and Porter; but their relation to the disease is uncertain, and methods of prevention have in no degree depended on their discovery. The plain facts of everyday experience were themselves enough to show the way to the extermination of typhus. It so constantly followed destitution, and physical and mental depression, and foul air and overcrowding and filth, and it was so constantly absent when these conditions were absent, that the conclusion as to a causal connection was natural, and experience has amply proved it to be correct. Typhus is above all others *the* disease produced by gross atmospheric impurity acting on debilitated subjects, and on that account its extirpation has been comparatively easy. Popular knowledge of its decline and practical disappearance has incidentally had much to do with the vague belief in the public mind that the same sanitation which has killed typhus is capable of killing every other infectious disease; but we shall see that other infections have other causes, and are far more difficult to prevent or control. Typhus is not conveyed by water nor milk nor food; it never enters the body by the alimentary canal; and as an air-borne disease it has a particularly short striking distance. A typhus patient may lie in the same hospital ward with patients suffering from other infectious diseases, yet if he be separated from the others by only a few feet, say a minimum of ten, and if between him and the others there be proper cross-ventilation by windows or otherwise, he will do them no harm.

The disappearance of typhus fever is, in short, the completest triumph of modern sanitation. The disease flourished in the absence of the very elements of a healthy life, and the provision of these elements has been sufficient to destroy it.

When typhus fever occurs now it is usually stamped out with comparative ease. The first requisite is to become aware of its existence, and medical men have so few opportunities of seeing it that they may pass through their whole college career without ever having looked on a case. Since it is not in their minds as one of the ordinary maladies requiring differential diagnosis, the possibility of an illness being due to typhus fever may very readily be overlooked, and influenza, pneumonia, or so-called continued fever may be the decision arrived at.

Typhus in Aberdeen.

Quite lately in Aberdeen, one of the university towns of Scotland, with a well-educated body of medical men in practice, a large number of cases of typhus were regarded as being influenza. As indicating the conditions under which that outbreak occurred, it may be mentioned that the constant presence of fleas in the beds of the patients suggested to Professor Matthew Hay, the medical officer, the query whether the disease was not being carried by these insects, and we shall see when we come to another disease which is not without points of analogy with typhus, that the flea plays a most important part in conveyance of infection. Certainly fleas abound in the houses in which typhus is ordinarily found, and Professor Hay adduces a good deal of evidence in support of the hypothesis. Every typhus case in hospital exhibited flea bites. Every case had been, at the probable time of infection, in the company of verminous patients, and the disease did not spread where fleas were absent. No nurse or wardmaid, however intimate her contact with the disease, was infected unless she had assisted in removing cases to hospital or in cleaning them when they arrived. But fleas are so constantly a manifestation of general uncleanliness, that it is at present impossible to separate out their influence from that of other associated conditions.

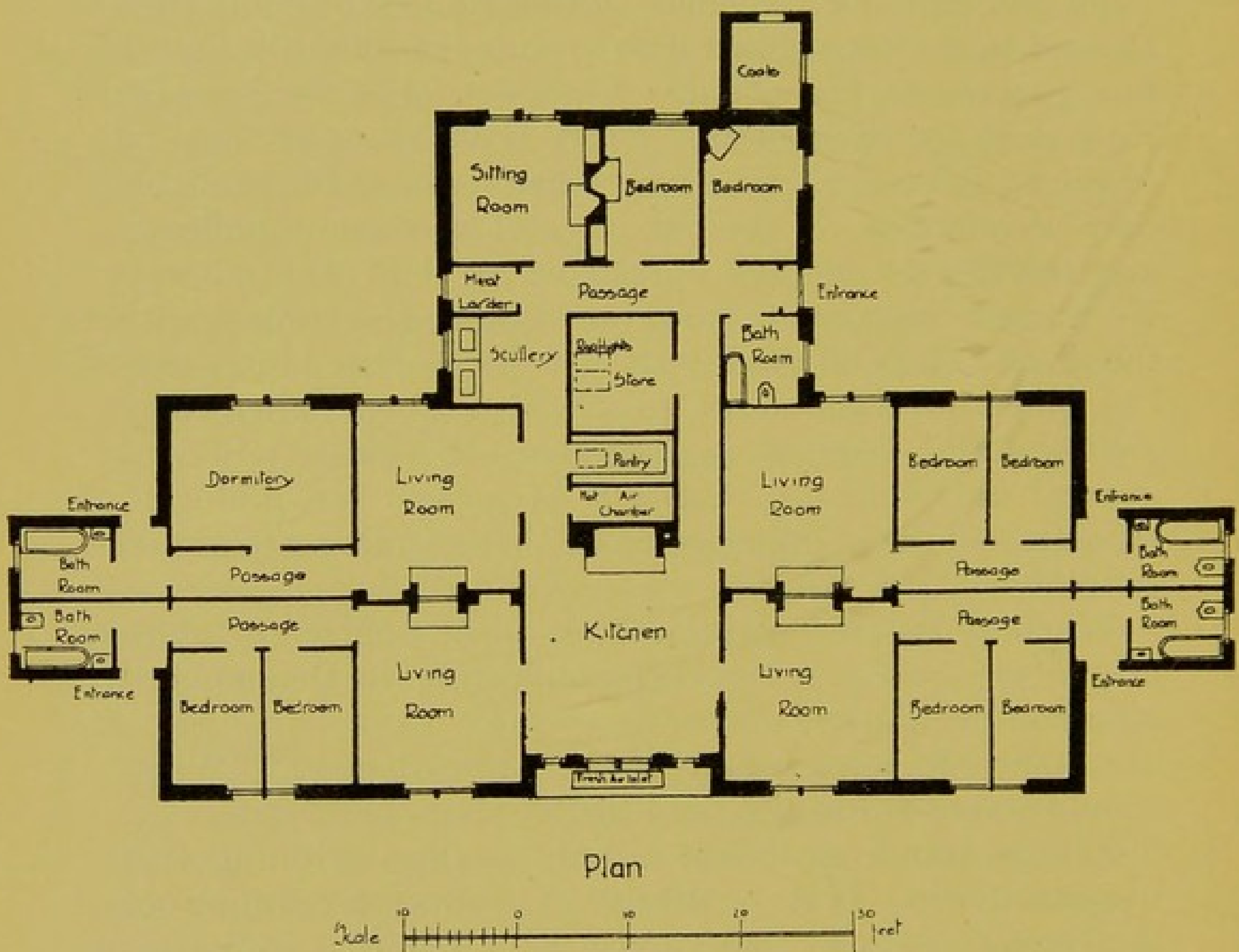
Fleas and Typhus.

When typhus is recognised, it is of course the duty of the medical man to send notification to the medical officer of health, and when two or three cases are known to have occurred, the profession should waken up to the need for keeping the disease in mind, so that it is only at the beginning that non-recognition is very likely. On the recognition of the disease the usual procedure with regard to all such maladies is entered on. Patients are removed to hospital. Houses and their contents are thoroughly disinfected and cleansed. Nuisances of every sort connected with infected localities are specially sought for and removed. Lime-washing is enforced, and the importance of fresh air is inculcated. Contacts are kept under observation (most conveniently in a reception house) until the incubation period is past.

Control of Outbreaks.

In large towns observation of contacts can most conveniently be carried out in a reception house belonging to the sanitary authority, which possesses statutory power to compel the removal to the reception house of persons who have been exposed to infection. Such persons are maintained there at the expense of the sanitary authority, and are detained until the incubation period of the disease is fully over. Here is the plan of a reception house

Reception Houses.



PLAN OF PARTICK RECEPTION HOUSE.
(From County and Municipal Record.)

recently built for the burgh of Partick, under the advice of its medical officer, Dr. Arbuckle Brown. It is so arranged that some degree of private family life can be preserved, three separate suites of apartments being provided, in addition to other accommodation. There is a central kitchen, with store pantry, scullery, etc., from which wings extend on either side, each wing being divided into two parts. For each of three families there is a small kitchen, two bedrooms, and bath-room. The fourth portion is a dormitory. Behind the kitchen is the accommodation for nurse and maid, each having a bed-room, and the nurse having a sitting-room in addition. The grounds are so arranged that each family can be kept apart from the rest both inside and out of doors.

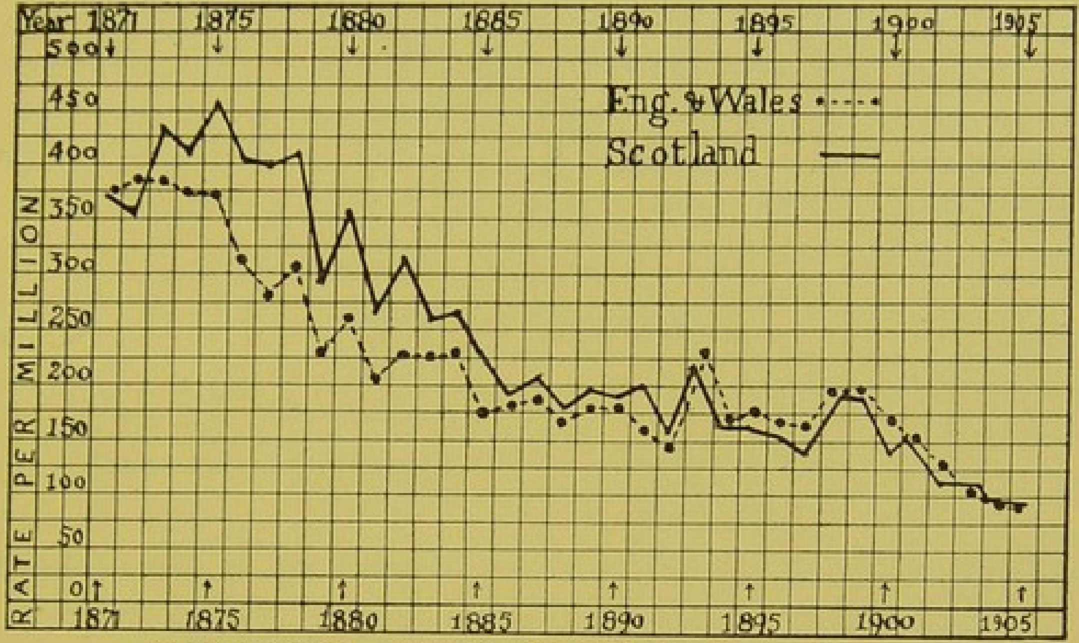
Much depends on circumstances as to whether removal to a reception house is necessary. Tramps may leave infected lodgings and roam all over the country unless controlled in this way. Typhus, smallpox, and plague are the diseases for which reception houses are most important. They are very seldom used for scarlet fever, diphtheria, measles, or enteric fever, and even smallpox contacts may often be kept under observation at home. In rural districts reception houses are seldom required for the ordinary resident population, and if typhus or smallpox breaks out in a navvies' hut or lodging-house, the building itself can sometimes be turned into a reception house.

Typhus fever, it may be said in conclusion, cannot get any very serious hold of a well-governed modern population, and is of interest in the present day, not as a practical contributor to the sum of human disease and death, but mainly as a reminder of a bygone time—as a disease still capable of appearing in the conditions in which it formerly grew and flourished, as a disease the disappearance of which constituted the first fruits of sanitary reform.

LECTURE III

THE PREVENTION OF ENTERIC FEVER

WHILE typhus has practically disappeared from civilised countries, enteric fever is always with us. It can be carried into the body by more vehicles than are usable by any other invader. It can be swallowed in water, ice, and milk, in oysters and other shellfish, possibly in water-cress, and almost in any other kind of food; it can be conveyed by the feet of flies, or by air-borne dust, or by unclean hands. And in practice, transmission of the disease is sometimes so very direct from the sick to the healthy as to make the term 'personal infection' quite justifiable in enteric fever, though such infection is not so common as in scarlet fever or diphtheria. Whether the virus of enteric fever is borne from the patient to the nurse by the handling of bed-sheets, or by contact with the sick, or by dust travelling on an indoor air current, the connection is practically as close as in the other diseases referred to. In that sense, personal infection in small and crowded houses, or even in the ward of an hospital, is an agency which even yet is not always sufficiently kept in view. But, very fortunately, the modes by which enteric fever can be spread are not only comparatively well known, they are at the same time capable of control. How far the disease has been prevented is indicated by the following chart and figures:



ENTERIC FEVER—DEATH RATE PER MILLION 1871 TO 1905.
ENGLAND AND WALES, SCOTLAND.

The mortality from enteric fever per million persons living in England and Wales and in Scotland was as follows in the last three decades:

	England and Wales.	Scotland.
1871-1880	322	390
1881-1890	198	230
1891-1900	174	180

The figures do not go back further, because in earlier years enteric fever was not distinguished in the death-records from typhus fever.

The statistics show a great diminution of the mortality from enteric fever. It is natural to regard the improvement as due to sanitary agencies; but there may be a fallacy in so doing. The fall in a death-rate may be owing to diminution either in the prevalence or in the fatality of the disease, or in both combined. Dr. Newsholme showed that the fatality from enteric fever—that is, the number of deaths per 100 cases of the disease at all ages—exhibited no diminution contemporaneously with a very decided fall in the death-rate. In the London Fever Hospital in 1848 to 1857 the fatality-rate was 17.3 per cent. In the hospitals of the Metropolitan Asylums

Undiminished Fatality.

Board in 1871-97, the rate was again 17.3 per cent., and in the single year 1897 it was 18.7 per cent. It was therefore practically stationary. Since 1897, however, there has been a diminution in fatality of enteric fever in the Metropolitan fever hospitals, the percentages being as follow:

1897,	18.60	1902,	15.48
1898,	17.70	1903,	15.40
1899,	16.50	1904,	14.58
1900,	14.09	1905,	13.15
1901,	14.22		

In quite recent years, therefore, some part of the lowered death-rate may be due to lowered fatality, and to a trivial degree the diminution in the national death-rates from enteric fever may be due to better diagnosis; but speaking broadly, the changes are real. The notification rates and death-rates for the counties of Stirling and Dunbarton given at pp. 18 and 20 *ante* show that independently of any lowering of fatality, the disease has greatly diminished in prevalence.

Taking the country as a whole, the fatality is probably rather under the rates experienced in the London hospitals, and in Scotland it appears to be somewhat less than in England. It is lowest in children and young adults, and highest in old persons. As regards the age incidence of the disease, its favourite period is usually set down as from fifteen to twenty-five years, but in some of the county districts of Scotland the range of ages appears to be lower.

Dr. Brownlee, of Belvidere Hospital, Glasgow, has published[1] the following table showing the susceptibility, mortality, and fatality of enteric fever in Glasgow at different ages in the period 1895-1903. The rates are calculated on the actual populations living at each age at the nearest census, and apply to the whole nine years, so that mean annual rates are obtainable by dividing by nine.

[1] *Journal of Hygiene*, October, 1905.

Age Period.	Susceptibility. (Cases per 100,000 of Population.)	Mortality. (Deaths per 100,000 of Population.)	Fatality. (Deaths per 100 Attacks.)
0-1 / 1-5	309	22	7·1
5-10	1216	94	7·7
10-15	1321	139	10.6
15-20	991	182	18.4
20-25	1043	229	22.5
25-30 / 30-35	830	221	26.6
35-40 / 40-45	437	137	31·3
45-50 / 50-55	148	41	27.8
55-60 / 60-65	90	30	33·3
65-70 / 70-75	13	13	100.0
75-80 / 80-	—	—	—

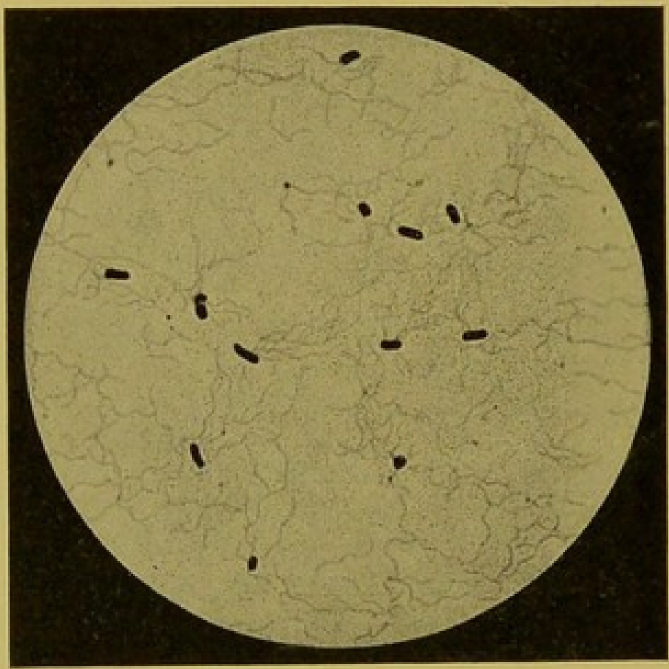
The season of greatest prevalence of the disease in London begins in September and culminates in November, after which it begins to fall towards its minimum in May and June. The prevalence is often high after a hot, dry summer.

Bacteriology.

Enteric fever differs from typhus in respect that bacteriology has thrown a great flood of light on its causation, and consequently on its prevention; but much of the reduction of death-rate and incidence shown in the figures already given had been accomplished independently of bacteriology.

It is about twenty-five years since Eberth published his discovery of the bacillus of typhoid, and about twenty years since the bacillus coli communis was distinguished; but Dr. Taylor, of Penrith, had observed in 1857 that enteric fever is conveyable by milk, and its transmission by water has long been known.

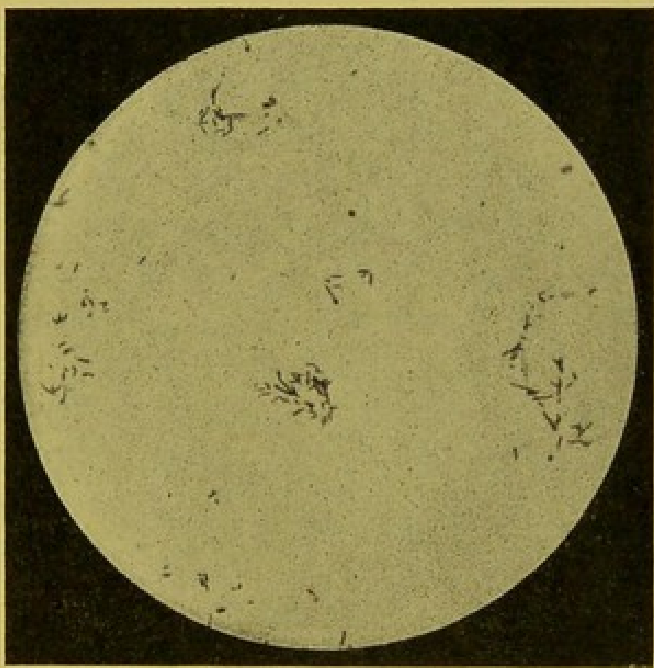
The bacillus is a non-sporulating organism. In cultures it is a short, somewhat plump rod of varying dimensions, and tends to form long threads, more especially at room temperature. It appears, as a rule, slenderer and more delicate than the majority of the great family of bacilli to which it belongs, and shows with them the peculiarity of being decolourised by the method of Gram. A lively motility is a constant characteristic of this bacillus, the short forms progressing with rapid rotating, oscillating, or tumbling movements, and the longer with a serpentine motion. This motility is accomplished by eight to



BACILLUS TYPHOSUS
(isolated from cockle), showing flagella stained by Richard Muir's modification of Pitfield's method. × 1,000. (Buchanan.)

fourteen long flagella affixed all round the surface of the bacillus. On nutrient media, as a rule, the growth of the bacillus typhosus is less luxuriant than that of bacillus coli, and along with this are associated certain negative characters which contribute to the differential diagnosis of the two organisms. Bacillus typhosus does not clot milk, does not produce indol, and does not form gas in glucose media. The well-known agglutination test foreshadowed by Pfeiffer's investigations, demonstrated as a specific reaction by Gruber and Durham, and applied to clinical work by Grünbaum and Widal, is of very great value in the identification of the bacillus as well as in the diagnosis of the fever. The blood serum of an enteric fever patient five to eight days, as a rule, after the illness has begun, will, when introduced into a suspension of a young culture of the bacillus in suitable dilution, destroy the motility of the microbes and cause them to agglutinate in masses.

All, however, that I wish to say regarding the bacteriology of enteric fever relates only to the means for



BACILLUS TYPHOSUS,
showing agglutination (Widal's diagnostic test). × 250. (Buchanan.)

diagnosing the disease. In the human body the organism usually reaches the intestine from without, passes into the blood, and so to the spleen and the most diverse parts of the system. The bacillus produces toxins which cause general poisoning, and evolve directly or indirectly the morbid phenomena of the disease, namely, parenchymatous changes in the various organs, enlargement of the spleen and mesenteric glands, general catarrh of the intestine, and swelling and ulceration of the lymphoid structures of the ileum. Pyrexia and diarrhœa furnish clinical evidence of the toxic processes at work. The stools contain the microbe, although it is not always easy of detection. In about one case in every four the urine contains the bacillus, usually in great numbers. It is seldom found in the urine before the third week of the disease, though there are many exceptions, both earlier and later—from the eighth to the seventieth day. Cases with respiratory complications may throw off the bacillus in the sputum.

In the air the bacillus cannot long resist destruction by desiccation, yet if it is kept alive by a very little moisture it may be blown about, and so may spread infection.

In milk the bacillus lives and flourishes, although an exposure of five minutes to a temperature of 140° F. is sufficient to kill it, while the natural development of souring destroys it in two or three days, or in about twenty-four hours after the acidity reaches 0.3 to 0.4 per cent.

In water and sewage, laboratory experiments are stated to indicate that the bacillus typhosus 'soon ceases to multiply and more or less readily dies.' But in practice the health officer is likely to form the opinion that the word 'less' in this statement should be strongly emphasised. For instance, the organism has been found to disappear in a few days from running water, but to persist in stagnant water and in mud for varying periods of from two to six months. It has retained its vitality in ice for three months. Shellfish, such as oysters, mussels, and cockles, not only take up the bacillus from impure water, but afford conditions favourable to its multiplication. In connection with an outbreak of enteric fever due to the eating of cockles in a Clyde watering-place, and referred to in the next lecture (p. 94), the bacillus was found by Dr. R. M. Buchanan, of Glasgow, in cockles gathered from the same site two months afterwards—as many as 3,000,000 of the germs being found in one shellfish.

As noted by Newman, in the soil viability or non-viability of the bacillus of enteric fever has been the subject of a great amount of scientific investigation with most diverse results. Robertson reported that it could be found after a year in the soil of an ordinary field, having thus withstood summer and winter, rain and frost, though bacilli within reach of direct sunlight, that is, on or close to the surface of the ground, are quickly killed. Under grass, also, the bacillus is said by the same authority to die out speedily. In sterilised garden soil Sidney Martin found the bacillus after 400 days, but from well-moistened (though not sloppy) cultivated ground it disappeared in two days, especially where the soil was warm and favourable for the growth of other organisms. If, however, the cultivated soil were not very moist, the bacillus could be found after twelve days. In uncultivated soil Martin failed to find it after twenty-four hours. Other bacteriologists report a viability in soil between the above-mentioned extremes of twenty-four hours and one year, such periods as twenty weeks and seventy-four days in ordinary and sewage soil, and eighty-eight days in moist garden soil, being mentioned. In peaty soil the evidence points to short viability, and so also in dry sand.

Antityphoid Vaccination.

In turning from the bacteriology of enteric fever to the consideration of its prevention, it will be appropriate to begin with antityphoid vaccination, a procedure which is directly dependent on bacteriological methods. Antityphoid vaccination or preventive inoculation aims at the production of immunity in the human subject by the injection of a vaccine or dead culture of typhoid bacilli. Up to the present time its application has been military rather than civil. It was tried in the case of British troops during the South African war, and the results of the experiment have been much under discussion. It has also been employed with a view to the protection of soldiers in India and in Egypt.

Since this lecture was delivered reports on the subject have been published by three officers of the Medical Corps of the British Army.* Lieut.-Colonel Leishman, in one of these, discusses recent modifications in the preparation of the vaccine. In another, Major Harrison, among various matters, describes his work on methods of killing the cultures, and on the duration of the immunity resulting from the injection of the protective material.

In the third of these reports Lieut. Luxmoore records the interesting

* *Journal of the Royal Army Medical Corps*, May, 1907.

experience of the 17th Lancers with reference to antityphoid inoculation. The regiment embarked at Southampton for India in September, 1905, with a total strength of 593 persons. In Scotland immediately prior to embarkation, and at sea during the voyage, 150 persons in all had injections of antityphoid vaccine. One hundred and twenty-seven of these received two doses of vaccine, while 23 refused the second dose.

In October, 1905, the regiment arrived at Meerut, and very shortly after its arrival it suffered severely from enteric fever. Out of a total of 63 cases, 61 occurred among persons who had not received the protective inoculation. Of the two inoculated men who developed the disease both had refused the second administration of vaccine. It is not too much to say that Lieut. Luxmoore's narrative is strong evidence in favour of inoculation, and especially of re-inoculation, as a protection against enteric fever.

With reference now to the general administrative measures which are used in the prevention and control of outbreaks of enteric fever, the first important point is, as usual, speedy recognition and notification of the disease. Unfortunately this is often impracticable.

Early Diagnosis.

In the earlier cases of an outbreak there is commonly an interval of a week, and sometimes even ten days or a fortnight, before the disease is known. The symptoms are so gradual in their onset, and so indefinite in their nature, that no medical man may be called in for several days after the beginning of the illness, and even then he may not feel justified in notifying enteric fever until he has watched the patient for a few days longer. This difficulty is unusually well illustrated by comparing the dates of (1) beginning of illness, (2) the doctor's first visit, and (3) notification, as recorded in a recent outbreak with which I have had to deal. In the first case the patient sickened about January 18th, and no doctor was sent for till the 30th, but by that time the disease was so well developed as to cause immediate notification. In case 4 the date of sickening was January 31st, of the doctor's first visit February 9th, and of receiving notification February 17th—an unusually long interval. It will be seen that there was in many cases a period of about a week between the first visit and the notification, but that the delay became less as the outbreak advanced, one case helping to throw light on another.

ENTERIC FEVER, RADNOR PARK, 1905.

No.	Initials.	Residence.	Age in Years.	Sex.	Dates of Sickening.	Dates of Doctor's first visit.	Dates of Notification Received.	Dates of Removal to Hospital.
1	W. F.	8 Baronial Ter. -	14	F.	Jan. 18	Jan. 30	Feb. 1	Feb. 1
2	G. C.	18 ,, -	13	F.	,, 26	Feb. 1	,, 3	,, 4
3	M. C.	15 ,, -	28	F.	,, 26	,, 4	,, 4	,, 4
4	C. P.	Hawthornbank -	29	F.	,, 31	,, 9	,, 17	,, 17
5	D. M.	Janetta Cottages -	55	M.	Feb. 4	,, 11	,, 17	At home
6	A. T.	8 Baronial Ter. -	4	F.	,, 9	,, 11	,, 17	Feb. 17
7	T. S.	Clydeview Cottages	11	M.	,, 7	,, 12	,, 17	,, 18
8	T. M.	10 Baronial Ter. -	6	M.	Jan. 31	,, 14	,, 20	,, 20
9	J. P.	Hawthornbank -	30	M.	Feb. 17	,, 17	,, 23	,, 23
10	J. B.	Clydeview Cottages	26	M.	,, 13	,, 14	,, 23	At home
11	J. B.	18 Churchill Pl. -	7	M.	,, 15	,, 17	,, 25	Mar. 1
12	E. P.	Clydeview Cottages	7	F.	,, 9	,, 11	,, 28	,, 1
13	J. R.	16 Baronial Ter. -	7	M.	,, 26	,, 28	Mar. 3	,, 3
14	M. C.	18 ,, -	9	F.	,, 28	Mar. 1	,, 4	,, 4
15	M. C.	23 Grove Place -	12	F.	,, 25	,, 1	,, 6	,, 7
16	R. D.	Stewart Cottage -	10	M.	,, 26	,, 1	,, 7	,, 7
17	J. N.	4 Gladstone Ter. -	12	M.	Mar. 5	,, 8	,, 11	,, 11
18	A. S.	15 Baronial Ter. -	13	F.	Feb. 20	,, 7	,, 13	,, 13
19	A. M'D.	5 Gladstone Ter. -	6	M.	Mar. 6	,, 10	,, 15	,, 15
20	W. B.	20 Baronial Ter. -	5	M.	,, 8	,, 13	,, 16	,, 16

Widal's test often gives valuable aid, but the fact that it does so indicates how long a case may remain doubtful, the reaction being obtained only after the patient's blood has become so altered by toxins as to produce specific agglutination. The effect of all this is that an enteric fever epidemic cannot be stamped out instantly. Before it is heard of there has already been opportunity for secondary infection of persons in contact with the patient.

Removal to Hospital.

The disease being once recognised, the next step is the removal of the patient to hospital, but here also there is sometimes difficulty. You will note on the above table of dates that in most cases of that outbreak the removal took place immediately after notification. But there are exceptions. By the time a diagnosis has been made an enteric fever patient may be too ill for safe removal to hospital. In that respect I may observe in passing that infectious diseases greatly differ from each other. Smallpox is usually recognised at a stage when the temperature is normal, and the patient can safely be carried ten or fifteen miles to hospital. With scarlet fever, too, though a bad throat and a high temperature may necessitate a day or two's delay, there is usually less difficulty than with enteric fever. In enteric fever, owing to high temperature and diarrhœa or abdominal tenderness, even the best ambulance waggon may cause dangerous jolting if the hospital is not at hand, and in the country it is impossible to build an hospital for every village.

Sometimes this difficulty can be overcome by establishing a temporary hospital, say in a public hall or in a school-room. And then the medical officer certainly has his hands full, arranging and equipping his hospital, providing nursing and medical attendance, looking after water supply and provisioning and refuse disposal, and all the numberless details that attach to the setting up of such an establishment. Yet there is pleasure in this work of organisation, and if it happen that the invaded hamlet is in a picturesque country amongst the hills, far away from town smoke and noises and traffic, the organiser may have as much interest and satisfaction in his scheme as a child has in planning and building a toy house, and in setting up imaginary house-keeping in it.

Ambulance Nurse.

Whether the hospital be near or distant, a trained nurse should always be sent to accompany the patient in the ambulance van. And the principle of which this particular action is one outcome should apply from beginning to end. The removal of a patient to a fever hospital differs essentially in purpose from removal to an ordinary medical and surgical hospital. In the latter case the patient goes voluntarily for his own benefit. In the former he is removed, if necessary by compulsion, for the benefit of the public, in order to prevent the spread of infectious disease. Whenever a public authority accepts the responsibility of removing a child from its home—from the care of the mother who is its natural nurse and protector—and places it in a public institution under hired nursing, then the local authority is bound both by law and by honour to see that everything that human skill can devise shall be done to protect the child from harm. The sanitary authority deliberately chooses to act *in loco parentis,* and if it fails in any single point to do its duty, it ought to be punished for its failure. Therefore, from the moment it takes charge of the patient, he should come under skilled supervision, beginning with the attendance of a nurse during the journey by ambulance. In the same way, the hospital itself should be built and equipped, not with wasteful extravagance, but with all due regard to the safety and welfare of the patients. I shall reserve, however, what I have to say about hospital construction until we come to discuss scarlet fever.

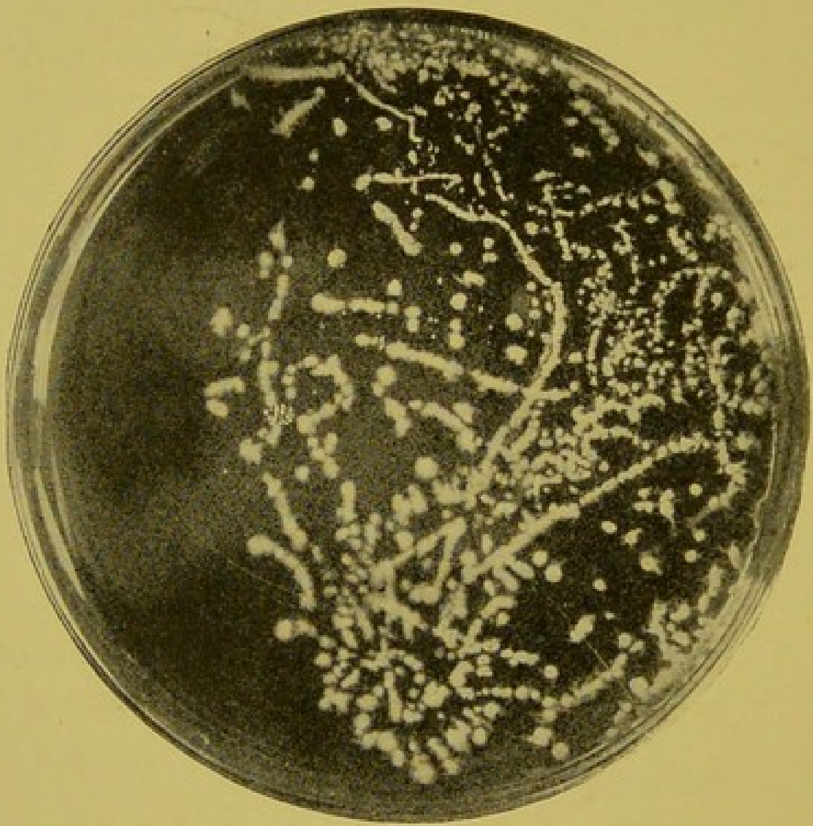
Isolation at Home.

Supposing that the patient is too ill for removal to hospital, and that the house in which he lives is very small, as many as possible of the other inmates should go to live elsewhere for the time, and should be kept under observation till it is seen whether they have already been infected by the disease. Those who must remain at home should be instructed in the precautions which can be taken to prevent spread of enteric fever within the house, and this is most conveniently done by a print or pamphlet such as is given at page 97.

If, as is very likely, the case has occurred at a season of the year when house flies prevail, war should be waged against these by means of fly-papers and by covering up all articles which are likely to attract them. The part played by flies in the spread of enteric fever need not be insisted on before an American audience, but I cannot refrain here from showing a plate of a preparation, which has been placed at my disposal by Dr. Buchanan as illustrative of fly infection, though it happens that it refers not to enteric fever but to anthrax. It shows in very striking fashion how the poison of infectious disease may be conveyed by flies. The trail of the fly's feet is apparent on the plate.

When the patient has been removed to hospital, or has recovered or died at home, the house and articles in it have to be disinfected. In Britain sulphur fumigation has been largely given up in favour of disinfectant spray, and the material used is an ordinary solution of formalin. In a country district with long distances between village and village there was for a time a difficulty owing to the weight and bulk of the

Disinfection.



CARRIAGE OF INFECTION BY FLIES.

A twenty-four hours' growth of Bacillus Anthracis on solidified agar in a Petri capsule, being the first surface over which a blue fly was allowed to walk after having alighted on the skinned carcase of a guinea-pig dead from Anthrax. (Buchanan.)

spraying apparatus, but this has been overcome by the Mackenzie spray, which is not cumbered with a receptacle for the disinfecting liquid, any convenient household vessel being used for the purpose. Such spraying does not necessarily destroy wall-paper. If the operation be begun at the floor level and be continued gradually up to the ceiling, the drops of liquid do not trickle down as in the case of dry walls, and there need be no streaking nor disfigurement of the paper. Manifestly it is the walls and ceiling and floor of a room which need disinfection, and not the air that it contains. That can easily and entirely be got rid of by freely opening the windows. Floors and furniture have of course to be disinfected and scrubbed *secundum artem*, and there is likewise to be free exposure to air and light.

Bedding, clothing, carpets, rugs, and the like, will be

A. Pump.

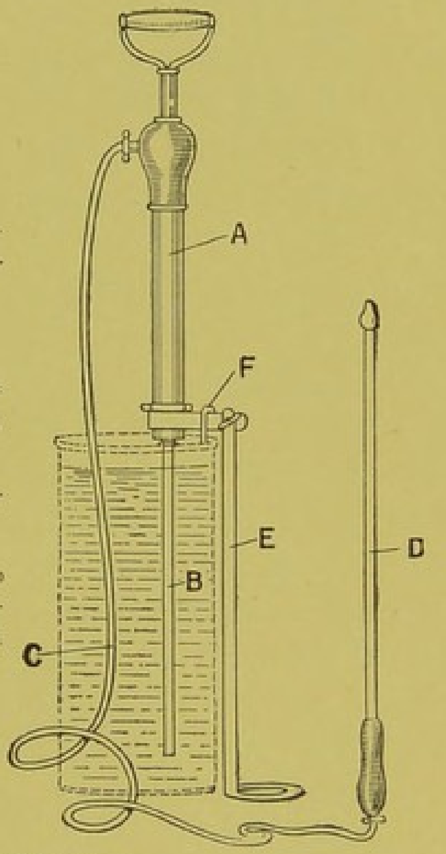
B. Tube (detachable) for immersing in vessel containing disinfecting fluid.

C. 6 ft. of rubber tubing.

D. Brass tube with wood handle at one end and spraying nozzle at other end.

E. Pump support — hinged for folding up.

F. Means of attaching vessel to pump support—not essential, since any household vessel can be used.

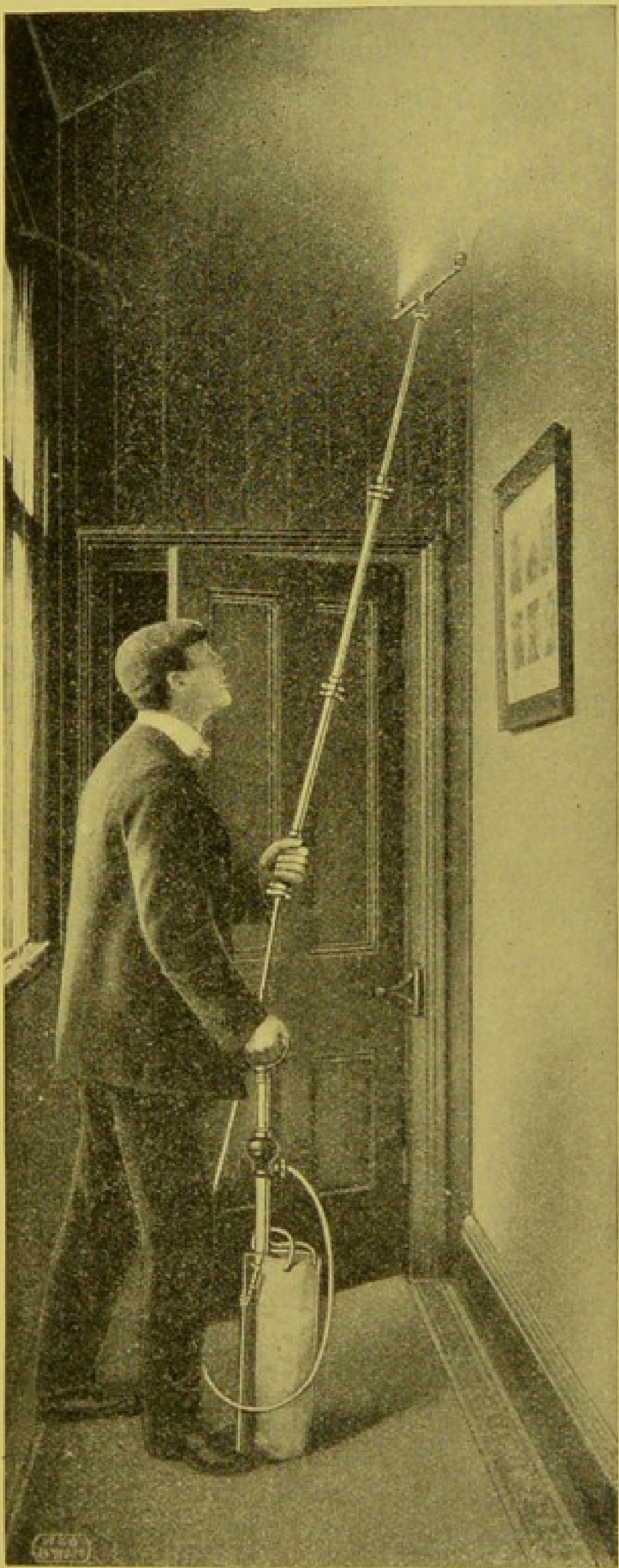


MACKENZIE SPRAY.

Steam Disinfection.

sent to a steam disinfector belonging to the sanitary authority, and it may be convenient here to say a few words about the principles and practice of disinfection by steam. In large cities municipal disinfectors need not be connected with the fever hospital, but in small towns and rural districts the same disinfector serves for all purposes, and no harm need result from its being in the grounds of the hospital. If it is a modern apparatus, it will be for the production not of hot air, but of steam, free from air but not superheated. Microbes are proteid bodies, and their destruction is easier if they are in a moist condition. There will also be an arrangement for drying the disinfected articles, either inside the disinfector or after removal from it. An automatic recorder, by which a note will be kept of the duration of the process and of the degree of temperature reached and maintained, will be a great convenience in checking the work of the attendant. The advantages of steam as compared with hot air are its penetrative power, and its faculty of moistening pathogenic organisms, which are more easily destroyed by heat when not entirely dry. The penetrative power of steam is due to its condensation on or in articles to be disinfected. As it reaches the inside of a mattress it meets with a lower temperature. Deposit of moisture consequently occurs, and the steam pushes further in, at the same time that the temperature of the article is raised by the steam parting with its latent heat in the act of condensation. But if the steam to begin with is superheated—that is to say, if its temperature is artificially raised beyond its saturation point, then when it begins to cool there is no condensation until after the temperature has fallen to below saturation point. So long as there is no condensation there is no aid to penetration, the advance of the steam into the body of the mattress is prevented, the organisms are not moistened, and disinfection is hindered. Therefore steam for disinfecting purposes should not be superheated. Another point in an ideal disinfector is that all air should be driven out in front of the steam. Air prevents penetration just as superheated steam prevents it.

The importance of mere temperature may be exaggerated, but it should be well above 212° F. In some disinfectors 230° F. is provided for, in others about 240° F. The standard test is the destruction of the spores of anthrax, but there is no evidence that the organisms of ordinary infectious disease are so resistant as anthrax spores. An ingenious method of obtaining a higher boiling point of water than 212° F. has been adopted in one form of disinfector. The water used contains chloride of calcium in solution, and such a solution does not boil



MACKENZIE SPRAY. SIZE A.

at 212° F., but at a temperature corresponding to the amount of the salt in the solution. This solution is contained in a jacket round the disinfecting chamber. It has been alleged that the salt may fall out of solution and encrust the jacket, which is very inaccessible, but endeavour is made to prevent this by maintaining a steadily regulated flow of water into and from the jacket, and by keeping down the strength of the solution.

As usual, one end of the disinfector will open into one chamber and the other into another, one chamber being for infected articles and the other for disinfected. A list will have been made of the articles removed from the house, and of their condition as to wear and tear, so as to prevent unjust claims for damage done. There will be in connection with the disinfector convenience for storing articles until the proper time for their return to the house from which they came. That time will depend on circumstances. The stock of bedding belonging to the house may be small, and immediate return may be required. Otherwise it may be better to keep the articles until it appears whether any other member of the household is in the incubation period of the disease, so as to save, in that event, the need for again disinfecting any of the same articles. If the case has occurred in a house far from the hospital and disinfector, then, to save expense, some of the articles may be removed in the ambulance van with the patient, or it may be found cheaper to burn some bedding rather than pay for its conveyance to the disinfector, and to give to the householder compensation on a scale arranged beforehand. The articles, if taken to the hospital, will be returned in a van kept for that purpose, and never used for infected goods.

Observation of Contacts.

The next point in administrative control of enteric fever is, as already indicated, the keeping of contacts under observation, so that the disease may be recognised early and the patient taken to hospital. This can easily be done at home, and removal to a reception house is quite needless.

These measures refer to the infected house and its inmates, but in addition steps have to be taken to check spread of infection from the surroundings of the house. What requires to be done will depend largely on the local system of refuse disposal. If the infected house has a properly constructed water closet into which excreta are discharged, then, provided the receptacle be kept clean, so that flies cannot find infective material to carry away, little danger need be feared, assuming the drainage system of the place to be satisfactory. When the microbe of almost any infectious disease gets into a liquid medium, it is for the time quite safe as regards atmospheric conveyance, though of course, in enteric fever and cholera, if there is any possibility of pollution of sources of drinking water the case is very different.

Infective Refuse.

So far as the surroundings of the house are concerned, great danger is to be feared if, instead of a water system being available for immediately carrying away sewage, all discharges are retained in a dry privy and ashpit. In too many villages in Scotland and England the privy and ashpit system still remains, and is one of the most certain means of spread of enteric fever. In mining villages these conveniences are often used in common, but whether or not that be so, there is the greatest risk of infection through the agency of flies, or through drying of the privy contents and consequent blowing about of dust containing the poison of the disease. Obviously, the privies are of much more importance than the ashpits. Not merely the privies themselves, but also the adjoining ground on which refuse may be spilled becomes a source of great danger. In small villages I have seen more spread of enteric fever in this way than through any other cause. Persons using the privies are infected, the surrounding ground becomes polluted by careless carrying of refuse to the ashpit and by careless emptying of privy and ashpit contents for removal by cart, so that children playing about in the neighbourhood are readily attacked. Where flies abound they act as regular carriers between the privy ashpit and the dwelling-houses and their inmates, and the fly season is largely coincident with the enteric fever season. When a case of enteric fever occurs in such circumstances, I make it an invariable rule to arrange for a very frequent—if practicable, a daily—system of refuse removal and disinfection of soil, carried out either by the mining firm owning the village, or by the sanitary authority if it has charge of scavenging. This is the direct and most certain way to minimise the risk that continually exists owing to unrecognised cases of the disease. Over and over again when all other means have failed to stop an outbreak daily cleansing has been successful. For disinfecting the ground, chloride of lime, used in abundance, is the most convenient. The structures themselves should be cleaned and lime-washed.

Every medical officer, I may say in passing, wages constant warfare against the whole privy ashpit system of refuse disposal. A tremendous difference between the health conditions of two communities, similar in every other respect, is made by the presence in one case and the absence in the other of accumulations of solid and liquid refuse in every back-yard throughout the town. The ideal is a water-carriage system, by water-closets connected with sewers, the sewage being purified before discharge into a river. For dry refuse there should be no middens nor ashpits, but movable galvanised iron buckets, emptied daily into a scavenger's cart, and removed from the locality for use as field manure or for cremation. This is a reform which soon should be so widely adopted as to reduce very greatly the amount of enteric fever still remaining in small towns and rural districts.

Investigation of Epidemics.

While all the measures above described are being taken to deal with an outbreak, namely, the removal of patients to hospital, the keeping of contacts under observation, the disinfection of houses, the emptying of ashpits and the cleansing of their surroundings, and the removal of every kind of nuisance, enquiry is also being made into the cause or causes of the epidemic, and steps are being taken to deal with these. Sometimes, without waiting to come to any definite conclusion, circumstances may very quickly justify the taking of provisional action with regard to water and milk supply. But until suspicion is verified, action may have to be limited to the issuing of notices to use neither water for primary purposes, nor milk, without previous boiling. Handbills may be issued, or, still better, a printed letter to this effect may be left at every house.

In searching for the cause of an outbreak, great light is thrown on the problem by the facts which it is the duty of the sanitary inspector in Scotland to obtain for the medical officer regarding every case of infectious disease. There is here shown a blank print of the form used for this purpose in the areas of which I have charge.

INFECTIOUS DISEASE (NOTIFICATION) ACT, 1889.

Sanitary Inspector's Report.

No............ PARISH........................
Notification Recd..
Visited by Inspector..
Disease ....
Name of Patient...Age......................
Residence ....
Occupation of Patient..
Name of Householder..
Occupation of Householder..
Medical Attendant ....
Date of Medical Attendant's first visit ....
,, first feeling ill...
,, Rash (if any)..
Supposed Source of Infection ....
School Attended by Patient ....
,, by others in Household...
Books from any Library ....
Milk Supply ....
Water Supply ....
Ventilation ....
Privy, Midden, Water Closet, etc..
Drainage..
Nature of Dwelling (Cottage, Tenement, etc.)..........................
....
No. of Apartments...
Total Inmates..................... No. of Children under 14....................
Inmates not had the disease...............Inmates left the house...............
Date of Removal to Hospital...
If treated at home, how isolated, and by whom nursed.......................
....
REMARKS ....
....
.... *Sanitary Inspector.*

You will observe that the queries to be answered include almost everything that is necessary as a basis for investigation.

In the case of a sudden outbreak the facts so ascertained and tabulated in columns will often at once direct attention to the source of the disease. Such a table is shown on page 71.

A Milk Epidemic.

Kippen is an out-of-the-world village with less than 300 inhabitants. The age column indicates that school attendance had nothing to do with the matter. Indeed, in enteric fever, school attendance is hardly ever of consequence. The sex column shows that no occupation confined to either males or females was responsible. The addresses show (to one acquainted with the place) that the disease was not limited to any one part of the village. The main water supply was from uninhabited hills to the south of the village, and the water was stored in a tank in a safe position, and was not liable to pollution. But the column of milk supply at once attracts notice. Of the forty cases constituting this outbreak the first twenty-two received the whole or part of their milk from one dairy, and the first case in the column was a girl residing at the dairy. But the column giving the dates when the attack began shows that this first case was not responsible for all the others. Cases one, two, and three began simultaneously. Then there was an interval of about a week, the minimum time for the incubation of enteric fever, which is usually regarded as ranging from one to three weeks, with many more cases about the middle of the period than at either of the extremes. The table, as it happens, does not state when the first notifications were received, but the date, as a matter of fact, was 23rd November, and eight notifications came by the same post. There had therefore been an 'explosion' of enteric fever, and this explosive character is a feature of milk epidemics. In the absence of evidence of any other kind of infected food, as to which point careful enquiry was made, there was every reason to conclude that the milk of Dairy A had been the vehicle for the spread of the disease.

EPIDEMIC OF ENTERIC FEVER IN VILLAGE OF KIPPEN.

Family.	Case	Attack began.	Sex.	Age in Years	Residence.	Milk Supply.	Whether Removed to Hospital, and Date of Removal.	Result. (R. = Recovered.)
I. (1)	1	Nov. 4 or 5	F.	14	Dairy A	Dairy A	Dec. 28	Jan. 15 R.
II.	2	,,	F.	20	Post Office	,, A	Jan. 11	Feb. 20 R.
II.	3	,,	F.	50	,,	,, A	No.	
III. (2)	4	Nov. 11 to 13	M.	31	Main Street	,, A	No.	Died.
II.	5	,,	F.	9	,,	,, A	Dec. 27	Jan. 11 R.
III.	6	,,	M.	2	,,	,, A	No.	R.
IV. (3)	7	,,	F.	14	,,	,, A, B and C	No.	Died.
IV.	8	,,	M.	8	,,	,, A, B and C	Dec. 23	Jan. 15 R.
V.	9	,,	M.	8	Crown Inn	,, A and D	,, 27	,, 13 R.
V.	10	,,	F.	14	,,	,, A and D	,, 27	,, 19 R.
V.	11	,,	F.	16	,,	,, A and D	,, 28	Feb. 3 R.
VI. (4)	12	Nov. 15	M.	13	Old Free Church	,, A and E	No.	
IV.	13	,, 18	M.	27	Main Street	,, A. B and C	Dec. 23	Jan. 24 R.
IV.	14	,, 18	M.	20	,,	,, A, B and C	,, 23	,, 22 R.
V.	15	,, 18	F.	6	Crown Inn	,, A and D	,, 27	,, 17 R.
VII. (5)	16	,, 23	M.	16	Main Street	,, A	,, 23	,, 11 R.
VIII.	17	,, 23	F.	16	Crosskeys Inn	,, A	No.	Died.
III.	18	,, 26	M.	$\frac{11}{12}$	Main Street	,, A	No.	R.
VIII.	19	Dec. 9	M.	11	Crosskeys Inn	,, A	Dec. 23	Jan. 12 R.
I.	20	,, 9	F.	30	Dairy A	,, A	,, 28	,, 15 R.
II.	21	,, 11	F.	13	Post Office	,, A	,, 27	,, 11 R.
III.	22	,, 12	F.	33	Main Street	,, A	,, 30	,, 18 R.
IX. (6)	23	,, 16	M.	11	Fordhead Farm	Own Cows	,, 23	Feb. 3 R.
VIII.	24	,, 17	F.	16	Crosskeys Inn	Dairy A	,, 27	Jan. 19 R.
V.	25	Jan. 3	F.	10	Crown Inn	,, A and D	Jan. 8	Feb. 20 R.
V.	26	,, 4	M.	11	,,	,, A and D	,, 8	,, 16 R.
IX.	27	,, 8	M.	17	Fordhead Farm	Own Cows	,, 15	Mar. 7 R.
IX.	28	,, 8	M.	10	,,	,,	,, 15	Feb. 16 R.
IX.	29	,, 8	M.	8	,,	,,	,, 15	,, 20 R.
IX.	30	,, 8	M.	5	,,	,,	,, 15	,, 17 R.
IX.	31	,, 10	F.	17	,,	,,	,, 17	,, 17 R.
IX.	32	,, 10	M.	12	,,	,,	,, 17	,, 10 R.
VII.	33	,, 10	M.	8	Main Street	Dairy A	,, 11	,, 16 R.
IX.	34	,, 17	M.	19	Fordhead Farm	Own Cows	,, 22	Mar. 7 R.
IX.	35	,, 17	F.	4	,,	,,	,, 22	Feb. 16 R.
IV.	36	,, 19	M.	4	Main Street	Diary A, B and C	,, 22	,, 13 R.
IV.	37	,, 23	M.	7	,,	,, A, B and C	,, 26	Mar. 17 R.
X. (7)	38	Feb. 6	M.	7	Back Road	,, G	,, 31	,, 14 R.
XI. (8)	39	,, 6	M.	14	Old Free Church	,, A and C	Feb. 19	,, 14 R.
	40	,, 14	F.		Nursein Hospital		,, 20	,, 17 R.

NOTES.—(1) Carried milk to Family III. Other families using milk from Dairy A sent for it to dairy.

(2) This man had influenza just previous to enteric fever.

(3) House in very insanitary condition and much overcrowded.

(4) Got milk from Dairy A until a fortnight before beginning of illness.

(5) Was in service of Family V.

(6) This family lived at a farm $1\frac{1}{2}$ miles from village. Case 23 attended village school.

(7) Had stopped using milk from Dairy A previous to beginning of outbreak.

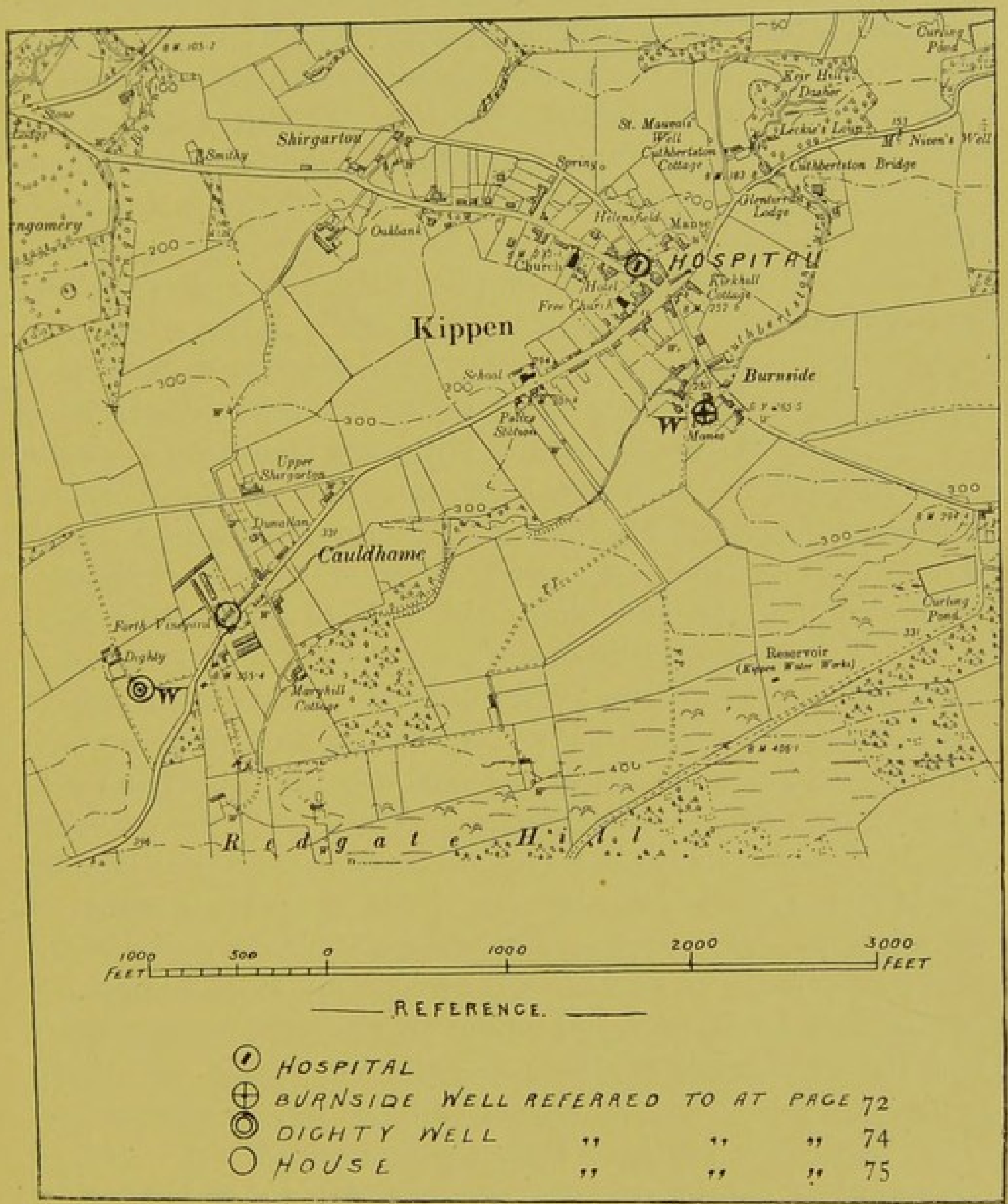
(8) House is in same passage with that occupied by Family III. Looking to date of attacks milk from Dairy A could not have caused this case.

This village is so far from a hospital, and the cases were already so numerous, that their removal was out of the question. Nurses were obtained from a nursing institution, and began to attend to the patients in their own houses, but this was found so unsatisfactory that the village hall was placed at the disposal of the sanitary authority, and was turned into an hospital, to which cases were removed near the end of December.

The most interesting question connected with the outbreak was how the milk of Dairy A became infected with enteric fever. There had been no visitors to the dairy. No new cows had been brought from a distance, and no one connected with the milk business had been from home. Kippen had in former years repeatedly suffered from enteric fever, but in the absence of compulsory notification the numbers of persons infected were unknown. Notification was in force when the outbreak in question occurred, and there had been in the course of the year no known or suspected case previous to those recorded in the table.

While the village obtained its main water supply from the source already stated, there were other and local sources close to the population. The dairy was situated on a hill to the south of the village, and took its water from a well near the house. On the moorland above there were no inhabited houses, and only one ploughed field, the house and well not being on the line of its drainage. There was no manured ground of any kind on the hill above the house. The house and premises had not been intended for dairy purposes, but the occupier had of his own accord established a small business, using an outbuilding as a byre for three cows.

The situation of the well is indicated in the map. It was an open dip-well cut in the rock closely adjoining a streamlet or burn which carries rain or soil-water from the hills behind Kippen to the river Forth. There were only a few inches of solid rock between the burn and the well, and the water-level was approximately the same in both. The well was barely two feet deep, and if its water had been identical with that of the moorland stream beside it, then it would have been water from a very safe source. But on a patch of ground immediately above the well the dairyman had accumulated a large heap of byre manure.



Chemical analysis of the water showed that it had been grossly polluted from this source. This water was used for all purposes, including the cleansing of milk vessels and of premises. Eight families used the water from the well for domestic purposes, and two of these were attacked by the disease. These two families, however, used the milk as well as the water. It thus appeared that the water itself did not cause enteric fever, but that the milk contaminated with polluted water was the means of spreading the disease. That the milk actually received its specific contamination from this source could not be absolutely proved, but most careful enquiry failed to find a suggestion of any other explanation. Needless to say, the milk sale was immediately prohibited. The outbreak came to an end by the middle of February. Of the forty cases, three were fatal.

'A little knowledge.'

From an outlying part of this village comes a curious illustration of the proverb that a little knowledge is a dangerous thing. Cauldhame, a hamlet to the south-west, is at a higher level than Kippen, and the Kippen water supply, at the time of which I speak, did not rise to Cauldhame. The people of Cauldhame, therefore, obtained water from local wells. A small burn or ditch, considerably polluted, passed along the side of the public road here. For many years before there was any systematic sanitary government, enteric fever had occasionally occurred in this locality. A new water supply was much needed, and as a preliminary I had chemical analysis made of samples from the local wells and also from the roadside burn. The wells themselves were in a very fairly safe situation, a considerable way from dwelling-houses or population, and were manifestly much less liable to pollution than the roadside burn. Yet, as it happened, the sample of burn water taken to the analyst was quite free from chemical evidence of pollution, while one of the wells, not open to dangerous contamination, chanced to show on that particular occasion such an amount of nitrogenous matter as led the chemist to report on it adversely from his point of view. A dead field mouse or two in the water, however, would have accounted for all the nitrogenous matter that was found. Unfortunately, the result of the chemical analysis became known to some of the inhabitants; one of them immediately gave up using the well, and resorted entirely to the burn water.

The change was unfortunate. It was speedily followed by the occurrence of enteric fever in his household. He straightway attributed the disease not to the water from the polluted burn but to that from the well, and he laid the blame on the sanitary authority or its officials for not having immediately warned him to cease using this well which the chemist had found contaminated. But the date at which the disease began was sufficient to indicate that infection had been incurred after the complainer had discontinued the old source and had resorted to the burn for his water supply. It was to the burn water, chemically unobjectionable, that the enteric fever was in all probability due. Not long after this outbreak Cauldhame got a new source of water from a deep spring in a safe situation, and it is now free from enteric fever.

A Typhoid Infected House.

The house in which the occurrence just noted took place had a peculiar history, which may be related here. It was invaded by enteric fever in November and in December, 1898, again in December, 1900, and once more in 1902, after the new water supply had been introduced. One of the invasions included three cases of the disease. When the last invasion occurred it emerged that, though the new and safe water supply had been introduced into Cauldhame, water from the roadside burn or ditch was still being used for personal ablutions and for washing of dishes and floors at the infected house. So long as that practice existed this ditch water could not be excluded as a possible cause of the disease, but the persistence with which the infection had attacked the house led to other steps being taken. The building was a one-storey cottage of four apartments, at the side of the public road. Behind there was a kitchen garden, with a wooden privy at the far end. Soil pollution could not be excluded as a possible cause of recurrence of the disease. In considering whether it would be practicable to deal with the soil, it was pertinent to bear in mind that the depth to which the bacillus was likely to have penetrated was probably not more than eighteen inches. Three alternatives, therefore, suggested themselves :—(1) To dig it up to a sufficient depth and remove it entirely; (2) to saturate it with a good chemical disinfectant, such as a solution of chloride of lime; and (3) to manure the ground freely with stable dung. Against the first alternative were the trouble and cost of carting away such a quantity of material, and the further possibility that the fresh soil which would then be exposed might be infected by the pathogenic bacillus by a process resembling inoculation, the inoculating instrument being the digger's spade used in removing the surface soil. There was also the possibility of infection of the new ground on which the garden earth might be deposited, and in view of the remarkable persistence of enteric fever in Cauldhame and Kippen that risk was not to be disregarded. For these reasons this alternative was put aside. The second alternative—the attempt to destroy all disease-producing organisms by means of chloride of lime—was open to the objection that it would be difficult to drench the ground with sufficient thoroughness to the required depth. The theoretical basis of the third course was to give opportunity to other organisms to destroy those of disease, and it was proposed to effect this by means of manure not itself likely to contain the poison of enteric fever, and not likely to create a nuisance if well mixed with the soil. This third procedure seemed, on consultation with Dr. Buchanan, of Glasgow, to be the best, and I instructed the sanitary inspector to see it carried out. Destruction of the wooden privy and chemical disinfection of the soil underneath and immediately around it were also ordered; and whatever be the cause, whether destruction of the bacillus in the soil or cessation of use of the burn water, the fact is that enteric fever did not again invade the house.

Another milk epidemic of enteric fever, almost similar to that above described, occurred in another remote village a year or two afterwards. In this case a school-house was turned into a temporary hospital, and similar administrative procedure was followed.

I propose to continue the subject of milk-borne enteric fever in lecture IV.

LECTURE IV

THE PREVENTION OF ENTERIC FEVER
(*Continued*)

Milk is so important an agency in the spread of enteric fever that I wish to give you another illustration of it. An outbreak which occurred two years ago at an old mining village near Glasgow presented some points of interest. The accompanying table indicates the main facts.

Another Milk Epidemic.

I need not recount the steps taken to stop the spread of infection. They were similar to those already described, and it will be observed that removal to hospital took place immediately after notification, excepting in one or two instances where it was unnecessary or impracticable. Once more the table of cases quickly indicates the cause of the disease. The water supply of the village was the same as that of the whole city of Glasgow and the surrounding country, where there was no unusual prevalence of enteric fever. At the same time there were no local opportunities for infection of the water supply whilst stored in a tank or otherwise. Water, indeed, was quickly excluded in searching for the cause of the outbreak. Separated from the village only by a dirty ditch is a fever hospital, but enteric fever is not carried aerially from hospitals. It will be noted from the table that information about the outbreak came not in driblets but in bulk, no less than fifteen cases being intimated in one day. The age and sex columns again show that the

Outbreak of Enteric Fever at Knightswood (and Temple) in the Parish of East Kilpatrick, August and September, 1904.

No.	Date of Notification.	Name.	Address.	Age.	Sex.	Occupation.	Date of First Feeling Ill.	School.	Milk Supply	Number of Apartments.	Total Inmates.	Children under 14.	Hospital.	
													Name.	Date of Removal
1	1904. Aug. 30	A. L.	73 Middle Row	9	M.	Schoolboy	About Aug. 23	Hillhead (Knightswood)	A, B	2	9	4	Lennox	1904. Sept. 1
2	,, 30	J. L.	,,	19	F.	Brickfield worker	,, 23	,,	A, B	2	9	4	,,	Aug. 31
3	,, 30	A. L.	,,	10½	M.	Schoolboy	,, 23	,,	A, B	2	9	4	,,	Sept. 1
4	,, 30	M. H.	21 Temple Place	21	F.	Ironer in Laundry	,, 23	Temple	B, D, E	2	6	1	At	Home.
5	,, 30	J. H.	Old Store, Top Row	25	M.	Brickfield labourer	,, 23	—	A, B	4	7	0	Knightswood	Aug. 31
6	,, 30	J. H.	,,	15	F.	Clerk	,, 24	—	A, B	4	7	0	Lennox	,, 31
7	,, 30	A. H.	,,	30	M.	Engineman	,, 26	—	A, B	4	7	0	,,	,, 31
8	,, 30	J. W.	70 Middle Row	26	M.	Miner	,, 25	—	A, B	4	8	0	Dunbarton	,, 31
9	,, 30	J. M'G.	68 ,,	24	F.	Housewife	,, 23	—	B	2	7	4	Knightswood	,, 31
10	,, 30	M. W.	67 ,,	25	F.	Housewife	,, 5	—	A, B	2	4	2	At	Home.
11	,, 30	A. H.	53 ,,	25½	M.	Brickfield worker (idle 5 months)	,, 23	—	A, B	2	2	0	Dunbarton	Sept. 1
12	,, 30	J. H.	52 ,,	23	M.	Miner	,, 21	—	A, *	2	2	0	Knightswood	,, 1
13	,, 30	J. A.	106 Lower Row	20	M.	Sawmiller	,, 24	Hillhead	A, B	2	8	3	Dunbarton	,, 1
14	,, 30	G. W.	104 ,,	37	M.	Miner	,, 21	,,	B, C	2	6	4	,,	,, 1
15	,, 30	J. A.	65 ,,	4	M.	—	,, 23	—	A, B	2	4	2	,,	Aug. 31
16	,, 31	A. M	96 ,,	18	M.	Miner	,, 25	Hillhead	B	2	7	4	,,	Sept. 1
17	,, 31	M. B.	99 ,,	8	F.	Schoolgirl	,, 28	,,	B	2	7	4	,,	,,
18	Sept. 3	C. H.	83 Middle Row	36	F.	Housewife	About Aug. 21	Hillhead and Maryhill (R.C.)	B, C	1	7	5	Lennox	
19	,, 3	M. H.	83 ,,	3½	F.	—	,, 30	—	B, C	1	7	5	,,	,, 3
20	,, 3	M. F.	105 Lower Row	20	F.	Housekeeper	,, 26	Temple	B	2	5	1	Dunbarton	,, 3
21	,, 6	J. L.	73 Middle Row	16	M.	Brickfield worker	,, 30, 31	Hillhead	A, B	2	6	2	Lennox	,, 6
22	,, 6	M. G.	74 ,,	15	F.	Brickfield worker	,, 30	,,	B, C	2	10	7	,,	,, 6
23	,, 9	J. F.	33 Top Row	9	M.	Schoolboy	Sept. 6	,,	B, & condensed milk	2	10	5	,,	,, 6
24	,, 9	A. H.	83 Middle Row	11	M.	Schoolboy	,, 5	Hillhead and Maryhill (R.C.)	B, C	2	5	4	,,	,, 6
25	,, 7	J. M'K.	101 Lower Row	12	F.	Schoolgirl	,, 5	Temple	A, B	2	7	4	Dunbarton	,, 10
26	,, 12	J. W.	104 ,,	12½	F.	Schoolgirl	,, 9	Hillhead	B, C	2	5	4	,,	,, 12
27	,, 12	M. F.	33 Top Row	5	F.	—	,, 9	,,	B, & condensed milk	2	10	5	Lennox	—
28	,, 23	C. H.	83 Middle Row	6	F.	Schoolgirl	About Aug. 21	Hillhead and Maryhill (R.C.)	B, C	1	7	5	,,	—
29	,, 28	M. M.	41 Top Row	40	F.	Housewife	About Sept. 7	—	A, B	2	2	0	Knightswood	—
30	Oct. 4	H. R.	2 ,,	9	M.	Schoolboy	About Sept. 13	Hillhead	B, C	3	9	3	Lennox	—
31	,, 4	A. A.	114 Lower Row	5	F.	Schoolgirl	About Sept. 20	,,	A, B	2	6	4	,,	—

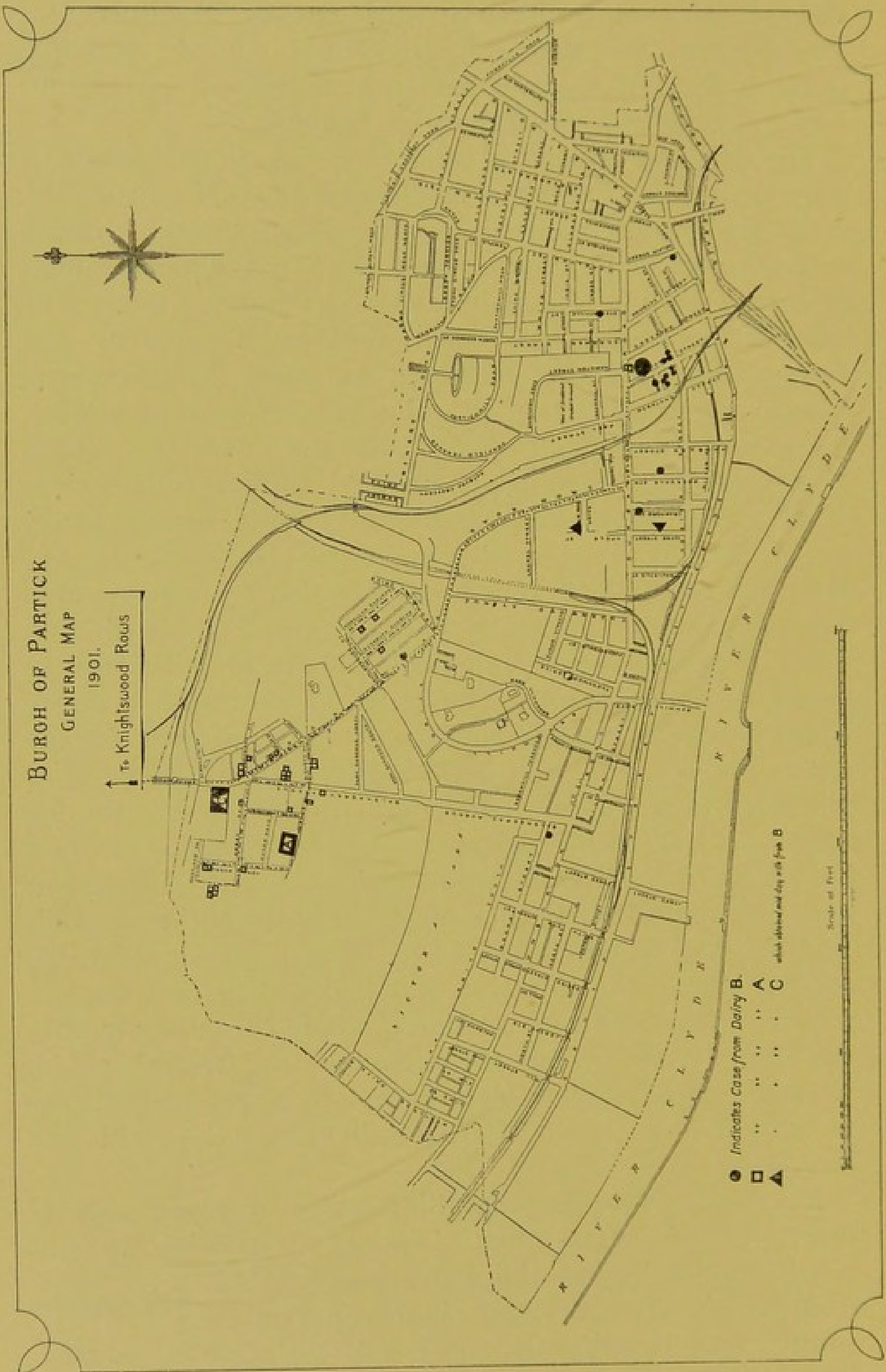
* B's milk used for animals.

disease was not confined to any age or to either sex. The occupations also varied. The obviously common factor is the milk supply, and the suddenness of the outbreak at once suggested such an agency.

The dairyman B carried on his business in the adjoining town of Partick, under a medical officer of its own, Dr. Arbuckle Brown, conference with whom showed that an explosion of enteric fever had occurred almost simultaneously among the dairyman's customers there. The map of the burgh of Partick, provided for me by Dr. Brown, shows Dairy B which supplied Knightswood. Round it you will observe a cluster of cases representing the sale of the milk direct from the dairy counter. Also, a small indefinite epidemic resulted from a milk carrier of B going about with ambulant enteric fever. Dairy A in Partick is not the same as Dairy A in the Knightswood table. It is a dairy which received a small quantity of milk from Dairy B for mid-day distribution in its immediate locality, and the sale of this milk resulted in an outbreak there. The letter C indicates a steam laundry where several employees were infected in the cooking depot, the milk being derived from Dairy A, as just explained. Four cases were traced directly to this source. The Partick dairyman, besides keeping cows of his own, received milk from various sources in distant parts of the country, the milk being brought by rail. Enquiry had to be made by Dr. Brown among all these, and ultimately the infection was believed to be traced to a farm in the south of Scotland, where the water supply was defective, and where the milk contained bacteriological proof of excretal contamination, though no recognised case of enteric fever could be found in connection with the farm.

Milk Enquiries.

In these enquiries regarding milk-conveyed enteric fever there is often great difficulty in coming to any conclusion owing to the numerous sources from which city dairymen obtain their milk supply, and investigation may have to be made regarding a large number of dairy farms in various parts


Burgh of Partick
General Map
1901.
To Knightswood Rows
Indicates Case from Dairy B.
" " " A
" " " C
River Clyde
River Clyde

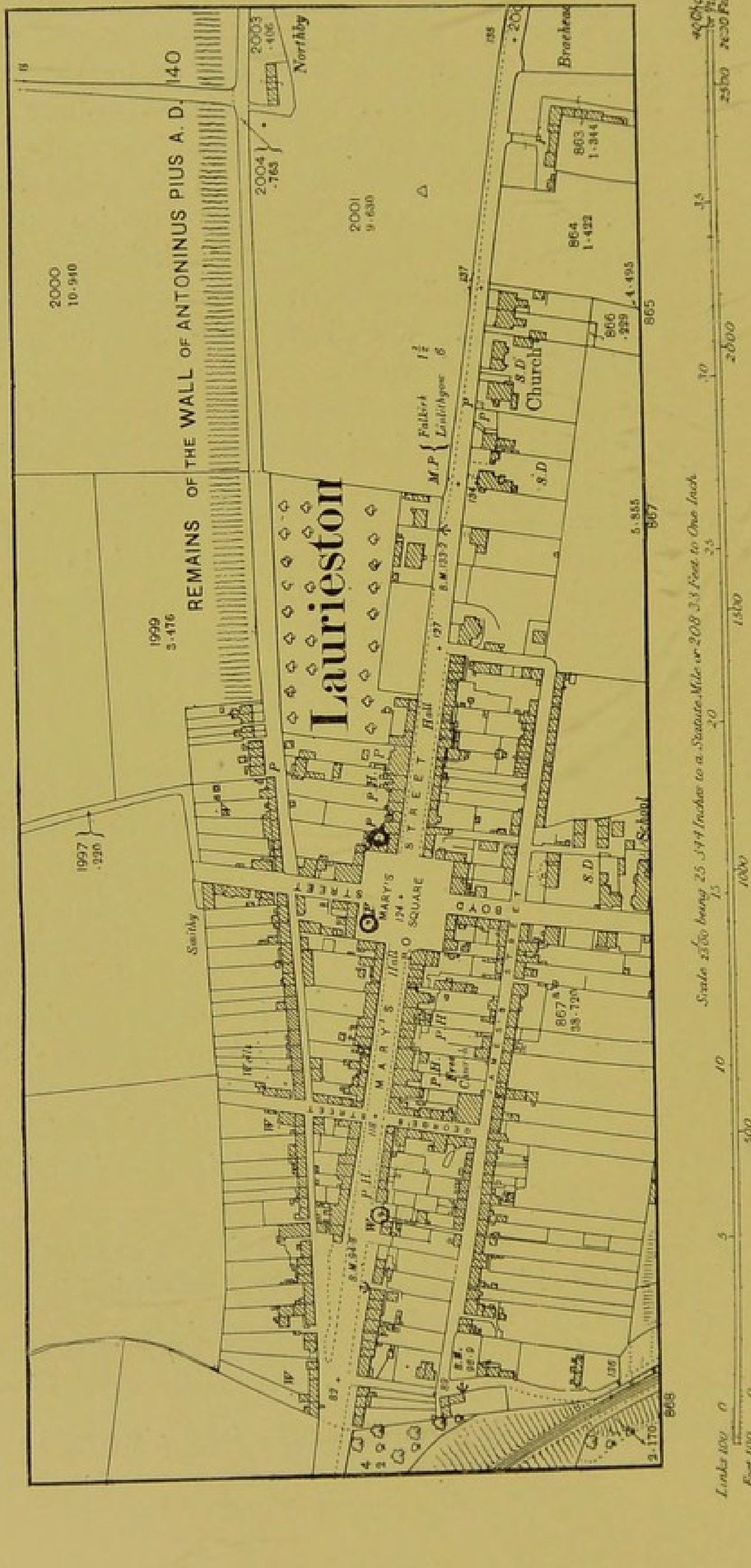
of the country. Sometimes the labour of enquiry can be diminished by separating out the sources of milk sold to customers in the morning from those of milk sold in the evening. It may be ascertained, for example, that the disease has existed only in houses receiving the evening milk, and this milk may have come from other dairies than those supplying the morning milk. Sometimes even it is possible to connect infection with one particular butt of milk obtained from a particular source, and sent daily to a definite locality within the area of the milk-seller's business.

Such tabular statements as those implicating Dairy A in Kippen and Dairy B in Knightswood are not always free from fallacy. It may happen that practically the whole milk supply of an invaded locality comes from a single dairyman. In such cases, whatever be the origin of an outbreak of enteric fever or of scarlet fever, manifestly it must prevail solely amongst the customers of the dairy. In any definite area, therefore, where the disease exists, it may be necessary to take a milk census of the whole community.

Indeed, a door-to-door visitation in enteric fever outbreaks is often very valuable. Each house in the locality is visited, whether or not it has been attacked by the infection, enquiry is made as to any suspicious illnesses, and a note taken in separate columns of milk supply and of water supply. If ice-cream, or shellfish, or any such possible vehicle of conveyance is under suspicion, questions in each household will extend to these articles also. Such inquiry has the indirect effect of warning people of the necessity for avoidance of all articles likely to be dangerous, and at the same time advice can be given to boil all water and milk.

Water-borne Epidemics.

As an example of water-borne enteric fever, I show you a plan of a Stirlingshire village of about 1800 inhabitants. Laurieston is built on a downward slope from south to north. The soil is very porous, consisting of open sand and gravel. Opportunity for pollution of ground water has always been



(The wells are indicated by small circles.)

abundant owing to an ancient privy ashpit system. In 1892 water from three local wells was analysed. All were bad: the water of the Cross Well in Mary's Square was found exceedingly dirty; but the common prejudice in favour of old wells existed, and the suggestion that a Special Water District should be formed,[1] and that water from a safe and distant source should be introduced, was received with the strongest opposition. The proposal had to be temporarily put aside. During 1893, however, the schoolmaster in the guise of enteric fever was astir, and his teaching proved effective. A single case occurred in March. The water used was from the Cross Well. The case was removed to hospital, and no more was heard of the disease till near the end of September, when two more cases occurred, both using the same well. Both were sent to hospital. In a few days other cases occurred, and from the beginning of November the numbers rapidly increased, so that up to the end of the year they amounted to forty-one. With the exception of one or two secondary cases, practically all were grouped round two wells, one the Cross well already referred to, and the other a private well a short distance further down the hill, both open to the same class of pollution. There was no doubt, indeed, that the drinking water was the means of spreading the disease. Usually in the actual presence of fever one has little difficulty in getting people to agree to give up drinking infected water or milk. In this case, however, it was different. The private well was easily dealt with, but when the sanitary inspector endeavoured to carry out an instruction to close the Cross Well, he assured me that a public riot was threatened. A house-to-house visitation was then made in the neighbourhood; people were individually coaxed or reasoned into discontinuing the use of the water, or boiling it before use; and placards of

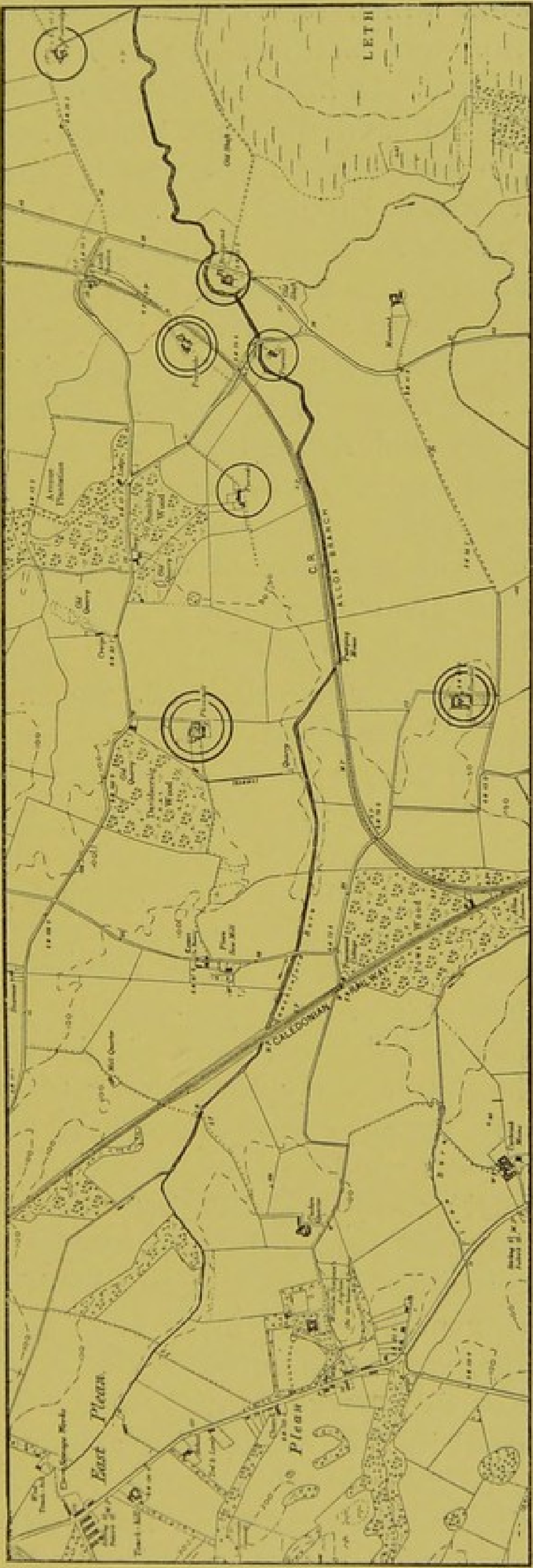
[1] A Special District under the Public Health Acts in Scotland is an area, usually a village or town or part of a town, but sometimes wholly or partly rural, set apart for any one or more of the following purposes: water supply, drainage, scavenging, and lighting. The necessary works are constructed and maintained by the sanitary authority, and the cost is met by an assessment imposed half on owners and half on occupiers within the Special District.

instructions were posted throughout the village. These means, along with the rapid increase of cases of the disease, ultimately brought the well into disuse, and the epidemic came to an end. There is a Latin proverb of which a free translation is, that he is happily wise who is wise by the experience of another, but Laurieston would not accept wisdom of this kind. The deaths were three, a lad aged twenty-one, a woman aged twenty-six, and a man aged forty-four; three useful lives needlessly lost. Then the new water supply was accepted, and the village has had no more epidemics of enteric fever.

The next plate also illustrates water-borne enteric fever.

Another Water-borne Outbreak.

East Plean is a modern mining village of 600 or 700 inhabitants. It has no water-closets, but its drainage before and during the epidemic was led into a small ditch or burn which passed into a larger streamlet called Sauchinford Burn. That burn about two miles from the village had from time immemorial been used for the water supply of about a dozen scattered farm-dwellings and cottages. Enteric fever was introduced into the village from Ireland in August, 1902. Ten cases occurred up to the end of that year. In November three cases occurred at two of the houses using Sauchinford Burn water lower down. In January, 1903, there was another case in a similar house. Then in February and March three cases occurred at East Plean, and these were followed in April by the attack of another family using the Sauchinford Burn water. In the course of 1903 cases continued to occur at East Plean, and there was another in the water-using area below. Then in April and May, 1904, there were eight cases at East Plean, and this was followed in June by the attack of a family in the Sauchinford area. Next, for a year from July, 1904, the disease practically disappeared from East Plean, there being only a single case in twelve months. At this time the disease also disappeared from the houses using the burn water. In July, 1905, however, the disease returned to East Plean, and, following this, infection reappeared lower down.



Places where Sauchinford Burn water was used and where enteric fever followed.

Places where Sauchinford Burn water was not used and where there was no consequent enteric fever.

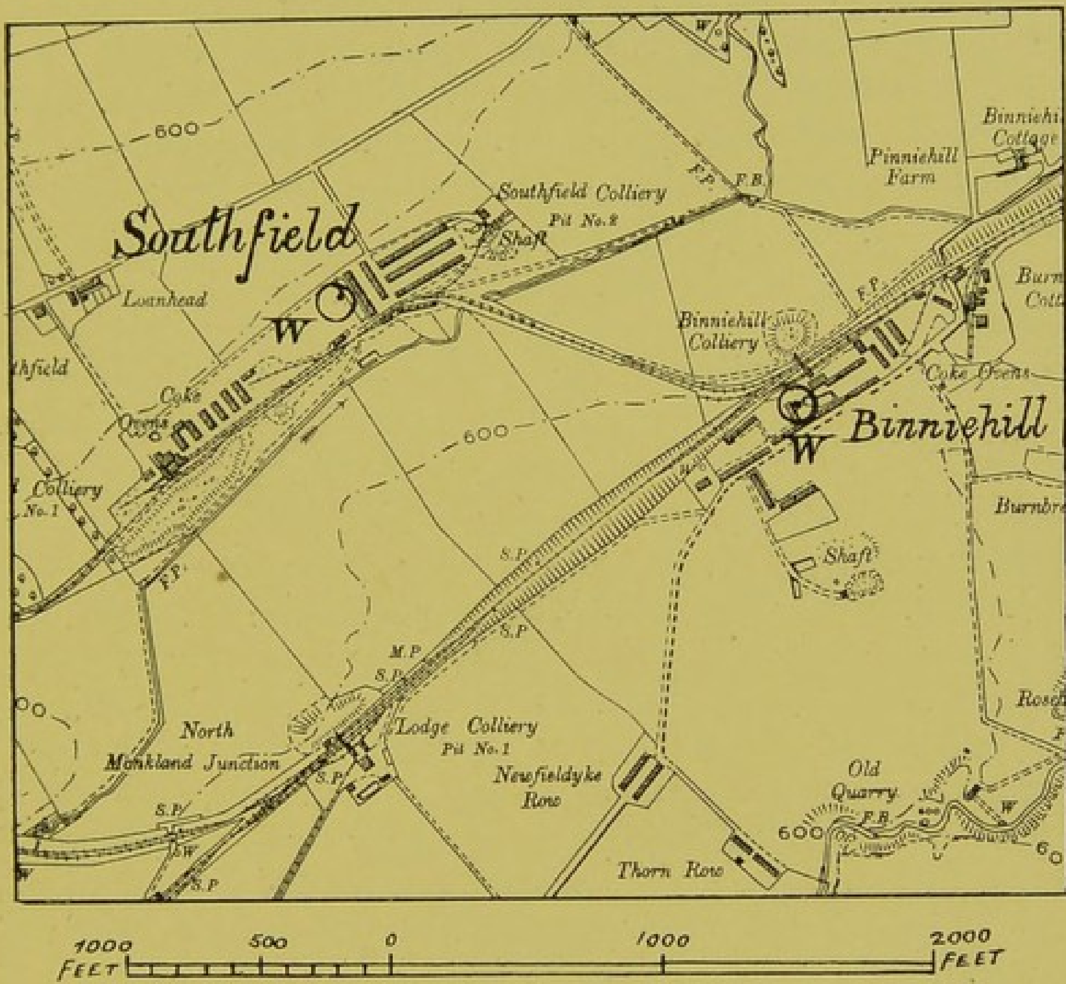
The ditch or burn which received the sewage is very small, and pollution was manifest at the point where it joins Sauchinford Burn. In it, however, the water quickly clears in appearance, and as the burn has a clean sandy and shingly bottom and a good gradient, by the time it comes within the water supply area lower down it is usually quite attractive-looking. Pending arrangements for thorough sewage treatment and for other water supply, the users of the burn water were warned to discontinue it, or at least to boil it. Where this advice was followed, the houses remained free from enteric fever, as in the case of a farm which resorted to another source of supply. Bacteriological examination of the water supply revealed the presence of the bacillus coli communis, but not of the bacillus typhosus. The difficulty of finding typhosus in such circumstances is greater than that of finding a needle, not in a haystack, but in a hayfield.

A Third Water Epidemic.

Southfield, which is now uninhabited, was a colliery village of less that 300 inhabitants. Its water was derived from working levels in the mine which gave employment to the inhabitants. The water was pumped up into an open pond, and was understood to be filtered before passing into another pond. The filtration, however, was farcical. Labourers occasionally washed soiled clothing in the pond. The water was found to contain excessive chlorine and excessive saline and albuminoid ammonia. Enteric fever broke out in the village owing to pollution of the water supply by an unrecognised case of enteric fever among the miners employed in the pit. Use of the water was immediately prohibited, but the disease had had time to secure a foothold before the first notification was received, and fifteen cases occurred at Southfield. Some of the people then went for water to an open dip-well in another colliery village a few hundred yards distant. The next step was that this supply thus became infected; twenty cases occurred in this village also among persons using the water; the disease spread into other adjoining hamlets, and in the end there were no less than eightynine cases, though many of these were probably secondary.

Nevertheless, it is not always so easy to trace the cause of enteric fever as in the examples which I have related.

Last year (1905) there was a very puzzling outbreak in



W = Well.

Dunbartonshire. The table of cases is given at page 59, and is repeated at page 88 for convenience. The total population of the affected locality—Radnor Park—as ascertained by a census taken in connection with the outbreak, was 1676, and the total number of houses was 340. The place has a high and airy situation, and consists mainly of three parallel streets of two-storey tenements, of which some have attics, in addition to about thirty cottages to the west and south.

An Unexplained Outbreak.

There were intervals of from six to twenty days between the beginning of illness and its notification. It will be observed, however, that removal to hospital was effected in almost every case on the day of notification. One or two cases were delayed owing to the desire of relatives to have the patient treated at home. Full enquiry was made as to the milk supply, a milk census of the population being taken and investigation being made as to its principal sources. Without entering into detail, it is sufficient to say that milk as a vehicle of the disease was definitely excluded. The water used was common to a population approaching 40,000, and enteric fever did not

ENTERIC FEVER, RADNOR PARK, 1905.

No.	Initials.	Residence.	Age in Years.	Sex.	Dates of Sickening.	Doctor's first visit.	Notification Received.	Removal to Hospital.
1	W. F.	8 Baronial Ter. -	14	F.	Jan. 18	Jan. 30	Feb. 1	Feb. 1
2	G. C.	18 ,, -	13	F.	,, 26	Feb. 1	,, 3	,, 4
3	M. C.	15 ,, -	28	F.	,, 26	,, 4	,, 4	,, 4
4	C. P.	Hawthornbank -	29	F.	,, 31	,, 9	,, 17	,, 17
5	D. M.	Janetta Cottages -	55	M.	Feb. 4	,, 11	,, 17	At home
6	A. T.	8 Baronial Ter. -	4	F.	,, 9	,, 11	,, 17	Feb. 17
7	T. S.	Clydeview Cottages	11	M.	,, 7	,, 12	,, 17	,, 18
8	T. M.	10 Baronial Ter. -	6	M.	Jan. 31	,, 14	,, 20	,, 20
9	J. P.	Hawthornbank -	30	M.	Feb. 17	,, 17	,, 23	,, 23
10	J. B.	Clydeview Cottages	26	M.	,, 13	,, 14	,, 23	At home
11	J. B.	18 Churchill Pl. -	7	M.	,, 15	,, 17	,, 25	Mar. 1
12	E. P.	Clydeview Cottages	7	F.	,, 9	,, 11	,, 28	,, 1
13	J. R.	16 Baronial Ter. -	7	M.	,, 26	,, 28	Mar. 3	,, 3
14	M. C.	18 ,, -	9	F.	,, 28	Mar. 1	,, 4	,, 4
15	M. C.	23 Grove Place -	12	F.	,, 25	,, 1	,, 6	,, 7
16	R. D.	Stewart Cottage -	10	M.	,, 26	,, 1	,, 7	,, 7
17	J. N.	4 Gladstone Ter. -	12	M.	Mar. 5	,, 8	,, 11	,, 11
18	A. S.	15 Baronial Ter. -	13	F.	Feb. 20	,, 7	,, 13	,, 13
19	A. M'D.	5 Gladstone Ter. -	6	M.	Mar. 6	,, 10	,, 15	,, 15
20	W. B.	20 Baronial Ter. -	5	M.	,, 8	,, 13	,, 16	,, 16

prevail elsewhere than in the village. But it was found that owing to the small size of a branch main pipe the dwellings in the upper flats of the tenement buildings had only an intermittent supply. Wherever underground pipes are frequently empty there is risk of soil pollution finding entrance into them if the pipes are not tight at the joints, or are otherwise defective. This may occur even when the pipes are full, material from the outside obtaining access by lateral insuction. It was impossible, however, to prove that spread of the fever was due to any such cause, though as a result of the enquiry a larger branch main was laid to convey water to the village. Radnor Park was built before county council government began in Scotland, and its drainage system was old. The disease began in the northern part of one of the streets, and that area throughout had a large proportion of the cases. The sewer here was unventilated; at the termination of the system there were no means whatever for the escape of sewer gases. Lower down, a house drain had been choked, and the material had come out on the footpath, but the main street sewer appeared never to have been obstructed. The drainage defects were also remedied, and the outbreak quickly came to an end. Its cause was not milk nor shellfish nor any article of food. Neither was it due to accumulation of infected refuse in the village, for all the houses have water-closets, and there are no ashpits, refuse being removed daily by scavengers employed by the sanitary authority. Flies, therefore, had no opportunity of spreading infection from privies. In recent years the old fear of bad drains as a cause of enteric fever has largely disappeared as a result of bacteriological discovery that sewer gases are free from pathogenic organisms. That being so, one seldom thinks of drains nowadays in the course of such enquiries, but the least unlikely hypothesis I can suggest as to the cause of this outbreak is that defective drainage had resulted in soil pollution, and that the intermittent water supply became infected by the polluted soil.

Fluorescin.

Both in America and in Britain colour tests are sometimes used to ascertain whether water supply can be contaminated by sewage. This method was employed in an outbreak of enteric fever last year (1905) at a lunatic asylum near Cambridge. The whole of the hill on which Fulbourn Asylum stands is composed of chalk of various sorts, marly in the upper layers, which themselves are covered by a compact sandy chalk. The strata are so placed that there is an enormous underground lake of water, which is pumped to supply the town and University of Cambridge, some adjoining villages, and Fulbourn Asylum. The asylum sewage is treated by broad irrigation on land which covers the chalk, and as fissures exist at some distance below the surface, the possibility of contamination of the water supply was pointed out several years ago by the Local Government Board. In 1905 a serious outbreak of enteric fever occurred at the asylum. To test whether the asylum sewage could reach the water supply, use was made of fluorescin, an aniline substance which even in an extraordinarily weak solution is capable of imparting a distinct green tint to water. An alkaline solution of fluorescin is perfectly obvious in a dilution of one in ten million parts, and is still appreciable in a dilution of one in a hundred million parts of water. The ground was opened up on the sewage irrigation area near the asylum. A hole about six and a half feet deep was dug. At the bottom of this hole the chalk marl showed the beginning of fissures. Into the hole a large quantity of a solution of fluorescin was discharged, and the green colour appeared, not only in the water from the asylum well nearly adjoining, but also in water from a well at the village of Fulbourn, belonging to the Cambridge Water Company, and about 3000 feet from the hole into which the solution of fluorescin was put. It took about nine days for the green colouration to appear at that point, but at some nearer points it showed much earlier—in four hours, and in two days, and after longer intervals. Of course it is not to be assumed that enteric fever can be carried wherever such colour appears, but fluorescin can often be used in discussing possibilities.[1]

I have recently used fluorescin successfully in demonstrating that a bore-well 300 feet deep was being contaminated by surface water. To supplement the existing water supplies of a small town a bore-well had been sunk to a depth of 300 feet, at a spot where the ground had always been wet and boggy owing to the emergence of underground water. In carrying out the work of con-

[1] Medical Inspector's Report No. 229, to English Local Government Board, Dr. Copeman, 1906.

structing a chamber to hold part of the pumping machinery at the top of the bore, the sub-soil and rock near the surface appeared to have been considerably disturbed; the well-chamber, which was of cement concrete, did not fully occupy the disturbed area, and so it was alleged that surface water could find its way into the bore. Suspicion of entrance of surface and sub-soil water was supported by the fact that, after pumping had been fairly established, soft or boggy ground in the neighbourhood of the bore became dried, and shallow wells so far distant as 150 to 200 yards also became dry. But the validity of these observations was doubted. It was pointed out that the rock, which comes to within a few feet of the surface, shelves away from one side of the bore, and it was urged that water could not be sucked into the bore from that side. It was even denied that the bore water was in any way subject to surface contamination. To test the matter, I had a hole dug to a depth of about four feet, within a few feet of the well chamber. A solution of fluorescin containing twenty-five grains in five gallons of water, was rendered alkaline by a few crystals of pure carbonate of soda. (Fluorescin, it may be mentioned, does not act in an acid solution nor in a peaty soil.) The solution thus made was discharged into the excavation, and was washed freely in by bucketsful of clean water. The operation was repeated, the total quantity of fluorescin used being roughly about forty-five grains. After about an hour's pumping, a sample of the water, when looked at through a depth of one foot in a clear glass tube on a white ground, showed a faintly green tint, as contrasted with a sample of water to which no fluorescin had been added. This green tint very quickly increased in depth, so that in a quarter of an hour the change in colour was quite unmistakable. The maximum depth of colour was reached less than an hour afterwards. It was manifest, therefore, that surface water was finding its way into the bore from a point immediately to the south of the well-chamber. A similar experiment was made a few feet from the other side of the bore-chamber —the side from which the rock shelved away—and the result was similar. The pumped water quickly showed the green tint of fluorescin. I desired to make a third experiment at a point further distant from the bore, but my inspection was made in winter, when the ground water was high. Steady pumping for thirty hours was quite insufficient to make any appreciable difference in the level of the ground water, as proved by the quantity discharged from a running pipe connected with an overflowing well near the surface. The facts ascertained, however, were quite sufficient to show that the bore-well was being contaminated by surface water.

Shellfish Outbreaks of Enteric Fever—Oysters.

As regards conveyance of enteric fever by shellfish, one outbreak came under my notice several years ago, where at a county ball a large number of persons had partaken of oysters, and where some were attacked immediately by symptoms of ptomaine poisoning, whilst others developed enteric fever after a period of incubation. It is the almost invariable history of these outbreaks that they produce these two groups of phenomena. Reason now exists for suspicion that the ptomaine group may be due to dead oysters remaining mixed with the living. The most important recent illustration of oyster poisoning in England occurred near the end of 1902, and is the subject of an admirable report to the Local Government Board by Dr. Timbrell Bulstrode. On 10th November municipal banquets were held both at Winchester and at Southampton. The number of guests at Winchester was 134, and at Southampton 133. Immediately after both banquets some of the guests became ill, and a large number were affected within three or four days, the total attacks in connection with the Winchester banquet being 52, and in connection with the Southampton banquet 54. The symptoms were those of gastro-intestinal disturbance, and most of the persons attacked recovered quickly. Between two and three weeks after the banquets, ten of those who had been at Winchester, and eleven of those who had been at Southampton, developed enteric fever.

To aid enquiry into all possible sources of infection

Dr. Bulstrode adopted the simple and ingenious plan of sending to each patient a copy of the menu of the banquet, and of getting each to mark on it every article he had partaken of. The information so obtained left no doubt that, so far as food was concerned, oysters were the one and only article associated with the disease. Following up this discovery, enquiry was made as to the source of the oysters, and it was found that the supply for the two banquets had been obtained from one and the same place, namely, oyster ponds at the town of Emsworth.

Now, there had been multiple cases of enteric fever at Emsworth. The main outfall of the sewer receiving the sewage of the infected houses closely adjoined the oyster ponds. These ponds were covered at high water, and so the oysters became contaminated with specifically infected sewage. The summary of the facts as given by Dr. Bulstrode is as follows:

1. *Two* mayoral banquets occur on *the same day* in separate towns several miles apart.

2. In connection with each banquet there occurs illness of analogous nature, attacking, approximately speaking, the same percentage of guests and at corresponding intervals.

3. At both banquets not every guest partook of oysters, but all those guests who suffered enteric fever, and approximately all those who suffered other illness, did partake of oysters. The exceptions to this rule appear insignificant when all the facts are marshalled.

4. Oysters derived directly from the same source constituted the only article of food which was common to the guests attacked.

5. *Oysters from this source* were at the same time and in other places proving themselves competent causes of enteric fever.

The other places referred to in the last of these conclusions include Portsmouth. Though in the laboratory the bacillus typhosus does not live long in sewage, yet it may live long enough to infect such oyster ponds, and on bacteriological examination in December, though the bacillus typhosus was not discovered, bacteria of sewage origin were found in abundance.

Cockles.

In 1903, as reported by Drs. Chalmers and Knight, the city of Glasgow had some experience of enteric fever conveyed by shellfish. Glasgow Fair, which usually begins in the latter half of July, is observed as a universal holiday in the city, and tens of thousands of people go for a fresh-air fortnight to coast or country. After the holiday was over, twenty-five cases of enteric fever were notified from different parts of the city. These could not be accounted for by any common milk or water supply, or by any kind of association excepting this—that persons from all the infected households (with one exception, about to be noted) had visited Lochgilphead during their holiday, and had there partaken of raw cockles gathered from the foreshore, within reach of sewage from the houses of the village. Lochgilphead is situated on Loch Fyne, one of the numerous estuaries on the broken coast line of the West of Scotland. Certain other cases of enteric fever which occurred in burghs contiguous to Glasgow had a similar factor in common. Of the twenty-five Glasgow cases, eighteen were primary and seven secondary. The secondary cases occurred, with one exception, in a single family, and in this family it happened that the people themselves had not gone to Lochgilphead, but that a Glasgow visitor to Lochgilphead had presented the family living in Glasgow with a quantity of cockles. The shellfish had been brought to Glasgow on 25th July, but they directly infected only one member of the household, the mother, who sickened on 12th August. On 22nd August two of her children sickened; on 23rd two children and the father; and the remaining child, who had been taken to the municipal reception house, sickened on 2nd September. The incubation period among the users of shellfish who were attacked ranged from seven to twenty-two days. Two of the victims had been at Lochgilphead for a considerable time before the holidays, but it turned out that neither had eaten any shellfish until friends came from Glasgow during the Fair. In one family, in which only a single member was attacked, he was the only member who had partaken of shellfish. Most of the attacks were in adults. Enquiry as to immediate bad effects elicited that among those who subsequently developed enteric fever only three had been affected by vomiting or diarrhœa as a direct result of eating shellfish. On the other hand, it was found that many persons who partook of shellfish had suffered from gastro-intestinal irritation, and Dr. Knight, who reported on the subject to the Local Government Board, suggests that very likely the diarrhœa and vomiting so induced may have got rid of the specific infection of the disease, and so may have saved attack by enteric fever. But in such outbreaks some individuals are unfortunate enough to have ptomaine poisoning first and enteric fever subsequently.

In the county of Dunbarton there are various coast holiday resorts where shellfish are habitually gathered by visitors, and the following public notice is placarded in the localities to give warning of the risk:

COUNTY COUNCIL OF DUNBARTON.

WESTERN DISTRICT COMMITTEE.

POISONOUS SHELLFISH.

The Local Authority desire to warn the public of the danger attaching to the eating of shellfish—mussels, "whelks," cockles—gathered from any part of the foreshore near the openings of sewers or drains. Such shellfish may cause blood-poisoning or enteric fever. None should be gathered excepting from clean ground, distant from all sources of pollution, and even then it is a wise precaution not to eat them raw, but to boil before use.

By Order.

Water-cress.

Another article of diet which has lately come under suspicion as a possible vehicle for the conveyance of enteric fever is water-cress, when grown in places liable to pollution by sewage. The evidence on the subject which has been collected by Dr. Hamer, assistant medical officer to the London County

Council, does not amount to proof, but it certainly gives ground for avoiding sewage-polluted areas for water-cress cultivation.

Personal Infection.

Whatever be the origin of an outbreak, personal infection has to be kept in mind as a means of spreading the disease. This has been particularly observed in military encampments, as in the United States volunteer camps during the Philippine War, and in the South African War. Soldiers are usually men of susceptible age, and they live and sleep in tents of small cubic capacity, so that conveyance by contact is greatly favoured. In some of the volunteer camps of the United States army the disease became very prevalent, even where the water supply was originally beyond suspicion, or was soon made safe. Of more than a thousand specifically investigated cases, nearly two-thirds were attributed to personal infection. In some camps the men living nearest the latrines were no more affected than those further away, so that air-borne or fly-borne infection did not explain all the facts; yet these agencies may safely be assumed to have had their share in spreading infection, especially as flies abounded, and pollution of the soil by urine would not be confined to the immediate area of the latrines, unless sanitary supervision were very thorough.

The above are all the instances that I wish to adduce of the methods by which enteric fever may be spread. The fact that epidemics can be traced to such causes as I have indicated, and can be controlled by removal of these causes, helps to explain the great reduction which has taken place in the prevalence of the disease in Britain, and serves also to indicate how further progress on the same lines will still further diminish enteric fever. Discussion of its prevention opens up for consideration almost every branch of sanitary work, including water supply; water filtration, both for municipal and domestic purposes; drainage, sewerage, and sewage disposal; scavenging and disposal of refuse; milk supply, the management of dairies, and the sterilisation of milk; the trade in shellfish and in ice-cream; and disinfection of houses and of household articles. It is impossible in a course of ten lectures to enter on all these subjects.

APPENDIX.

(See p. 61 ante.)

PRECAUTIONS TO BE USED FOR PREVENTING THE SPREAD OF ENTERIC FEVER.

This disease is also known by the names of Typhoid and Gastric Fever. Its poison is contained almost entirely in the contents of the bowel, and it is usually spread by the drinking or eating of some article which has become infected from this source. The discharges from the mouth are also infectious.

In Enteric Fever, therefore, there is less risk than in most other such maladies of infection through the atmosphere, as by inhaling the air of the sick room. But even here, if the room be not well ventilated, minute particles of the poison may float in the air and find their way into the body of the attendants. Ventilation is best accomplished by keeping a bright fire burning, and by leaving the window a little way open at the top.

Mainly, however, the measures on which safety depends have to do with the discharges from the patient's bowels. These should be received into a vessel containing a sufficient quantity—a wine-glassful —of a strong disinfectant, as crude carbolic acid, or Jeyes' Fluid.* Another wine-glassful should be poured on the contents, and being thoroughly mixed, and having stood for an hour, the whole should be emptied down the water-closet or buried, not in the ashpit, but in the garden or in a field. In burying, it is essential to take care that the place is not near any well or stream used for water supply.

The bowels in Enteric Fever are usually loose. This indicates how readily the poison may spread. Bed clothes and body clothes, or the patient's hands, or the hands of the nurse, or the food vessels handled by the patient, may all be vehicles for its conveyance. Hence the greatest care must be observed in regard to all these matters. Soiled clothing must be put to steep in a tub of water containing a wine-glassful of crude carbolic acid, or Jeyes' Fluid, for an hour at least, immediately after being taken from the bed or

* A 2 per cent. solution of corrosive sublimate, dissolved in water by the aid of ammonium chloride, is an admirable disinfectant. This solution is colourless and ordourless, and being also poisonous, great care must be used not to mistake it for water. It is to be noted that carbolic acid is also poisonous, and should be kept in a distinctive bottle, and in a place where it cannot be readily mistaken for anything else.

the patient, and before being washed. The washing should not be done in a common washing-house, but in a tub in the open air. The patient's body should be kept as clean as the nature of the case will allow. Separate cups, spoons, towels, etc., should be reserved for the patient's use alone, and should be washed in the sick room, the washings being disinfected before removal. Instead of pocket handkerchiefs, rags should be used, to be afterwards burned. The nurse's hands should be kept very clean, and be washed with disinfectant soap or in a disinfectant solution,* after attending to the patient, and invariably before taking food. The finger nails should be kept short and scrupulously clean.

The patient should be placed in a room by himself or herself—never in the kitchen—and on no account should any one lie down in the same bed. No food, and especially no milk, should be stored in the sick room. All carpets, curtains, stuffed chairs, cushions, sofas, and every unnecessary piece of furniture should be removed from the room. Iron bedsteads, hair, or still better, straw mattresses and kitchen chairs, in short, all articles which will not easily take in infection, and which can be easily disinfected, are to be preferred.

The disease is very easily conveyed by either milk or water. Occurring in connection with a dairy there is great danger of its spread. No one living in a house where the fever exists should milk cows, or take anything to do with dairy work. No can or other vessel which has stood in the infected house should be dipped into any well or other source of domestic water supply.

It may also be readily carried by house flies which have been in contact with infective discharges. Where flies exist, fly papers or other means of destroying them should be freely used.

In case of death the body should be interred with the least possible delay.

* Corrosive sublimate, of strength 1 in 1000, is good for this purpose.

LECTURE V

THE PREVENTION OF PLAGUE

PLAGUE being an infectious disease which has recently visited both San Francisco and Glasgow, and which is of much interest to all centres of oversea trade and commerce, I am asked to devote a lecture to it, and I willingly comply.

The Rat-flea Hypothesis.

Shortly after these lectures were delivered, there was published (in the *Journal of Hygiene* for September, 1906) the first part of the report of an invaluable investigation of the rat-flea hypothesis of plague infection, which has been so much debated since recrudescence of the disease has enabled it to be submitted to modern methods of research. Also, in the October issue of the same journal, the views deducible from the plague epidemics of Sydney are well stated by Dr. Ashburton Thompson. It will facilitate an understanding of the whole subject if I attempt a very brief indication of the conclusions which are being approached. The investigation referred to has been under the charge of an advisory committee appointed in January, 1905, by the Secretary of State for India. The committee is jointly representative of the Medical Board of the India Office, the Royal Society, and the Lister Institute. It selected a working commission to conduct the necessary researches. The reports begin by an introductory synopsis of the work of previous enquirers —Simond, Liston, Tidswell, and others—and then proceed to give an account of the Commission's own work.

Plague is to be regarded as primarily a rat disease which may attack man; an epizootic which may become an epidemic. Rats may be infected by eating the bodies of other rats which have died of the disease; but much more usually the infection is conveyed from rat to rat by fleas, and rats do not infect each other by contact in the absence of fleas. The bacillus pestis may be found in the stomach of fleas which have fed on plague-infected rats and mice. The bacillus is not destroyed but flourishes in the flea's gastric juice. An extract of crushed fleas from plague-rats injected into mice has sometimes caused plague, though many other attempts have yielded a negative result. A healthy rat, placed in a cage near, but not in contact with, a dying plague-rat infested with fleas, will often be infected. The proboscis of the flea is not so likely to inoculate the disease as the excreta, which, it has been observed, are discharged on the skin of the host whilst the flea is sucking, and may readily enter at the little wound. But Hankin (*Journal of Hygiene,* January, 1905) suggests that the plague bacillus sets up disease in the flea itself, and that only then does the flea infect man. Fleas desert a dead rat, and will then resort to live rats, or even to guinea pigs, which are customarily flealess, and will infect them with plague. Guinea pigs in certain plague-infected houses attracted many rat-fleas, and 29 per cent. of these guinea pigs took plague and died of it, the bubo in most of them being cervical. Monkeys may be attacked in the same way. But a monkey which was surrounded by an area of 'tangle foot,' a sticky, resinous preparation used in India for fly-catching, escaped infection in circumstances in which another monkey not so protected was attacked. Fleas were caught on the unprotected monkey, but were found stuck in the 'tangle foot' surrounding the other. It appears that a radius of about six inches of 'tangle foot' was enough to protect the rat, and it is surprising to know that the jumping distance of the flea is so short. Contact with earth is not necessary for infection in such experiments with rats, and aerial infection is excluded. The epizootic does not spread in the absence of fleas, and young rats suckling a plague-infected mother remain free from the disease if fleas are absent.

Rats have various flea parasites, of which some will attack man and others will not. In India the Pulex pallidus, or Pulex cheopis is the commonest rat-flea, and readily bites human beings after it deserts the dead body of its natural host. Liston relates an experience in Bombay which illustrates this. Four or five days after numerous rats had died of plague in a 'chawl' (see p. 102) fleas became so troublesome that the people resorted to sleeping out on the verandah. Two of them took plague. Subsequently thirty fleas taken from the bodies of the inmates were examined, and fourteen of the thirty were found to be Pulex pallidus. A control experiment was made by examining 246 fleas on body clothing under ordinary conditions, and only a single specimen of Pulex pallidus was found. The flea found in the Sydney plague epidemics appears also to be the Pulex cheopis or pallidus, and the same rat-flea is common in Italy, where likewise it bites man. In different countries different names have been given to it, and Rothschild, who has made a special study of the subject,[1] has concluded that the insects designated P. murinus and P. philippinensis are identical with P. cheopis or pallidus. In wire-cage experiments, a rat being exposed to infection by fleas, but not by contact, where Pulex cheopis was the parasite employed, twenty-one experiments were successful in a total of thirty-eight. Pulex cheopis is the commonest rat-flea, excepting in Northern and Central Europe. In Britain the ordinary rat-flea is Ceratophyllus fasciatus, and the flea usually found on man is Pulex irritans. The rat-fleas of Northern and Central America have not yet been examined by the Commission.

The bearing of these data on the natural history of plague is obviously of the first importance.

Like typhus, plague has usually been associated with

[1] The Hon. N. Charles Rothschild, in the *Journal of Hygiene*, September, 1906, pp. 483 *et seq.*

dark, dirty, ill-ventilated and overcrowded dwellings. The wynds and closes of Glasgow as they existed a century ago have their parallel in the chawls of Bombay—buildings a hundred feet deep, five or six stories high, and with only a few feet of space between the eaves. Absence of sunlight and of fresh air and a superabounding presence of filth belong to both. So in San Francisco, overcrowded Chinatown was the breeding-ground of the disease. And rats must find a suitable home in such surroundings. The resemblance between plague and typhus is perhaps carried a little further by a fact to which Professor Matthew Hay, of Aberdeen, has recently called attention, and which is mentioned in the lecture on typhus, p. 47. In an outbreak of typhus in that city, the houses where the disease occurred were invariably infested with fleas, and where, as in the hospital, fleas were absent, typhus did not spread. But typhus is not nearly so persistent an infection as plague. It does not affect rats, nor any such animals. In addition to rats, numerous other animals, such as cats, dogs, domestic fowls, pigs, goats, sheep, oxen, and squirrels may be attacked by plague. In Sydney, during the outbreak of 1902, six species of animals in the Zoological Gardens were affected.

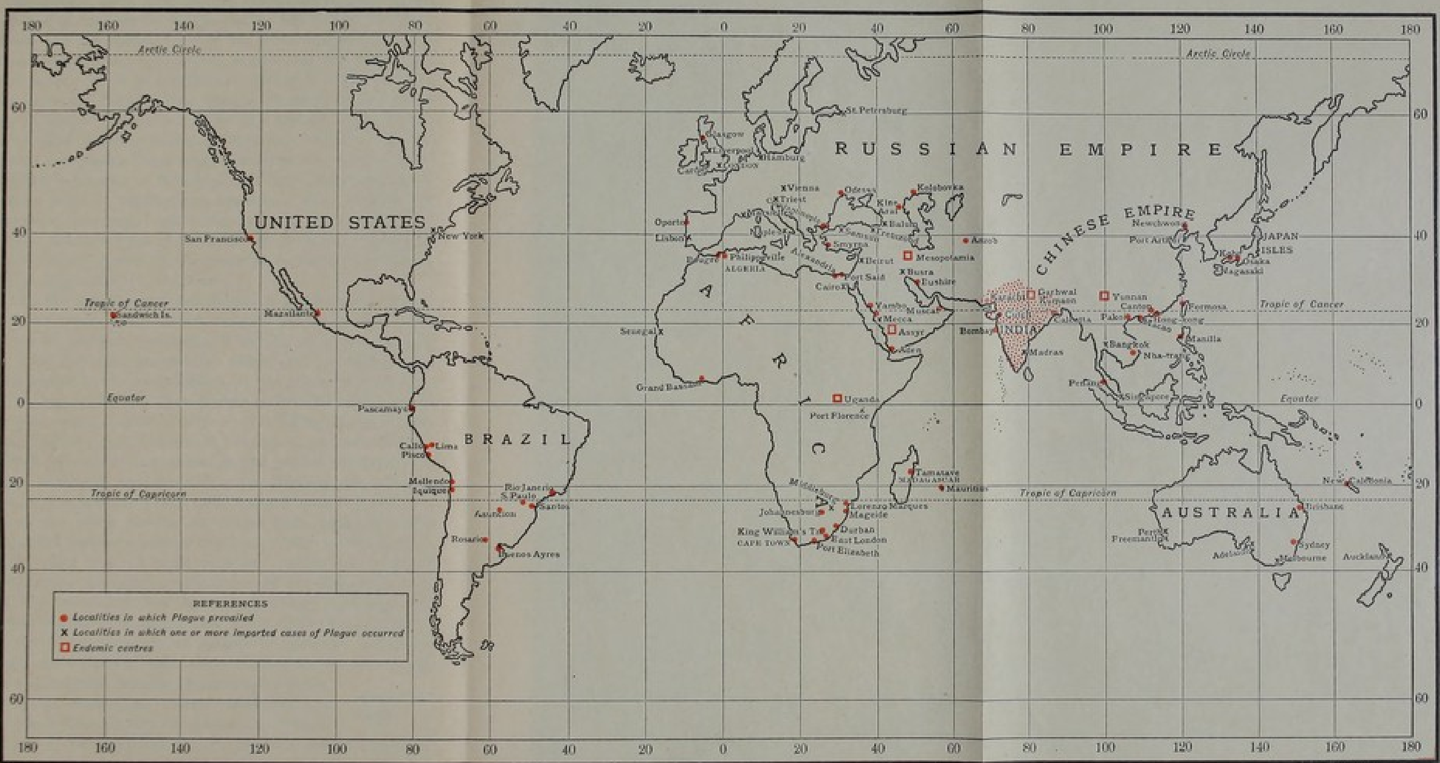
Plague and Typhus.

The recrudescence of plague in modern times is one of the most wonderful facts in the history of epidemiology. For the long period of more than two centuries, though the disease had lingered in certain endemic centres, it was unknown in countries which had formerly suffered from terrible epidemics. But within the last decade it has appeared in every quarter of the globe, as is seen in the accompanying plague map.[1]

Modern Recrudescence of Plague.

Simpson, whose admirable treatise on plague, published by the Cambridge University Press in 1905, is an invaluable storehouse of fact and suggestion on every aspect of the subject, states that the endemic areas as now known are chiefly notable for their high altitudes,

[1] Taken, by permission, from Prof. Simpson's treatise on Plague.



Facing page 102.

for the poverty and filth of the inhabitants, and for the promiscuous manner in which cattle, fowls, and domestic animals are permitted to live in close association with human beings, the former often occupying the same room as the latter. It is in conditions similar to these existing in its endemic centres that plague is most to be feared when it makes excursions from its natural strongholds. One of these endemic areas is Garhwal, and the German Plague Commission have suggested that the present long-continued epidemic in Bombay may have been originally due to a band of fakirs from Garhwal, who, though not themselves infected, were capable of conveying the disease. Hankin even shows some grounds for supposing that the 'black death' of the fourteenth century in Europe perhaps originated in Garhwal.

When the disease invaded Bombay in 1896, and began to prevail there, little doubt existed in the public mind that, under modern methods, it would soon be stamped out. The fact has proved far otherwise. Finding conditions suited to its propagation, it has recurred year after year; it has spread all over India, and it has been carried thence to many parts of the world—Hong-Kong, Cape Town, Sydney, San Francisco, Glasgow, and elsewhere.

It will be noted that some of the places attacked are modern civilised communities. In Sydney the disease persisted for several years, and caused many deaths, in spite of the town having an active and competent and well-guided sanitary administration, whilst in Glasgow it speedily died out. I shall indicate, before the close of this lecture, a probable explanation of the difference. In India the mortality has been tremendous, so that the reported deaths in a single year have reached a million.

Portents of Plague.

In the older accounts of plague in Europe, which so recently as a decade ago were looked on as of merely historical interest, various remarkable cosmic or telluric conditions were described as having been forerunners of epidemics. These were apt to be regarded by the modern reader as either fabulous or accidental, and as having no kind of relationship to the disease. Floods or droughts, excessive cold or excessive heat, famine, earthquakes, and volcanoes, are among the phenomena set down in old records. It is a curious fact that, as Simpson observes, more or less similar notes can be made concerning conditions precedent to recent epidemics. In Bombay there was an abnormally high temperature and high rainfall, so that the soil became sewage flooded, and the unventilated grain stores under the houses, which are so common in Bombay, were soaked with moisture. In the surrounding country there were famines which resulted in crowds of destitute persons being driven into Bombay. In Cape Town before the disease appeared in 1901 there had been a period of war and anxiety and scarcity, and the weather conditions had been very unusual. In Hong-Kong before the epidemic of 1894 there had been various extraordinary phenomena, such as excessive cold, and several visitations of caterpillars, which, accompanied as they were by an eclipse of the sun, led the Chinese to predict an epidemic of some kind. Though such occurrences are manifestly not in the nature of definite causes, yet on consideration it will be apparent that they may after all have some effect in favouring the spread of plague. War, famine, exposure to severities of climate, mental shock, depression of spirits, superstitious fears, and all such conditions, will tend to lower the general vitality, and to make a population susceptible to infection. Soil pollution by floods, as at Bombay, and unusual meteorological conditions, may favour the growth and multiplication of the bacillus of the disease, and may influence the prevalence of plague both in rats and in human beings. Putrefaction of dead bodies is another cause which has often been regarded as related to epidemic plague, and it is easy to see that by affecting soil and air, or by affording food for rats, exposed or imperfectly buried or crowded dead bodies might pave the way for spread of infection.

Regarding the prevention of plague invasion in olden times, some places adopted measures which would not be permissible in the present day. The city of Aberdeen was nothing if not thorough in this matter. As recorded by Dr. Creighton,[1] the townsmen, in 1585, followed the Draconian example of Good Queen Bess at Windsor some twenty years before. They erected three gibbets, 'ane at the mercat cross, ane other at the Brig of Dee, and the third at the haven mouth, that in case ony infectit person arrive or repair by sea or land to this burgh, or in case ony indweller of this burgh receive, house, or harbour, or give meat or drink to the infectit person or persons, the man be hangit, and the woman drownit.'

Old Measures of Prevention.

Other means used long ago, and also recently in Indian villages, consist in the total evacuation of infected areas and the camping out of the inhabitants. There is no doubt that the balance of advantage has been on the right side in such measures. Though exposure and privation may lower vitality, the removal from a rat-infested and polluted area and from foul houses to a clean soil and fresh country air must do much to check infection, which, however, might still be fostered if, as would usually be the case where the disease had already obtained a strong hold, the population so moving contained many persons in whom plague was already incubating. The too early return of villagers to their houses after such camping out has been followed by a new outburst of the disease, and such a renewal is easily explained by the persistence in the temporarily deserted village of an epizootic amongst rats. Of course, removal of a whole community to a health camp is not at all the same thing as the terror-stricken rush of inhabitants of an infected area into the heart of other communities, where they introduce and serve to establish the infection.

Very different, Dr. Creighton points out, was the course pursued at the village of Eyam, in Derbyshire, in 1666. It had a population of about 350. Plague was introduced in September by a parcel of infected clothing from London, which was then

Eyam.

[1] *A History of Epidemics in Great Britain*, Charles Creighton, Cambridge University Press, 1891.

recovering from the last of its great visitations. The disease spread gradually, sometimes intermitting for a little, and then recurring. The church rector, Mompesson, a young married man, urged the people not to flee and spread the disease throughout the land, but to confine themselves to the village. They obeyed him. A border-line was fixed, beyond which no one passed out, nor did anyone come in. Food was brought to the village and laid down at the border-line. The epidemic continued for fully a year, and in the end only about thirty of the inhabitants were left alive, including the rector himself, though his wife died. It was a case of wonderful individual and communal heroism. In protecting the country around from plague, such isolation was bound to be very largely successful, but had a camp been established, and had the whole village temporarily shifted its quarters, there might have been no such terrible death-toll. They did their best according to their lights, and the story of their self-sacrifice will be read for centuries to come.

Early Recognition of Plague.

In the control of plague one preliminary danger has been common, alike to ancient and modern times—the danger of failure to recognise or to acknowledge the nature of the malady. At first, plague cases are usually very mild, and are readily confused with other cases of illness, especially where the disease has been previously unknown, and where medical men have had no chance of ever seeing it. The records of the Marseilles epidemic of 1720 are an example of this hesitation to acknowledge the existence of plague. The disease was introduced by a ship arriving on 25th May, and death after death occurred, but the 'marks' (of which so much is said in old times) could never be found, and even on 7th July it is recorded regarding two cases, 'the Surgeon finds tumours in their Groyns, and says in his Report that he does not believe however it is the Plague.' Writing after the event, the record goes on—'He pays for his incredulity perhaps for not right understanding the Distemper, by dying himself soon after, with part of his Family.'

In modern times there is a curious tendency to resist the conclusion that plague exists in a town. Especially in a seaport, fear of the consequences to trade and commerce is so great that people will hope against hope that after all the disease is something else than plague. But it is very difficult to take precautions against an infection whose existence is denied, and it is a matter of public duty to warn the world about every outbreak. The penalty for giving information is not nearly so great as formerly. Present-day international regulations, as we shall see, are very reasonable, and do not unduly hamper commerce.

The early recognition of plague is made immensely easier by bacteriology.

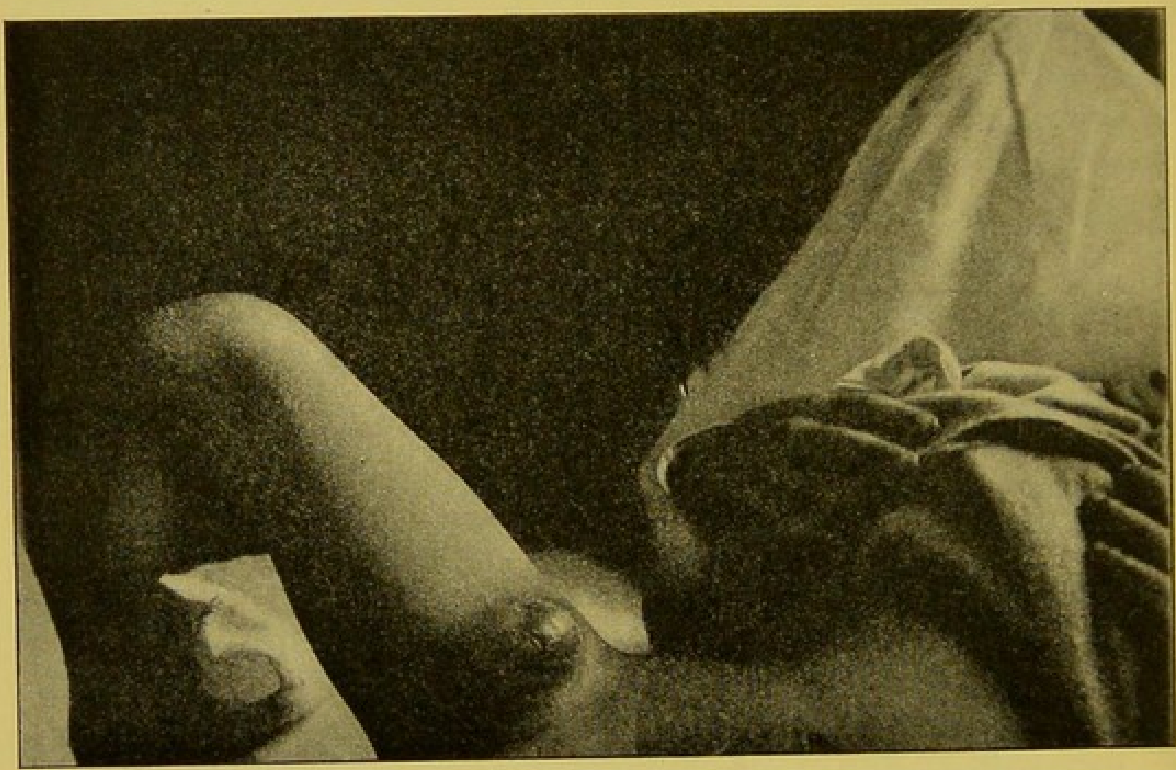
Bacteriology.

The bacillus was discovered by Kitasato and Yersin in 1894. It is always to be found in those tissues where the morbid process manifests itself—in the glands in bubonic cases, in the lungs in pneumonic cases, and in the blood, the glands, and the spleen in septicaemic cases. The most frequent and characteristic localisation of the morbid process is in the rapid swelling of a gland or group of glands in one or more regions of the body—most commonly the inguinal. This swelling is usually associated with much oedema and haemorrhage, and haemorrhagic and necrotic foci may be met with in the parenchymatous organs.

The bacillus is a non-sporing, short, plump rod with rounded ends and slightly bulging sides, staining more deeply at the ends than in the middle. Growth readily takes place at room temperature, and is best between 77° F. and 86° F. A neutral or slightly alkaline medium possessed of a proper degree of moisture is essential. The colonies are very characteristic on agar. Gelatine is not liquefied, and growth in milk and on potato is slow and not characteristic. Very notable features are the development of the bacillus in long chains of ten to twelve elements in broth cultures, and the formation of large, bloated, deeply-staining 'involution forms' on dry agar, or on agar containing three per cent. of common salt.

The organism is non-motile, and does not stain by Gram's method. The accompanying plates are from a paper by Dr. R. M. Buchanan, and are reproduced by kind permission from the *Transactions* of the Royal Philosophical Society of Glasgow.

In the blood of plague-rats the bacillus exists in millions. It is found in small numbers in their urine in a minority of cases, but the faeces seem almost harmless.

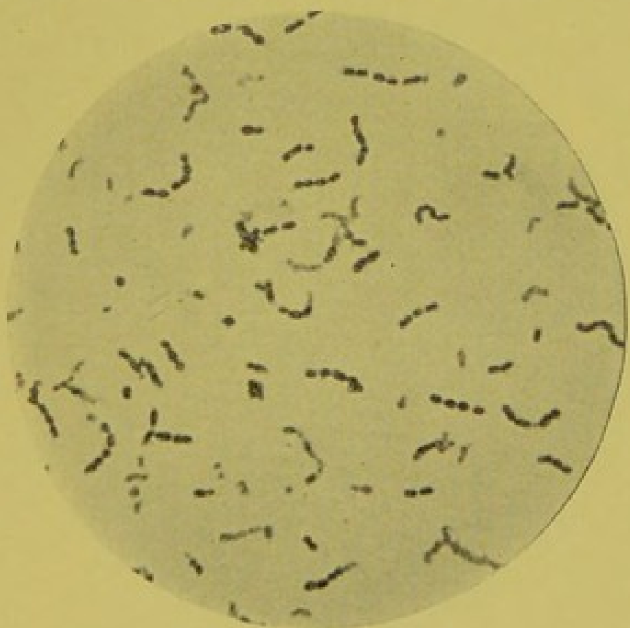


PLAGUE—GLASGOW OUTBREAK.
(Medical Officer's Report.)
Dennis T., æt. 6 (Case No. 6). Right inguinal bubo; enlargement limited to the vertical set of glands; surface skin necrosed and bubo about to rupture. Rupture took place on sixteenth day; discharge sterile.

The resistance of the bacillus outside the body is very variable according to circumstances. In pure cultures, protected from the light and from drying, it lives for years. In the Glasgow Public Health Laboratory the original cultures made by Dr. Buchanan from patients in 1900 were capable for over three years of giving rise to fresh sub-cultures. In various media, such as fresh water, sea water, milk, and fruits, the bacillus is capable of maintaining life for considerable periods, which depend upon the number of saprophytic bacteria present and upon the temperature. The higher the temperature and the greater

BACILLUS PESTIS.
Culture on agar after twenty-four hours. (Carbol-fuchsin.) × 1000. (Buchanan.)

the number of saprophytes, the shorter is its life. In sputum it has been found alive after ten days. It resists

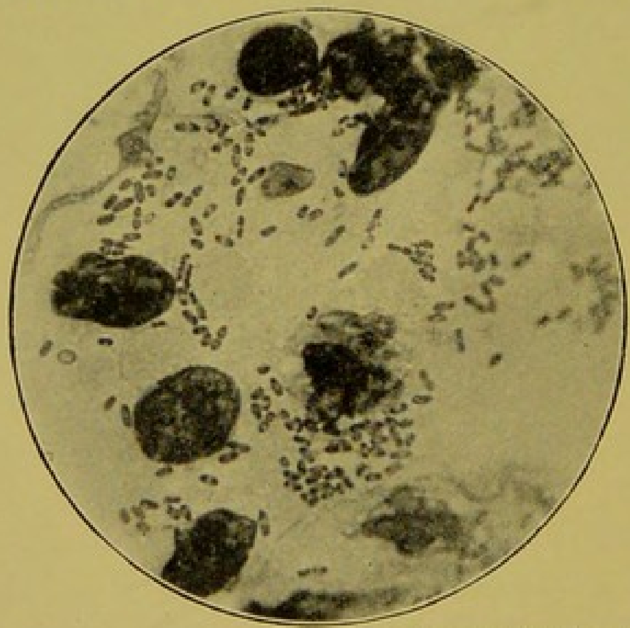


BACILLUS PESTIS IN CHAINS.
Culture in bouillon after four days. (Carbol-fuchsin.) × 1000. (Buchanan.)

cold, but is killed by a temperature of 145° F. or 150° F. in ten minutes. Desiccation is also fatal to the bacillus, but the destructive power of desiccation is greatly influenced by the temperature at which it takes place. Outside the body the bacillus gradually loses its virulence.

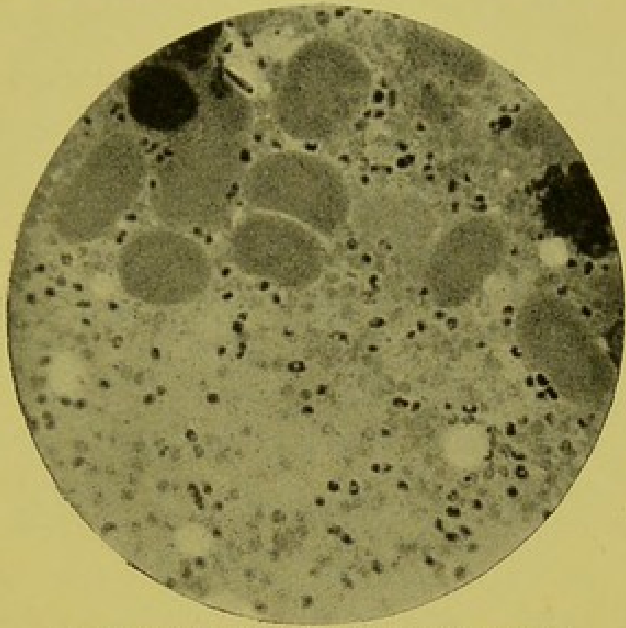
BACILLUS PESTIS.
Involution from a six weeks' old culture on ordinary agar.
(Carbol-fuchsin.) × 1000. (Buchanan.)

The plague-infected cow-dung floors of Indian chawls remained infective for forty-eight hours, if tested by rubbing



BACILLUS PESTIS FROM SPLEEN OF INFECTED MOUSE.
Showing the bacillus in very typical form and in active proliferation.
(Carbol-fuchsin.) × 1000. (Buchanan.)

scrapings into susceptible animals. In warm climates, as in Bombay, the bacillus is killed by direct sunlight, but this statement only applies to bacilli on the surface of the ground. The sunlight of temperate zones has much



BACILLUS PESTIS FROM INGUINAL BUBO.
Shows the bacillus in process of degeneration and extinction.
(Gentian-violet.) × 1000. (Buchanan.)

less bactericidal influence. The organism is said to be killed quickly by alternate wetting and drying, and it is

BACILLUS PESTIS AND PNEUMOCOCCUS.
To show mixed infection. (Carbol-fuchsin.) × 1000. (Buchanan.)

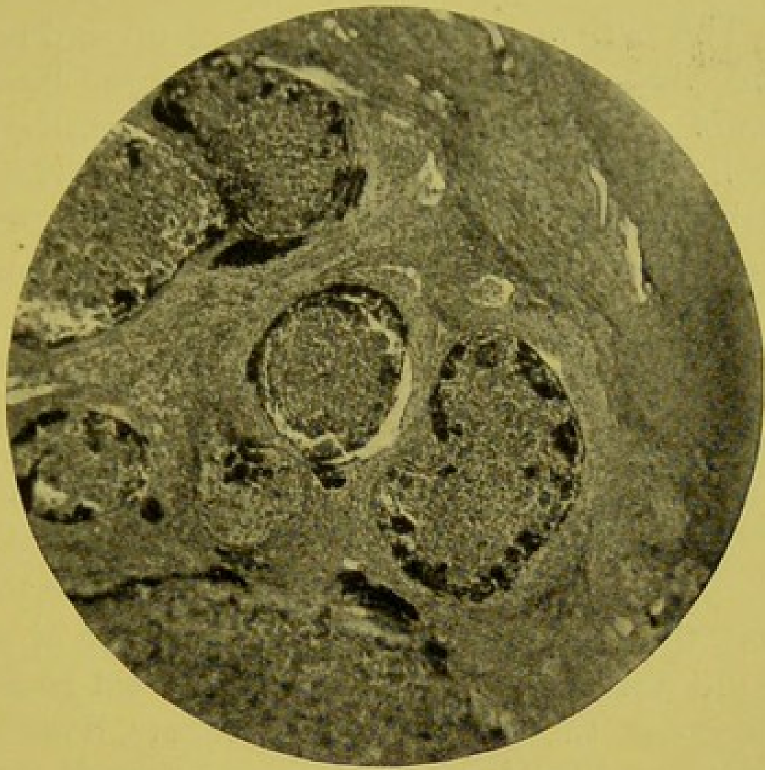
reported that a hot and moist atmosphere is inimical to it. The vitality of the bacillus is strengthened by a vitiated atmosphere containing excess of carbonic acid gas and deficiency of oxygen. The relation of these facts of bacteriology to the prevention of plague is manifest.

The bacillus, which specially affects the lymph glands, is usually regarded as capable of entering the body through the skin, the mucous membranes, especially of the mouth, nose, and throat, the respiratory tract, and the alimentary canal. The frequency with which the glands of the groin are affected has naturally been associated in a place like Bombay with the native practice of going about bare-footed on polluted soil such as the cow-dung floors of the houses; but even in the absence of special exposure of the lower limbs to infection, the disease appears to have a selective preference for the groin—as in the case of its entrance by an accidental wound of the arm during experimental work, where inguinal bubo resulted. In Australia also, where the feet and legs are well protected, a similar preference has been shown.

Mode of Entry into Body.

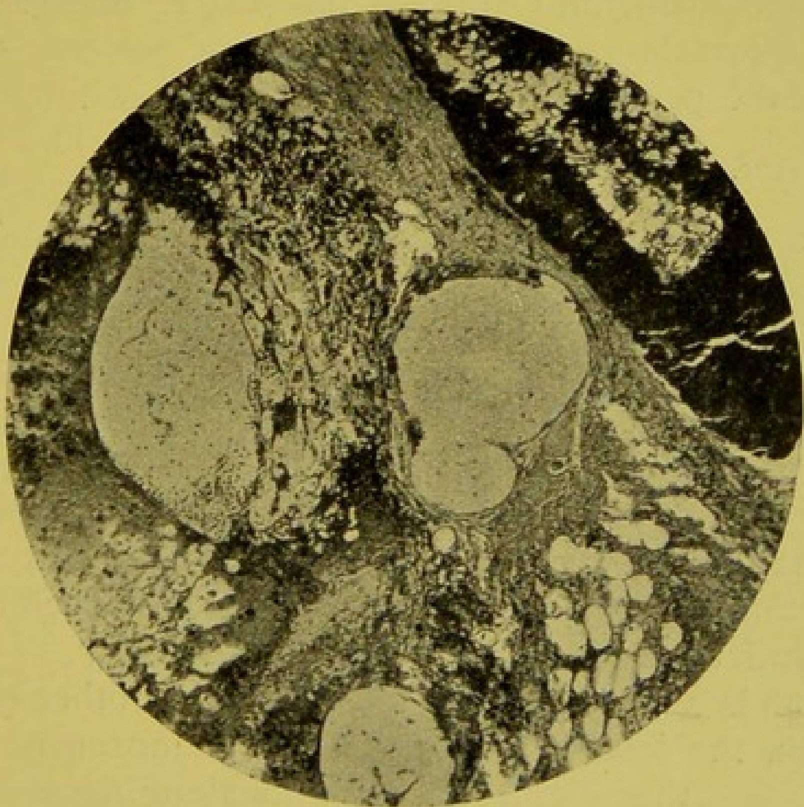
The fact that Europeans in India have usually escaped infection has been attributed to their protection by foot-gear from soil contamination; but it is impossible to separate this out from other differences—better general health and stamina, better housing, greater personal cleanliness, and fewer fleas. The entrance of plague into the body through the alimentary canal is evidenced by the fact that animals fed on material containing the bacillus often develop the disease, and also by the fact that in fatal cases in man the stomach and intestines are often found congested. As is well known, the infectivity of pneumonic cases is greatest. Nurses and doctors are not infrequently attacked in attending such cases. But even in this respect cleanly Americans and Europeans are at a great advantage. Dr. Bannerman, director of the Plague Research Laboratory in Bombay, describes the disgusting habits of the natives in a very realistic fashion :

'To anyone acquainted with the careless and insanitary habits of the lower-class native of India, the spread of the disease around those affected with pneumonic plague must seem a matter of certainty and not of possibility



CERVICAL BUBO.

Showing several lymphatic glands and ducts with plague bacilli massed in the periphery of each in enormous numbers (black in figure). (Carbol-thionin-blue and Eosin.) × 60. (Buchanan.)



MARGIN OF BRONCHIAL GLAND.

Showing the fibrous capsule with three greatly distended blood vessels and a small portion of the periphery of the gland occupied by bacilli in almost homogeneous mass (black part in right side of figure). (Carbol-thionin-blue and Eosin.) × 60. (Buchanan.)

merely. The patient is freely coughing up and scattering all around him a virulent culture of plague bacilli, and regardless of all civilised customs, spitting on the floor on which he lies and the walls in his vicinity. His sympathising friends are ever ready to offer their open hands to receive the sputum, and thereafter wipe them on the walls or door-posts, or their own garments.'

Under circumstances like these it is impossible for plague not to spread.

Climatic conditions favourable to its extension include a temperature of 55° F. to 75° F. The importance of seasonal influences is illustrated by the fact that when the disease was dying out one year in Bombay the return to the city of a quarter of a million pilgrims did not revive it, yet when the next season came round there was the usual recrudescence. Even seasonal incidence is capable of explanation in terms of the rat-flea hypothesis. In Sydney, though fleas exist all the year round, the season of their greatest prevalence (the months of March, April, and May) is the plague season.

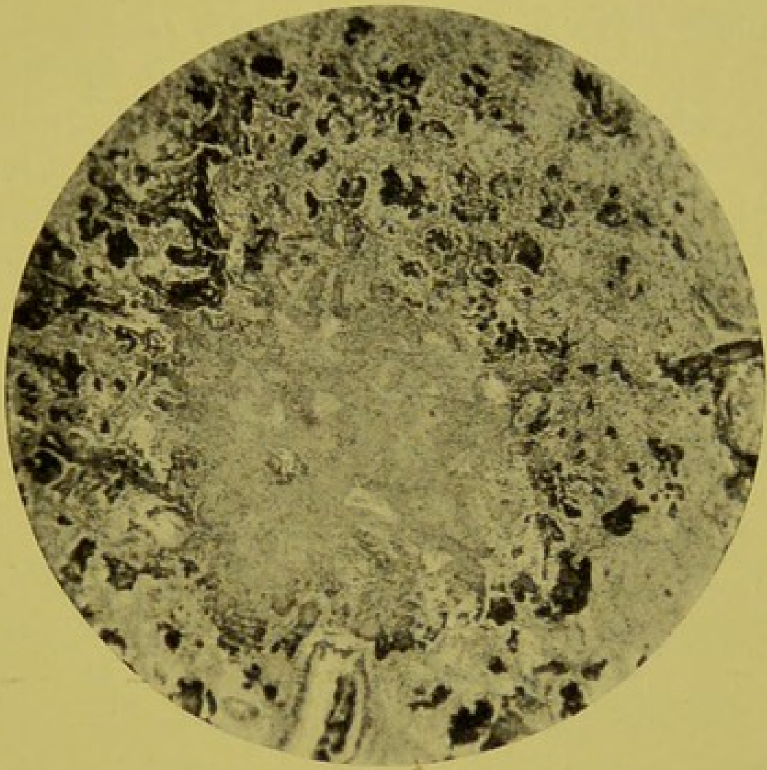
Season.

The intervals of non-prevalence are perhaps bridged over by the persistence of the infection in a chronic form in a limited number of rats. The chronic lesions are said to be mainly abdominal. Chronic rat-plague was searched for by the Commission in two Indian villages in which plague had recurred annually among the inhabitants for three years without discoverable reinfection, and of 1800 rats caught in December six were found suffering from old abscesses due to chronic plague, whilst in thirty-two rats in which plague was produced experimentally by flea inoculation two instances of chronic plague occurred. But in Sydney, Ashburton Thompson has not found any such chronic form, and thinks the hypothesis unnecessary.

Chronic Plague.

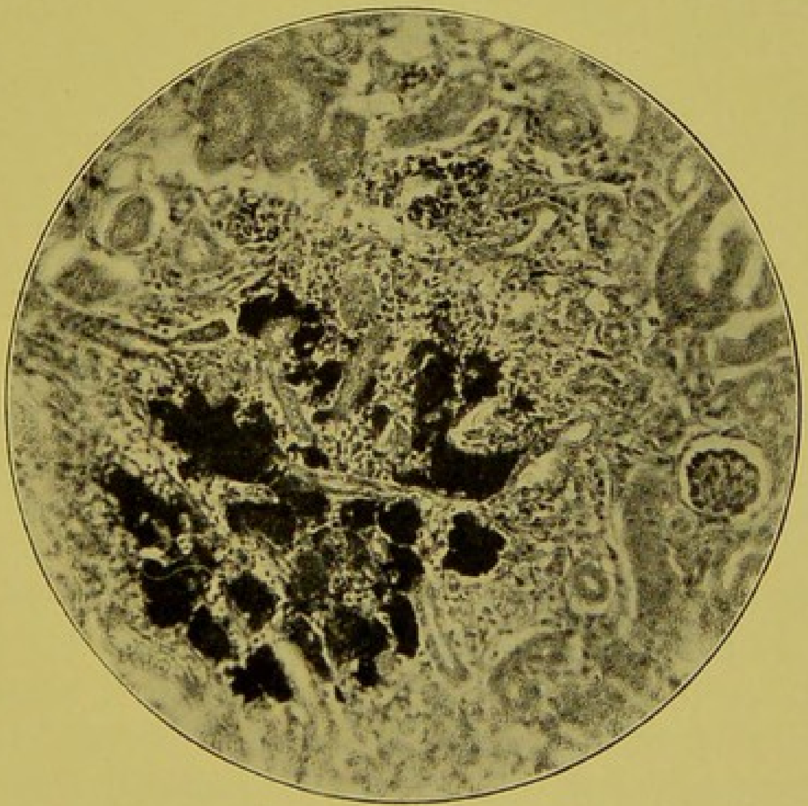
Plague is a most fatal disease, but, as in other epidemic maladies, the fatality varies greatly. Simpson points out that owing to exceptional mildness a whole epidemic may pass without its nature being recognised. In 1877, at Astrakhan, on the Delta of the

Fatality.



SECTION OF LUNG.

Showing an area of air vesicles which are occupied by dense masses of bacillus pestis (black in figure). The central portion has undergone necrosis. (Carbol-thionin-blue.) × 60. (Buchanan.)



SECTION OF KIDNEY.

Showing a portion of the cortex in which bacillus pestis has developed between the tubules in great masses. (Carbol-thionin-blue.) × 100. (Buchanan.)

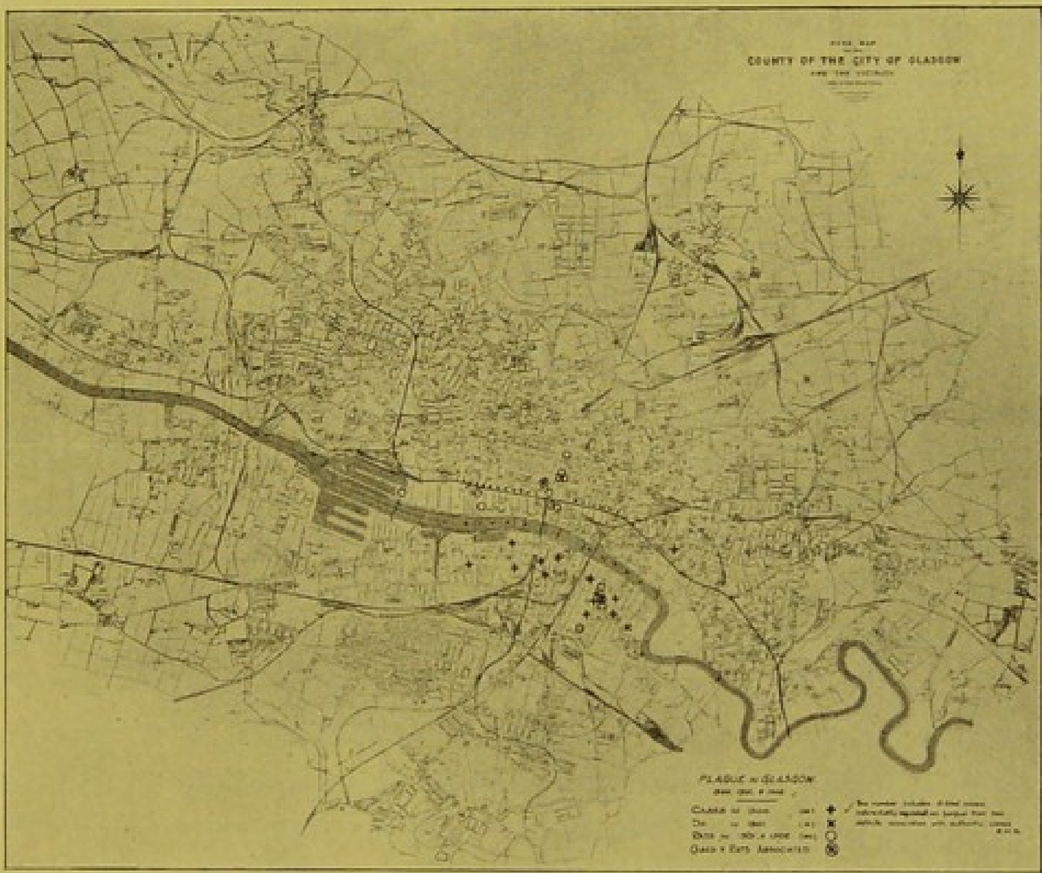
Volga, there were 200 cases with only one death, and in the following year at Vetlianka, higher up the Volga, another epidemic occurred, mild in its beginning, but suddenly becoming very severe, and assuming the pneumonic type. The fatality in Bombay has ranged from 50 to 80 per cent., and has been even higher in India generally, whilst in Hong-Kong it reached to 90 and 95 per cent. Among the white races, however, whether in Bombay, Hong-Kong, Glasgow, South Africa, or Australia, the fatality has been lower, ranging from about 30 to 60 per cent.

Means of Conveyance.

As to the means by which the disease may be conveyed, human agency and rats are the two great factors. The relation of rats to plague has been known from the remotest times. When plague attacked the Philistines after their invasion of Israel, they made five golden images of their emerods and of the 'mice which mar the land.' Plague as an epizootic among the rats of a locality is often a precursor of an epidemic in the human population. Sir Patrick Manson has illustrated his view of the importance of rats by comparing them to the paper and wood which are placed underneath the coals in a fireplace as kindling for the fire. The match is the bacillus, but if applied to the coal direct it will die out without causing combustion. If applied, however, to the paper and wood underneath, the coal will soon be involved.

Relation of Rats to Glasgow Outbreak.

But the paper and wood may be damp. This was so in Glasgow, where, as Dr. Buchanan informs me, rats appeared to have a very indefinite relation to the spread of plague. In three well-defined outbreaks no infected rats were associated with the first, a few were found *after* the second, and a few preceded and followed the third. In August and September, 1900, there were about thirty-six cases of the disease, and most careful search for infected rats quite failed to discover any, either in the infected area or elsewhere in the city. Early in August, 1901, there was a slight return of plague to one end of the previously affected district. About five cases were known, and at the end of the month one infected rat was found in the locality. In September other five plague-rats only were found, three living and two dead. In the following month the disease appeared in a different part of the city, and was confined to the servants in a large hotel, there being five cases in all. Under the floor of a refreshment-room



PLAGUE.
Map showing distribution of Plague in Glasgow, 1900, 1901 and 1902; and its relation to the Epizootic in Rats.

where the infected persons had been mostly occupied, the dead and mummified bodies of plague-rats were found up to the middle of November, by which time twenty-one infected rats, dead or living, had been discovered. Also, in premises in the vicinity of the hotel, and in the line of an underground railway passing the hotel and leading from one of the harbour docks, infected rats were found up to the end of January, 1902. Yet the disease did not attack any human beings outside the hotel. Once more, in July, 1902, infected rats were found around the hotel and at the dock, but no cases were known in the human subject. With the exception of the hotel, no cases were found in premises infected with plague-rats, though most of the premises were restaurants employing a considerable number of people. The accompanying plate illustrates these facts. They are easily explained if we regard the Pulex cheopis as the ordinary link between the rat and the human being, and recollect that in Britain this flea is unknown, or most uncommon. This also helps to explain why in the well-governed city of Sydney the disease was so much more difficult to exterminate than in Glasgow. In Sydney they had the Pulex cheopis as the rat-flea.

The Rat-flea Hypothesis historically applied.

Indeed, the rat-flea hypothesis appears to explain satisfactorily a great part of what is known of the conduct of plague in the present day. But is it consistent with the facts of history? For many centuries plague epidemics were common in Britain, and mere absence of sanitation can hardly account for the remarkable prevalence and infectivity of the disease. It can hardly be supposed that the rat-fleas of those days differed from the rat-fleas of the present time, for each species of animal has its own specific parasites, the same in the seventeenth century as in the twentieth. If, then, Pulex cheopis is almost unknown in Britain in 1905, how could it have been common at the time, say, of the Great Plague of London in 1665? The solution of the puzzle appears to be, not that rats have taken on new fleas, but that the rats which were commonest in Britain in the old plague times have been supplanted and practically exterminated by a species formerly unknown here. The Mus rattus with its Pulex cheopis has been driven out by the Mus decumanus with its Ceratophyllus fasciatus, which does not bite man. In his work on the geographical distribution of mammals Andrew Murray, writing forty years ago, states that the black rat (Mus rattus) has been from time immemorial the house-rat of the civilised world, but that 'it is, however, now fading away before the brown rat (Mus decumanus), and is so nearly exterminated in Britain that in most cases it has become a matter of difficulty to procure a specimen.' According to Rothschild, Mus rattus is now a rare animal in the British Islands, and on the few occasions on which he has had an opportunity of examining its fleas he has found them to be the species C. fasciatus. The Pulex cheopis, therefore, was absent even from the few black rats that were found.

The Mus decumanus which expelled the Mus rattus from Britain appears at one time to have got mixed up in politics. It over-ran England in the eighteenth century, and was called the Hanoverian rat by the Jacobites, who regarded the Hanoverian succession as the cause of all evils. They did not dream that the expulsion of the old rat by the new might be largely responsible for cessation of the terrible pestilences which had so often swept through Britain, and especially through its towns and cities, in previous centuries.

The Pulex cheopis, though not now discovered in England, is still sometimes found elsewhere in Europe, and it constituted about 25 per cent. of the flea population of ship-rats at Marseilles several years ago, and it is interesting to read that it became scarcer there as the distance from the docks increased.

The researches of Dr. Klein, conducted on behalf of the English Local Government Board, have also to be noted here. He has found that rats are subject to two forms of plague, one virulent and presumably highly infectious, and the other a strain of insignificant virulence with correspondingly feeble infectivity. The latter is provisionally regarded as 'proper' to the rat, at least in temperate zones.

Destruction of Rats.

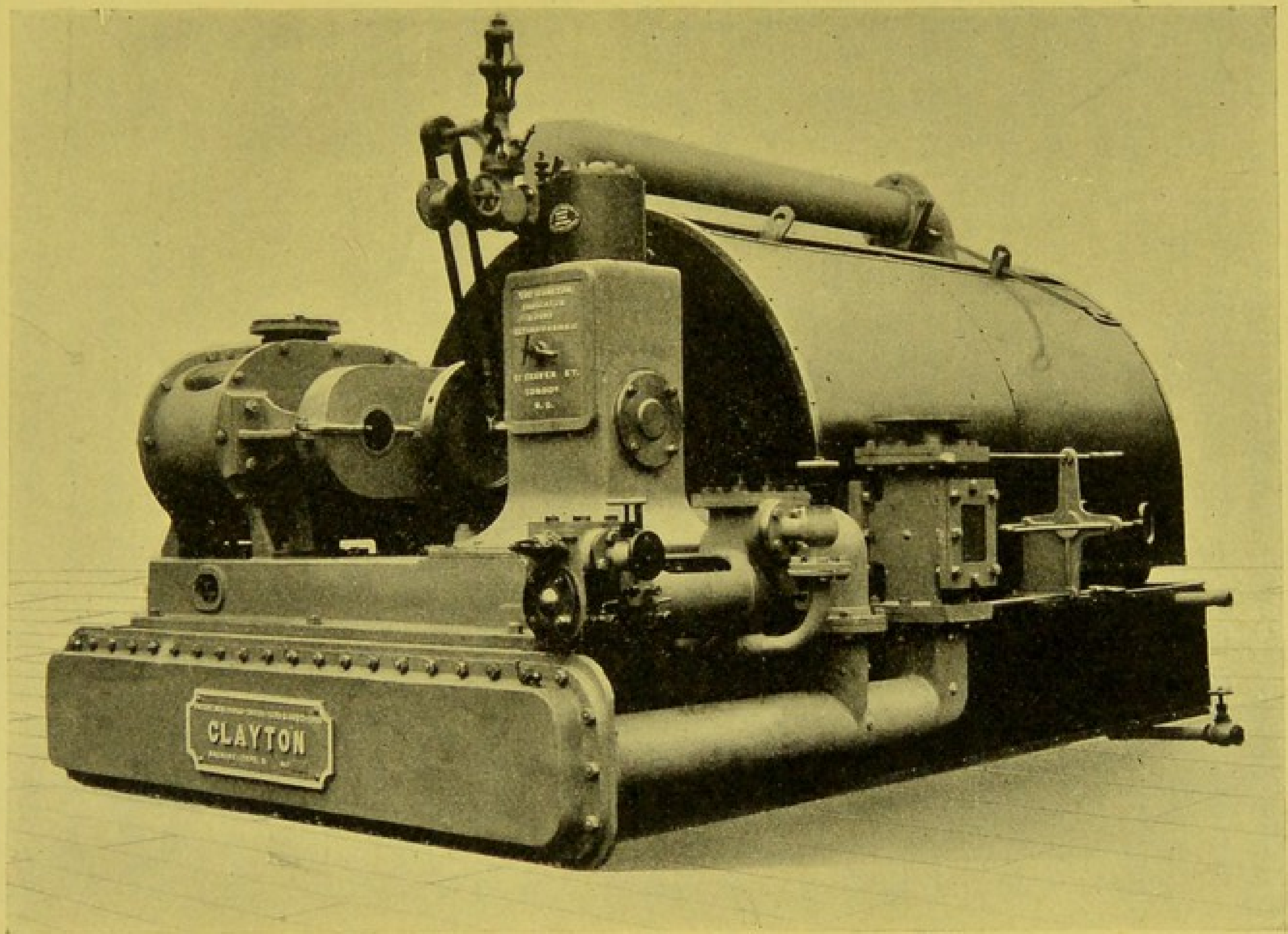
In the destruction of rats, besides the work of rat-catchers and poisoning by rat-pastes, two methods are available, one the use of the Danysz virus, and the other the Clayton method of sulphur fumigation.

The Danysz virus is often effective. It is prepared from cultures of a bacillus which causes an epizootic amongst rodents. Its strength and reliability do not seem quite uniform, as in one or two places it is reported to have had very little effect. In my own experience it has been most active, and an epizootic set up amongst rats infesting a refuse depot took many months to die out.

Clayton Apparatus.

The Clayton fumigation apparatus has destruction of rats as only one of its purposes, fire extinction being its main and original object. Its principle is the burning of sulphur at a very high temperature. When sulphur is burned in the air by ordinary means the gas SO_2 alone is produced. By the Clayton process it has been alleged that higher oxides are formed, and that it is these which give the system its special value. But enquiry on behalf of the Local Government Board has resulted in the conclusion that though SO_3 is produced, it has no part in the process of disinfection, and that, being a solid, it rapidly subsides, SO_2 being the only disinfecting agent. The method can be applied to ships and dwelling-houses. If it can reach them, and if it can be applied sufficiently long, the gas usually kills not only rats, but bugs, fleas, mosquitoes, and other insects. It is equally useful for plague and cholera, though experimentally it has been found that the gas does not destroy the spores of anthrax. It does no injury to textile fabrics protected in bales in the ordinary way, but is very readily absorbed by woollen goods, and to some extent by jute and by cargoes of grain. It is not absorbed by cotton goods, and therefore acts more quickly on rats in holds loaded with cotton than with any other textile or organic merchandise. For empty holds and for rooms in dwelling-houses it is most useful; but even in these it must be applied for a good many hours to secure completeness of disinfection. Fruit and vegetables are rendered useless by the gas, but dry merchandise, silks, books, tea, coffee, upholstery, and machinery are not injured, and tarnished metal can be cleaned again. There is no risk of fire, and the apparatus gives off the gas in white fumes, which, unlike CO and CO_2

CLAYTON MACHINE TYPE "B" FOR PORT PURPOSES USUALLY FITTED ON A BARGE.



WEIGHT, 5 TONS.

are visible. It has a further advantage over these invisible gases in being most irritating to the air-passages, so as at once to warn off all who come within its reach. This same quality drives rats and other vermin from their holes in their endeavour to escape, while in the case of carbonic oxide and carbon dioxide they are likely to die in inaccessible parts of the ship. The gas produced is heavier than the atmosphere, and by prolonging the process it gradually sinks and finds its way into the deepest parts of the hold, provided it is not absorbed by cargo. In large ships an application of from twelve to twenty-four hours is desirable, and even in small vessels it is better to err on the safe side. The apparatus may be fitted on a launch for incoming vessels, or large vessels may themselves carry a small destructor. It can be used on land for disinfection of warehouses, dwelling-houses, railway carriages, and so forth.

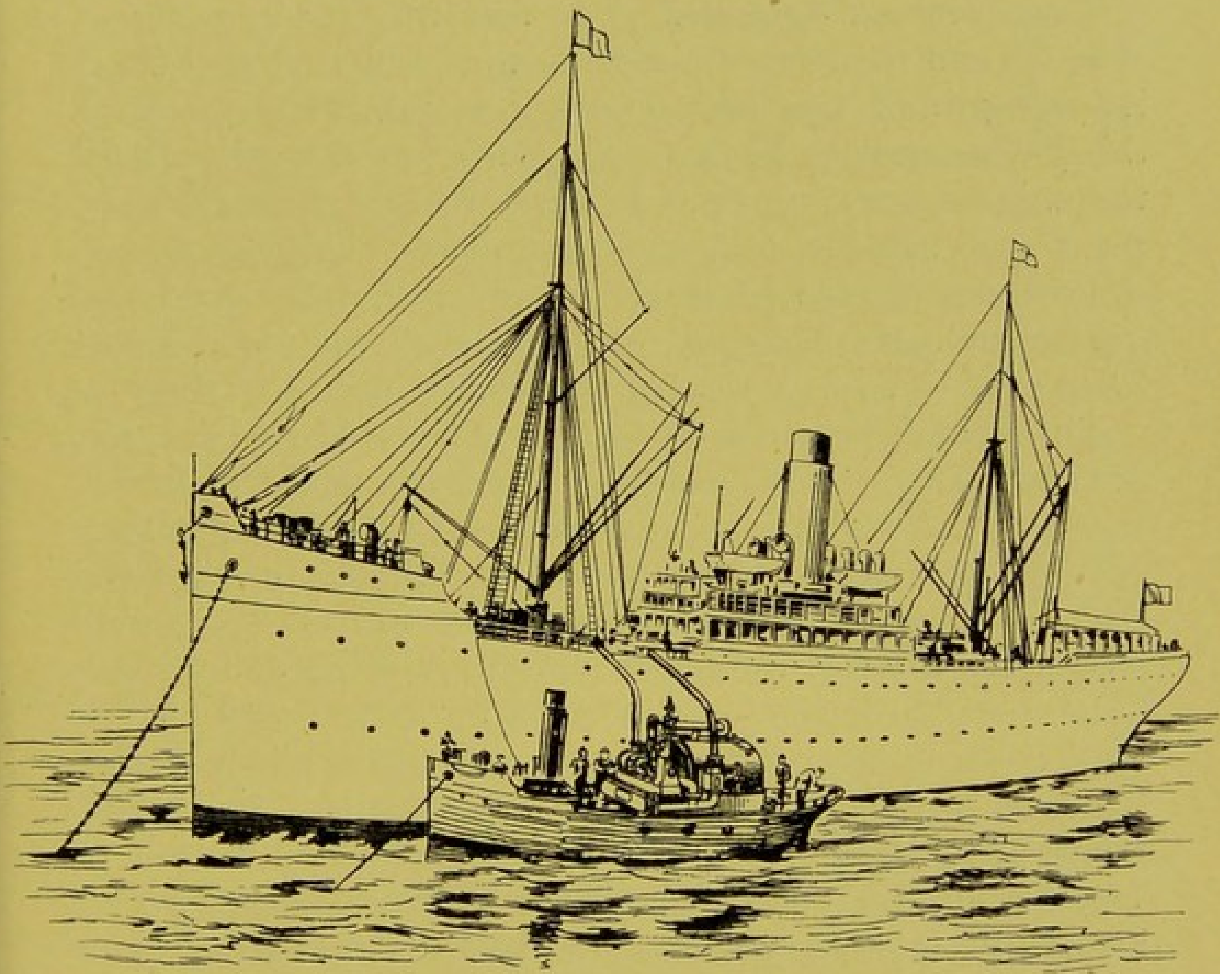
In the disinfection of premises there is nothing to differentiate plague specially from other infectious diseases. Milk of lime, and ordinary disinfectants for drains and back-yards are to be applied in the usual manner.

In addition to rats, plague may be conveyed by human beings, whether sick or healthy, and by their clothing. They may themselves have the disease, or their clothing may convey the infection. It is along routes of traffic that the disease is spread, and travellers and rats are its two carriers. Merchandise, apart from rats, has not been proved to be dangerous.

Glasgow Procedure.

When plague invaded Glasgow in the year 1900 its prevention was undertaken on the same lines as are followed in other infectious diseases. How the outbreak began was never discovered, but the locality affected was near the river, where the docks are. There is little doubt that the infection was introduced through the port of Glasgow, though whether by rats or by human beings remains unknown. As usual, the nature of the first case or two was not recognised. Then there was sent to the isolation hospital a case certified 'Enteric fever?'—the query calling attention to the uncertainty of diagnosis. The hospital physician, Dr. Brownlee, speedily concluded that he had to deal with plague, and this was confirmed by discovery of the bacillus.

The steps taken by the health authorities, as recorded in the report by Dr. Chalmers, the city medical officer



PLAGUE INFECTED STEAMER,
with cargo on board, being disinfected by Clayton system.

of health, included the publication of a pamphlet describing the symptoms of all the varieties of plague, the adoption of compulsory notification, the isolation of discovered cases, the disinfection of houses and premises, the keeping of contacts under regular medical observation, the elaborate search for unrecognised cases in the affected locality, the disinfection of premises, and the destruction of rats. Under statutory powers possessed by the corporation, a special area in the invaded part of the town was defined for special sanitary measures. Within this area all owners of property were compelled to cleanse and lime-wash their premises. Very frequent removal of refuse was undertaken. A strict search for nuisances of every kind was entered on, and all discovered insanitary conditions were dealt with vigorously.

The outbreak extended over less than two months—August and September—and the time which elapsed after its recognition was only about a month. In a total of thirty-six cases, eight had occurred before the existence of the disease was known. I have already referred to its recurrence in 1901, and again in 1902. This shows how, even under conditions most unfavourable to its obtaining a permanent hold, plague may have to be guarded against for a year or two after it has apparently been overcome.

The use of Yersin's serum was advocated in Glasgow, but only persons who had been in contact with the disease could be persuaded to submit to its insertion.

Preventive Inoculation.

Yersin's serum and Haffkine's prophylactic are both of value. The former appears to have only a short influence, but its injection causes less irritation. Either should be used for nurses and attendants in hospitals where plague is being treated, and if Yersin's serum is chosen, its introduction should be repeated in about a fortnight. It is held that Haffkine's vaccine diminishes the attacks to one-fourth, and also lowers the fatality-rate, and that its influence, which does not begin for several days after its use, lasts for weeks, or even months. Klein has lately published a preliminary report on a new prophylactic which he has prepared, and for which he claims (1) that it can be prepared in ten or twelve days, instead of four or six weeks, the time required for Haffkine's vaccine; (2) that a large amount can be prepared of uniform strength; (3) that it is easily standardised by injection into the rat ; (4) that being dry and sterile it is easily preserved; (5) that the protection lasts for many weeks; and (6) that the cost is much less than that of Haffkine's prophylactic.

International prevention of plague has now reached a stage of very elaborate organisation. In Venice, when that city was the centre of trade between east and west, the measures taken included notification, observation, quarantine, and disinfection. Of these the most troublesome and the most useless was quarantine in the entire absence of any evidence of the disease. The principle of the modern system is that action shall depend on the facts of each case. If no illness has occurred during the voyage on board a vessel from a plague-infected locality, then there is no detention. The destination of passengers is noted, and intimation is sent to their respective districts, so that they may be kept under observation there. While quarantine is abolished as regards individuals, companies of gipsies may still have it applied to them, under the Convention of Venice. Merchandise is never quarantined. If it requires to be dealt with, it is either prohibited or disinfected. Prohibition applies to articles likely to carry infection, such as rags, sacking, carpets, raw hides, animal refuse, horse hair and human hair. These were the measures decided on by the Venice Conference of 1897. By the Convention of Paris in 1903 effect was given to increasing knowledge of the means of propagation of the disease. The incubation period being now known seldom to exceed five days, the detention of passengers from infected vessels has been reduced to five days. Rats now also come under the regulations, and their destruction is required. An international office has been established in Paris, from which office information is systematically circulated regarding the movements of the disease.

International Prevention.

LECTURE VI

THE PREVENTION OF MEASLES

HITHERTO I have been considering infectious diseases whose incidence is largely on adult life, though childhood is by no means free from them. We now come to a group of maladies whose main prevalence is in childhood, though, when opportunity offers, they invade later-age periods also. Further, the diseases hitherto discussed are largely controlled by some of the measures embraced within the wide domain of sanitation, but we are now to consider a malady towards the diminution of whose prevalence sanitation has been practically powerless.

The death-rate from measles in England and Wales was

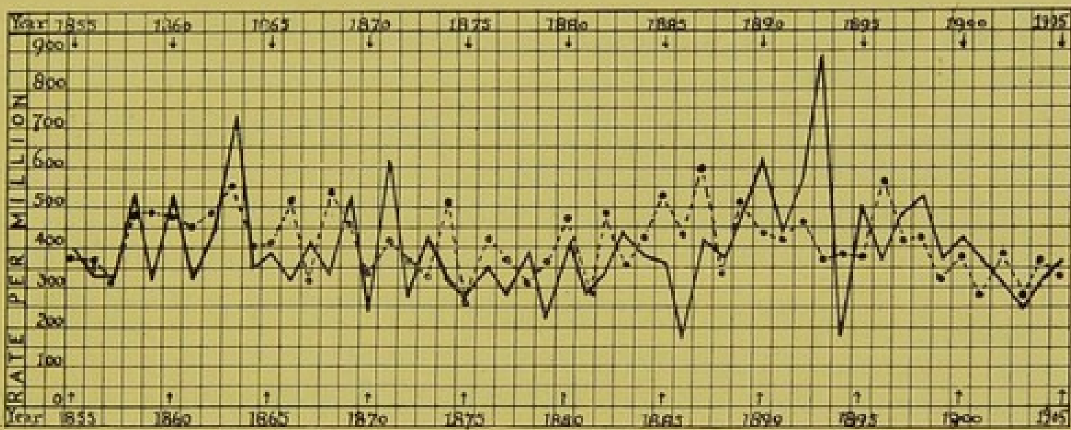
In 1861-1870 -	- 391	per million of population.
1871-1880 -	- 378	,, ,,
1881-1890 -	- 406	,, ,,
1891-1900 -	- 414	,, ,,

The death-rates of England and Wales and of Scotland are indicated in the chart on page 127, and it will be seen that there has been no diminution, but rather an increase.

This continued prevalence of measles is very remarkable, and we shall have to seek an explanation for the failure of public health administration to influence in the right direction one of the most ordinary and important causes of the loss of child life.

I would emphasise the word important. Measles-attack is often thought of and spoken of as a trivial incident of childhood. As a matter of fact, the disease kills in England and Wales more than twice as many people as does scarlet fever, more than twice as many as enteric fever, fully a half more than diphtheria, about twenty times as many as smallpox, and a hundred times as many as typhus fever. In England and Wales the deaths from measles have been from 6000 to 14,000 a year, and, as summed up by Dr. Theodore Thomson [1] from the Registrar General's reports, they reached the enormous total of 367,602 in the forty years ending 1887.

High Mortality.



MEASLES—DEATH RATE PER MILLION, 1855 TO 1905.
England and Wales—interrupted curve. Scotland—continuous curve.

I see that in the United States in a single year (1900) there were 12,000 deaths. Measles, then, is a most serious and dangerous disease.

The cause of its high mortality is not its high fatality. It is not a very mortal disease. Though the fatality varies in different epidemics and in different circumstances, it averages, perhaps, only 3 to 6 per cent. In Edinburgh in the decade 1881-90, when the disease was notifiable, it killed from 1.5 to 6 per cent. of those attacked, the average being 3 per cent. Deaths from measles are mainly due to complications, especially to catarrhal inflammation of the respiratory passages. And here there is good evidence that vitiation of atmosphere

Low Fatality.

[1] English Local Government Board, Medical Officer's Report for 1894-95, page 137.

in institutions where weakly children are aggregated in large numbers may greatly increase the fatality-rate of measles amongst their inmates. This has been observed both in Paris and in New York, the Hospice des Enfants Assistés having had in 1882-6 a fatality rate of 46 per cent., and the Nursery and Child's Hospital of New York in 1892 and 1895 a rate of about 35 per cent. Speaking broadly, however, measles is very mortal because it is very universal. Its greatest fatality is in the second year of life. Its greatest incidence—its greatest prevalence—is in the period three to five years, but that is simply because epidemics recur so often that a child has a strong chance of exposure to the infection of measles within a very few years of birth. In remote islands, where the disease may be absent for nearly a generation, when it does come it attacks all ages.

Season.

As regards seasonal prevalence, the measles curve in Britain is notable in having two apices, one in June and one in December, the latter being the higher. Its minimum prevalence is in September, and it is also at low ebb in February. I have read that in the United States the measles season is in late winter and early spring. One attack does not give such certain protection against a second as in the case of smallpox, typhus, and scarlet fever. It has been found that about 5 per cent. of cases amongst school children are second attacks. I knew an adult—a policeman—who was infected by measles three or four times within a few years. Every time, in fact, that any of his children were attacked he took the opportunity of having another dose, and very much ashamed he was of what he regarded as a childish weakness.

Immunity.

Evanescent Infectivity.

The infection of measles is transmitted by the air. It is said by some observers that cats also take measles, and spread it amongst children, but the statement is difficult to establish. Perhaps it can be carried by mediate transmission, but this is not at all so certain as in enteric fever, smallpox, diphtheria, scarlet fever, and the like. The reason of the uncertainty is that the infection of measles is very evanescent. It does not hang about a house like smallpox or scarlet fever, which may recur months or even years afterwards, on exposure or disturbance of infected articles.

Disinfection.

Hence, in practice, less attention than usual is paid to disinfection of houses after measles. Bedding and clothing are not commonly taken to a steam disinfector, and even spraying of walls by formalin is not invariably practised. I usually myself trust to thorough washing and cleansing, to scrubbing of floors and furniture, to scouring of bed and body clothing, and to free access of fresh air. Perhaps part of the somewhat perfunctory disinfection after measles may, after all, be due to the very incomplete control which sanitary authorities have over the whole spread of the disease. At the beginning of an epidemic some effort is made to cope with it, but measles usually defies preventive measures, spreading widely and rapidly, and the attempt to fight it is given up in despair, so that its ravages come to be looked on as unavoidable.

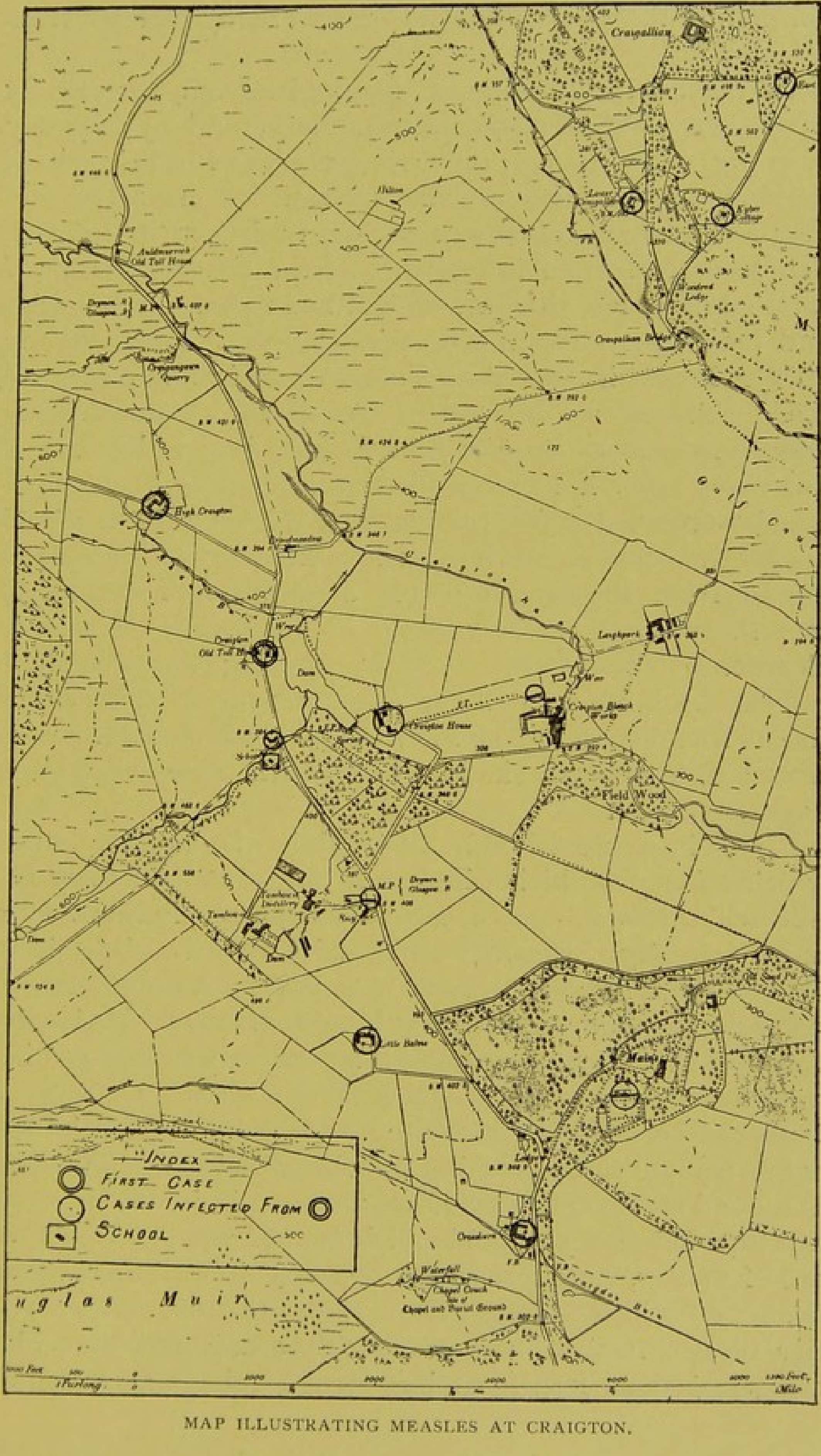
What, then, are the causes of the failure to stamp out measles?

Causes of Failure.

In the first place, though its infectivity is evanescent, yet, while it lasts, measles is one of the most infectious of all diseases. It is a very rare thing to see a single case of measles. Nearly every first case produces a crop of others. In the second place, it is very infectious before the eruption appears, and therefore before the disease is recognised as measles. When a medical man is called in, the presence on the buccal mucous membrane of Koplik's spots, which often appear a day or two before the rash, may aid diagnosis, but the difficulty is that very many cases are not seen by a doctor at this stage. Thirdly, parents look on measles as of no consequence, and often do not send for a doctor. Fourthly, very few local authorities apply to the disease the powers of the Compulsory Notification Act. Fifthly, epidemics come on so quickly and so extensively that hardly any sanitary authority has a staff sufficient to cope with them. Sixthly, as compared with smallpox, there is no vaccine to protect individuals against attack. Seventhly, school attendance gives the infection every facility for spreading, and countries where education is compulsory are correspondingly liable to measles.

An Illustration of High Infectivity.

How very infectious the disease is health officers know by every-day experience. The following is rather a striking example. Just before the New Year holidays of 1906, two children in a little country school in Dunbartonshire, with sixty-nine on its roll of attendance, appeared to be suffering from a cold, but as the school was to close soon they were not withdrawn from attendance. The catarrhal symptoms dated from 26th December, 1905, and on the 29th, the day the school was closed, the rash of measles began to appear on the face. The school serves a scattered country district, not containing any town or village, and its pupils come from isolated farm-houses or cottages, and from two or three hamlets of perhaps half-a-dozen dwellings. During the nine days of school closure the children were not living in any common centre, and were not in contact with the two cases of the disease. But the incubation period of measles is from ten to fourteen days, and so the holiday was included within the incubation period. Immediately after the school re-opened the dénouement came. In five children the eruption of measles appeared on 9th January, in eight children on 10th January, in seven children on 11th January, and in one child on 12th January. Thus twenty-one of the sixty-nine children on the school roll had been infected by their contact with the two first cases, and that during the early or catarrhal stage of the disease in these cases, the school having broken up, and the children having scattered to their several homes in different parts of the district just when this pre-eruptive stage was coming to an end. The two children who originated the school outbreak had themselves got the disease by attending a soiree on 15th December in a neighbouring town, and by sitting beside



MAP ILLUSTRATING MEASLES AT CRAIGTON.

children at the soiree who had quite recently suffered from measles.

Of the total sixty-nine on the register only twenty-six were present on Friday, 12th January, and by Monday morning, 15th January, the attendance was further reduced to sixteen, not because all the rest had measles, but because many were absent owing to living in infected houses or to fear of infection. Of the sixteen present, I found that no less than fifteen had had measles previously, and notwithstanding the occasional occurrence of second attacks it was in the circumstances permissible to regard these children as immune. Owing to an unfortunate feature in our system of school finance, into which I need not enter here, it is more profitable temporarily to close a badly-attended school than to keep it open, so that school boards in such circumstances are often very desirous to obtain from the health officer a certificate for closure. But in this case there was no public health reason for closure. Instead, therefore, of shutting the school, I caused the houses of all the absentees to be visited, and found that about ten children were being kept at home who had previously had measles. All these were sent back to school.

There is a provision in the Public Health Act under which, if any child is allowed to attend school from an infected house, the parent is liable to prosecution and to a money penalty. But the Act contains no list of infectious diseases, and the powers to be exercised have to be selected according to their applicability to each disease. Obviously it would be folly to prosecute a father for sending a child to school from a house in which there was puerperal fever. It would be folly to prosecute where public health is not being injured and education is being advanced. The law is a good servant, but a bad master, and in its administration a public body should put it into its proper position, not of master, but of servant. These children, then, were brought back, and they raised the attendance to twenty-five or twenty-six. Next, so soon as each patient could be regarded as free from infection he also was brought back, even if in his house secondary cases had occurred. In this way the attendance was quickly made up by children who were insusceptible to measles, and education was much less interfered with than if the school had been closed.

The spread of measles through school attendance has lately received much more attention than ever before. In London, Dr. Thomas has reported that measles may be expected to appear and to spread in a department when the number of children unprotected reaches to about one-third of the total, and that it usually ceases to spread when the proportion is reduced to about 18 per cent. Also, he states that it only spreads in classes under five years of age, excepting in certain well-to-do districts, where the range of ages at attack is later. Among children above five years old in the infant departments of schools he found that 75 per cent. had already suffered from the disease.

What, then, can be done to prevent the spread of measles?

Hospitals.

Is hospital isolation the remedy? Unfortunately, no. Cases of measles in Britain are not nearly so systematically removed to hospital as are cases of scarlet fever, smallpox, enteric fever, and the like. The reasons are two. The root purpose of removal to a fever hospital is not the benefit of the individual, nor the convenience of his friends at home, but prevention of spread of disease. Owing, however, to the infectivity of measles from the beginning of its first manifestations—in the catarrhal stage, the stage of sneezing and coughing and running nose and red, watery eyes—all the susceptible individuals in an invaded household have probably been already infected before ever measles is known to be present. Few sanitary authorities have hospital accommodation sufficient for a measles epidemic. Yet in large cities many cases of measles are sent to hospital, mainly, however, because, in addition to their employment for preventing spread of disease, fever hospitals have now come to be used for the convenience of parents or for the better nursing of individuals. Hygienic surroundings being favourable to recovery from measles, treatment in a well-ventilated hospital, with skilled nursing, must naturally diminish the fatality of the disease, so that though hospital isolation has little or no effect in preventing spread of infection, removal to hospital of cases occurring in small and crowded houses is a useful line of action where sufficient hospital accommodation is available.

Notification.

As to compulsory notification of measles, various places have tried the experiment, but nearly all have given it up. The fees mounted to a large sum, and no corresponding advantage was gleaned in preventing spread of the disease. In some places, however, this failure may have been more or less due to neglect of precautions to which notification should only have been a preliminary. Manifestly, notifying of measles can do no good if no action follows the notification.

In presence of facts already stated the question naturally arises, Is it worth while to endeavour to prevent this year the attack of a disease which is practically certain to get hold of the child some other year, and that at no very long interval? Is it not a waste of time and money to try to fight measles? It must be confessed that the view indicated by these queries has too often prevailed, that the contest has been given up in disgust, that the efforts of the health authority have been directed into some other more obviously profitable channels, and that measles has been allowed to do its deadly work unchecked.

Fatality in Relation to Age.

But certain very simple statistical facts, when their lesson is read aright, condemn this counsel of despair, and give much hope of good results from well-directed efforts to lower the mortality due to measles. The following is an example of such facts. As recorded by Dr. Theodore Thomson,[1] an epidemic of measles occurred in the years 1892-4 in an English urban district with a population of 35,606.

[1] *Loc. cit.*

Notification of measles was compulsory, so that exact details were ascertainable. The total attacks were 2031, and the deaths were 125, so that the fatality-rate was 6.1 per cent. But the point of special interest is *the fatality rates at different ages*. These are as follows:

Age Groups.	Attacks.	Deaths.	Rate of Fatality per 100 Cases.
0-1, - - -	166	16	9.6
1-2, - - -	233	46	19.7
2-3, - - -	354	36	10.2
3-4, - - -	324	16	4.9
4-5, - - -	324	5	1.5
Total under 5, -	1401	119	8.5
5-10, - - -	560	6	1.1
10 and upwards, -	39	0	0.0

Thus, among the children who took measles under four years of age there was a fatality-rate of 5 to 20 per cent., among those who took the disease in the fifth year the rate was only 1½ per cent., between five and ten years the rate was very little over 1 per cent., whilst among persons over ten years the disease was entirely non-fatal. It is true that if very old persons, say sixty to a hundred years of age, are attacked, as in the Faroe Islands, where the disease had been entirely absent for a very long period of time, there is among these a considerable fatality, but for practical purposes, and as referring to ordinary communities, the consideration of fatality at high ages may be put aside. Broadly speaking, the disease is decidedly dangerous up till the beginning of the fifth year of life, is very little dangerous from that time to the end of the tenth year, and afterwards is free from danger to life. In the 367,602 deaths from measles already referred to as occurring in England and Wales, only 31,728 were in persons over five years old. And in the epidemic in the urban district above mentioned, of 2031 attacks at all ages, 1401 were in children under five, 560 were between five and ten years of age, and only 39 were over ten years of age. Thus the disease is most fatal under five years of age, and at present its greatest prevalence is in the quinquennium of its greatest fatality. I have just said that in London schools it is found that 75 per cent. of children five years old have already had measles. The 75 per cent. are those who have recovered from a disease which has already killed 10 to 20 per cent. of their brothers and sisters under three years old, and about 5 per cent. of those who were in their fourth year. But if these children had not been attacked until they had reached the age period 5-10 years, only 1 per cent. would have been slain, and if the attack had been deferred until they were over ten years old, practically all would have recovered.

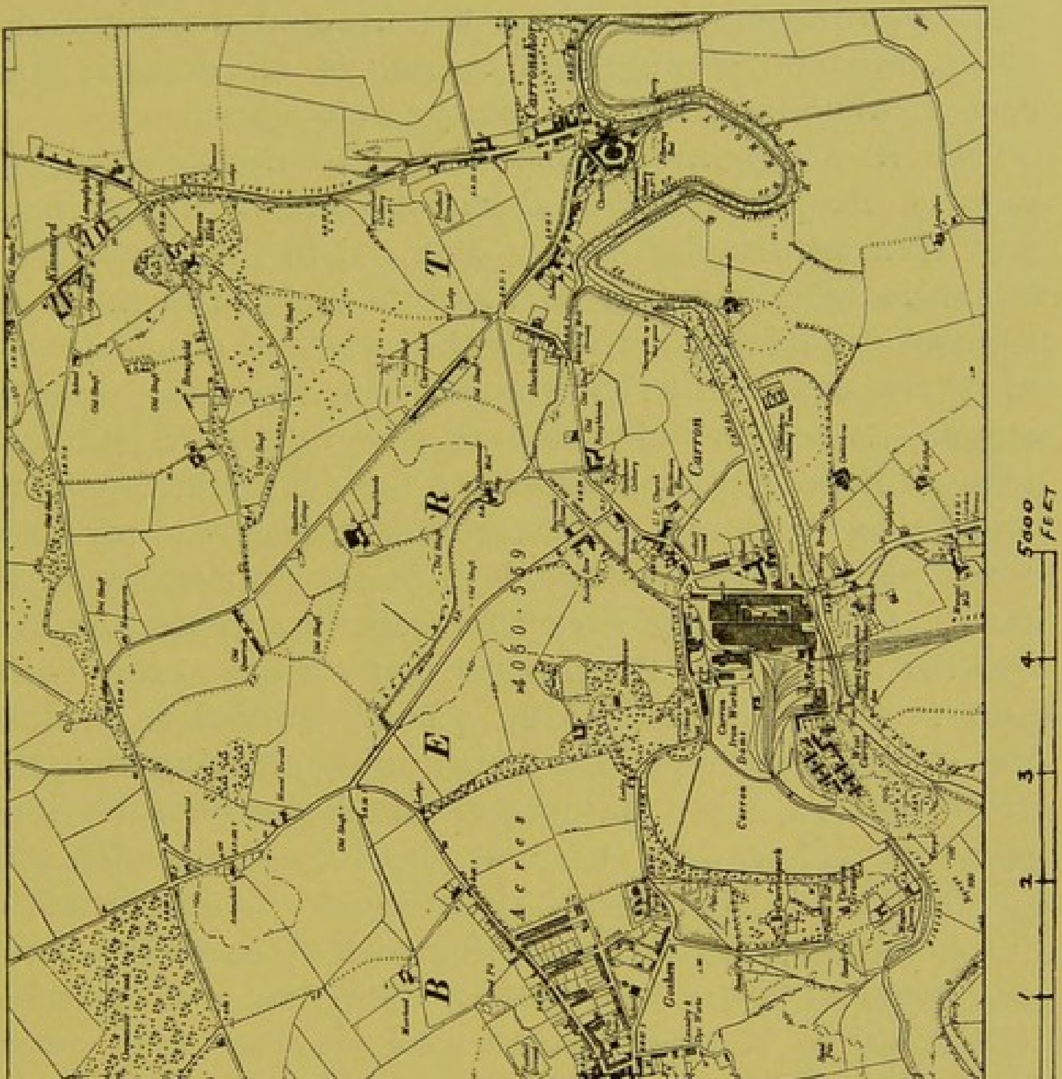
The policy, therefore, is to delay attack by measles. How can that be attempted? The school is the main agency of spread. The school child is infected, and carries home the disease to the younger members of the family. If infection can be prevented from extending amongst school children, their brothers and sisters at home run much less risk, and, even if they are ultimately attacked, their chance of recovery increases enormously with every year of deferment of the seizure.

The Right Policy.

As measles is spread mainly by schools, attempts to check it must also relate to schools. It is all-important to receive early information of its occurrence. The first case in a school is nearly certain to be missed during the catarrhal stage. The disease is looked on as a common cold until the rash appears. By that time, however, a dozen or a score of classmates have almost certainly been infected—the first crop, as they are aptly called.

In the somewhat straggling and scattered town of about 10,000 inhabitants shown in this map there are two schools, A with about 700 pupils and B with about 1000. Measles had prevailed amongst the children attending Larbert village school (A), and had practically spent itself. The distance

An Example of Prevention.



MAP OF LARBERT, STENHOUSEMUIR, AND CARRONSHORE.

between the schools is about a mile, and the population along the connecting road is not at all dense. Each school, therefore, has a pretty well-defined area from which it draws its pupils. And, as it happened, the disease did not attack any school children living in the east area until it had nearly died out in the west. Then a single case occurred in the infant department of the Central school (B), and the child attended school for two or three days whilst in the acutely infectious catarrhal stage. When the disease was recognised the child was kept at home. Now, it happened that, through the teacher and the local sanitary inspector, this case came to my knowledge within three or four days of the appearance of the rash. I immediately visited the school, and after explaining the rationale of the proposed procedure to the teacher and to the convener of the school committee, I closed the infant department for a fortnight. During that fortnight about a dozen children of this department developed measles. They were the first crop from the seed planted in the school. Before the department was re-opened, all the households sending children to it were visited, and a list made of those who had by this time been attacked. The children of these houses were excluded from attendance, and the result was that the epidemic was nipped in the bud. There was no second crop in the school. Three or four children were attacked who lived near those of the first crop and played with them during their catarrhal stage; but the propinquity of the other cases, and the publicity resulting from school closure and the visitation of infected houses had warned the parents to be on the outlook, and these three or four children were kept at home from the beginning of the catarrhal stage.

School Closure.

With reference to the circumstances under which there is reason to hope that closure of a school, or of the infant department of a school, will be effective in arresting the spread of measles, the general dictum may be taken to be *closure on account of the first case present in school during the infective stage.*

If it should so happen that a first case is detained at home by parents from the onset of catarrhal symptoms, or if a first case develops catarrhal symptoms on a weekly holiday and does not return to school thereafter, the child may be regarded as not having been in school during the infective phase, and a medical officer may correctly stay his hand from closure. But if a first case has been present, say, in the infant department, red-eyed and sneezing, that first case is an indication for closure of the department.

In determining the time for which a school, or part of a school, should be closed, with the object of checking measles, the medical officer will again be guided by circumstances; but his ultimate criterion will be *the reputed incubation limit of measles, which may, for practical purposes, be taken as ten to fourteen days.* It follows that the beginning of closure cannot be delayed without risk much longer than a week from the date of the last presence in the school of an infective case, for the case may have been infective for two days or three before it ceased attendance. It follows also that the end of closure need not be carried beyond fifteen days from the same date, which allows a margin for safety. It may occur in actual practice, more frequently than not, and especially in the absence of notification, that a case of measles escapes the notice of the medical officer of health during its earlier days. Alertness on the part of school officials may effect much towards obviating this omission, but in most instances a few days will have passed before the data for closure are before the medical officer.

Under these conditions the medical officer will observe, in the first place, that, despite the lapse of a few days, he may still have a day or two in hand before closure need take effect. Incubating measles is not infectious, and these few days of grace will give him time to make the necessary arrangements, or to explain to incredulous officials the benefits which will follow the step proposed. It is not essential that he should justify the scientific faith that is in him by postponing closure to the limit of safety, but the knowledge that closure need not in all cases instantly follow the discovery of an infective child may prove helpful to him at a time of stress.

The medical officer will observe, in the second place, as suggested above, that it is not necessary to continue closure beyond fifteen days from the last exposure of the infant department to infection. If, therefore, closure does not begin for a few days after the last exposure, it is clear that a total period of less than fifteen days may in these circumstances prove adequate. An example will make these general statements plain. A child becomes infective on 29th May, but attends the infant department of the school till 31st May. On 3rd June the medical officer becomes aware that the child is at home with measles. Now, the earliest date at which a case is probable will be ten days from the first exposure of the school children on 29th May, that is to say, 8th June, and the latest date at which a case is probable will be fourteen days from the last exposure of the school on 31st May, that is to say, 14th June. The medical officer decides on closure. He closes the department on the 5th or 6th of June with two or three safe days in hand, and he keeps it closed from the 5th or 6th to the 15th June, a period of nine or ten days in all.

At present it is not very often that the disease is heard of early enough to make this system of dealing with it practicable. And, even where notification is compulsory, parents frequently do not send for a doctor at all, so that medical notification is a broken reed, while notification by parents is almost entirely neglected. But much more is likely to be done in the future than has been attempted hitherto for prevention of spread of measles by schools. In London it is now the habit to obtain with regard to every admission to school, definite information as to whether the entrant has already had measles, and, if so, when. This information is registered, and is available for reference whenever the disease breaks out, so that it is possible to make a rough division of the children into susceptible and insusceptible. The introduction of regular medical inspection of school children is the likeliest way to prevent spread of measles by means of schools. Some more advanced sanitary authorities in large towns have appointed medical officers to devote all their time to school hygiene and disease prevention. I have read that in Boston (U.S.A.) the schools are visited and the pupils seen every morning by a medical man. It is manifest that in this way children threatened with measles have a fair chance of being excluded before they have had opportunity of doing mischief. But I do not for a moment suggest that it is worth while examining every school child in the United States or the United Kingdom every morning throughout every year by a medical man in order to prevent measles. If there is a definite medical organisation, headmasters and class teachers can be quite well taught the early symptoms of measles and scarlet fever and whooping cough, and can have laid on them the duty of observing the condition of their pupils. An intelligent and painstaking teacher can be of great assistance. He can note any children who appear to be in the catarrhal stage of the disease, and if these can be quickly enough excluded, then the step most likely to prove effectual has been taken. Also, though systematic notification by parents cannot be expected, they can be warned whenever a case occurs in a school to which they send children. They can be told to notice the onset of the first symptoms, to withdraw the children from school in the public interest, and to keep them warm in bed in their own interest. At the same time they should immediately intimate to the teacher the occurrence of any case of measles in their family. Prints, stating in simple language the usual appearance of the disease, can be readily distributed from the school or from the public health department. Appended to this lecture is an example of such a print. It is taken mainly from one issued in the county of Renfrew by Dr. A. Campbell Munro, who has been very successful in the prevention of measles epidemics.

Medical Inspection of Schools.

It must be admitted that school closure is of much less use in large towns than in the country, because, independently of school attendance, children in towns are brought into close contact in back-yards and on the streets. Yet boys and girls playing about in a courtyard or on a street are in much less close contact than when packed together on crowded benches in a school-room. Nothing, indeed, could be more favourable to spread of measles than the proximity of child to child which is unavoidable in school. Whole schools, however, should be closed as seldom as possible, so as to avoid needless interference with education.

School Entrance Age.

The figures of age fatality of measles help to emphasise another lesson which health officers are endeavouring to instil into the public mind in Britain. Very young children should not be sent to school. The age of six years is certainly early enough, if not too early. Quite independently of measles, it is great, though unintentional, cruelty to send children too soon to school. Instead of being crammed together in even the best-ventilated class-rooms, their little bodies should be developing in health and strength in the open air. The atmosphere of a school is very often appreciably offensive to anyone newly entering from the outside. It is essential for future physical well-being that the delicate organisation of the young child should get every opportunity to grow sound and stable in the first few years of life. And not only is the body involved, but also the mind. The childish brain should be set no hard tasks, and no systematic study should be imposed on it. There is abundance for the baby to learn outside of school. Impressions are coming to it from all sides, and should be allowed to come freely. I do not, indeed, believe that even as regards ultimate success in school there is any loss, but rather gain, through delay in going there. I have personally watched cases where, owing to delicate health, school attendance has not been begun till the child was eight or nine years old, and the rate of progress has been such that by the age of fourteen the whole lee-way has been made up. It may be said that working mothers are glad to be relieved of the care of their children by getting them away to school at four years old. But that kind of relief should on no account be encouraged. For needful cases public nurseries may be established, but resort even to these should not be allowed unless where really required.

School Ventilation.

The whole subject of school ventilation naturally arises in the discussion of measles. Air space and ventilation are important everywhere, and in proportion as an ideal amount of cubic space becomes difficult or impracticable, so does better ventilation become requisite in atonement. Every child should be provided with 2000 to 3000 cubic feet of air hourly. In a fever hospital with 2000 cubic feet of air space per patient, uncomfortably frequent change of air is not required. But if the air space comes down to 1000 cubic feet the rate of change has to be doubled, and if to 200 cubic feet or 100 cubic feet, the rate has to be increased correspondingly. Such limited air space would be quite unjustifiable otherwise, and for even partial justification it requires frequent dismissal of classes for a few minutes during which the open class-rooms can be flooded with fresh air through windows and doors. Constant change is necessary in schools, both for the provision of new air to breathe and for the removal of effete matter.

Standards of Air Purity.

And here it is necessary to say a word or two as to the meaning of the terms purity and impurity, used with regard to the air of schools or public halls or churches or ordinary inhabited rooms. Every one acquainted with the elements of sanitation knows De Chaumont's standard of aerial impurity. The atmosphere naturally contains about four parts of carbonic acid gas in 10,000 parts of air. De Chaumont found that if in an inhabited room the amount of CO_2 increased beyond six parts per 10,000, that is, if two volumes of CO_2 from respiration were added to the original four volumes in the air, a close or offensive smell began to be perceptible in the room. Other observers, it may be mentioned, have not noticed this smell until a distinctly larger amount than six parts of CO_2 per 10,000 has been reached. But, putting that point aside, a misunderstanding of De Chaumont's rule seems to have given rise to the belief that the amount of CO_2 in the air is itself the essential factor in atmospheric vitiation of inhabited rooms. This is a mistake. The serious agencies are not in practice the CO_2, but the other results of human occupation, namely, increase of water vapour, increase of organic matter, and rise of temperature of the air. In questioning candidates for certificates of competency to act as sanitary inspectors, and even medical students in their examination for degrees in medicine, I have been impressed by the extent of the misunderstanding. Supposing that in the operations of a chemical laboratory the amount of CO_2 in the air is raised very considerably beyond six parts per 10,000, there will yet be no real effect on the health of the occupants. And the CO_2 of respiration is no more hurtful than that produced in a laboratory. Under conditions like those of the Black Hole of Calcutta, the gas will kill quickly enough, but I am not discussing such cases of asphyxiation here. In ordinary circumstances the other results of animal life in a room are much more important. When the atmosphere becomes loaded with water vapour, the natural action of the skin is interfered with. The moisture which is continually being given off from the surface of the body, instead of dissipating into the air, lies on the skin and saturates the clothing. When an individual after a crowded meeting goes out into the open air, rapid evaporation immediately commences, and the whole surface of the body is chilled, with the result that congestion of internal organs is apt to occur and to cause serious injury to health. Also, the regulation of the bodily temperature has already been interfered with by the cessation of cutaneous evaporation in the heated room. Obviously too the foul-smelling organic matter given off from the body and not immediately removed from the air, is injurious when reinhaled. It is these agencies which are seriously detrimental in an insufficiently ventilated apartment, and the carbonic acid gas is little more than a convenient measure of the amount of such impurities.

In school-rooms (but not in hospitals) artificial ventilation, though not perfect, is unquestionably the best known method of procuring sufficiently frequent change of air. Dr. Kerr, medical officer of the Education Department of the London County Council, has kindly prepared for me the following diagram, showing the difference between the results of natural and artificial ventilation of schools, as observed by him in Bradford. (See page 146.)

Artificial Ventilation.

In a good installation of the Plenum system incoming air is drawn from a clean source, is washed by passing through a screen of dripping water, is heated by going over coils of hot-water pipes, and is then driven by a powerful fan along clean, smooth passages, which divide and sub-divide so as to send a proper supply to each individual class-room by means of suitably placed openings. Great care has to be taken to keep these passages clean. They should be regularly washed with a hose-pipe. So, also, the hot-water coils should not be allowed to collect dust, nor the gratings, nor the tubes conveying the air into the class-rooms. It is sometimes difficult to avoid the impression that under such a scheme the indrawing of fresh air is not so successfully achieved as the dispersion of foul air. That is surprising, for there is usually no extraction fan to suck out the foul air, which is instead allowed to find its own way through shafts leading to the roof. On entering a school-room so ventilated one is struck by the absence of foetid vapour which alone belongs to overcrowding. It has been driven out through the exit-stacks by propulsion of the entering air. But a curious thing is that the entering air itself does not usually give the bracing and stimulating feeling that belongs to a perfectly fresh outside atmosphere. Something appears to be lost in the passage of the air through the dark channels and gratings and tubes that lead it into the class-rooms, and the teacher very likely feels an overwhelming desire to

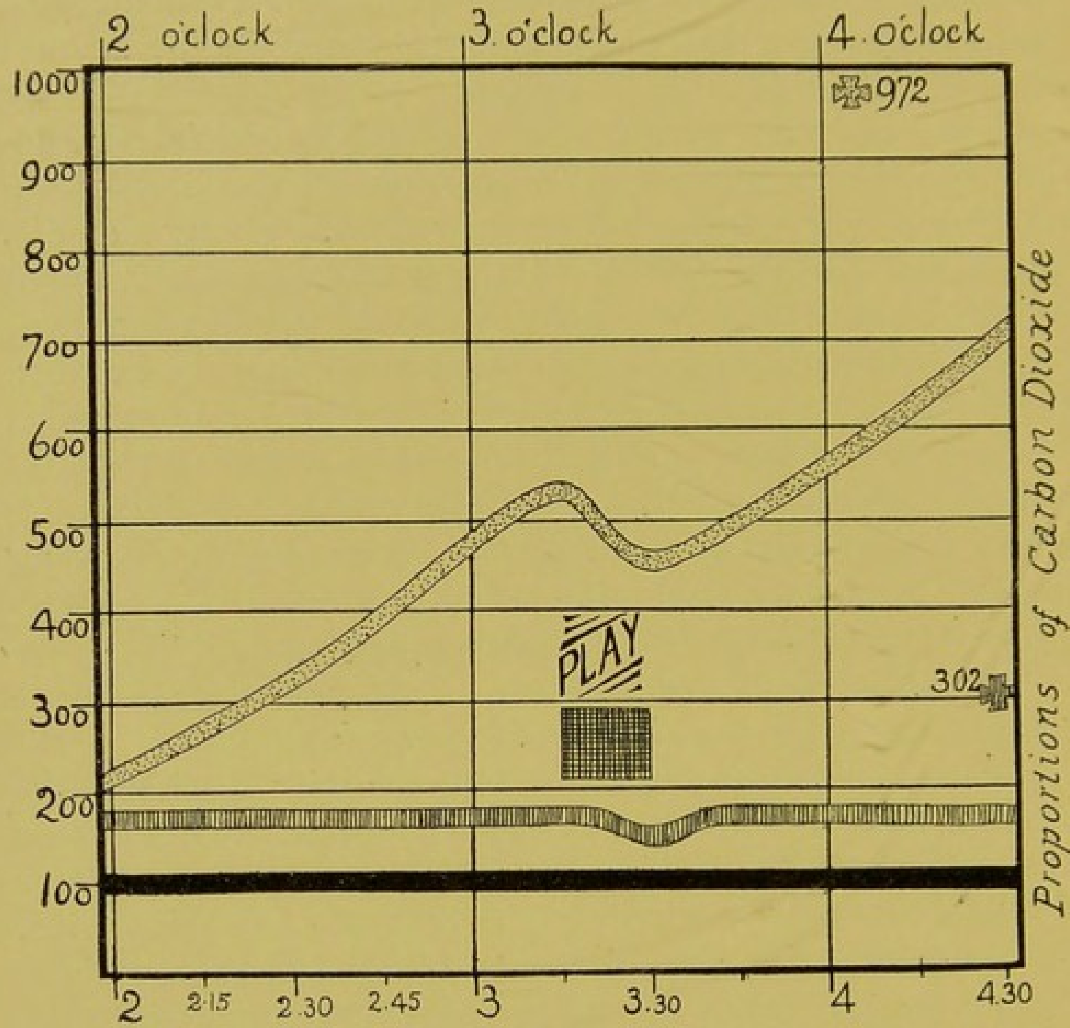


DIAGRAM TO SHOW DETERIORATION OF AIR IN SCHOOL-ROOMS DURING COURSE OF AFTERNOON SCHOOL SESSION.

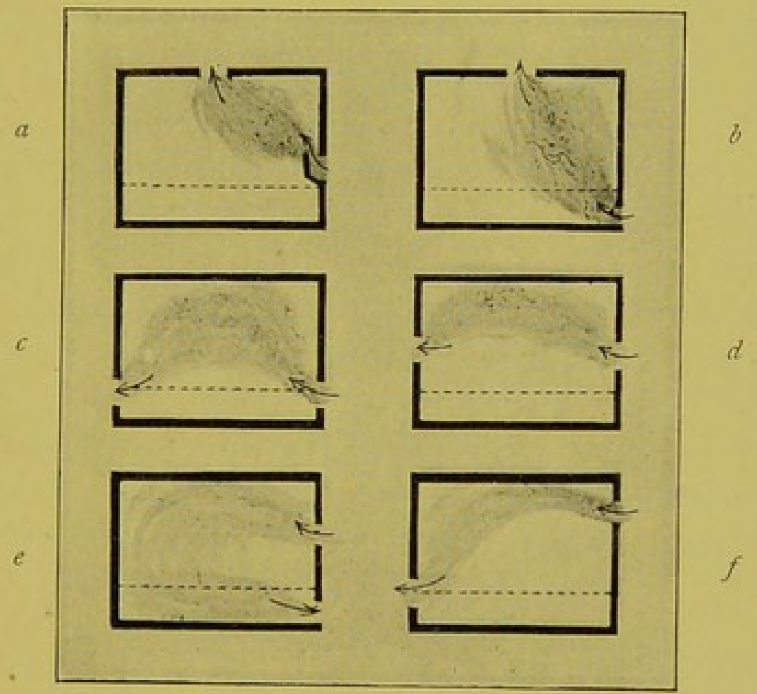
Outer air of playground—black band—taken as standard (= 100). Air in mechanically ventilated rooms shown by vertically shaded band, and in naturally ventilated rooms by dotted band. Highest single readings represented by crosses. Influence of interval for Play shown in temporary drop in CO_2 under both methods of ventilation.

NOTE.

This diagram was compiled from about 250 estimations taken at a height of 2½ feet from the floor about the middle of various class-rooms, and compared with the air taken in the playgrounds at the same time. The work was carried out in still clear weather during September, 1897, in schools under the Bradford School Board (Ninth Triennial Report). It was found after the publication of the diagram that the weather, from absence of wind and from even temperature, caused the contrast between natural and mechanical ventilation to show up strongly.

J. KERR.

throw the windows open, and so let in the outer air directly and abundantly. I would never recommend that school windows should be sealed so as to prevent temporary direct access of air in substitution for the artificially-induced currents. But windows can only be opened conveniently if the atmospheric pressure in the school is not raised by the system of ventilation in use. If inlet ventilation alone is provided artificially the air in the school-room is likely to be at a pressure equal to about



ARTIFICIAL VENTILATION.
The best arrangement of inlet and outlet is indicated by letter *e*.

a half-inch of water. And it is possible that this pressure itself partly explains the uncomfortable feeling of the air, and the instinctive desire to throw open the windows. There should be a ventilating fan both for introduction and for expulsion of the air, and the exits should be as large as the inlets. Plenum and vacuum should be combined on the same lines, and then the windows can be safely opened. Also, it is necessary to see that each room really does get its fair share of air supply. Rooms whose ducts are led from the far end of the system may be at a disadvantage, just as in a water supply area the pressure is weakest at the extremities. That, however, is not an insuperable difficulty in the hands of a competent engineer. Again, it is necessary to see that short-circuiting between inlet and outlet does not take place in the class-rooms. The best position for inlets and outlets was a subject of investigation in America, with results shown in the preceding plate. It will be observed that when the inlet is near the ceiling, and the outlet near the floor, the change of air is the most thorough.

"These little ones."

In conclusion, I wish to inculcate the very serious duty which we have to perform to little children in all matters of school hygiene. Their helplessness appeals to humanity. Scripture commands us to take heed not to offend these little ones. If parents, for their own convenience, send their children too early to school, they offend the little ones by depriving them too soon of their free and irresponsible child-life, by imposing on them a burden of steady duty, and by putting them in danger of attack by infectious disease. If, for self-glorification, a father enforces home work beyond what a child can properly overtake, so as to see it carry off prizes at the end of the school year, then he is directly and very seriously offending the little one. The intellect, precociously forced, will end by being stunted, and the whole life may be blighted. If an educational course is ill-devised, and unsuitable either for the proper development of the mind, or for aid in after-life, the authorities responsible for the course are offending the little ones. If teachers are careless in their duty of properly ventilating their class-rooms, or if they drive the children too hard in their lessons, or if they have insufficient regard for differences of strength and capacity, they also are offending the little ones. And if school boards, to save the rates, build ill-ventilated schools, or fail to ensure their cleanliness, or do not prevent overcrowding, they, too, are offending the little ones. The sin is thoughtlessly committed, but is none the less serious in its results. Let every man in his own sphere, whether as parent, teacher, health officer, school manager, or ratepayer, see that he is in no way guilty of this crime against those who are at present the offspring, but will by-and-by be the parents of the world's population.

APPENDIX. (*See* p. 141.)

PRECAUTIONS AGAINST THE SPREAD OF MEASLES.

A dangerous disease.—Measles is popularly looked upon as a trifling disease. That is a very serious mistake. Nowadays far more children die from Measles than from Scarlet Fever. It is especially dangerous to very young children, and the longer the disease can be warded off in childhood the greater are the chances of recovery.

Its early intimation.—Its notification is not compulsory, but in the interests of infected families, and of the public generally, it is very important that the earliest possible intimation of its existence should be made through the Sanitary Inspectors.

Its symptoms.—To make early intimation practicable early recognition of the disease is necessary. It begins with the signs of a bad cold in the head—a hard cough, running at the nose, sneezing, and tender and watery eyes. The rash appears first on the face and spreads from it to other parts of the body. It consists of red blotches, and the face looks swollen. It seldom appears until three or four days after the first catarrhal symptoms, yet the disease is very infectious from the beginning. Measles is indeed among the most infectious of all diseases.

Isolation of cases.—Wherever therefore its invasion appears likely, parents and teachers should be on the outlook for the first manifestations of Measles, and whenever a child is attacked by what appears to be a cold in the head it should at once be isolated and all precautions taken against spread of infection. Mild and severe cases are equally infectious. A medical man should be sent for in every case, because it is often a fatal blunder to regard the disease as not dangerous. The only safe place for the child is in bed, where it should be kept warm, as most of the deaths are due to chest complications developing from the supposed "cold." At the same time, as noted below, the room should be reasonably ventilated. Isolation should be maintained for at least a fortnight from the appearance of the rash, and the child should not return to school for at least another week. Complications may readily extend these periods.

The sick room.—The patient should have a room to himself, and whoever is in attendance on him should avoid mixing with the rest of the household. Unnecessary articles of furniture should be removed from the sick room, and a fire should be kept burning.

both to warm the air and to promote ventilation. The windows should be kept a little open at the top, but the bed should be out of reach of a draught.

The patient should have his own cups, plates, glasses, spoons, knives, forks, etc., which should be kept in the room and washed there.

Disinfection.—All bed and body linen, handkerchiefs, pinafores, and other such articles should be disinfected before being removed from the sick room. They may be disinfected either by steeping in a solution provided for the purpose, or by boiling in water. Discharges from the throat and nose should be received in old handkerchiefs or pieces of linen or cotton, which should afterwards be disinfected as above or burned if worthless. Any person necessarily visiting the sick room should cover his clothing with a loose coat and should avoid contact with the patient and the bedclothes and should wash his hands before leaving the room.

Cleansing.—After the patient has recovered, the whole house and its contents should be thoroughly cleaned—floor, walls, woodwork, furniture, bed and body clothing. Soap and water should be abundantly used. The house should also be well aired by opening the windows.

LECTURE VII

THE PREVENTION OF SCARLET FEVER

SCARLET fever is one of the commonest infectious diseases of childhood, and it has received an immense amount of attention from sanitary authorities and their officers. Indeed, in proportion to its importance, it has probably been the subject of a greater amount of preventive work than any other malady of any kind. The reason, no doubt, is that when modern sanitary organisation began to be active thirty or forty years ago scarlet fever was a disease which made quite a considerable contribution to the total mortality of the country. Yet it is not nearly so infectious as measles. Murchison estimated that less than one-half of the children born are attacked by scarlet fever, and more modern estimates make the proportion even less, but it must be borne in mind that many children die before reaching the age when the disease most prevails.

Age Incidence.

More persons *die* of scarlet fever in the third year of life than in any other year, but susceptibility to *attack* appears to increase from birth up to the fifth year, and then to diminish. Of 1000 cases of the disease, Murchison found that 67 occurred under one year, 141 between one and two years, 160 between two and three years, 151 between three and four years, and 119 between four and five years. Then between five and ten years the cases were 259, and between ten and fifteen years 58. About 95½ per cent., therefore, of all the cases were under the age of fifteen years.

The season of the year at which scarlet fever is most prevalent differs in different parts of the world. In England the maximum is in October, and the minimum in March and April, but the difference is not so striking as in some other infectious diseases. In New York the maximum is in April and the minimum in September. In Berlin, as in England, September to November is the worst period.

Season.

Investigation is busy with the microbic cause of scarlet fever, but no certainty has yet been reached. It is even disputed whether the responsible organism is a streptococcus or a protozoon. Dr. Mervyn Gordon's bacteriological investigation on behalf of the English Local Government Board has led him to conclusions which are thus summarised by Mr. W. H. Power in the board's *Thirtieth Report*:

Bacteriology.

'Dr. Gordon infers, as a result of these and further parallel observations, that the graver manifestations are due not to a single but to a twofold agency; that the infectious malady scarlatina is to be referred to Streptococcus scarlatinae, whereas the dangerous phases of this disease, and especially its fatal tendency, frequently result from supplementary invasion of the blood and tissues of the patient by Streptococcus pyogenes. Thus he ascertained that Streptococcus scarlatinae is the micro-organism which is uniformly present and predominant in the mucous secretion of the tonsil of ordinary milk scarlatina; that in the nasal discharge of the disease this micro-organism is exceptionally, and in the ear discharge only rarely, to be detected; and that in the blood and organs of fatal cases, where its presence in abundance might have been anticipated, Streptococcus scarlatinae is by no means universally found. On the other hand, Streptococcus pyogenes was found by him to be seldom absent from scarlatina at any stage of the disease. Frequently it was present, in association with Streptococcus scarlatinae, in the tonsillar mucus of even uncomplicated benign cases at a very early stage of their attack; and in the nasal and aural discharges of the disease it abounded, to the exclusion almost of other micro-organisms. Finally, in the blood and organs of fatal scarlatina Dr. Gordon found Streptococcus pyogenes commonly present—in circumstances, indeed, and under conditions, in the majority of cases, highly suggestive that death had resulted by the agency, not of Streptococcus scarlatinae, but of this and other septicaemic micro-organisms.'

The throat is the chief seat of the Streptococcus scarlatinae. Dr. Class, of Chicago, and others, hold that scarlatina is due, not to a streptococcus, but to a microbe resembling a large gonococcus.

Infection.

Though the poison of scarlet fever is probably drawn in with the inspired air, it does not enter the system through the respiratory tract, but rather by the pharynx and tonsils which belong to the digestive tract. In all likelihood it is through the same doorway that the infection is introduced by milk. In the individual, infection is ordinarily regarded as residing in the throat and nasal passages and in the skin. It may be conveyed either directly from the patient, or mediately, especially by body-clothing and bedding, and even by letters or other articles transmitted to a distance.

Whilst measles is most infectious in its early catarrhal stage before the rash appears, scarlet fever infectivity is greatest when the body temperature is at its maximum. There is no period of mere suspicion as at the beginning of an attack of measles. Scarlet fever also differs from measles in the greater persistence of infectivity in the patient, measles being most active, but evanescent, whilst scarlet fever is less active, but retains its power much longer. In scarlet fever the patient may continue infectious for several months, and, though the time varies greatly, very few cases can be regarded as free from infection in less than five or six weeks. In adults the duration of infectivity is often shorter than in children. Again, in measles infection does not hang about a house or about articles in it after the patient has recovered and the house is cleansed, whilst in scarlet fever, unless after the most thorough disinfection, and sometimes even in spite of such disinfection, the disease may crop up again after an interval of many months. A while ago, in Dunbartonshire, a case was removed to hospital immediately after notification. Disinfection was supposed to be complete, the child's bedroom and the passage and stair leading to it having all been thoroughly purified. But eight months later two children staying in the house on a visit were attacked by scarlet fever, and it turned out on enquiry that a sitting-room carpet on which the child originally infected had vomited before going to bed had been overlooked in the disinfection, and had been lifted and beaten in the presence of the visiting children.

A Milk Epidemic.

Like measles, scarlet fever is not carried by water, but unlike measles, its infection is very frequently conveyed by milk. Milk epidemics are so numerous, and have been so frequently reported, that it is needless to dilate on them, and I shall give only one illustration of their occurrence.

The little town of Bridge of Allan, in Stirlingshire, has a population of about 3300, and is a favourite health resort. On Saturday, 7th December, 1901, six notifications of scarlet fever in Bridge of Allan were received, on Sunday two more, and on Monday eight more. The ages of the first twelve cases were as follow: Twenty-six, fourteen, five, seventeen, fifty-five, fifteen, three, thirteen, four, seventeen, twenty-eight, and four years. This list of ages excluded school attendance as the cause of spread of infection. The sudden or explosive nature of the outbreak entirely corresponded with what is known of milk-conveyed disease, and it was found that every one of the families received milk from one dairy. Six got some milk also from other dairies, but only the single source was common to all; and with regard to one of the families receiving other milk there was the notable fact that only two members of it were so circumstanced as to use the suspected milk, and that both of these were among the list of cases, while the other members of the family were free from the disease. On visiting the dairy I examined the members of the household, and found that the dairymaid had been suffering from sore throat. She was a girl aged eighteen, who had come to the dairy only on 2nd December from a village in eastern Stirlingshire, in which there had been considerable prevalence of scarlet fever for some time previously. Her illness had begun with sore throat and headache on 25th November, and these had been so severe as to make her go to bed for part of 26th November. She stated, however, that no rash had been observed, but that there had been a case of scarlet fever on the other side of the street from where she lived, though she had not visited at the infected house. In view of all the facts I had no hesitation in causing the milk supply to be discontinued, and getting the dairymaid removed to hospital. I had already explained to the local health committee that though the milk sale was now discontinued cases would occur for several days, the incubation period being from two to four days; but that by the end of the week there should be no more notifications, so far as direct infection through the milk was concerned, though no doubt secondary cases might occur. The dairymaid's case, which was also formally notified on the 9th, made nine cases for that day. On the 10th there were seven notifications, on the 11th five, on the 12th four, on the 13th ten, on the 14th four, on the 16th one, on the 18th one (this being secondary to two others in the same family), and on the 21st one (this being secondary to four others in the same family). The single pertinent fact common to these cases was that they received milk from the suspected dairy. The residences, occupations, and ages were very diverse. The great majority of the cases were very mild, and that also is a characteristic of milk epidemics. Among the forty-six, however, there were several very severe attacks. The cases directly due to milk infection were forty-three. In addition there was the dairymaid's case, and the total secondary cases ultimately amounted to ten, so that the epidemic consisted of fifty-four cases. On visiting the village whence the dairymaid had come I found that she had not been living in her mother's house there, but with a sister who was in service.

In the house of the mother there was a case of scarlet fever, and the dairymaid had evidently called repeatedly, even on the morning before going to Bridge of Allan. In presence of her own sore throat and other symptoms I did not regard these visits as responsible for mediate spread of the disease in Bridge of Allan, my conclusion being that the girl had directly infected the milk through having the disease herself, though only in a very mild form. Some of the cases were so mild that there was a disposition on the part of the persons notified to deny that they were suffering from scarlet fever, and in one family where two adults, husband and wife, were notified, their refusal to regard themselves as infected, which was not without medical support, was followed by infection and very serious illness of their only child. This child had an attack of post-scarlatinal inflammation of the kidneys which might easily have proved fatal. Fully one-half of the cases were removed to hospital, but many of the houses in Bridge of Allan are commodious, and have convenience for isolation of infectious disease, so that it was possible to allow a large minority to remain at home under proper precautions as to isolation and nursing.

Cow Scarlatina.

Weighty evidence has been led that cows suffer from a streptococcal disease of the teats, which may by means of milk set up scarlet fever in the human subject. The only experience I have had of this sort was in a country district of Stirlingshire in 1900. Notification of a case of scarlet fever was received on 2nd January, and the report showed that the eruption had appeared on 30th December. Up till 3rd January ten notifications were made, all from families getting milk from the same source. I visited on the following day, with the medical attendant and the county veterinary surgeon. Investigation on the usual lines was sufficient to exclude school attendance and other similar facts as causes of the disease. A careful examination of all the members of the household, and of all persons in any way connected with the milk sale, gave absolutely no indication of scarlet fever, nor could detailed enquiry as to visitors, etc., suggest any human source of infection. Not very far from the farm there had been a case of scarlet fever in a household quite unrelated to the dairyman's, but no connection could be traced between this case and the farm milk supply. The cows themselves, however, as the medical attendant had ascertained from the farmer, had had an eruptive disease of the teats, apparently such as was described in connection with certain previous outbreaks of scarlet fever in England, and one outbreak in Glasgow. Unfortunately, the existence of this condition of the cows' teats in the Stirlingshire outbreak was not heard of early enough to enable any proper bacteriological enquiry to be instituted. The outbreak, however, being of special interest, I arranged with Dr. Chalmers, medical officer for Glasgow, and Dr. R. M. Buchanan to visit with me next day, 5th January, by which date other three cases were known of, though, of course, the milk sale had now been discontinued. An attempt was made to obtain from the teats and udders satisfactory material for bacteriological examination, but without success. The products of ordinary inflammation and suppuration were so abundant as to make quite impossible any cultivation of any specific organism which might have existed. I asked Dr. Chalmers, who has had exceptional experience in the investigation of milk epidemics of scarlet fever, to re-examine the household and revise the enquiries I had already made as to human sources of infection. He was good enough to do so, but without success in eliciting any such origin of the disease. The milk sale was resumed when the veterinary surgeon was able to certify that the disease on the teats and udders had ceased. I regret that investigation of the matter at an earlier stage was not possible; but that must often be the case where similar suspicion arises, and the facts, such as they are, appeared worth making a note of.

It may be remarked in passing that independently of a well-defined disease like scarlet fever, there may result from the drinking of milk from cows with ulcerated teats, inflamed tonsils with a whitish exudation, accompanied by distinct febrile attack, and occasionally by convulsive seizures or delirium. The symptoms usually pass off in two or three days. Streptococci have been found abundantly in such cases. The immense importance of a healthy condition of the throat and tonsils in children must always be borne in mind. If they are soft and spongey they are the gateway by which various infections may enter the body. If firm and healthy they are a closed door by which these are excluded.

Sporadic Scarlet Fever.

The health officer is often struck by a fact to which Hirsch calls attention, namely, the frequency of sporadic or occasional cases of scarlet fever which do not end in any local or general outbreak. In measles it is rare to hear of a single case without hearing of an epidemic. In scarlet fever, on the other hand, cases may be dotted irregularly all through a year and all over a locality without any serious or definite prevalence. It seems reasonable to suppose that there must be some important difference in the character or quality of the scarlet fever micro-organism or micro-organisms, or in their symbiotic action, to account for the very striking difference of infectivity exhibited by the disease at different times, and perhaps by-and-by bacteriology will be able to explain what is at present so puzzling.

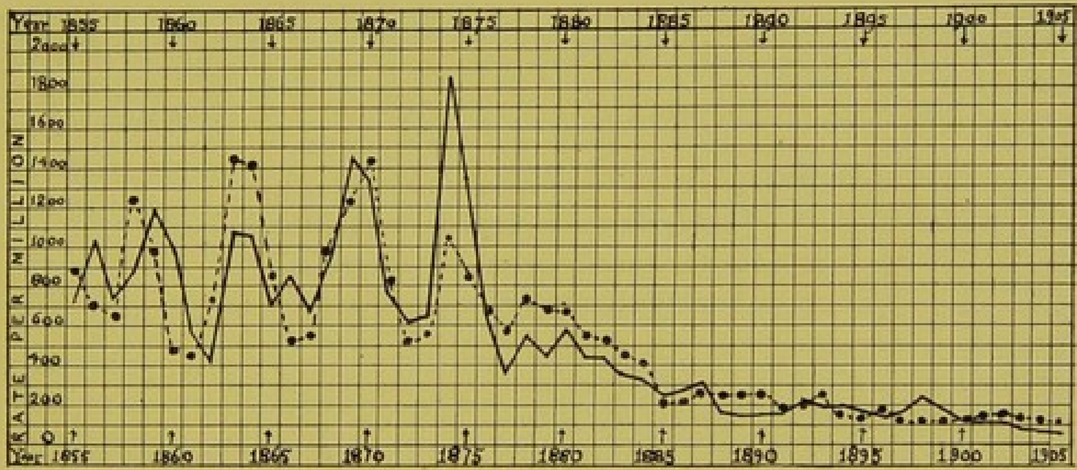
Periodicity.

Epidemics of scarlet fever do not come so frequently as those of measles. There is irregularity in both, but measles sometimes recurs after only two or three years' absence, whilst in scarlet fever the intervals are often four to six years. There is hardly anything to call widespread or general periodicity, though in localities steadier sequence may sometimes be noticeable. In these shorter waves of scarlatinal prevalence there is no great difference in fatality of the disease, but in addition there are larger cyclical epidemics, when the disease is more virulent as well as more prevalent. As will be noted immediately, we seem for the last quarter of a century to have been passing through a period of diminishing fatality in Britain. Whether this is only a cyclical change, or whether it is partly due to improved hygienic conditions and better public health organisation, is difficult to say, though the health officer naturally tends to favour the latter hypothesis.

Diminution of Mortality.

That the mortality from scarlet fever has greatly diminished in recent years in England and Wales and in Scotland is shown in the chart. The following are the annual deaths per million of population in decades from 1861 onwards:

	1861-1870	1871-1880	1881-1890	1891-1900
England and Wales,	890	649	312	156
Scotland, - -	910	780	290	190



SCARLET FEVER—DEATH RATE PER MILLION 1855 TO 1905.
England and Wales—interrupted curve. Scotland—continuous curve.

Diminution of Fatality.

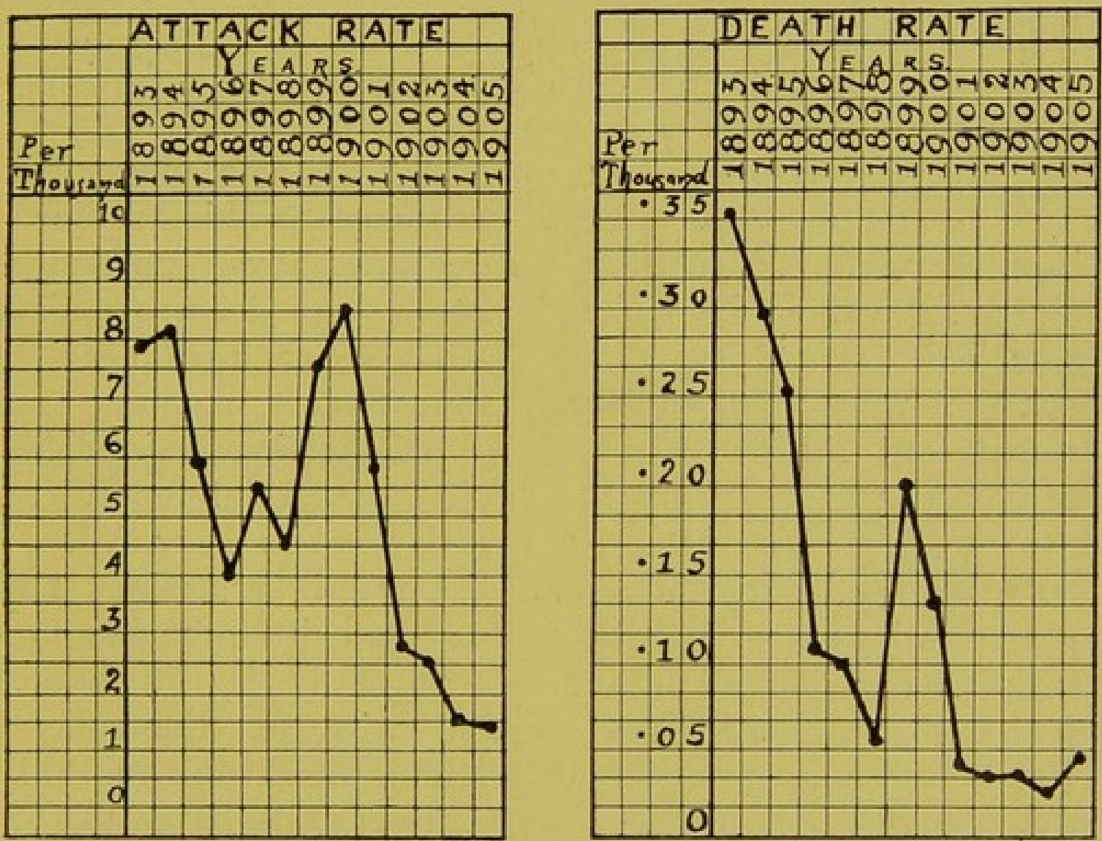
But it is not permissible to assume straightway that these figures represent diminished prevalence of the disease. There is the other possible explanation, that scarlet fever has become very much less fatal than before—that the proportion of deaths to cases has so diminished as to cause the lowering of the contribution which scarlet fever makes to the national death-rate. Investigation indicates that this is a very important factor in the case. So far as whole communities are concerned, exact facts as to prevalence of scarlet fever are available only since 1889, when local authorities were empowered, if they so agreed, to make notification of infectious diseases compulsory. The question was very fully investigated in 1897 by Dr.

J. T. Wilson, county medical officer of Lanarkshire, and he found that in the fever hospitals of London and Glasgow there had been a steady fall in fatality, the Glasgow rate having been 20 per cent. in 1866-70 and only 6.3 per cent. in 1891-94. Since that time the disease has become still milder, so that in quite recent years probably not more than two or three per cent. of cases have ended fatally.

The discussion as to whether scarlet fever has been reduced in prevalence as well as in fatality has given rise to another of a most important nature, namely, the value of isolation hospitals in the prevention of scarlet fever. In Britain isolation has in modern times been very extensively used for this disease, and until within the last ten years its worth has never been doubted. But after Dr. Wilson had raised the question, the statistics of scarlet fever prevalence of a number of large towns were collected by Dr. C. K. Millard, of Leicester, and the towns were divided into two groups according as they had or had not largely practised hospital isolation. The results of the comparison of these two groups were certainly unexpected. They do not indicate that the isolating towns have had any advantage over the non-isolating towns. The disease appears to have prevailed at least as much in the former as in the latter. Among hospital authorities and medical officers the facts have caused much discussion, and possible fallacies of conclusions from such figures as Dr. Millard collected have been well pointed out by several writers.

Hospital Isolation.

Prima facie it is most difficult to believe that hospital isolation of scarlet fever is useless. The disease is infectious, and no one doubts that where a case is treated at home the patient is best kept in a room by himself, as far away as possible from the rest of the household, and attended by a nurse similarly isolated. In this way, as we all hold, infection may often be kept from spreading. But if that be so, surely it is still better to remove the patient right out of the house into a hospital where no visitors are allowed, and where there is no communication whatever with the patient's home. In reply to this view it is urged that other agencies are brought into play in the hospital. Patients are collected together in wards containing perhaps as many as twenty beds, so that although they are isolated each from his own home, they are in the hospital not isolated but aggregated. This aggregation, it is alleged, increases infectivity, and the



SCARLET FEVER—COUNTIES OF STIRLING AND DUNBARTON, 1893 TO 1905.

patient leaves the hospital in a condition capable of spreading infection.

Now, I am not going to attempt to argue out this question of hospital influence in scarlet fever. In the areas of which I have charge it happens fortunately that the question has not arisen, because coincidently with increased provision and use of hospitals scarlet fever has diminished not merely in fatality but in prevalence. The charts show irregularity, but diminution is very notable both in attack-rates and in death-rates. For convenience the charts are of the same size, but the scale figures indicate that the fall in the death-rate is much greater than the fall in the attack-rate.

And, striking as are the figures submitted with regard to the want of effect of hospital isolation, it is particularly difficult to separate out the influence of every agency which is at work, and to believe that a patient suffering from a communicable disease like scarlet fever is not less dangerous to his household if treated in hospital than if kept at home.

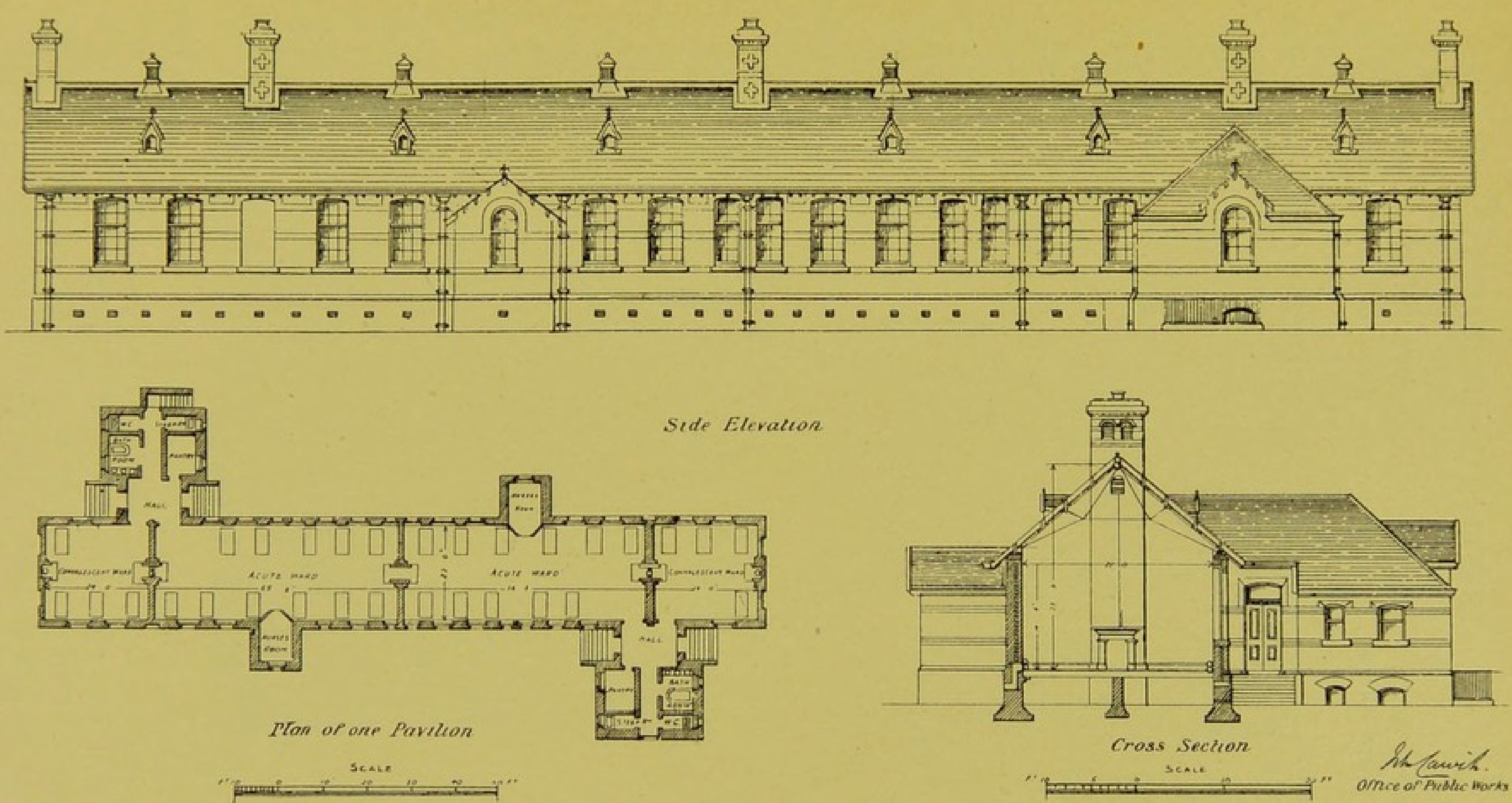
'Return Cases.'

Such facts as have been adduced, however, make it all the more important to see that in every conceivable respect hospital structure and hospital management shall be above reproach. This subject, indeed, engaged attention before these recent questions about the value of hospital isolation were debated. The so-called 'return cases' of scarlet fever have been a constant worry and anxiety in almost every hospital, and a constant theme of discussion at meetings of health officers, and have been the subject of special reports to the Metropolitan Asylums Board by Professor W. J. Simpson and Dr. Cameron. It is not surprising that parents who have reluctantly allowed a child to be taken to hospital in order to protect the rest of the family should feel indignant when, four or five days after the patient comes home, a second child develops the disease, and all the danger and anxiety and discomfort have to be encountered again.

I therefore propose briefly to direct attention to the hospital management of scarlet fever, and to the prevention of 'return' cases.

Hospital Structure.

Firstly, as to the structural arrangements of hospitals. A rule in force in Britain for hospitals for all ordinary infectious diseases is that for each bed there shall be air space of not less than 2000 cubic feet and floor space of not less than 144 square feet. Unless where land is exceptionally dear, fever pavilions are of one story, and are well separated from each other, so that there is abundance of fresh air

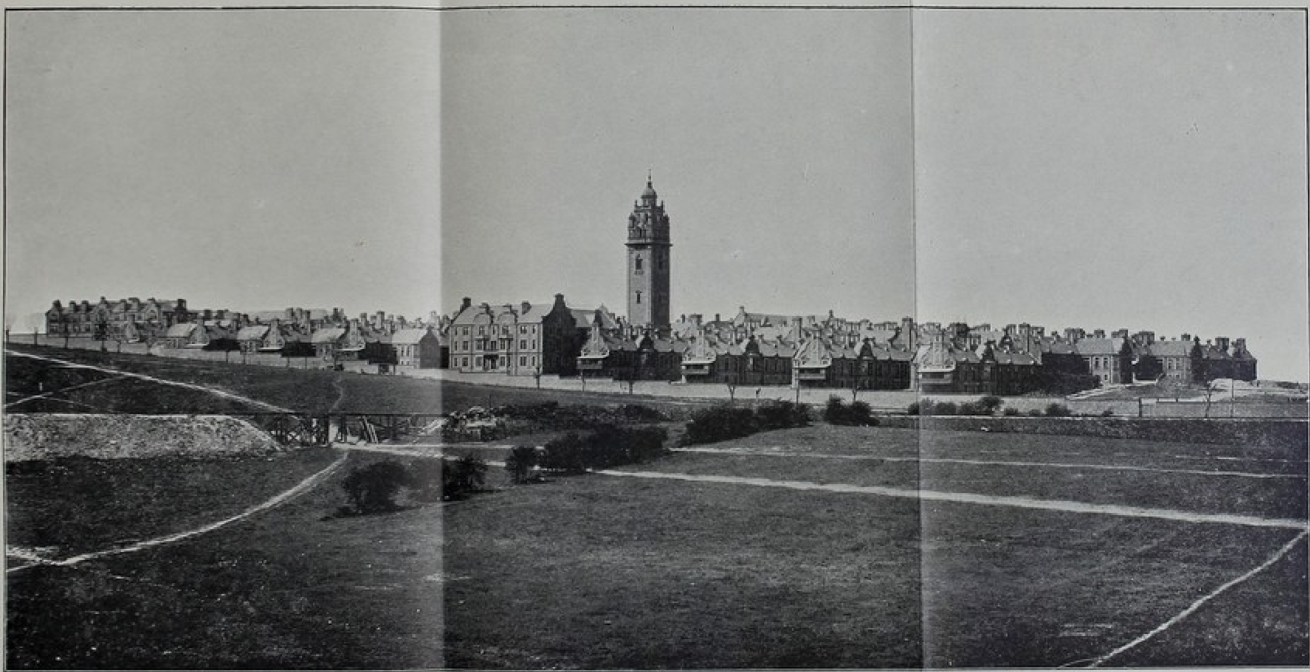


A PAVILION, CITY OF GLASGOW FEVER HOSPITAL, BELVIDERE.

around them. These details are exemplified in the accompanying plates. Ventilation may be either natural or artificial, but for fever hospitals the disadvantages of artificial ventilation are considerable. In order to meet emergencies such hospitals must always have much more accommodation than is regularly in use. Half of their beds or more are often unoccupied, and sometimes whole wards stand empty for considerable periods. But a system of artificial ventilation must be constructed to meet the maximum requirements of such hospitals, and where only one-fourth or one-fifth of the institution is in use the trouble and outlay of artificial ventilation are by no means correspondingly diminished. As I mentioned with reference to schools, my own feeling is that, notwithstanding the washing of air as a preliminary to its entrance into the wards, and all the care that is otherwise taken, nevertheless the air loses something of its freshness; and wards hermetically sealed as to walls and windows in order to suit a pressure system of plenum ventilation are apt to feel close and oppressive. On entering such a ward my own instinctive inclination always is to go and immediately throw open a window and let the fresh air rush straight in. In a fever hospital with only one patient to every 2000 cubic feet of air space, and with large windows on both sides of the wards, ventilation by natural means is usually so easy that the wards ought never to be in the least degree offensive to the senses. But I readily admit that in America, with its much greater range of temperature as between summer and winter, the problem is very different, and I do not know enough of the facts to justify me in expressing any opinion as to the practicability of natural ventilation in hospitals in the New World.

Hospital Ventilation.

Opposite windows may be used either for inlet or outlet ventilation according to the direction of the wind, and in still weather even a single window may act in both capacities, the lower part as an inlet ventilator and the upper part as an outlet. In addition ventilation is greatly



GENERAL VIEW OF RUCHILL HOSPITAL, GLASGOW.

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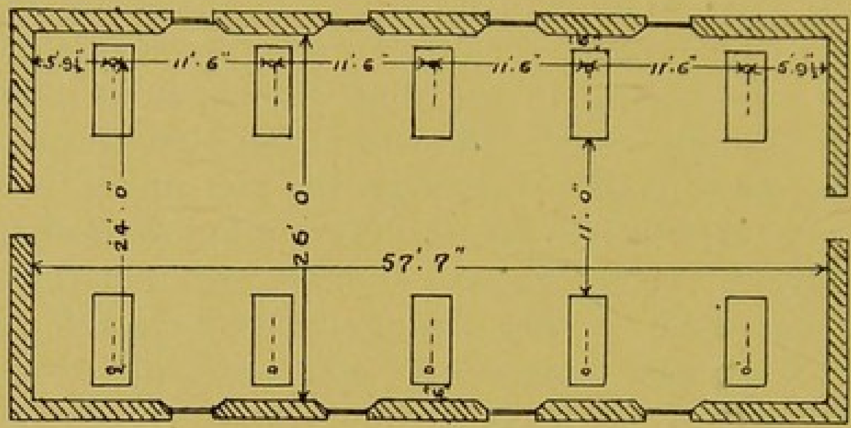
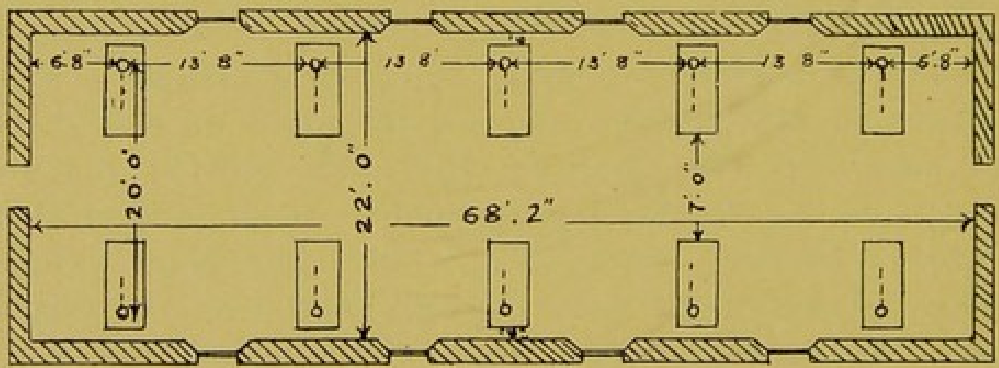
aided by such simple means as a shaft laid underneath the floors to a small chamber just behind a ward stove or fireplace where the entering air is heated by impinging upon iron flanges projecting from the back of the grate. Also, in each window space a coil of hot-water pipes is often placed, and underneath the window an inlet-grating leads to an opening in the floor immediately below the coil and directly connected with it, so that the entering air is bound to pass up through the coil on its way into the ward. Appliances for outlet ventilation through the ceiling are so numerous and well known that they need not be described. These arrangements have reference to all fever hospitals, whatever the diseases under treatment.

Width of Wards.

The width of wards in the newest hospitals is often twenty-six feet. This, I think, is a mistake. If the total cubic space remains at 2000 feet, the widening of a ward must mean at the same time either shortening it or lowering the ceiling. But the ceiling usually remains at a standard height, so that widening involves shortening. Now, the infection and the septicity of scarlet fever depend far more on the throat and nose and ears than on the skin, and in keeping patients as far apart as possible the distance should be measured between head and head. The same remark applies to diphtheria and measles, and even to typhus fever. Assuming, then, that the area per patient is 150 square feet, if you look at the ground plan of a ward 26 feet wide and of another ward 22 feet wide, the objection to the former becomes obvious. Measuring from head to head in the wider ward, a patient is only $11\frac{1}{2}$ feet distant from each of the two patients adjoining him on the same side, while he is about 24 feet from the nearest patient on the opposite side of the ward. But in the narrower ward the lateral distance from each of the two patients is $13\frac{2}{3}$ feet, and the transverse distance to the patient opposite is about twenty feet. Manifestly this is the better arrangement, the distances being more nearly equal. For administrative purposes a ward cannot be conveniently less than 22 feet wide, but the matrons and staff nurses of county hospitals who have had experience of wards of these two widths assure me that there is no advantage in the 26 feet width as compared with the 22 feet width.



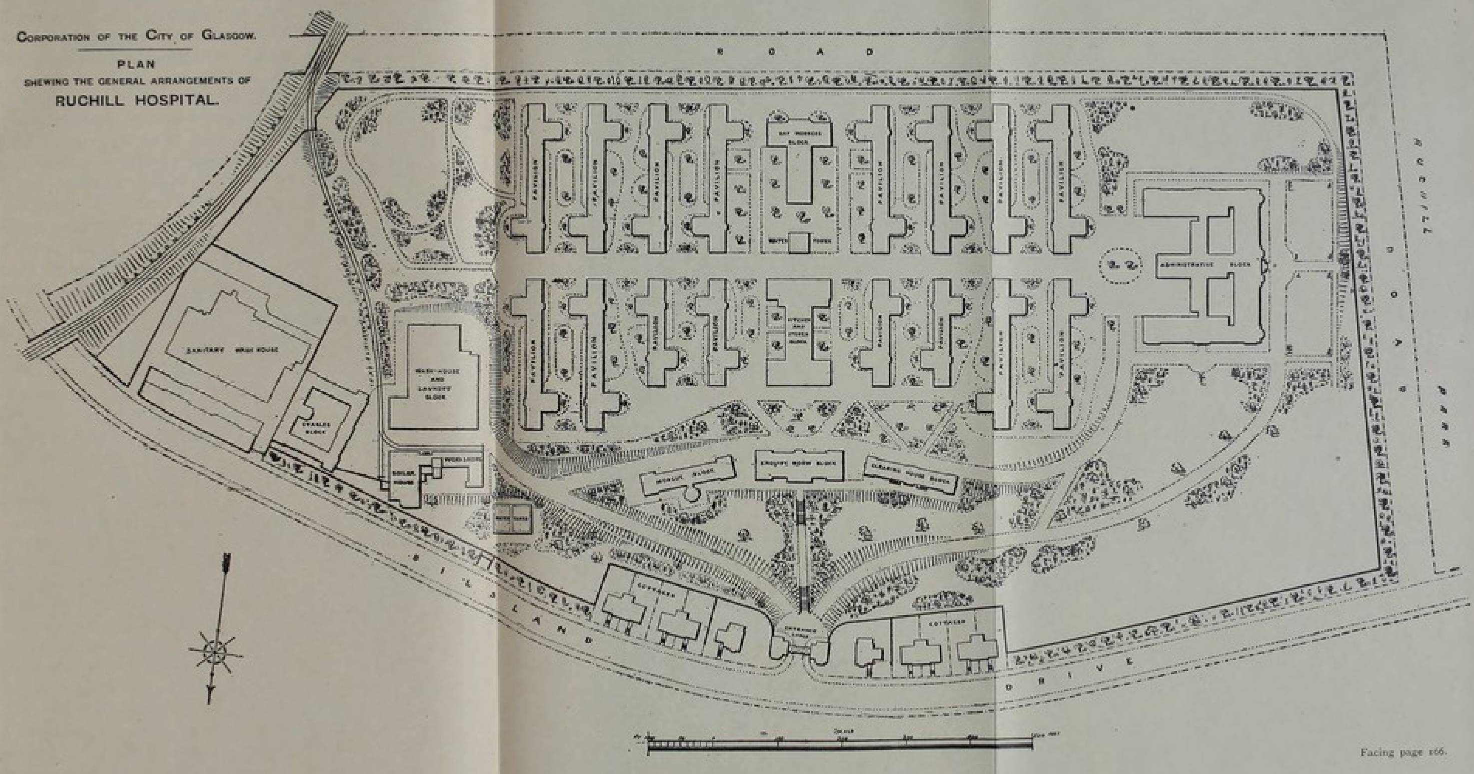
WARD 26 FEET WIDE



WARD 22 FEET WIDE

Classification of Cases.

A more important point is that hospital accommodation for scarlet fever should be arranged so as to permit complete separation of septic from clean or non-septic cases. This is of consequence as regards both the welfare of the patients in the ward and their freedom from infectivity when dis-



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charged. As already noted, the severity and fatality of scarlet fever are probably not due to the Streptococcus scarlatinae, the specific poison of the disease itself, but to the Streptococcus pyogenes, which sets up septicaemia, a condition of serious import alike in scarlatina and in other infectious diseases. Independently of sepsis, it is customary in many large hospitals to divide scarlet fever wards into acute and convalescent, the former for cases during the first three or four weeks of illness, when all are confined to bed, and the latter for those who are sufficiently recovered to be out of bed during the day. Where practicable, septic cases should be kept in neither of these wards, but entirely apart from all the rest. In small hospitals with limited accommodation for each admitted disease this sub-division is often very difficult to arrange, but an intelligent physician or matron will so utilise the wards as to overcome or minimise the difficulty. Women, and young children of both sexes, can without objection be treated in one ward; and male adult patients with scarlet fever are not very common, so that their ward may often be devoted to convalescents, any male adult being isolated in a small side ward. Or if there are only one or two septic cases, they may go to the side ward. Where there is a spare pavilion the difficulties of course are less.

Dismissal from Hospital.

After a patient has become free from every evidence of infection, after the nose and throat and ears are absolutely right, he should for a period of eight or ten days before dismissal live in a separate part of the hospital, perhaps in a cottage reserved entirely for such cases as his own. This period of quarantine is most valuable in aiding the prevention of return cases of the disease. In the act of dismissal the patient usually passes through what is now to be found in almost every hospital, namely, a discharge department. It consists of a series of three small rooms. The patient enters one of these and divests himself of the clothing he has worn during his convalescent stage in the hospital He passes next into the second room, where there is a bath, in which he is well washed before entering the third room, where his mother or some other relative is waiting with fresh clothing. From the discharge department the custom has often been for the patient to go right out of the hospital, so as to avoid all risk of mediate conveyance of infection. But this excess of precaution has been found accompanied by defects of its own. Everyone knows that at the great bathing institutions which are resorted to all over the world for the cure of rheumatism and other diseases there is in connection with each set of baths a cooling-room, where the patient rests for perhaps an hour before leaving, so that he may not be chilled by too sudden change of temperature between his bath and the outer air. Owing to a desire to get a fever patient away from hospital immediately after passing through the discharge department, this risk of catching cold has not always been borne in mind. On leaving a hospital in the country the parent and child may have to travel a long way to their home, sometimes walking, sometimes driving in an open vehicle, sometimes waiting for a train at a draughty railway station. Not very infrequently a day or two after the return of such a patient from hospital the parents observe a discharge from the nose or throat or ears, and they readily conclude that the child has been sent out before being fit for dismissal, whilst the truth is that the discharge is a new development owing to exposure on the way home. And it has been found that such discharges are sometimes infectious. After the final bath, therefore, the patient should sit for an hour or two in a warm waiting-room at the porter's lodge. In hospitals where a cottage or a convalescent ward without septic cases is provided for a stay of eight or ten days after all evidences of the disease have disappeared, the discharge department is practically unnecessary, and the final bath can quite well be taken the night before dismissal.

In dismissing cases from hospital parents should be warned to be very careful not to permit, for a week or two, close contact between the child and the rest of the family. A copy of the following leaflet is handed to parents or guardians of scarlet-fever patients dismissed from hospital in Stirlingshire and Dunbartonshire:

DISMISSAL FROM HOSPITAL AFTER SCARLET FEVER.

ADVICE TO PARENTS AND GUARDIANS.

When a child is to be dismissed from Hospital after an attack of scarlet fever, the greatest care is taken at the Hospital to see that the child is free from infection. But the aid of the parent is wanted to make assurance doubly sure. Your child is dismissed to-day. Be sure to protect it from cold on the way from the Hospital. If any discharge from the ears or nose occurs, consult a doctor at once.

For the sake of other children you are requested to give heed to the following advice:—

If practicable, let the child go to live for a fortnight at a house where there are no other children.

If you cannot avoid taking the child straight home, do not let it immediately come into close contact with your other children. Do not let the child kiss or fondle the other children of the family. Above all, do not let it sleep with another child. Maintain these precautions for a fortnight.

Let the child have a bath every night.

Let the child be taken into the open air as much as possible, but see that it is warmly clothed.

For at least two weeks after dismissal the child must not go to school or to any children's assembly.

Isolation Cubicles.

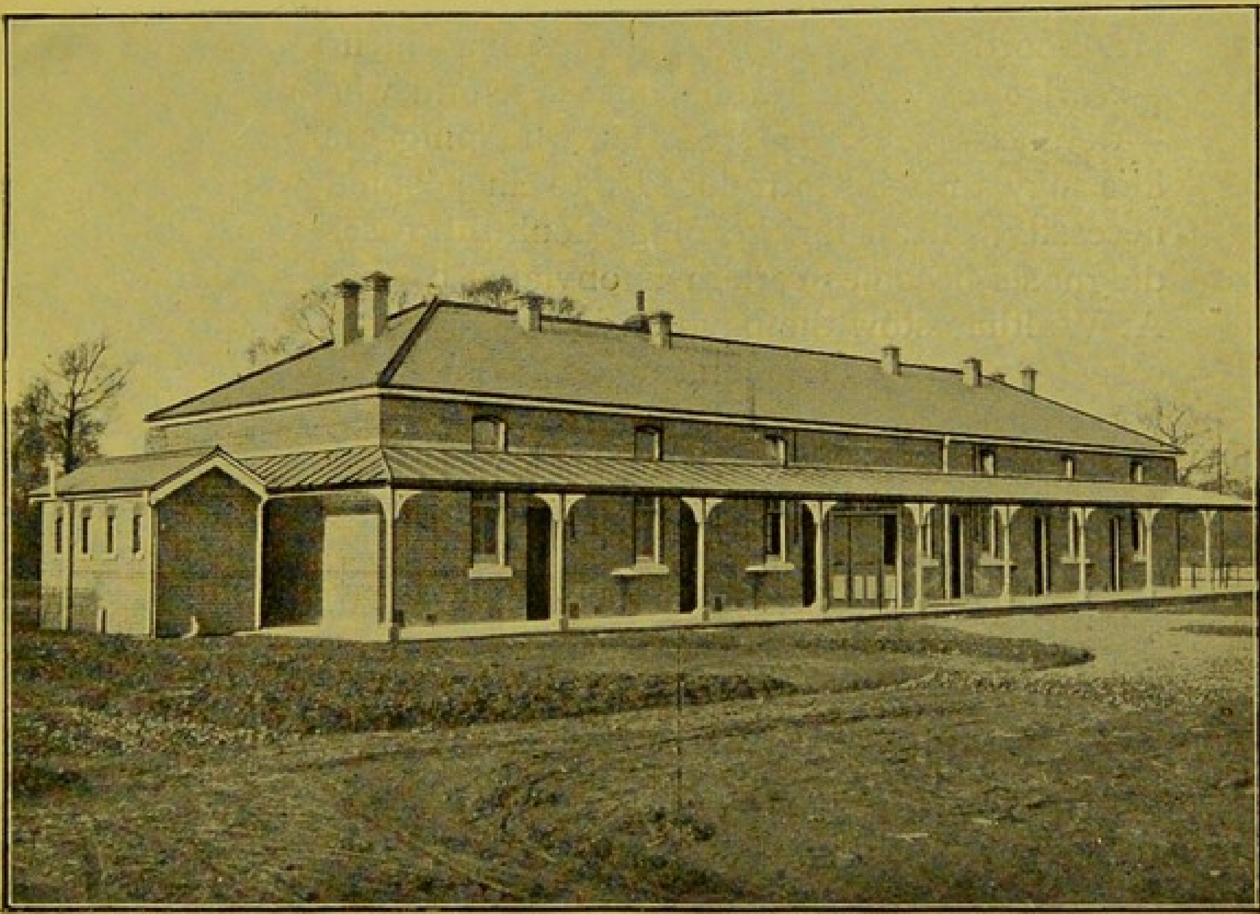
Within the last few years still more elaborate attempts have been made to prevent all the evils which have been alleged to attach to the treatment of scarlet fever patients in hospitals. These evils being assumed to be due to aggregation, the purpose has been to prevent aggregation absolutely. That could be done by construction of numerous cottages, each to hold only a single patient, but the financial and administrative objections to such a scheme are manifest. Initial cost of construction would be very great, and the number of nurses required would be multiplied several fold above the present high standard, which is, when both night and day staff are included, not less than one nurse to every five beds. To overcome this difficulty and the difficulties of 'mixed infection,' at least in some measure, a few attempts have been made to combine the hospital pavilion system with absolute separation of patient from patient. This is accomplished by means of glass partitions, reaching from floor to ceiling, throughout an ordinary fever ward, so as to give to each patient a cubicle entirely to himself. The plates show the latest, and, so far as I am aware, the best arrangement of such a pavilion.[1] It belongs to Walthamstow Hospital for Infectious Diseases, and was suggested by Dr. Clarke, the medical officer of Walthamstow, a large suburb of London. The plan shows a building on the general lines of an ordinary fever pavilion as regards width and length and height, and as regards also the existence in the same pavilion of two wards (which in small hospitals are used one for either sex) with a nurses' observation room between. But there are important differences. Down the middle of the ward is a partition of thick glass, resting on a low parapet wall and reaching to the ceiling. This separates entirely the two sides of the ward. Similar partitions run across the ward so as to separate every bed from every other bed. Each cubicle thus formed has its own door and window. The door opens directly to the open air, there being immediately outside the pavilion a paved area with a verandah roof. Each cubicle has its own electric light, and from the nurses' duty-room these lights are individually controlled, so that the furthest off cubicle can be lit and the patient seen through all the intervening glass partitions. Wash-hand basins and conveniences are erected in the verandah for patients who are able to use them, and water-closets are placed at the two ends of the pavilion opening off the verandah. Those who are entirely confined to bed are dealt with as in an ordinary ward.

Walthamstow Hospital.

Two criticisms naturally occur regarding this arrangement. One is concerned with ventilation of the cubicles. A great advantage of the ordinary ward is its cross ventilation by windows on opposite sides. This is partly obtained in these cubicles by a ventilation shaft leading

[1] The plates are from the *Municipal Journal*, Feb. 16, 1906.

from the outside under the floor and rising up against the central partition wall. This is decidedly better than nothing, but is not so satisfactory as cross ventilation by windows. The other criticism is as to convenience of nursing, and there is no doubt that an extra nurse will much oftener be required in such a pavilion than in an ordinary one. A delirious patient cannot be left for a



ISOLATION PAVILION AT WALTHAMSTOW HOSPITAL, OUTSIDE VIEW.
(*Municipal Journal*, Feb. 16th, 1906.)

moment, and unless by employing an extra staff the wants and nursing and feeding of a patient cannot be so quickly attended to. Yet the system is well worth trying. In some previous attempts the doors did not open to an outside verandah, but into a passage along the centre of the pavilion from end to end, so that the cubicles were not very effectively separated. Obviously the Walthamstow hospital is better in this respect. Obviously, also, it absolutely prevents direct communication between patients, and all direct conveyance of infection from septic to non-septic cases.

But the prevention of return cases has not been the only purpose of Walthamstow hospital, nor even its main purpose, though it is for that purpose I show it. It is primarily designed against risk of mixed infection. A child may be suffering from two, or even three, infectious diseases simultaneously. Dr. Foord Caiger records one case in which four diseases —scarlet fever, diphtheria, measles, and whooping-cough —were co-existent.[1] Measles, whooping-cough, and the like may thus be introduced into an hospital ward. The necessity, also, for keeping doubtful cases apart until diagnosis becomes certain is obviated by such a pavilion. At Walthamstow the pavilion is reserved entirely for acute cases. After the temperature falls to normal, if there are no septic conditions and no mixed infections, patients are removed into a ward where nursing can be more conveniently and more economically carried on, the partitioned ward being used only for cases newly received. For the ward to which cases are transferred the Local Government Board have sanctioned a minimum cubic space of 1500 feet per patient, thus allowing a third more cases to be treated in the ward than would be permitted in an ordinary ward under ordinary circumstances. The reason, of course, is that less cubic space suffices for patients with normal temperature. The scheme has not been sufficiently long in operation to allow of testing by results, but it will be watched with much interest.

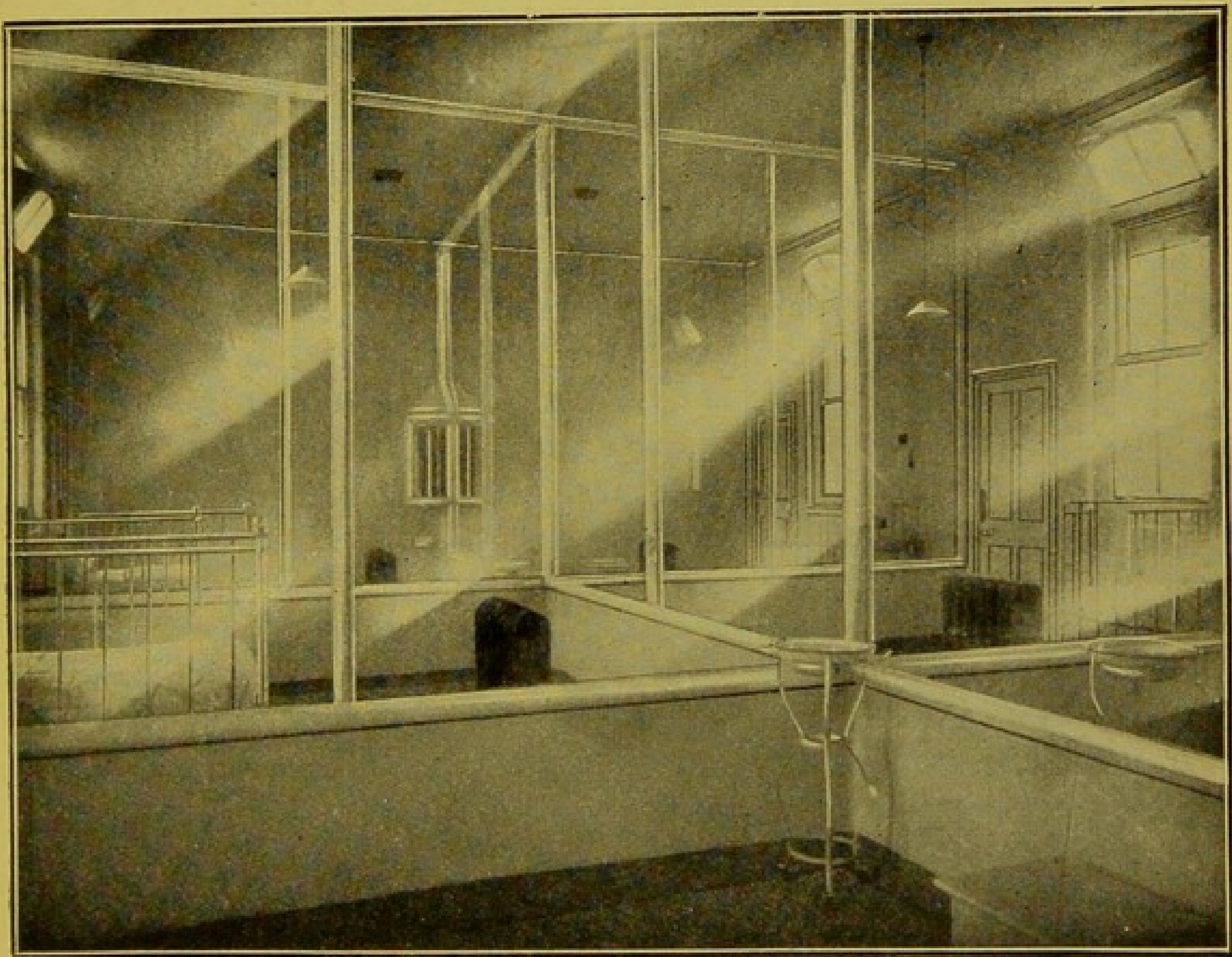
Mixed Infections.

I have already made incidental reference to the importance of the condition of the throat and nostrils and ears as the site of infectivity in scarlet fever. The opinion which long prevailed that desquamation is practically the sole source of infection is now given up. But in giving it up there has, perhaps, been too great a tendency to rush to the opposite extreme and to conclude that in no stage of the disease can infection come from the skin. It would be most unsafe

Length of stay in Hospital.

[1] Allbutt and Rolleston's *System of Medicine*, vol. ii. part i.

to act on such a supposition. In the latest stages the peeling skin is probably harmless, but in the early stages this cannot be assumed. When bacteriology is able to give more definite information we may hope to have the point settled. In the meantime any conclusion one way or the other is not absolutely necessary. Even mild cases of scarlet fever should be isolated for fully a month, and



ISOLATION PAVILION AT WALTHAMSTOW HOSPITAL, INSIDE VIEW.
(*Municipal Journal*, Feb. 16th, 1906.)

this is quite essential if the throat and its neighbourhood are in any degree involved in the disease. I watched with interest an attempt made several years ago to discharge scarlet fever cases after only a short residence of about four weeks in hospital, but the results were unsatisfactory. Return cases occurred with unusual frequency, and the experiment was abandoned.

When return cases first began to receive serious attention there was usually a rival explanatory theory. The hospital staff, naturally jealous to maintain the good name of their institution, were apt to suggest that infection had remained in the house itself, and had not come from the hospital. Quite recently the matron of one of the hospitals of which I have supervision pointed out to me that a child had been in hospital for seven weeks, and that the day before its intended dismissal a second case occurred in the same house, and that had this second case developed a few days after dismissal of the first I would have been apt to blame the one on the other. It is certainly necessary to be cautious in forming conclusions, but the fact that a house has for a period of seven or eight weeks from a child's going to hospital been incapable of infecting those remaining in it has always seemed to me to throw great doubt on its acquirement of a sudden capacity for infectivity after the return of the patient. The reply to this view, however, has sometimes been that, owing to this very return, some little change may have so occurred in the daily life of the household as to account for renewal of infection. Some articles of clothing may have been worn by the child before he was sent to hospital, been put away in a drawer or wardrobe, and not disturbed again until he came back, when a garment would be taken out once more in order to be worn. This explanation may once in a while be the true one, but usually it has no basis in fact. The cases in which it may most likely be true are those where, owing to mildness of type, the nature of the illness had not at first been known, so that there has been delay in sending the patient to hospital, and corresponding opportunity of infection of household articles.

House Disinfection.

There is in scarlet fever frequent difficulty in knowing how much to remove to hospital from an infected house, and how much to leave at home. Each case must in that matter be judged on its own merits. If the disease has been recognised at the very beginning, if the child has been put to bed, and is thence removed to hospital without delay, the number of articles and rooms and passages requiring disinfection is correspondingly limited. If, on the other hand, there has been delay, if the child has been in sitting-rooms and stairways and passages, as well as in its own bedroom, then more articles have to be taken for disinfection, and sometimes the whole house has to be treated. But with regard to acute cases recognised at the beginning, their infectivity is probably not very great during the first day or two, and this fact should have its influence in deciding what articles require disinfection. The bedroom itself should, of course, always be very thoroughly disinfected, bedding, carpets, curtains, and so forth being treated. Walls and ceiling should also be dealt with, most conveniently by spraying with a solution of formalin. Floors, woodwork, and furniture should be thoroughly cleaned, and the room should be thrown open to the fresh air.

To sum up, then, as to the prevention of return cases of scarlet fever, the important points are these:

Synopsis.

(1) Avoid overcrowding the wards. Do not imagine that because the child of a poor man may have had only 300 or 400 or 500 cubic feet of space as its share of its own bedroom at home it can safely have any such small space in hospital during the acute stage of the disease. The hospital atmosphere, with aggregation of acute cases, is probably in a more dangerous condition than the home atmosphere.

(2) Keep septic cases apart from all others. Allow no 'clean' case to be in the ward with patients who have discharging throat or nose or ears. Aural discharge appears, however, to be less dangerous than the others.

(3) Keep acute cases separate from convalescents. An acute case is one requiring confinement to bed. Transfer to another ward children who are well enough to be allowed out of bed during the day.

(4) In small hospitals, where such complete separation is not practicable owing to want of accommodation, use sun-rooms for convalescents, and make use of existing

accommodation in the manner which will most nearly carry out the principles already stated.

(5) Treat carefully and thoroughly all septic cases, and make it a rule not to send them out until all suppurations have been cured.

(6) Use the hospital's discharge department with discretion. Do not send out a patient immediately after a warm bath.

(7) Give parents and guardians clear instructions as to precautions from the moment of dismissal—the avoidance of exposure of the child to cold on the way home, the keeping of the child apart from others for a few days, the prohibition of kissing and fondling, the use of a separate bed, or even the sending of the child to a grand-parent in the country.

(8) With all such precautions, do not be surprised if, once in a while, a return case does occur. Some outgoing patients apparently retain infectivity for an exceptionally long time, notwithstanding all efforts to the contrary.

A print such as the following (slightly altered from one prepared by the late Dr. Russell, of Glasgow) is useful in informing parents and guardians as to precautions to be used in cases of scarlet fever.

County Councils of Stirlingshire and Dunbartonshire.

PRECAUTIONS TO BE USED FOR PREVENTING THE SPREAD OF SCARLET FEVER.

The District Committee hope that parents and others will read this Paper carefully, and adopt the instructions which it contains, and any others given by the Medical Attendant having the same end in view.

Notification.—When a case is recognised as Scarlet Fever, it must forthwith be reported to the Medical Officer of Health, and each fresh case occurring in the same household must also be reported.

Scarlet Fever is a very infectious and a dangerous disease. A mild case is infectious in the same way as a severe one, and Scarlet Fever is never so mild that it may not in the long run prove dangerous to life or even fatal. Especially it is apt to be followed by kidney disease, sometimes acute and quickly dangerous or fatal, at other times slow and insidious in course. Want of care in mild cases is a common cause of such untoward events.

One case of Scarlet Fever is always derived from some other. It is therefore the duty of parents or other persons in charge of a case to remember that they are responsible for a disease which tends to spread, and to adopt such precautions as will prevent it from doing so. These are all embraced in the words Isolation or Separation, and Disinfection.

ISOLATION.

Isolation.—Isolation means the separation of the sick from the neighbourhood of every person not necessary for proper nursing and treatment. This may be done in two ways.

By sending the patient to a Hospital, which, as a rule, is the only perfect way. Further, this allows the other children in the house to attend school, and, after the disinfection of the house, etc., prevents the need for the various measures detailed below.

By keeping the patient at home, and cutting off all communication with the healthy. This is always difficult, and often impossible, to carry out. Moreover, all precautions have to be persevered in for a period of six to eight weeks, as the infection usually lasts that time. The chief points are as follow :—

House Arrangements.

1. Send the children who are well out of the house. At least keep them out of the sick room.
2. When a choice is possible, the room selected should be at the top of the house, large, well-ventilated, and have a fire burning. *Never choose the kitchen, as it is the centre of the house, and disease there cannot be separated.*
3. Remove carpets, curtains, haircloth chairs or sofas, and every unnecessary piece of furniture. Iron bedsteads, hair, or still better, straw mattresses, and kitchen chairs, in short, all articles which will not easily take in infection, and which can be easily disinfected, are to be preferred.
4. The room must be occupied only by the patient and the person nursing, and never entered by any one unnecessarily. All children in the house must be excluded from school. No person nursing a child in Scarlet Fever should go shopping or visiting. The gown or outer garment should be a washing print, and winceys or other stuff dresses should not be worn. Women especially should avoid neighbours' houses where Scarlet Fever is, particularly during convalescence. Much mischief is done by parents gossiping in each others' houses, or even making sympathetic visits, in such circumstances.
5. Lying-in women are extremely ready to take Scarlet Fever, and generally die when they do take it. Therefore, when-

ever Scarlet Fever appears in a house where a woman is about to be, or has recently been, confined, the case should be sent to Hospital, or the woman removed elsewhere. Midwives ought to avoid all contact with this Fever.

DISINFECTION.

Disinfection.—The body, and everything about and discharged from the body of a person infected with Scarlet Fever, is infected, and therefore capable of imparting the disease to other persons. Disinfection includes all methods by which the infected matter or material can be deprived of infecting power.

Cleanliness.—Cleanliness throughout all the holes and corners of the house, below the furniture as well as in the middle of the floor, in all the folds of the bedding as well as in the coverlet, is the first and essential step towards disinfection. All the dust swept up or rubbed down should be placed in the heart of the fire, and so burned, not thrown among the ashes, nor sent to the ashpit.

Ventilation.—Fresh air is by far the best disinfectant, and is best supplied by leaving the window a little way open at the top, and keeping a bright fire burning. There is no danger of cold draughts if this is done constantly, but there is danger if now and then, or only when the Doctor or Inspector calls, the window is drawn down, and a rush of cold air admitted to the overheated room. Proper ventilation will invariably promote the recovery of the patient besides preventing the spread of the infection. To aid in preventing the infected air of the room finding its way into the rest of the house, a sheet, completely covering the door, should be hung in the doorway and kept wet with a solution (half a tumbler to the gallon) of Jeyes' fluid or carbolic acid. Put no faith in spraying the atmosphere of the room with toilet vinegar, nor in placing about the room saucers of chloride of lime, solutions of permanganate of potash, etc.

Light.—Light is necessary to thorough cleanliness and ventilation. Sunlight is one of the best purifiers, and should be admitted as freely to the sick room as the comfort of the patient will permit.

Disinfection during Sickness.—The poison lies chiefly in the breath and material from the throat and nostrils, and in the scales from the skin.

As the discharges from the mouth and nose are very infectious, separate bits of rag should be used instead of handkerchiefs, and each bit burned as it is used.

One set of eating utensils—cups, plates, spoons, etc.—should be kept for the use of the patient, and should be washed in the sick room, the washings being disinfected before removal.

Peeling of the Skin.—The dead skin comes off partly in flakes, but partly also as dust, which flies everywhere and clings to everything. To prevent this, so soon as the redness begins to disappear, rub the whole surface of the body over with camphorated or carbolic oil, or any other agreeable and convenient oil or fat. Do so every night, and so soon as the medical attendant sanctions it, give a warm bath, washing the whole body with carbolic or Jeyes' soap, and taking special care to rid the hair of all particles. A succession of such baths, followed by oiling, until the whole skin is removed, will prevent the infectious dust from flying about, and in the end will disinfect the patient's body. The scalp and soles of the feet usually demand attention longer than any other parts of the body.

Put chloride of lime or Jeyes' fluid (a tablespoonful) or "crude" carbolic acid into the vessels used for the discharges, including any spittoons, etc. Even after disinfection, the slops should not be emptied into a sink.

Prepare a steep in a tub containing a wineglassful of clear carbolic acid, or of Jeyes' fluid, to each gallon of water, and put all bed and body clothes removed from the patient therein until washed. They should afterwards be well boiled. The washing must on no account be done in a wash-house used by other families.

Disinfection after Recovery or Death.—After the last bath, when recovery is perfect, a fresh suit of clothes from the skin out should be put on by the patient, and also by the nurse; and disinfection of the apartment, bedding, and other infected articles should forthwith be carried out. It is impossible to give instructions which unskilled persons can follow as to disinfection of rooms, etc., etc. The services of the Health Department for the Counties of Stirling and Dunbarton are at the disposal of all classes within the several districts. The Central Office of the Department is at 24 George Square, Glasgow, and there are also Offices at Stirling, Falkirk, Blanefield, and Alexandria.

In case of death, the body should be interred with the least possible delay.

LECTURE VIII

THE PREVENTION OF DIPHTHERIA[1]

THE registered death-rate from diphtheria per million persons living in England and Wales during the last four decades—from 1861 to 1900—is apt to suggest that sanitation has been as powerless to prevent that disease as to prevent measles. The figures are:

1861-1870	1871-1880	1881-1890	1891-1900
171	112	153	263

Among every million inhabitants in the last decennium no less than 263 deaths were registered annually as due to diphtheria, as contrasted with 112, or less than a half, twenty years earlier. But in dealing with death-rates it is not sufficient to reckon with the figures alone. Disease nomenclature alters with increasing knowledge, and this has been very specially the case with regard to diphtheria. Much that is now recognised as diphtheria was formerly called croup, and to ascertain more nearly the real tendency of the malady it is necessary to learn how croup has fared as a registered cause of death. The following are its figures for the same decades:

1861-1870	1871-1880	1881-1890	1891-1900
219	149	133	51

In croup there has been a rapid and steady diminution, from 219 in the first decade to 51 in the last. If, then, we

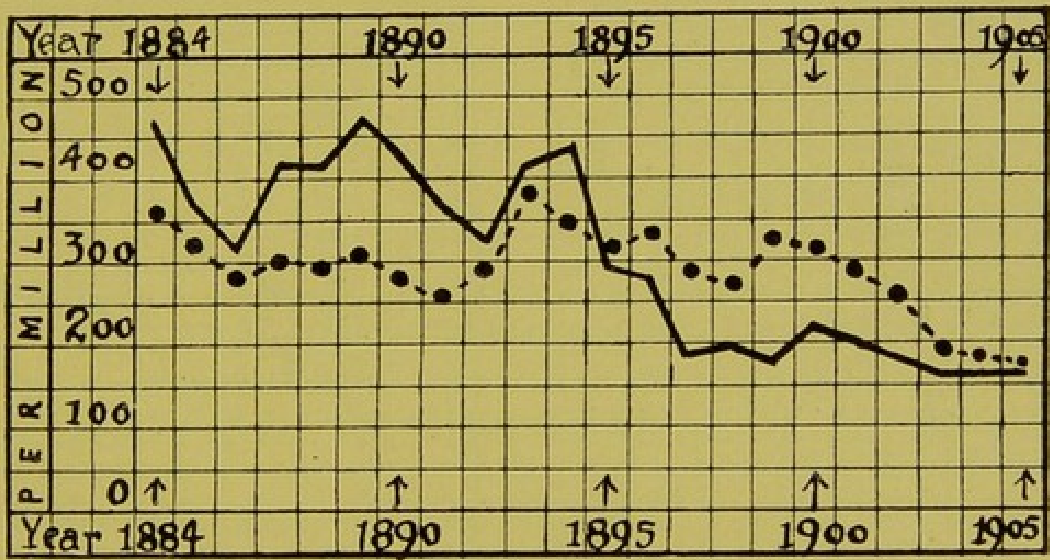
[1] Want of time prevented delivery of this lecture, but it is included here to complete the course as originally arranged.

add diphtheria and croup together we find the following result :

1861-1870	1871-1880	1881-1890	1891-1900
390	261	286	314

These figures are not nearly so unsatisfactory as those for diphtheria alone, the last period having much less mortality than the first. Yet they show an increase as between the second and third decades, and a still further increase as between the third and fourth.

Very curiously, Scottish statistics show a diminution of diphtheria and croup fairly steady and continuous ever

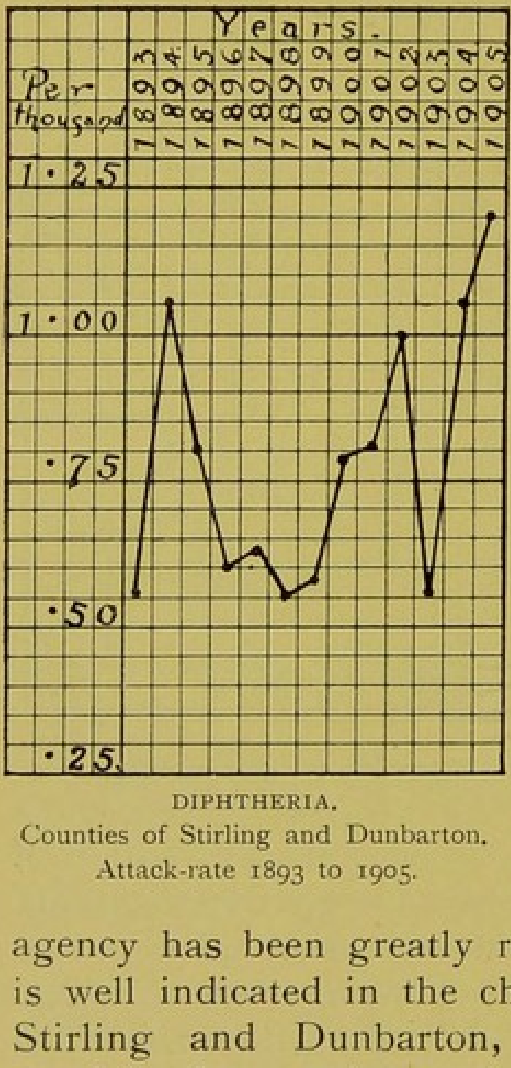


DIPHTHERIA AND CROUP—DEATH-RATE PER MILLION, 1884 TO 1905.
England and Wales—interrupted curve. Scotland—continuous curve.

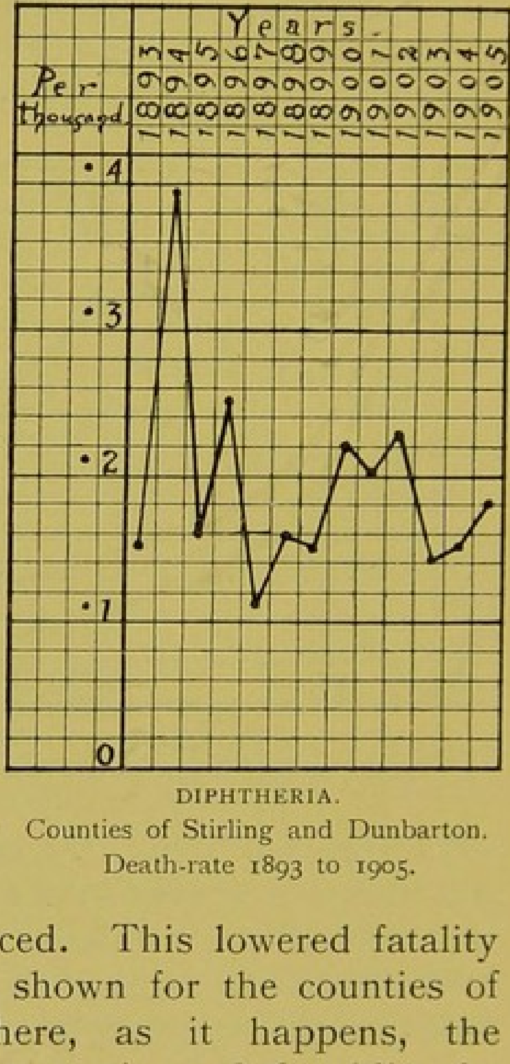
since the year 1864. I have not seen any explanation of this difference between the course of registered mortality in England and Scotland, and have none to offer.

Within periods of a few years, however, very considerable changes may take place, and, leaving these decennial subdivisions of time, we turn to a chart showing for England and Wales and for Scotland the annual course of croup and diphtheria combined for twenty-two years, up to 1905, which is the latest available for statistical purposes.

This chart tells a pleasing story. It shows that in quite recent years there has been rapid general diminution in the diphtheria death-rate. It is within the knowledge of every man who is in medical practice in these days that this satisfactory change corresponds in time with a notable advance in the treatment of the disease. The antitoxin method for the treatment of diphtheria is now almost universally employed. Even when prevalence of the disease has not diminished as represented by the number of cases, yet the fatality-rate under this precise and specific



DIPHTHERIA.
Counties of Stirling and Dunbarton.
Attack-rate 1893 to 1905.



DIPHTHERIA.
Counties of Stirling and Dunbarton.
Death-rate 1893 to 1905.

agency has been greatly reduced. This lowered fatality is well indicated in the chart shown for the counties of Stirling and Dunbarton, where, as it happens, the number of cases shows an increase since 1896, whilst the death-rate, on the contrary, has considerably diminished. Curative medicine has, indeed, been much more successful than preventive medicine in its dealings with this disease.

There is little that relates to diphtheria at the present day that is not closely in touch with the science of bacteriology. Much that was dark and dubious has emerged by the light of bacteriological research into clearness and definition; and though the most modern knowledge of the subject is still far from complete, the aid which it offers in the detection, control, and treatment of the disease is invaluable. A great part of what we have recently learned regarding diphtheria is due to the admirable work of American investigators, among whom I need only mention the names of Wesbrook, Councilman, Mallory, and Pearce, and the whole subject is not anywhere better set forth than in Welch and Schamberg's work on the Acute Contagious Diseases.

Bacteriology.

The organism which is now known as the Klebs-Loeffler bacillus was described by Klebs in the false membrane in 1883. It was cultivated by Loeffler from diphtheria cases in 1884, and there ensued the usual investigation and discussion as to whether it could be regarded as a *causa causans*. But Koch's requirements for the acceptance of a given microbe as the specific agent in producing a definite infection were all fulfilled. These requirements are, constant presence of the microbe, its isolation in pure culture, reproduction of the disease in animals by means of pure culture, and existence of the microbe both in the original and in the experimentally produced disease. And so, after the *advocatus diaboli* had said his last word, canonisation of the Klebs-Loeffler bacillus was finally granted.

The bacillus varies greatly in form and size, and shows certain morphological types. Its characteristic form is a straight rod, about the same length as the tubercle bacillus and about twice the thickness. There are also short forms and long forms, and the rod may be bent slightly, or it may be shaped like a club. It stains either uniformly throughout, or interruptedly in granules or in transverse bands. The most typical result is obtained when with appropriate methods a deeply coloured granule appears at each pole of the bacillus. The organism is not motile. It does not evolve gas nor liquefy gelatine. It does not form spores. It is ordinarily aerobic, preferring air in motion, but is said also to be facultatively anaerobic. It grows in milk at a temperature so low as 68° F., and does not cause any change in the milk, but it is said that the bacillus itself changes and degenerates. It is quickly destroyed by a temperature of about 136° F. It is very resistant to death by desiccation, surviving so long as four months or more in the dark. Dr. R. M. Buchanan found in two experi-

BACILLUS DIPHTHERIAE.
From twenty-four hours culture on serum, stained by Neisser's method.
(Buchanan.)

ments that the bacillus lived for nineteen and twenty-one days respectively on strips of cotton exposed at the back wall of the laboratory to ordinary indirect sunlight.

Vitality of Bacillus in Human Throat.

The vitality of the organism in the human throat is very great. Sometimes it is found three months or later after the throat looks clean, though customarily it disappears in a week or two. Though in such throats its life is usually not very active, yet its infective power often persists. In some cases a discharge from the nostrils containing infective bacilli may continue for months, and in post-mortem examination of such cases it has been found that in a large proportion the disease had infected the antrum and persisted there.

Of still more importance is the presence of the microbe in the throats of 'contacts' who have not themselves any clinical symptoms of the disease. Various observers give different accounts of the frequency of such cases, the percentages of exposed persons in whose throats the bacillus has been found ranging from figures like seven and ten to twenty, thirty, fifty and even a hundred: and it is alleged that these high percentages are not due to the pseudo-diphtheria or Hofmann bacillus. A committee of the Massachusetts Association of Boards of Health have concluded that at least one or two per cent. of sound persons in the general public in towns, and 8 to 50 per cent. of exposed persons, have the Klebs-Loeffler bacillus in their throats. Independently of any known exposure to infection, it does seem certain that a small percentage of the general population harbour the bacillus in their throats, but it is stated that the bacillus is virulent in less than a fifth of such throats (Welch and Schamberg). On the other hand, there is a quite appreciable number of cases in which the disease is actually present without the appearance of any membrane on the throat, the toxic phenomena being due to Klebs-Loeffler bacilli in the lung, the spleen, and elsewhere.

Differences of Type of Bacillus

Since this lecture was written, Dr. Davies, of Bristol,[1] has recorded his experience that at one time in the same town the type of diphtheria bacillus may be distinctly different from that found at another time, and that these differences of type are accompanied by a different habit of the disease, both as to fatality and infectivity. Previous to the year 1900 in Bristol the typical long, round-ended, beaded, or granular staining bacillus was rare, the form found being shorter, thinner, usually pointed at one end, and staining either solid or in granules. At this time the fatality of the disease was singularly and consistently low, school out-

[1] *Public Health*, March, 1907.

breaks were practically unknown, and hospital accommodation was apparently needless. Then, in 1900, there came a change. In one part of the city the disease became much more fatal, and the bacilli found were typical in form. This new and virulent variety of the disease gradually spread over the city, and in 1902 'school outbreaks became urgent, widespread, and with difficulty controllable.' Dr. Davies has formed the opinion that in such a period as preceded 1900 normal resistance to diphtheria is sufficient to protect the majority against even parasitic attachment of the existing type of the bacillus, so that 'carrier cases' are rare and clinical cases well marked, whilst the advent of a virulent bacillus overcomes resistance, and all varieties of the disease occur, including slight cases readily overlooked. He also refers to American records of differences of bacillary type in different towns at the same time. The essential bearing of such facts on the spread of diphtheria is manifest.

The Spread of Diphtheria.

Passing now to the more special consideration of the channels or agencies by which this disease is spread, we change our point of view, but not our subject. We continue to study the life-history of the Klebs-Loeffler bacillus, but we study it in its practical aspect. In brief, we direct our attention to the applied bacteriology of diphtheria.

Opinions which are of interest with reference to the means by which the disease may extend are to the effect that it attacks not only man, but also cats, cows, horses, pigeons, domestic fowls, and other animals. With regard to certain of these animals, it is doubtful if the bacillus is identical with that of human diphtheria. In the pigeon it appears to be quite distinguishably different. The bacillus has been discovered in cats and fowls, but no epidemic is known to have resulted, yet cats, if affected, should be very likely to cause spread of infection to human beings. The subject demands renewed investigation in presence of increasing knowledge of the bacteriology of the disease.

Diphtheria is undoubtedly conveyed by milk, as was concluded by Power in reporting on an epidemic in North London so long ago as 1878, several years before the Klebs-Loeffler bacillus was discovered. Since that time numerous epidemics have been recorded, but not nearly so many as in scarlet fever and enteric fever. In the counties of Stirling and Dunbarton there have been no milk epidemics since 1891 (I cannot speak of earlier years), and in Glasgow I think there has been only one. Much discussion has taken place as to whether in all milk outbreaks the infection is introduced from human sources, or whether in any of them the cow itself is responsible. Power suspected the cow when he wrote in 1878, and Klein concluded, as a result of experiments with the Klebs-Loeffler bacillus, that cows could by injection be infected with diphtheria, which included in its manifestations on the cow a teat and udder eruption, capable in its turn of producing the disease in calves by inoculation. But Loeffler doubted the soundness of Klein's conclusions, and the existence of bovine diphtheria has been disputed. In the end of 1901 Drs. George Dean and Charles Todd, of the Jenner Institute (now the Lister Institute) of Preventive Medicine, met with an outbreak of diphtheria regarding which, on careful investigation, they concluded that the cause was to be found in milk obtained from two cows suffering from a teat eruption. Material from the ulcers of this eruption, when cultivated on blood serum, yielded, in addition to numerous cocci and other organisms, a considerable number of colonies indistinguishable from those of the Klebs-Loeffler bacillus. The cultures when injected into guinea pigs proved virulent, and in some instances fatal, and diphtheria antitoxin, given at or before inoculation, afforded complete protection. Similar experiments with a swab from the throat of one of the persons infected gave similar results. But in calves infected by this eruptive disease of the cows' teats, though an eruption resulted, no diphtheria bacilli were found, and antitoxin gave no protection.[1]

Milk Epidemics.

Bovine Diphtheria.

[1] *Journal of Hygiene*, 1902, p. 194.

Since this lecture was written, Dr. Alfred Ashby has given (in *Public Health,* December, 1906) a most interesting account of an outbreak of a similar kind.

From the end of July to the end of August, 1904, seventy-five cases of diphtheria (nearly two-thirds of them over fifteen years old) occurred in forty-three houses in two Berkshire villages, Twyford and Ruscombe. The disease was remarkably mild, there being only one fatal case, though the mildness is partly attributed to the use of antitoxin. Milk was supplied to the two villages by three dairymen, X, Y, and Z. Only one of the invaded houses was supplied by X, fifteen were supplied by Y alone, seventeen by Z alone, and ten by Y and Z. Of the houses supplied by X, 3.1 per cent. were invaded; of those supplied by Y alone, 6.8 per cent.; and of those supplied by Z alone, 42.5 per cent.; the mixed supplies being left out of account. Samples of Y's and Z's milk were not found to contain the diphtheria bacillus, but a second sample of Y's yielded 'a diphtheroid bacillus, perhaps an avirulent diphtheria bacillus.' The teats of five of Z's cows were ulcerated, two of them badly. Swabs from the two last yielded a culture which was fatal to guinea pigs, but could be neutralised by anti-diphtheritic serum, and Dr. Ashby wrote that the results 'led to the conclusion that the organism from the ulcers on the cows' teats was identical with the diphtheria bacillus, and fully corroborated the conclusion I had arrived at, that the outbreak of diphtheria in Twyford and Ruscombe was a milk-borne epidemic.'

Diphtheria and Manure Traffic.

Spread of diphtheria has often been attributed to effluvia from deposits of town manure in agricultural districts. Dr. Franklin Parsons carried out, for the Local Government Board of England, a very valuable enquiry into the whole subject of manure nuisances (Local Government Board, 21st *Annual Report,* 1893) and gives an account of the association of diphtheria with such nuisances in various parts of England, principally in localities within reach of the London manure traffic. Dr. Parsons writes: 'The instances quoted seem to point to some relation between diphtheria and manure effluvia, but what that relation is cannot be stated'; and he goes on to mention three hypotheses:

(1) That the manure forms a specially favourable breeding ground for specific organisms already existing in it, or which have gained access to it.

(2) That in localities where sore throat allied to diphtheria already prevails, the inhalation of manure effluvia imparts to a comparatively mild affection a more definitely specific and severe character, and

(3) That the action of manure effluvia, like that of other septic effluvia, is to produce a non-specific sore throat, upon which the specific germ of diphtheria is more readily engrafted than upon a healthy mucous membrane.

I may mention in passing that on more than one occasion in my experience there has appeared reason to suspect that cerebro-spinal fever was similarly related to manure nuisances.

Independently of specific disease, it is obvious that effluvia which cause nausea or general malaise, and which prevent people from opening their windows for ventilation, are deleterious to health, and while the use of manure for agricultural land cannot and ought not to be prevented, it should be so regulated as to minimise complaint. The following letter prepared by me was issued several years ago to farmers in some parts of Stirlingshire and Dunbartonshire where manure nuisances existed:

Sir,—We are requested by the District Committee, as Local Authority under the Public Health Acts, to call the attention of farmers in the district to nuisance that may arise from the manuring of fields, especially near dwelling houses, or populous places, or public roads.

In recent years a large railway trade has developed in refuse of various sorts, brought principally from towns and cities for use as field manure. The materials include refuse from ashpits and privies, fish shops, slaughter houses, and cattle ships. Refuse from ashpits and privies may convey the poison of certain infectious diseases, while fish refuse and offal from slaughter houses yield a most offensive and sickening odour. Cattle ship manure is often heated, and is then also very offensive.

The committee recognises, however, that in this matter the interests of the farmer as well as of the public must be considered. The farmer has a right to manure his land to the advantage of his farm, and the public have a right to expect that the business of farming shall not be conducted in such a manner as to prove seriously offensive or injurious to health.

The committee is of opinion that both objects can be fairly attained without undue hardship by the exercise of care and foresight with regard to the manure. The following are some of the main points to be attended to in order to minimise the nuisance:—(1) Manure conveyed by rail should be carted away by the farmer as soon as possible after its arrival at the railway siding. In doing this, care should be taken that no refuse be spilled on the ground, either at a siding or along a public road. Loads of offensive manure should be covered by a tarpaulin. (2) Effluvium nuisance arises when the manure is tossed up or disturbed, as by pitchforking or emptying from carts. Offensive manure should not be first collected in heaps on the fields and subsequently distributed over the ground. The two operations should be combined so that a double nuisance may not result from repeated disturbance of the manure. It is a direct infringement of the Public Health Acts to accumulate such deposits within fifty yards of a public or parish road or dwelling house; but even beyond this distance manure may be a nuisance under the Acts. (3) In fields which are subsequently to be ploughed for crops, *the plough should follow the manure cart* as closely as possible. The ground should be turned over at once in order to prevent nuisance. (4) For top dressing, where the ground is not to be ploughed, only old manure should be used, from which the worst of the odour has disappeared. (5) Care should be taken, especially with regard to privy manure, that it be not laid down in the neighbourhood of wells used for domestic water supply either by the farmer's household or by the public.

The committee trust that farmers will attend to the spirit of these directions, and will do their best in every way to prevent their operations from being offensive either to their neighbours or to the general public.

Insanitary Conditions.

We shall see later on (p. 201) that diphtheria appears to prevail in years of low rainfall, but this does not necessarily disprove its connection with localised conditions of mingled damp and filth. Looking back through my experience of the disease, I have often found it associated with such conditions. One small farm steading, where the courtyard was very low-lying and was shut in so as to be seldom swept by clean air, and where, also, numerous fowls were kept, so as to cause much pollution of the surface, was repeatedly invaded by diphtheria at irregular intervals, sometimes of two or three years.

Another instance of a somewhat similar nature came under my notice last year (1905). At an isolated farm steading in a remote country district, two children, aged eleven and thirteen years respectively, developed diphtheria almost simultaneously near the end of September. They were treated at home, and one of the two died in a few days. A fortnight later a brother aged fifteen was attacked, and ten days afterwards another brother aged eight. These two latter attacks can readily be explained by the first cases not having been removed to hospital, but I found it impossible to discover any source of infection for the first two. They attended a village school about two miles distant, but there was no diphtheria among the school children. There was not, indeed, in the counties of Stirling and Dunbarton another known case of diphtheria within twenty miles of the farm steading. There had been no visitors, not even any tramps or wayfarers, the house being well away from any public road; and the children had not been from home. On the farm steading there was a large accumulation of surface filth consisting of slop-water and dungstead drainage. The water supply was from a well in the courtyard, and though the source was a spring, there was chemical evidence of contamination. It was definitely ascertained that a day or two before the development of the disease one of the two children had been playing about close to the accumulation of filth. The other, also, was easily within its influence, for the distance from the dwelling-house was only a few yards. Under these conditions a non-virulent bacillus may have become virulent, or a healthy throat may have become unhealthy, or both changes may have occurred simultaneously. The filth deposit was no new creation, and the children must often have been near it. But it is of interest to note that the disease developed at the season of the year which is always favoured by diphtheria.

Another suggestion might have been advanced with regard to these cases had they occurred twenty years ago. At that time the theory had been put forward that the poison of diphtheria might possibly be carried by the winds for twenty or thirty miles, and that apparently autochthonous cases might be so explained; and I observe that one competent bacteriologist still seems inclined to give support to the view that diphtheria can be so conveyed, his opinion being based on the capacity of resistance to destruction by desiccation which the microbe is known to possess. Aerial convection is a reasonable explanation of spread of smallpox; but no sufficient evidence has been adduced with regard to diphtheria, and in smallpox no such distances as twenty or thirty miles are ever mentioned.

On more than one occasion I have seen the disease attack children who had been looking on, a day or two before, whilst choked drains were being cleaned out by workmen. Quite recently two cases of diphtheria occurred in a town in Dunbartonshire, where there appeared pretty direct association with drain effluvia. The kitchen sink of a small working-class dwelling on the ground floor of a flatted building was connected to the house drain by a metal pipe brought through and attached to the outside of the house wall, under the sill of the window in which the sink was situated. This pipe, just at its shoulder immediately after passing through the wall, had a perforation an inch or two in diameter. Drain gases escaped by this opening, and the child first attacked had been in the habit of standing beside the pipe and looking into and examining the hole, and listening to the running of the waste water. There had been no known contact with any previous case of diphtheria. This child infected the other, and both died.

Diphtheria and School Attendance.

The age at which diphtheria prevails is chiefly from two to five years, and to a great extent, therefore, before school life is begun. Yet school attendance is often a very obvious cause of spread, as was shown by Power in 1882, when at Pirbright the disease broke out four successive times on re-opening a school, after every precaution then known had been taken to stamp it out. In London, Murphy has recorded how diphtheria diminishes when schools are closed for summer holidays. It is easy now, in the light of bacteriology, to see how compulsory school attendance has made for prevalence where children are seated together in the same class-room, some who have recovered from the disease still having the bacillus in the throat, and others giving it a lodgment, though themselves entirely unaffected. But compulsory school attendance began thirty years ago, and there has not been such an increase in attendance as would account for the increase in diphtheria in England between the last two decades, though the growth may perhaps have been partly due to children being nowadays sent to school at an earlier and more susceptible age than formerly.

Diphtheria in Healthy Dwellings.

Also, it is now possible to understand how diphtheria may at one time be found in a slum, and the next in a typically healthy dwelling. The disease being conveyable by persons themselves unaffected, may quite readily be carried into any kind of dwelling without any suspicion of its source, and in spite of perfect sanitary conditions.

Cyclical Diphtheria.

In considering the whole question of the prevalence of diphtheria, regard must be had to its acknowledged cyclical nature. Its prevalence has greatly varied in different countries from time to time. In its history there are both longer and shorter cycles, some lasting several decades, others only a few years. But for well on to half a century now its prevalence has been world wide. This prevalence is probably due to the propagation of a more active and virulent bacillus, but why this change of type should have occurred and continued is not known.

Preventive Measures.

Discussion of the causes of diphtheria has already led to reference to measures of prevention and control. These have now to be more specifically considered.

In the first place, as already stated with regard to scarlet fever, great attention should be paid to procuring a healthy condition of the throats of the whole child community. In the deep crypts of soft, spongey tonsils the bacillus readily takes up its abode and finds a most suitable work-room for its business of production of toxins, which quickly invade the body and cause the well-known phenomena of the disease, including the frequently fatal paralysis.

When the disease does prevail, the course to be followed includes the usual means of checking the spread of infection. In Britain diphtheria is everywhere compulsorily notifiable. Patients are to be sent at once to hospital. And though, owing to unrecognised cases in the general community, diphtheria can hardly be stamped out by hospital isolation of known cases, yet in a mixed population there is perhaps no malady which is more benefited by hospital treatment. It is usually impracticable in working-class dwellings to carry out conveniently either intubation or tracheotomy. Trained nursing is often absolutely essential. This cannot well be had in a small house. Early removal is of great importance, especially if, as often is the case in the country, the hospital is some distance away. I do not know the procedure in California, but in Scotland, in ordinary infectious diseases such as scarlet fever, the case is visited by an officer of the local authority immediately after notification is received, and before the ambulance van is ordered. In diphtheria no such delay should intervene. The best system is that in accordance with which the medical attendant may telephone or telegraph directly to the hospital to have the van sent for the patient, while at the same time intimation is made to the health office, in order that disinfection may be done and other precautions taken, and enquiries made as to causation.

Hospital Treatment.

The patient being removed, disinfection of house and bedding and clothing and other articles should be carried out.

If bacteriological facilities exist, the throats of all the inmates of the invaded house should be examined, and dealt with as the facts so ascertained may indicate to be necessary. Enquiry should be made as to any prevalence of sore throat in the locality, and all suspects should be visited and examined.

Examination of Throats.

Whether discovered cases are removed to hospital or not, if a sanitary authority is prepared to do all that is practicable for prevention of diphtheria, there should be included amongst the measures taken a final bacteriological examination of all known cases, as a preliminary to their being declared free from infection. This, no doubt, may sometimes raise difficult questions as to pathogenicity and activity of microbes found in the throat, and may sometimes involve prolonged detention; but the steps to be taken with regard to doubtful cases would depend on the circumstances, and it would only be as to a minority that any doubt would exist. Such systematic investigation can best be done by sanitary authorities which possess a laboratory of their own.

In the history of preventive and curative inoculation, diphtheria occupies a very interesting place. For well on to a century the Jennerian method of smallpox prevention, with all its enormous saving of human life, stood absolutely alone. No other infection could be dealt with in the same way, and any hope that such measures might be extended to other diseases was only a pious aspiration. But at last Pasteur's day dawned, and he splendidly resumed the work which Jenner had so splendidly begun. He proved that in chicken cholera a non-virulent inoculated disease could forestall and prevent subsequent severe attack. So also with anthrax in sheep, and again, as shown by other workers, with cholera in swine. Then Behring and Kitasato discovered that the blood serum of animals immunised against diphtheria and tetanus can, if injected into other animals, either protect or cure. In the next place, it was shown by Behring that the toxins of diphtheria—which cause the phenomena of the malady—can be controlled by antitoxin obtained from

Antitoxin.

the blood of animals previously immunised; and the method was applied to the treatment of the disease in the human subject by Behring and Kossel, Ehrlich and Wassermann, Katz and Baginsky. Commended by Roux in 1894, and adopted somewhat gradually by medical men, the antitoxin treatment is now in general use. The practical result is that the diphtheria fatality-rate has been greatly reduced, and that, where it seems necessary, exposed persons can be protected against attack.

It may be remarked in this place that the same general principles of disease-prevention, though greatly differing in detail, are being applied, with a degree of success corresponding to increasing knowledge and experience, to rabies, and tetanus, and typhoid fever, and plague, and cerebro-spinal meningitis. The same goal may be reached by different roads—by inoculation of weakened virus, dead cultures, antitoxins, and the like.[1]

In the matter of the antitoxin treatment of diphtheria preventive and curative medicine touch each other very closely.

Curative Antitoxin.

In the curative use of antitoxin there is no precept more momentous than this —that the remedy should be applied without delay. *Bis dat qui cito dat,* says the proverb, and the medical attendant should postpone or omit the use of antitoxin on no account or pretext, not even because the patient is about to go to hospital. If the prospect of removal to hospital defers resort to antitoxin much harm will be done. In the *Annual Report of the Metropolitan Asylums Board* for the year 1905 (p. 205) the following statistics are given, showing the fatality of diphtheria in relation to the time of beginning the injection of antitoxin:

	Days of Disease on which Treatment began.				
	1st	2nd	3rd	4th	5th
Cases, - -	15	86	111	82	116
Deaths, - -	0	3	7	9	21
Fatality per cent.,	0.0	3.44	6.30	10.97	18.10

[1] See Newman's *Bacteriology and the Public Health* (London: John Murray, Albemarle Street, 1904).

These figures are eloquent of the importance of promptitude, and they raise a question of public health policy. The primary and theoretically the sole duty of a sanitary authority has been regarded as the prevention of disease, in distinction from the cure of disease. But in a poor district, or amongst poor patients, while a medical man may not object to give his time and skill to persons from whom there is no prospect of payment, he yet may hesitate to spend money in providing them with antitoxin. In such cases there should be an understanding between the sanitary authority and the medical men that antitoxin should be used wherever necessary whilst the ambulance van is being sent for to take the patient to hospital, and that if the price of the antitoxin cannot be recovered from the parent or guardian, the doctor will be recouped by the public authority. Already, indeed, some sanitary boards have frankly adopted the policy of free provision of antitoxin.

Preventive Antitoxin.

Concerning antitoxin it is often recommended that, as a preventive, a dose should be injected into all members of a household who have been in close contact with a patient. The need for this will partly depend on circumstances—on the duration of illness prior to removal to hospital, on the character of the house, the closeness of contact, and the condition of the throats concerned. But the temporary eruption and discomfort which so often result from antitoxin should not be lost sight of, and a clear warning should be given. Moreover, if the contacts can be kept under medical observation, the value of antitoxin as a curative agent, when used as soon as the first symptoms appear, is so great, that there is room for legitimate difference of opinion as to whether it is not better to wait on symptoms. As just said, however, much depends on the circumstances of the individual cases.

Along with all such measures, investigation is made as to the origin of any outbreak. Nuisances may require removal, schools may need visitation for suspects, or temporary closure for disinfection.

In houses where the disease occurs, a short print of precautions, like the following, may be left for guidance of the inmates:

PRECAUTIONS AGAINST DIPHTHERIA.

A dangerous disease.—Diphtheria is a very dangerous infectious disease. Among those attacked by it a far greater proportion die than in most of the commoner infectious diseases of childhood. As is well known, its ordinary place of attack is the throat and sometimes the nostrils. Every effort should be made to prevent its spread in any household which it has invaded.

Isolation and disinfection.—If treated at home the patient should have a room to himself, and the person nursing him should avoid mixing with others in the household. All bed and body linen, handkerchiefs, pinafores, and other such articles should be disinfected before being removed from the sick room. Any toys or books which the patient has handled should be burned. Discharges from the patient's mouth and nose and throat should be received on rags, which ought to be burned after use. Cups, spoons, etc., used by the patient should be used by no one else during the illness, and should be regularly steeped in a disinfecting solution in the sick room.

Any other children in the house should be kept strictly away from the patient. No child living in the infected house can be allowed to go to school until the house and everything in it are free from infection. When the parents or guardians of a patient treated at home send to the sanitary authority a medical certificate that the patient is free from infection the sanitary inspector will visit to carry out disinfection of the premises.

Importance of early recognition of attacks of the disease.—In any locality where diphtheria exists it is most important that a medical man should be sent for at once if there is any complaint of sore throat, however trifling. Fatal diphtheria is often spread by infection from very mild cases, sometimes, indeed, from children who may have the microbe of the disease lodged in the throat without themselves being affected by it. Very early recognition of the disease is most important for the welfare both of the patient and of others. The success of modern treatment of diphtheria depends largely on its being begun early. Also, a case may require to be sent to hospital, perhaps for operation, and if a doctor is not sent for at once the child may be too ill for safe removal to hospital, or the chance of a successful operation may be much diminished.

It is believed by some that the disease may be spread by cats, which are liable to a sore throat like that of diphtheria. This should be borne in mind, and when diphtheria is known to prevail in any locality children should not be allowed to fondle cats, especially if these have any appearance of illness.

As I bring this lecture to a conclusion, I propose to recount briefly the history of an outbreak of diphtheria which occurred in 1905 in a district under my charge. It will help to recall considerations which must be kept in mind in dealing with such an occurrence, and will indicate the influences exerted by school attendance, by weather conditions, by conformation of land and river, and the like; it will show also, partly in negative fashion, the measures which must be adopted and persevered in if the disease is to be brought under control.

A Local Outbreak.

The village of Carronshore, with a population of about 1200, is situated near to Carron Iron Works, whose name has been perpetuated in medicine by the term Carron oil, consisting of equal parts of linseed oil and lime water, which was used for the treatment of burns at the works. Within about two miles from Carronshore are Stenhousemuir and Larbert, with a scattered population of about 10,000. In the latter part of August, 1905, notification was received of nine cases of diphtheria in Carronshore. The patients were all children aged from one to thirteen years, most of them being four, five, and six years old. Five of the cases were in one street called Dock Street. The others were scattered through the neighbourhood. All the infected families had children attending Carronshore school, and all the infected children attending the school were in the infant department. The position of the school is shown in the plate on p. 137 at C. The school was the only factor in common. It is true that all the houses had the same water supply, but water is not known to carry diphtheria, and the supply was common to a population of 40,000, among whom there was no prevalence of diphtheria. There was no common milk supply. The steps taken were these: The patients were immediately removed to hospital and treated there. The infected houses were visited to ascertain that all remaining in them were healthy. The school was closed for a fortnight, and its floors, woodwork, slates, sponges, and kindergarten material were thoroughly disinfected. School books belonging to the infant department were destroyed, and the walls and ceilings of the whole school, including stairways, lavatory, etc., were sprayed with formalin. These measures had the effect of practically stopping the outbreak in Carronshore. But the disease spread into Larbert and Stenhousemuir and neighbouring populous places. No such direct association or grouping of cases as at Carronshore occurred anywhere else during the epidemic. It is seldom necessary to close schools on account of diphtheria, and the schools at Larbert and Stenhousemuir were not specially involved, yet, no doubt because of unrecognised attacks, or carrier cases, the disease had got out of hand, and as cases continued to occur in the latter months of the year, I recommended that the Christmas holidays at Larbert and Stenhousemuir schools, which usually cover only a week or so, should be extended to a fortnight. During this closure the same disinfection was carried out as at Carronshore school. Attention of the local medical men had been called to the sanitary authority's willingness to obtain bacteriological examination of throat swabs, and this aid was resorted to in various doubtful cases. The counties have a working arrangement with the Public Health Laboratory of the University of Edinburgh, but they have no laboratory of their own. As cases occurred, the houses were visited, the patients removed to hospital, the premises disinfected, some doubtful throats examined, and the usual measures taken, but the disease did not disappear until fifty-seven cases had been notified in a population of 12,000. This prevalence has often been exceeded, but since county council health administration began fifteen years ago I had met with no such experience in Stirlingshire or Dunbartonshire. Had it been practicable to ascertain the presence or absence of the bacillus in the throat of every contact, I have little doubt that the outbreak would have been curtailed.

The question as to any conditions favouring this exceptional persistence of the disease naturally gave me concern. Newsholme has found from extensive enquiry into epidemics in various countries that diphtheria is never epidemic excepting in dry years. The nearest rain gauge stations to Carronshore are at Kerse, about two miles distant, and at Laurieston, about three miles distant. The average rainfall at Kerse for forty-four years beginning 1860 was 32.25 inches. The following are the figures for the past thirteen years:

Year.	At Kerse (inches).	At Laurieston (inches).
1893,	22.9	—
1894,	41.0	—
1895.	31.0	—
1896,	28.0	34.08
1897,	33.5	35.88
1898,	35.4	38.31
1899,	38.0	41.11
1900.	40.2	41.04
1901,	27.8	27.95
1902,	24.1	24.71
1903,	50.2	53.35
1904,	30.2	32.54
1905,	26.8	30.30

The years 1901-2 had been exceptionally dry, with no unusual prevalence of diphtheria. The year 1903, on the contrary, was exceptionally wet, the rainfall being fully 50 inches. In 1904 the rainfall at Kerse was 30 inches, and in 1905 it was 26.8 inches, both of these being quite appreciably below the average. The other rainfall station not far from the infected locality gave practically similar results. These figures, therefore, on the whole, correspond with the conclusions reached by Newsholme, and it may be mentioned that diphtheria was at the same time exceptionally common in the West of Scotland generally, where similar rainfall conditions existed. The chart of attack-rates and death-rates from diphtheria in Stirlingshire and Dunbartonshire in the thirteen years 1893-1905 inclusive (p. 182) shows that there were four epidemic years, namely, 1894, 1902, 1904, and 1905. The first of these had a high rainfall, and the other three had a low rainfall.

Note was made of any local conditions of insanitation.

Close to Dock Street, in which several of the group of school children first affected had their homes, there was a decided effluvium nuisance at a point where the village sewage was intercepted in an open pond before its discharge into the river Carron. The Dock Street houses were only about a hundred yards distant from this pond, and in warm weather the smell was most offensive. Also, the Carron, which is here a tidal river, hemmed in by banks to prevent its waters spreading over the surrounding ground, had a year or two previously burst its bank at two points close to Carronshore, with the result that a field lying between the river and the village had been turned into a marsh, covered with water at high tide and exposed to sun and air at low tide. The Carron, whose waters thus soaked the field, is itself a river very considerably polluted by sewage from neighbouring populations. Then, again, in Stenhousemuir, to which the disease spread, there were various complaints of effluvium nuisance from the street manholes of its sewerage system. All the land here is very flat, and the sewers consequently are also rather flat. Though the year 1905 had a low rainfall, it happens that August, the month in which the disease began in Carronshore, had been very wet; but from the middle of September to the end of the year the fall was well below the average, so that the sewers had less than the normal flow, though this is supplemented by automatic flush tanks. The effluvium nuisances which I have spoken of would not themselves directly cause diphtheria, but they would tend to produce an unhealthy condition of throat and tonsils and a lowering of general vitality. Under these conditions the disease, having once been started, was no doubt conveyed by unrecognised cases—by throats containing the bacillus—and so spread readily among the more susceptible.

Conclusion.

It seems to me undeniable that, notwithstanding all apparent contradictions as to the conditions which foster diphtheria, insanitation plays an important part in its propagation, and that its invasion of healthy houses, free from defects either of structure or of cleanliness, is to be explained by conveyance of the bacillus by persons not themselves suffering from the disease. This also would account for cases of post-scarlatinal diphtheria in hospitals, infection being introduced from the outside, or from diphtheria wards, and finding a suitable soil in the unhealthy throats of scarlet fever patients. Whatever be the degree of diphtheria prevalence at any time, I have no doubt that it will be less prevalent than otherwise in a strong and healthy community, living in healthy conditions, and that we are on safe lines in continuing to fight its infection by means of sanitation, notification, isolation, disinfection, observation and control of contacts, inspection of apparently healthy throats, and the use of antitoxin serum for cases and sometimes for contacts.

LECTURE IX

THE PREVENTION OF SMALLPOX

THE nature of the contagion of variola and vaccinia has been the subject of much study in recent years. Various bacteria have been put forward from time to time as causative agents, but the description by Van der Loeff and L. Pfeiffer in 1886-7 of small protoplasmic bodies in the pustules drew attention to the fact that the infective organism was possibly protozoal in nature. In the course of experiments with vaccine lymph in 1892 Guarnieri found bodies of the same nature, and called them 'Cytoryctes vaccinae.' On the other hand, these were regarded by several observers as simply cell degeneration products, a view which appeared to be successfully combated by Von Wieselewski in his inoculation experiments through forty-eight generations in the rabbit.

Bacteriology.

Our knowledge of the subject has been considerably extended since 1900 by workers in Belgium, France, America, Canada, and England, and, while the progress of the parasitic organism is unknown or only conjectural until it reaches the skin, its life history in this situation has been so closely studied that vaccinia and variola have come to be regarded as probably dependent on definite reproductive phases of the same organism. The observations of Calkins, working with Councilman, are of special interest. He regards vaccinia as dependent on asexual reproduction of an amœboid organism in the protoplasm of the cells of the rete mucosum, and variola as dependent on the fact that the same parasite is further endowed with capacity to penetrate the nuclei of these cells, and therein to develop a sexual cycle with the ultimate production of multitudinous spores. It is assumed that in vaccinia this nuclear phase is inhibited.

The artificial culture of the organism has not been attended with much success, but the experiments of Copeman in vivo (*British Medical Journal,* February 23, 1901) and of Ballah in vitro (*British Medical Journal,* December 22, 1906) are so far encouraging.

The whole subject is still very imperfectly known, and all that can be said is that we appear now to be on the right path towards its elucidation.

Smallpox in Kilmarnock in the Eighteenth Century.

About twenty-five years ago the parish minister of Kilmarnock, in Ayrshire, gave to an old friend of mine, the late Dr. John Borland, of that town, an ancient register of mortality in Kilmarnock, covering a period of thirty-six years from March, 1728, to March, 1764. The register had been begun by the parish schoolmaster, and, as changes in the handwriting show, was afterwards carried on by two successors. At that time there was no national system of death registration, and, excepting some large cities, very few localities had records of any value relating to mortality. The Kilmarnock schoolmaster who began the register was a man considerably in advance of his time. In a beautifully written old volume he set down the date, name, age, and cause of death of all persons who were interred in the parish burying ground. The register was given to me to examine, and the information which it yielded as to prevalence of smallpox in these days was very startling. The old volume is now in the national Register House in Edinburgh, where all such documents are kept. A reproduction of one of its folios is given here. It will be observed how frequently the disease appears. In some epidemics it is set down as smallpox, and in others simply as pox. The town had a population of not more than 4200. The total deaths recorded in the register in the thirty-six years were 3860, and of these 622 were due to smallpox. It contributed 161 in every 1000 deaths from all causes. As shown in

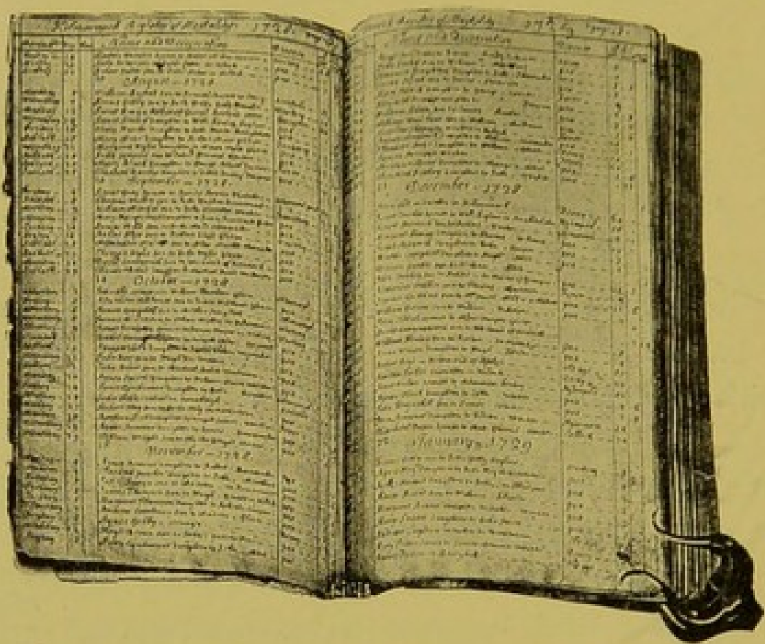


Table I., epidemics came on an average every four years, there being nine in the total period 1728-1764. Sometimes one outbreak was a little after its time, and then the next would come a little earlier. The influence of these epidemics was such that in seven of the nine the total death-rate exceeded the total birth-rate, in one year to the extent of 72 per cent. Here are the particulars:

TABLE I.

KILMARNOCK.

DEATHS FROM SMALLPOX, 1728-1764.

Year.	Total Deaths.	Age in Years at Death. Under 1	1	2	3	4	5	6 and upwards.	Age not stated.
May 11th, 1728 to Feb. 29th, 1729	66	7	14	12	14	9	5	1 each aged 6, 11, 16 and 22	1
1730	—	—	—	—	—	—	—	—	—
1731	—	—	—	—	—	—	—	—	—
1732	—	—	—	—	—	—	—	—	—
Jan. 4th to Aug. 2nd, 1733	45	12	9	13	6	4	—	1 aged 7	—
1734	—	—	—	—	—	—	—	—	—
1735	—	—	—	—	—	—	—	—	—
July 6th to Dec. 20th, 1736	66	12	20	20	8	1	1	3 aged 6, 1 and 10	—
1737	—	—	—	—	—	—	—	—	—
1738	—	—	—	—	—	—	—	—	—
1739	—	—	—	—	—	—	—	—	—
Feb. 25th to Aug. 3rd, 1740	66	15	21	9	14	2	2	1 aged 6, 1 aged 8	1
1741	—	—	—	—	—	—	—	—	—
1742	—	—	—	—	—	—	—	—	—
1743	—	—	—	—	—	—	—	—	—
Aug. 6th, 1744 to May 17th, 1745	74	15	13	19	11	10	2	1 each aged 6, 7 and 9	1
June 9th to Dec. 29th, 1746	8	3	2	1	1	—	—	1 aged 6	—
1747	—	—	—	—	—	—	—	—	—
1748	2	—	—	1	1	—	—	—	—
Oct. 20th, 1749 to Mar. 15th, 1750	84	12	17	22	15	12	—	3 aged 6, 1 each aged 7 and 21	1
1751	1	—	—	—	1	—	—	—	—
1752	—	—	—	—	—	—	—	—	—
1753	1	1	—	—	—	—	—	—	—
Mar. 1st to Oct. 5th, 1754	95	23	25	15	15	10	5	2 aged 7	—
1755	—	—	—	—	—	—	—	—	—
1756	—	—	—	—	—	—	—	—	—
Mar. 15th, 1757 to Sept. 5th, 1758	46	11	10	13	6	4	—	—	2
1759	—	—	—	—	—	—	—	—	—
1760	—	—	—	—	—	—	—	—	—
1761	—	—	—	—	—	—	—	—	—
Mar. 5th to Aug. 30th, 1762	66	7	15	10	9	10	8	2 aged 6, 1 each aged 9 and 20	3
1763	2	—	—	1	—	—	—	1 aged 26	—
Totals, -	622	118	146	136	101	62	23	27	9

TABLE II.

SMALLPOX IN KILMARNOCK.

EPIDEMIC YEARS IN WHICH THE TOTAL DEATHS EXCEEDED THE TOTAL BIRTHS.

Year.	Births.	Deaths from all Causes.	Deaths from Small-Pox.	Excess of Deaths over Births.
1728-1729	111	162	66	51
1736-1737	135	147	66	12
1740-1741	95	164	65	69
1749-1750	134	149	79	15
1754-1755	146	203	95	57
1757-1758	125	132	37	7
1762-1763	132	173	66	41
Total,	878	1,130	474	252

The contribution which smallpox made to the total mortality is very striking, but there is another fact which to the student of epidemiology is even more remarkable. It is brought out in the annexed table.

TABLE III.

SMALLPOX IN KILMARNOCK.

INCIDENCE ON YOUNG CHILDREN.

Date of Epidemic.	Interval since height of former Epidemic.	Total Deaths.	Deaths in Children Born since height of former Epidemic.	Deaths in Children who had passed safely through one Epidemic.	Deaths in Individuals who had passed through more than one Epidemic.
1728-1729	Unknown	66	—	—	—
1733	4 years 5 months	45	44	1	0
1736	3 ,, 5 ,,	66	58	7	1
1740	3 ,, 7 ,,	66	60	5	1
1744-1745	4 ,, 8 ,,	74	67	6	1
1749-1750	5 ,, 0 ,,	84	79	4	1
1754	4 ,, 6 ,,	95	84	11	0
1757-1758	3 ,, 2 ,,	45	39	6	0
1762	4 ,, 8 ,,	66	53	11	2
Cases occurring between Epidemics, - - -		14	8	5	1
Totals, - - -		555	492 or 88.6 per cent.	56 or 10 per cent.	7 or 1.2 per cent.

TABLE IV.

SMALLPOX IN KILMARNOCK.

SECTION OF POPULATION BORN SINCE FORMER EPIDEMIC.

Height of Epidemic.	Born since height of former Epidemic.	Died from various Diseases, excluding Smallpox.	Remaining to form field for new Epidemic.
May, 1733, -	614	90	524
October, 1736, -	476	82	394
May, 1740, -	501	89	412
January, 1745, -	506	68	438
January, 1750, -	634	107	527
July, 1754, -	648	131	517
September, 1757, -	445	41	404
May, 1762, -	690	110	580
Totals, - -	4,514	718	3,796
Averages, - -	564	89	475

Smallpox in these days was a disease of childhood, just as measles and whooping-cough are at the present time. Nine out of every ten of the victims of one epidemic had been born since the previous epidemic, and only one in seventy-nine of the persons killed by smallpox had safely passed through two previous epidemics. In the whole thirty-six years there were only three deaths from smallpox in persons over twenty years of age.

What was the reason that the disease was confined to childhood? It was for exactly the same reason that measles is now confined to childhood. In the Faroe Islands, as I may recall, when measles had been absent for a very long period, the disease, once introduced, attacked old and young alike, because none had previously had an opportunity of being infected by it, whilst in ordinary communities hardly any can pass through childhood without receiving the immunity which is conferred by attack. So it is with smallpox. The adolescent and adult population of Kilmarnock were immune because they had already suffered from it. Tables III. and IV.

show that as regards smallpox there were indeed three Kilmarnocks. One, a Kilmarnock of 3700 persons, had no personal cause for fear. They had already met and battled with the disease fiend, and had escaped with their lives, though many were scarred and disfigured and some were permanently blinded. The second Kilmarnock was to be found under the green sod of the kirkyard. The names of those who composed it are written in the old register of mortality. The third Kilmarnock consisted of a community of little children numbering less than 500 in all. They had been born since the last previous visit of the pestilence, and they were doomed to meet in their early childhood the most terrible physical enemy they would ever encounter. Fighting their battle with this foe, some would be added to the lists in the book kept by the parish schoolmaster, and the rest, many of them maimed in the conflict, would pass on into a life of dearly purchased security. Can one imagine the feelings of a mother in presence of these awful visitations? Human affections were as keen then as now, and the grief and misery caused by smallpox epidemics can hardly be overstated.

It may be suggested that the experience of Kilmarnock was perhaps exceptional, and that other places could not have suffered so terribly.

Pre-Vaccination Mortality.

But the little town only illustrated a general truth. In Edinburgh in 1744-63 in a total of 11,613 deaths, 1185 were due to smallpox. In Glasgow in 1783-1800, of 31,089 deaths from all causes, 5959 were due to smallpox. In London in 1660-79, of every 80,000 deaths, 4170 were from smallpox, and in 1796, in every 1000 deaths from all causes, 184 were from smallpox. In Cheshire in 1775, in a population of 15,000, only 1060 persons had not suffered from smallpox. In a Hertfordshire village named Ware, in a population of 2515, there were, at the end of an epidemic in the year 1722, only 302 persons who had not had smallpox, and the disease was looked on as so certain to come to every one that these 302 were tabulated as

'To have the smallpox.' Information as to the rest of Europe is similar. In an epidemic in Iceland in 1707-9, in a population of 50,000, 18,000 persons died from smallpox. In Russia, the physician to the Emperor, writing in 1812, calculated that every seventh child had died of smallpox. In Sweden it was estimated that the disease killed every ninth girl and every tenth boy, and in France 10 per cent. of all deaths were attributed to it.

Before the days of exact statistics there are many indications of the prevalence of the disease. So common was it that charms and amulets were worn to guard against attack, and an old Anglo-Saxon physician, Bald, in the tenth century gave in his 'Leech Book' six prescriptions for pock disease. The monastic records of Ireland, written in the dark ages, when the lamp of learning had been almost extinguished elsewhere in Europe, show that the disease was well known there, and when literature revived in England references to smallpox were common. Ben Jonson's 'Epigram to the Smallpox' begins

> 'Envious and foul disease, could there not be
> One beauty in an age and free from thee?'

In 'Love's Labour's Lost' Shakespeare makes Rosaline exclaim, 'O, that your face were not so full of O's!' to which the Princess replies, 'A pox of that jest!' and Donne, in his *Anatomie of the World,* asks, 'Are these but warts and pock-holes on the face of the earth?'

These statements relate only to the prevalence of the disease. But the evidence that it was ordinarily an affection of childhood is no less convincing. In Geneva, in 1580 to 1760, there were 25,349 deaths from smallpox at all ages, and of these 21,078 were under five years old, and 961 per 1000 were under ten years old. In Edinburgh, in 1764-83, the proportion under ten years old was 993 per 1000. In the Chester epidemic of 1774 there were 202 deaths, all among children under ten years old. In 36,755 deaths at all ages in Kilmarnock, Edinburgh, Manchester, Warrington, Chester, Geneva, and The Hague, 17,252 were under two years of age. The facts, therefore, are indisputable, (1) that smallpox was a very prevalent and fatal disease, and (2) that it was a disease of childhood.

Smallpox Inoculation.

Before Jenner's time, in the eighteenth century, extensive attempts were made to control smallpox by means of smallpox inoculation. The attempts began in England in the years 1721-22, when Lady Mary Wortley Montagu brought the practice from Turkey, but largely owing to mistaken methods of practice the inoculated disease proved so serious, causing probably one death in fifty cases, that after seven or eight years the project was practically abandoned for a time. It was revived between 1740 and 1750, and the new or Suttonian method was so much milder and better than the old that probably only about one person in 300 died from inoculated smallpox. Variolation was very general up to the end of the eighteenth century, but it is now impossible to say whether it did more good by protecting the inoculated individuals than harm by infecting those who did not submit to it. Where it was extensively carried out it would do more good than harm. Where it was practised only to a small extent it might set up epidemics among the susceptible who did not themselves get inoculated, and so do more harm than good. A profit and loss balance cannot be struck, but in Scotland there is a considerable amount of contemporary evidence that its effects were on the whole decidedly beneficial.

Jenner.

Edward Jenner's first vaccination was done in the year 1796, a year in which smallpox was causing 184 of every 1000 deaths from all causes in London. At this time Jenner was a man about forty-seven years old. As is well known, his attention was first directed to the subject during his medical apprenticeship, when he heard a milkmaid declare that she could not take smallpox owing to having already had the cowpox. In the midst of a busy country practice, with a kind of loitering persistence he kept turning the matter over in his mind, and enquiring about it, and discussing it at medical societies, for more than a quarter of a century.

Incidentally in 1789 he directed his attention to a particularly mild form of smallpox which was then prevalent, and which went by the name of swinepox. He considered whether from this much modified smallpox there could be obtained material for inoculation, which would give an even milder disease than ordinary smallpox matter. Americans have recently had much experience of a very mild variety or 'sport' of smallpox, which appears to correspond in its freedom from fatal results with the swinepox of Jenner's time, and with 'pearl pox,' which was written about in the year 1806 by Dr. Adams, physician to the London Smallpox Hospital. Jenner, however, gave up this project, and in 1798, or thirty years after he heard the milkmaid's remark, he published his famous *Inquiry into the Causes and Effects of the Variolae Vaccinae*.

Though Jenner hoped that vaccination would be 'essentially beneficial to mankind,' it is very doubtful whether at first he had any sufficient conception of its tremendous importance. His *Inquiry* (which was little more than a pamphlet) caused extraordinary interest all over the country, and especially in London, where, notwithstanding a good deal of criticism, vaccination was soon established. From England it quickly spread all over the civilised world, and it has been very generally practised now for over a hundred years.

But there have always been critics of vaccination, and I am told that even California is not without its anti-vaccinists. In one sense opposition is perhaps the greatest tribute to Jenner's work. To most people smallpox is now a mere name. They have never known it as the world knew it in past centuries, and their acquaintance with history is not such as to enable them to conjure up any ghost of the pestilence as it existed before being bound and fettered by the Jennerian prophylaxis. On the other hand, a mother sees the vaccine vesicles on her child's arm, and experiences the few days of usually trivial discomfort and inconvenience which they cause. At the same time she hears the most astounding stories of vaccinal mischief, and, having no experience of the danger which vaccination averts, she permits her next child to enter on its life journey unprotected against smallpox.

I am asked to give a short synopsis of the facts which make medical men in Britain believe in vaccination, but that evidence is so abundant, and has been so often published, that I have some diffidence in repeating it even with the brevity which the limits of these lectures impose. A very condensed synopsis of information on the subject will be found in the revised edition (1905) of a pamphlet entitled *Facts about Smallpox and Vaccination*, issued by the British Medical Association. I have given a fuller statement of the case in an article in *Allbutt and Rolleston's System of Medicine,* published this year by Macmillan in London and New York.

From time to time Parliament has conducted enquiries by Special Committee or Royal Commission into the evidence of the value of vaccination as a preventive of smallpox and of the risks alleged to attend the operation. These enquiries have all ended in the vindication of the practice, and in showing the triviality of the disadvantages attaching to it. The latest investigation was by a Royal Commission, which sat from 1889 to 1896, and heard no less than 187 witnesses, the great majority of whom represented anti-vaccination. The Commission also appointed several medical men of high standing to investigate and report on various outbreaks of smallpox and alleged cases of vaccinal injury which occurred during the seven years over which the enquiry extended. An opinion appears to have obtained some currency that the Commission's report was unfavourable to vaccination. This mistaken view has probably been due to its recommendation that strenuous objectors to vaccination in England should be relieved by what is popularly known as the Conscience Clause. It cannot be too clearly understood that this was advised for the direct purpose of promoting the practice of vaccination. The English law has never sanctioned the forcible vaccination of any child.

The Royal Commission on Vaccination.

The furthest it went in that direction was to provide for the imposition of penalties for neglect of the operation. Under the old law parents could be penalised repeatedly until a child had reached fourteen years of age. But the effect was not always to promote vaccination. It often did the opposite, especially if instead of paying the money penalty a parent chose to go to prison and obtain a cheap martyrdom which went far to defeat the purpose of the so-called compulsory provisions of the Vaccination Acts. It was with a view to remove this defect in the law that an exemption clause was recommended, and was ultimately provided. The conclusions of the Commission as to the value of vaccination are clearly stated as follows in their final report:

'We think—

1. That it diminishes the liability to be attacked by the disease.

2. That it modifies the character of the disease, and renders it (*a*) less fatal, and (*b*) of a milder or less severe type.

3. That the protection it affords against attacks of the disease is greatest during the years immediately succeeding the operation of vaccination. It is impossible to fix with precision the length of this period of highest protection. Though not in all cases the same, if a period is to be fixed, it might, we think, fairly be said to cover in general a period of nine or ten years.

4. That after the lapse of the period of highest protective potency the efficacy of vaccination to protect against attack rapidly diminishes, but that it is still considerable in the next quinquennium, and possibly never altogether ceases.

5. That its power to modify the character of the disease is also greatest in the period in which its power to protect from attack is greatest, but that its power thus to modify the disease does not diminish as rapidly as its protective influence against attacks, and its efficacy during the later periods of life to modify the disease is still very considerable.

6. That re-vaccination restores the protection which lapse of time has diminished, but the evidence shows that this protection again diminishes, and that, to ensure the highest degree of protection which vaccination can give, the operation should be at intervals repeated.

7. That the beneficial effects of vaccination are most experienced by those in whose case it has been most thorough. We think it may fairly be concluded that where the vaccine matter is inserted in three or four places it is more effectual than where introduced into one or two places only, and that if the vaccination marks are of an area of half a square inch they indicate a better state of protection than if their area be at all considerably below this.'

The Royal Commission which reached these conclusions was not a medical body, though it contained several distinguished medical men. It was presided over by Lord Herschell, Lord Chancellor of England—the highest legal authority in the realm, accustomed to weigh evidence and to state a verdict in the most carefully chosen terms. The report was also signed by Judge Meadows White, Q.C.; Mr. John S. Dugdale, Q.C.; Sir Edwin Galsworthy, Chairman of the Metropolitan Asylums Board; Sir Charles Dalrymple, M.P.; Mr. Samuel Whitbread, ex-M.P.; Mr. John Albert Bright, ex-M.P.; Sir W. Guyer Hunter, ex-M.P.; Professor (Sir) Michael Foster, and Mr. Jonathan Hutchinson, F.R.S. The last four of these were members of the medical profession. There were two dissentients, Dr. W. J. Collins (now Sir William Collins), formerly a Vice-President of the London Society for the Abolition of Compulsory Vaccination, and Mr. J. A. Picton, formerly Member of Parliament for Leicester.

In furnishing a brief resumé of the evidence for vaccination, the remarkable decline in smallpox prevalence has first to be noted. It began in a very striking fashion wherever vaccination was practised. The Royal Commission emphasised the remarkable diminution which took place in the disease during the first quarter of the nineteenth century.

Smallpox Mortality.

The following is part of a table prepared from official sources by the late Sir John Simon :[1]

Terms of Years respecting which particulars are given.	Territory.	Approximate Average Annual Death-Rate by Smallpox per Million of Living Population.	
		Before Introduction of Vaccination.	After Introduction of Vaccination.
1777-1806 and 1807-1850	Austria, Lower, - - - -	2,484	340
,, ,,	Austria, Upper and Salzburg,	1,421	501
,, ,,	Styria, - - - - - -	1,052	446
,, ,,	Illyria, - - - - -	518	244
1777-1806 and 1838-1850	Trieste, - - - - -	14,046	182
1777-1803 and 1807-1850	Tyrol and Voralberg, - -	911	170
1777-1806 and 1807-1850	Bohemia, - - - -	2,174	215
,, ,,	Moravia, - - - - -	5,402	255
,, ,,	Silesia (Austrian), - -	5,812	198
,, ,,	Galicia, - - - - -	1,194	676
1787-1806 and 1807-1850	Bukowina, - - - -	3,527	516
1776-1780 and 1810-1850	Prussia (Eastern Provinces), -	3,321	556
,, ,,	Brandenburg, - - - -	2,181	181
1776-1780 and 1816-1850	Westphalia, - - - -	2,643	114
,, ,,	Rhenish Provinces, - -	908	90
1781-1805 and 1810-1850	Berlin, - - - - -	3,422	176
1776-1780 and 1816-1850	Saxony (Prussian), - -	719	170
1774-1801 and 1810-1850	Sweden, - - - - -	2,050	158
1751-1800 and 1801-1850	Copenhagen, - - -	3,128	286

The contrasts which it shows are sufficiently striking, but in certain cases the totals when analysed are even more remarkable. In Sweden, from 1774 to 1801, the approximate annual average death-rate from smallpox per million living was 2050, and then there began a rapid diminution, which culminated in the period 1817-1822, when the annual rates were respectively, 96, 120, 63, 55, 14, and 4. But the diminution ceased with the figure 4, and in the three years 1823-25 there was an increase, the rates being 15, 226, and 449 respectively. In Copenhagen, as shown in the table, the pre-vaccination rate averaged 3128. In 1803-10 the figures were remarkably low, namely, 5, 13, 5, 5, 2, 46, 5, and 4. Then there was absolute freedom from smallpox mortality for thirteen

[1] *Public Health Reports*, by John Simon, edited for San. Instit. of Great Britain by Edward Seaton. 1887. Vol. I., p. 204.

years, there being not a single death during that time. Afterwards deaths began to occur again, and this fact will be commented on.

An ingenious criticism of such figures has been made by opponents of vaccination, it being urged that the amount of vaccination during the first quarter of the nineteenth century was quite insufficient to account for the decline in smallpox. That criticism at once fails when it is remembered that at the end of the eighteenth century only a fraction of the population required vaccination. The great majority had already suffered from smallpox in the natural way, or else had been protected by smallpox inoculation. It was only the small minority that needed protection, and the amount of vaccination performed was quite sufficient to include a large part of this susceptible remnant.

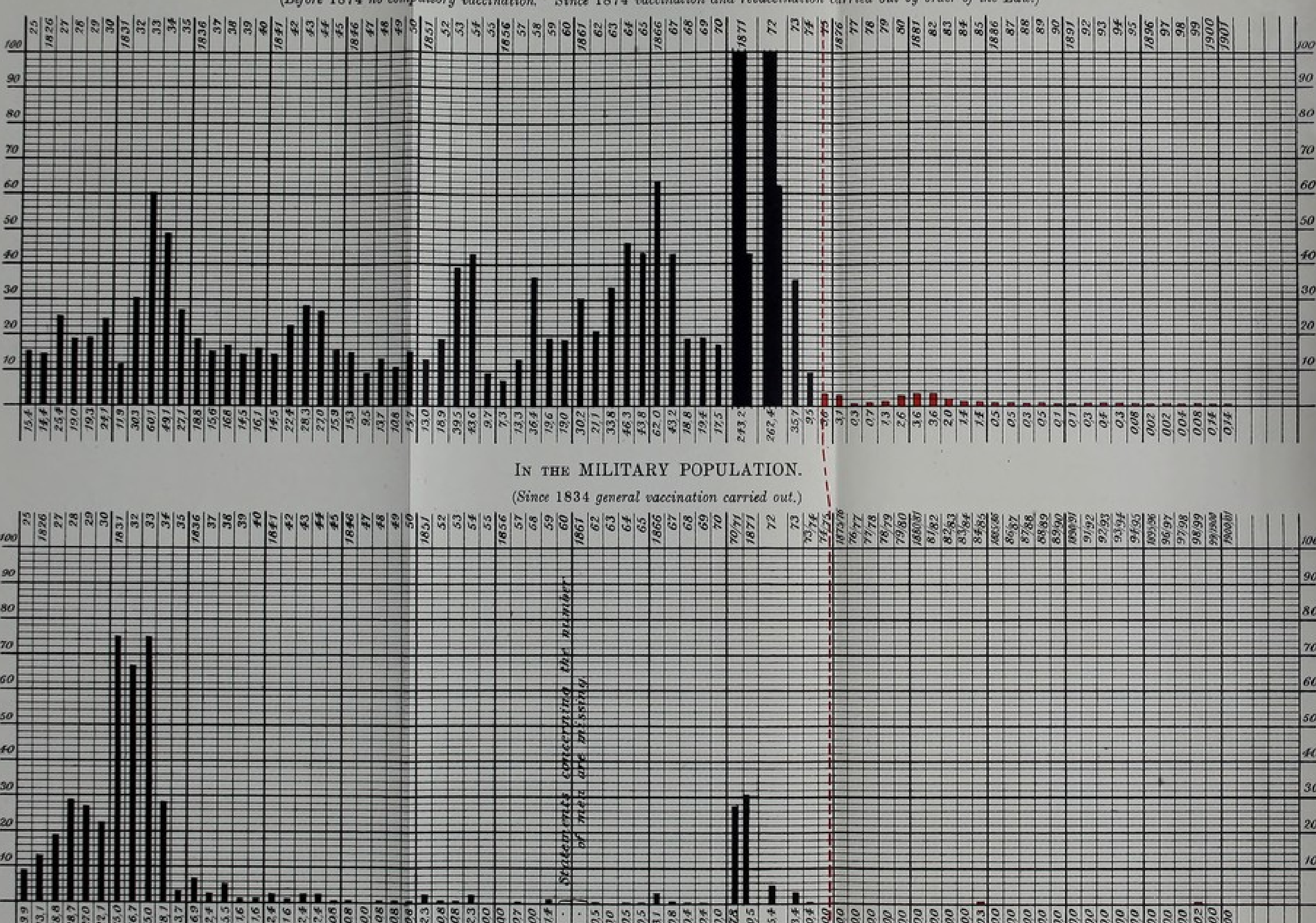
Two explanations of the decline have been submitted by anti-vaccinists. One, that the practice of smallpox inoculation diminished, so that there was less opportunity for the disease being spread by inoculated persons, and the other that sanitation was the agency in the lessening of smallpox. As regards the former explanation, it has already been pointed out that where smallpox inoculation was largely practised it would diminish mortality by protecting individuals, but that where only a fraction of the community were inoculated, while they themselves would be protected, they would spread the disease to others. Diminution of the practice would therefore be quite as likely to increase smallpox mortality as to lower it. Also, nearly everywhere there was still a sufficient prevalence of smallpox to provide material for infection of all who were susceptible, seeing that disinfection and isolation were almost entirely neglected. As regards the influence of sanitation, the epoch of modern improvement had not then begun. On the contrary, the population was rapidly herding into towns, and overcrowding was going from bad to worse. I have already (Lecture II.) described the terribly insanitary conditions which existed in Glasgow. In that town it happens that vaccination was extensively

MORTALITY FROM SMALL-POX OF THE CIVIL AND MILITARY POPULATION OF PRUSSIA.

OF EVERY 100,000 PERSONS THERE DIED FROM SMALL-POX

IN THE CIVIL POPULATION.

(Before 1874 no compulsory vaccination. Since 1874 vaccination and revaccination carried out by order of the Law.)



16th June 1834.
Vaccination and revaccination of all (for the first time) entered recruits obligatory.

After publication of the vaccination law.

1st *April* 1875 *the commencement of the validity of the German Imperial vaccination law.*

The figures are taken from: Contributions for judging the utility of vaccination against small-pox, Berlin, 1888. *Prussian statistics. Medico-statistical communications*

To face p. 219.

practised in the entire absence of the very elements of sanitation. A contemporary authority divided the thirty years 1783-1812 into five equal periods of six years, three of the periods being before and two after the introduction of vaccination. During the three former periods the percentages of deaths from all causes due to smallpox were (1) 19.55, (2) 18.22, and (3) 18.70. In the next two periods the proportions fell to 8.90 and 3.90 per cent. In Glasgow, while fevers and measles increased, smallpox, under the influence of vaccination, rapidly diminished.

Re-vaccination.

I have stated that at the end of the first quarter of the nineteenth century smallpox again began to rear its head. The explanation will at once occur to the student of the subject. As already pointed out, the population at the beginning of the century was in large measure protected against smallpox by previous smallpox, either natural or artificial, and vaccination did much to fill up the lacunae in the defensive armour. But protection by smallpox was more enduring than that given by vaccination, and it was not then known that vaccination ought to be repeated. When the disease began to reappear it was thought by some that the efficacy of the vaccine lymph in use must have lessened owing to its removal by so many generations from its bovine source, and proposals were made for a return to the cow for fresh supplies. But in Germany the truth was quickly apprehended and reduced to practice. Re-vaccination was systematically carried out in various armies in the empire—the Wurtemburg army in 1833, the

German Armies.

Prussian army in 1834, the Hanoverian army in 1837, that of Baden in 1840, and that of Bavaria in 1843. Taking the Prussian army to indicate the results, these are well shown in the lower half of the diagram facing this page.

German Civil Population.

While smallpox almost disappeared in the army from 1834 onwards, it continued to prevail in the general population, and the compulsory law was accordingly extended to the whole German Empire in 1874. The result is shown in the upper half of the diagram facing page 219, and it will be seen that now smallpox is almost unknown alike in the civil and the military population of that country.

Regarding the military population the diagram brings out one very interesting fact. The effect of its re-vaccination in diminution of smallpox was tremendous, but the disease did not entirely disappear. Up to 1874 the army was living in a kingdom in which there was much smallpox, so that any remaining susceptibility was constantly tested, and it will be observed that a few deaths still occurred, especially in 1870-71, during the European pandemic. But from 1874 onward the whole population was subject to a law of re-vaccination, so that the army then became surrounded by a protected nation, and under these circumstances there has been practically no death-rate from smallpox in the military population. This co-operative benefit is of much importance, and, as we shall see by-and-by, is useful even to the unvaccinated, whose risks of infection are greatly diminished by living in an almost insusceptible community. The diagram facing this page contrasts Prussia with Austria where vaccination has been promoted only since 1891.

In no other country than Prussia has there been any such thoroughness of prevention, and no other country shows any such change in its smallpox prevalence. But in Britain, on a much smaller scale, and referring to particular classes of the population, evidence of the value of re-vaccination is abundant.

Glasgow.

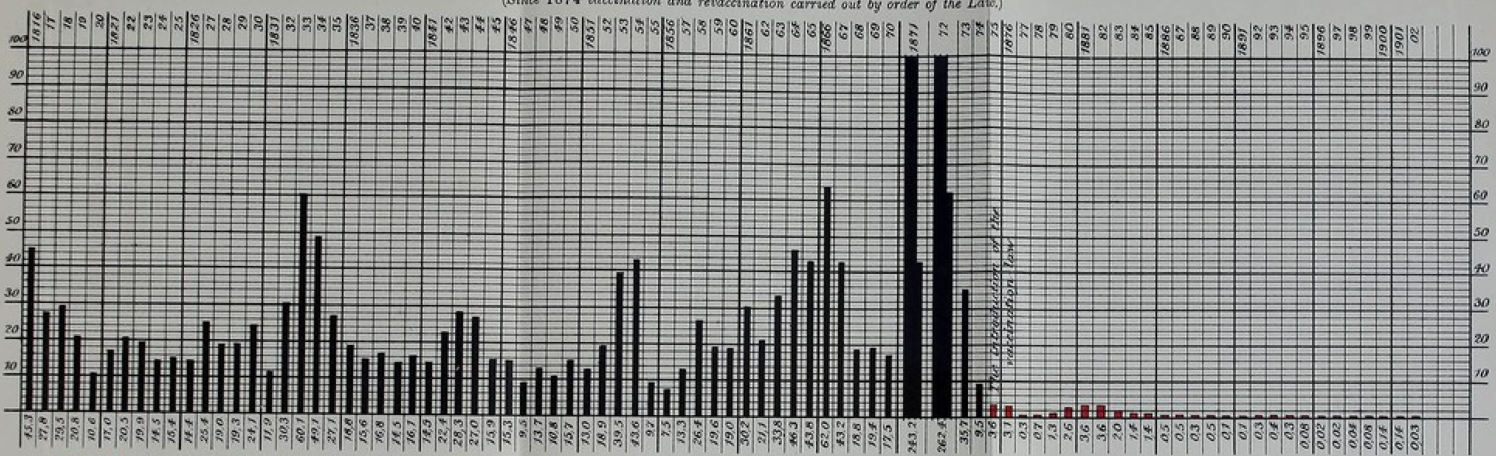
In Glasgow, in the year and a half beginning January, 1901, there was an outbreak of smallpox in which the total cases were 1858. Excluding children under five years old the population was estimated at 675,887. To this population re-vaccination was freely offered by the Corporation, all the medical men in the city being empowered to operate in the public interest. The following table, taken from the Medical Officer's *Report*, shows what took place :

MORTALITY FROM SMALL-POX IN PRUSSIA AND AUSTRIA DURING THE YEARS 1816–1902.

OF EVERY 100,000 INHABITANTS THERE DIED FROM SMALL-POX

IN PRUSSIA.

(*Since* 1874 *vaccination and revaccination carried out by order of the Law.*)

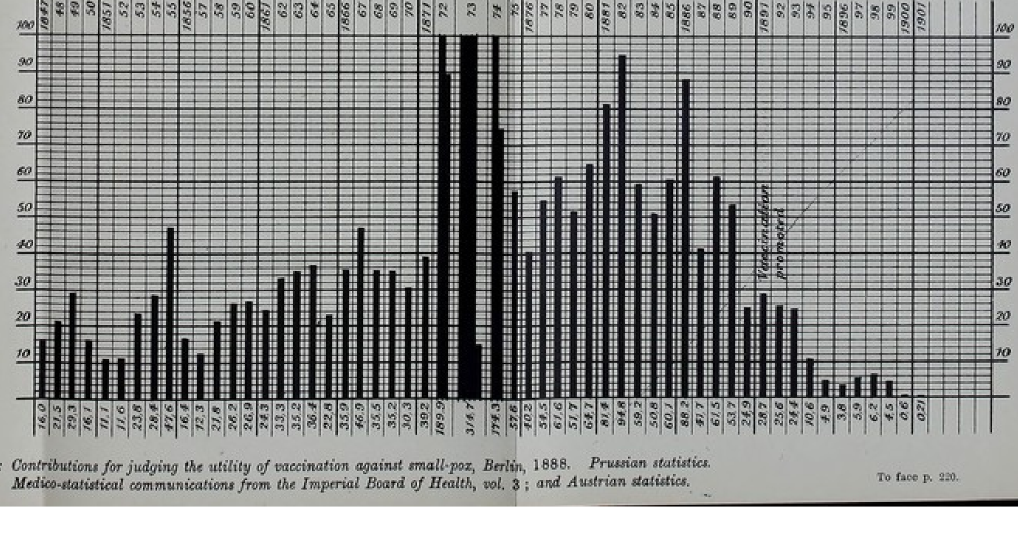


After publication of the vaccination law.

IN AUSTRIA.

(*No compulsory vaccination. Since* 1891 *the administrative government authorities promote vaccination.*)

No statements in existence.



The figures are taken from: Contributions for judging the utility of vaccination against small-pox, Berlin, 1888. *Prussian statistics. Medico-statistical communications from the Imperial Board of Health, vol.* 3; *and Austrian statistics.*

To face p. 220.

Not Recently Re-vaccinated and Recently Re-vaccinated Population of Glasgow, over five years of age, in each fortnight, with the Cases of Smallpox occurring in each class.

	Not Recently Re-vaccinated.		Recently Re-vaccinated.	
	Population.	Cases Registered.	Population.	Cases Registered.
January 12, 1901	675,887	23	0	0
" 26, "	674,816	350	1,071	0
February 9, "	671,025	202	4,862	0
" 23, "	634,213	127	41,674	0
March 9, "	556,561	299	119,326	0
" 23, "	518,426	161	157,461	0
April 6, "	474,694	92	201,193	0
" 20, "	429,056	67	246,831	0
May 4, "	384,371	28	291,516	0
" 18, "	366,125	18	309,762	0
June 1, "	352,633	11	323,254	0
" 15, "	347,777	2	328,110	0
" 29, "	345,293	8	330,594	0
July 13, "	281,867	1	394,020	0
November 16, "	279,452	1	396,435	0
" 30, "	279,232	5	396,855	0
December 14, "	279,020	4	396,867	0
" 28, "	278,796	0	397,091	0
January 11, 1902	278,623	28	397,264	0
" 25, "	278,152	23	397,735	0
February 8, "	277,653	23	398,234	0
" 22, "	277,134	147	398,753	0
March 8, "	276,033	92	399,854	0
" 22, "	274,611	85	401,276	0
April 5, "	272,694	36	403,193	0
" 19, "	271,619	15	404,268	0
May 3, "	271,032	10	404,855	0

The cases of smallpox under five years old have not been excluded, as their allocation through the various fortnights would have been difficult and their inclusion is not important. In the 1900-1901 part of the outbreak they numbered 60; 54 of them, including 30 cases under one year, had been unvaccinated primarily.

It will be seen how in the table the population is grouped into two classes, those who had not been recently re-vaccinated and those who accepted the offer of re-vaccination. It will be seen, also, how a great change in the grouping of population took place fortnight by fortnight, those not recently re-vaccinated beginning in January, 1901, at 675,887, and gradually falling, until in May the total was only 271,032. Conversely, the recently re-vaccinated population, which for convenience is assumed to be nil in January, 1901, gradually mounted up to a total of 404,855 in May, 1902. The other columns in the table show fortnight by fortnight the number of smallpox cases registered in each of these two groups of population. And the figures are most striking. The whole of the smallpox occurred amongst those who had not been recently re-vaccinated, and there was not one case among those who accepted the offer. This test of the value of re-vaccination was in Glasgow a particularly severe one for two reasons. (1) The great bulk of the population lives in tenement buildings, most of them four flats high, with several families on each flat, so that there is excellent opportunity for infection wherever infectious disease breaks out, and (2) The greatest prevalence of the disease in Glasgow was in the east end of the city in the neighbourhood of the smallpox hospital, and it was here consequently that re-vaccination was most freely accepted by the people. Yet, in presence of this exceptional prevalence of the disease and exceptional exposure to it in the East End, those who took advantage of the proffered re-vaccination remained entirely free from infection. Fortnight by fortnight the disease passed by those who had accepted the Corporation's advice to be re-vaccinated; fortnight by fortnight it raided those who had refused protection. This is the largest single experiment in re-vaccination that has ever been made in Britain.

Hospital Nurses.

One class of population, however, is more exposed to infection than was even this artisan and labour community of Glasgow. Nurses in smallpox hospitals have unequalled opportunities of being infected, yet smallpox is practically unknown among them. It is true that now and then exceptions do occur, but these are the exceptions that prove the rule. Over and over again it has been shown that nurses who take smallpox have not been duly re-vaccinated. In California some of you may have heard of the opposition to vaccination on which the town of Leicester prides itself. Anti-vaccination was so much the fashion there that when smallpox broke out in 1892-3 some of the nurses refused the protective operation. The total hospital staff was forty, of whom fourteen had either had smallpox or had been re-vaccinated before the outbreak, and twenty were vaccinated owing to the outbreak. Among those thirty-four one nurse, whose re-vaccination was ten years old, had a very slight attack of the disease. The other thirty-three entirely escaped. It was different with the six of the staff who refused re-vaccination. Only one of these needed any protection against smallpox at the end of the epidemic. Five of them took the disease, and one of the five paid for her error with her life. Leicester had another smallpox epidemic in 1903-4, when there were 715 notified cases. The hospital staff numbered seventy-four. The lesson of 1892-3 had not been forgotten. All the seventy-four, excepting three who had suffered from smallpox, had been recently re-vaccinated, and all escaped the disease. Two workmen, however, were temporarily employed at the hospital, and were not re-vaccinated. Though they were never in the wards, both took smallpox. In Glasgow the smallpox hospital accommodation was added to during the epidemic there, and 230 workmen were employed. All but thirteen of these were successfully re-vaccinated. Of the thirteen five were attacked by smallpox, and one died. Among the re-vaccinated 217 there was not a single case. At Highgate Smallpox Hospital, London, as reported by the Royal Commission, among 137 nurses and attendants thirty had suffered from smallpox before coming on the staff. Of the remaining 107, all excepting the gardener were re-vaccinated, and the gardener was the only one who took smallpox. It has been suggested with regard to facts like these that hospital nurses are a hardened class, and would not have become nurses if they had been afraid of or liable to infection. But it is only against smallpox that they are hardened. The Medical Officer of Gateshead, in England, wrote that 'every nurse who has been more than a fortnight in the typhus wards has suffered from typhus.' In Newcastle, in 1882, only five of fourteen nurses escaped typhus, and among the nine attacks there were two deaths. The Royal Commission reported that in the hospitals of the Metropolitan Asylums Board, in the years 1887-95, there were among the attendants 704 cases of scarlet fever, diphtheria, and enteric fever.

Babies in Smallpox Hospitals.

In Dewsbury, which, like Leicester, is a centre of antivaccination in England, there was recently a serious epidemic of smallpox, and regarding it the hospital physician wrote, 'there was a considerable number of children and infants, who, though not themselves suffering from the disease, were admitted to the hospital because the houses they lived in had to be closed owing to the parents being stricken with smallpox, or because the mother could not leave the infant at home; these children were efficiently vaccinated, and never in any single case did they show the slightest trace of smallpox, and yet they were daily in contact with and living amongst persons suffering from the disease, often in its most severe forms and in all stages.' I have had similar experience in Stirlingshire. Vaccinated babies admitted to the wards with their infected mothers, and re-vaccinated nurses, are like the Hebrew children in the fiery furnace, they pass through it without even the smell of fire on their garments.

Sanitation.

As already indicated, sanitation is the alternative hypothesis advanced in the present day to account for what are ordinarily regarded as the beneficial results of the practice of vaccination. It needs little argument to show that sanitation cannot explain the changed age incidence of smallpox. Measles and whooping-cough still remain diseases of childhood, while smallpox has been driven from vaccinated childhood into later periods of life. In Scotland vaccination is obligatory on all children under six months old. The second half-year of life, therefore, is the first period in which the influence of vaccination can be seen. Now the Scottish Vaccination Act was passed in 1855. Before that time, of every 1000 deaths from smallpox 139 occurred in the first half-year of life and 153 in the second half-year. What happened subsequent to the passing of the Act? In the first half-year the contribution to 1000 deaths from all causes was still 138, or practically the same as before, but in the second half-year the contribution fell from 153 to 47. It is manifest that the agency which made this difference was vaccination and not sanitation. And in Kilmarnock, in the eighteenth century, when there was no vaccination, nearly five times as many smallpox deaths occurred in the second half-year of life as in the first half-year. In Germany the age for primary vaccination is not so early as in Scotland. The operation may there be performed any time during the second year of life, and it was shown by Dr. Sweeting, in 1892, that of all the smallpox which then remained in Germany no less than 40 per cent. was crowded into the first two years of life.

But in this matter of age incidence vaccination is beneficial even to the unvaccinated. Epidemics of smallpox are more difficult to establish, and unvaccinated children may grow up protected against attack by the fact that they live in a national cordon of vaccination. Even amongst them, therefore, the age incidence of the disease is higher than before, though not nearly so high as among the vaccinated. This was illustrated by an official investigation which was made in London in 1884, when it was found that among the vaccinated only 8.6 per cent. of all cases occurred under the age of ten years, whilst among the unvaccinated no less than 61 per cent. of all their cases were under ten years of age. Again it is manifest that vaccination and not sanitation has to be called in to explain this difference of age incidence.

It is equally obvious that sanitation cannot be the reason for re-vaccinated hospital nurses remaining free from smallpox, whilst nurses who have not been re-vaccinated fall victims to the disease. Nor can sanitation account for the sudden and remarkable drop that took place in smallpox in the German armies when re-vaccination became compulsory in 1834, whilst the same drop was in the general population deferred until 1874, when compulsory re-vaccination was extended to the whole empire.

Smallpox in invaded Households.

Similar evidence is furnished by investigation of the incidence of smallpox on the vaccinated and unvaccinated members of households invaded by the disease, and here, as naturally happens, a good deal of the information relates to towns which have neglected vaccination. This is fortunate, because it has sometimes been alleged that the unvaccinated are in Britain a weakly class, whose vaccination has been postponed owing to ill-health and debility, and who, therefore, are more liable than other children to death by any disease which may attack them. But in towns where anti-vaccination has been a popular craze, there can be no such excuse for the dealings of smallpox with the unvaccinated. The Royal Commission gave statistics which included three centres of anti-vaccination—Dewsbury, Leicester, and Gloucester. They divided the inmates of infected houses into two age groups, those under ten years old and those over that age. These, again, were divided into vaccinated and unvaccinated. In Dewsbury, among the children under ten years old, 10.2 per cent. of the vaccinated were attacked, and 50.8 per cent. of the unvaccinated. In Leicester the percentage attacks in invaded households were 2.5 of the vaccinated and 35 of the unvaccinated, and in Gloucester 8.8 of the vaccinated and 46.3 of the unvaccinated. These children were living in the same sanitary or insanitary surroundings, eating the same food, and under the same parental guidance. Manifestly once more it was vaccination and not sanitation that drew the distinction between the two groups. Not only so, but if there were any truth in the allegation that vaccination is a dangerous operation, weakening the system, and rendering children easily liable to disease and death, then the unvaccinated, whose blood is held to be pure and uncontaminated by a bestial poison, should have escaped smallpox attack far more readily than those who had been submitted to the Jennerian 'rite.'

These figures relate to attack-rates, but the same reasoning applies to fatality rates, and the difference between the fatality-rates of smallpox amongst the vaccinated and unvaccinated respectively has been observed ever since it became known that through lapse of time vaccinated persons who neglect re-vaccination may be attacked by smallpox. Here, to begin with, the figures may be taken without any distinction of ages or of sufficiency or insufficiency of vaccination. In Belvidere Hospital, Glasgow, in 1900-1, there were 1810 cases of smallpox. Of these 122 were unvaccinated, and the deaths were 63, or 51.6 per cent., whilst 1688 were vaccinated, including all doubtful cases, and the deaths were 175, or 10.4 per cent. In London, in 1901-2, 9659 smallpox cases were treated in hospital, with 1629 deaths. The unvaccinated cases were 2278, with 753 deaths, or 33.1 per cent., and the vaccinated were 6945, with 705 deaths, or 11.5 per cent. In addition there were 436 cases doubtful as to vaccination, and amongst them there were 171 deaths.

Smallpox Fatality in Vaccinated and Unvaccinated.

But in giving these comparative figures the case for vaccination is much understated, for they take no note of the age of the persons attacked. The value of vaccination diminishes as the interval lengthens since the time of its performance. In 10,403 cases treated in Homerton Hospital, London, in 1873-84, it was found that in the age period 0-2 years the deaths among the unvaccinated were 66 per cent. and in the vaccinated 20.7 per cent. At 2-5 years the corresponding percentages were 50 and 18.4. At 5-10 years the fatality-rates were 37 and 7.3 per cent., at 10-15 years, 23 and 3.49 per cent.; at 15-20, 42 and 6.4 per cent.; at 20-25, 48 and 11.9 per cent.; at 25-30, 53 and 15.2 per cent.; at 30-40, 41 and 7.4 per cent.; at 40-50, 43 and 20 per cent.; and over 50 years, 43 and 27.5 per cent. respectively.

Fatality at Different Ages.

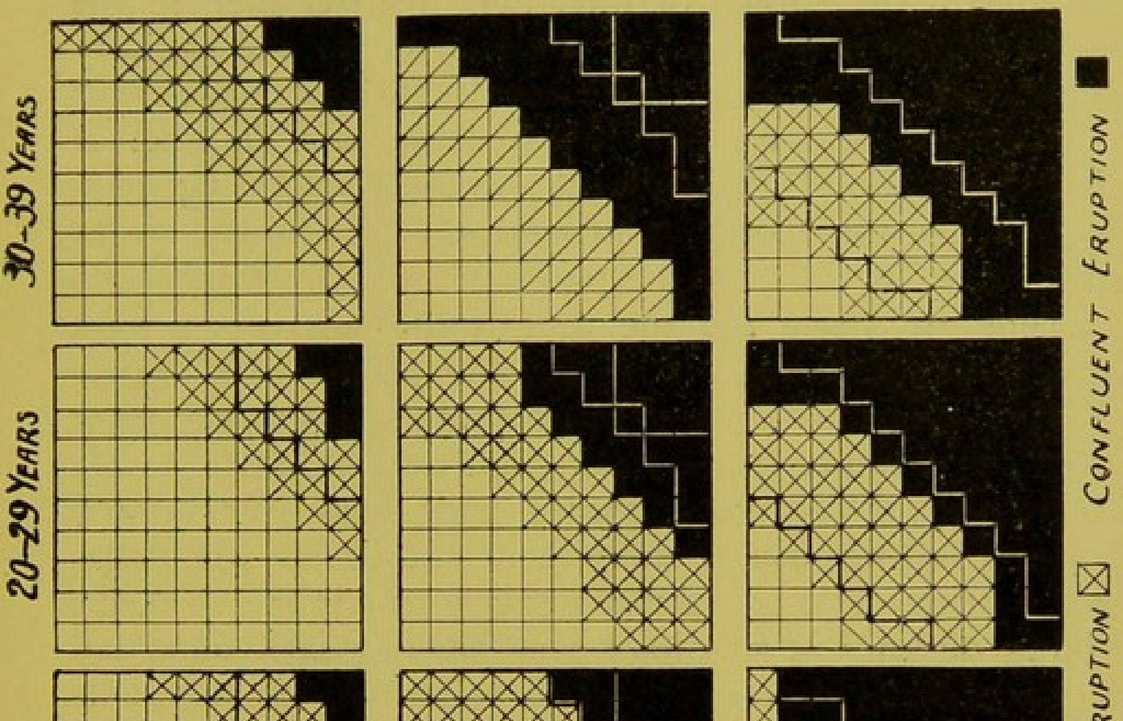
While it is manifest that sanitation cannot explain either these differences between the unvaccinated and the vaccinated, or the fact that the differences are greater at the ages when vaccination is most recent, it might conceivably be urged that in London, to which the figures refer, the amount of vaccination default was not very great, and that the unvaccinated might be appreciably composed of weakly and unhealthy children whose vaccination had been postponed. I shall, therefore, again refer to Dewsbury, Leicester, and Gloucester, as to which towns no such suggestion can be made. In them, as shown by the Royal Commission, of 72 vaccinated children under ten years old, two died, or 2.7 per cent.; but among 961 unvaccinated, 350 died, or 37.3 per cent.; whilst among persons over ten years old there were 1959 vaccinated, with 136 deaths, or 6.9 per cent.; and 331 unvaccinated, with 75 deaths, or 22.6 per cent. Once again it is vaccination and not sanitation that explains the facts.

Sufficient and Insufficient Vaccination.

But even these comparisons do not show the full benefits of vaccination, because much depends on the thoroughness with which the operation is done. Three or four vaccination marks give more protection than one or two, and a large is better than a small area of insertion. In England a standard requirement for public vaccinators is that the total area shall not be less than one-half of a square inch. The difference which sufficiency and insufficiency of vaccination makes cannot be better illustrated than in a frequently reproduced diagram by the late Dr. J. B. Russell, the former medical officer of health of Glasgow. The diagram tells its own story. It shows how the quality of the operation influences the character of the smallpox eruption, which is classified into rare, copious, and confluent. It shows, also, how as time passes the influence of vaccination against smallpox diminishes, though it is never entirely lost; and once again I have to point out how impossible it is to explain this difference by means of sanitation.

The Meaning and Worth of Sanitation.

Yet it is not to be understood that sanitation is powerless in smallpox. In a previous lecture I have urged that it is useful not merely against infectious disease but against all diseases—that healthy surroundings will benefit every part of a man's body—that his brain and his heart and lungs will be the sounder for a sanitary environment. But as regards infectious disease, the particular measures which



N.B.—The large squares contain 100 smaller ones, so that the varieties of the smaller squares represent percentages. V.M. means vaccination marks. The thicker black and white lines indicate the original percentages at 0—9 years.

are specially useful against one are not necessarily of any value against another. Plague may be conveyed by rats, therefore the killing of rats is good against plague, but it is of no use against typhus. Enteric fever may be conveyed by water, but measles is not carried in that way; therefore, protection of a water supply will not prevent measles. Scarlet fever may be carried by milk, but not whooping-cough. In short, if the term sanitation is to be used as including every agency that helps to prevent and control the spread of infectious disease, then in the case of smallpox vaccination itself is the special sanitary agency, just as for malaria the destruction of mosquitoes is important, and for enteric fever the safe disposal of infected excreta. But, in addition to these special agencies for each disease, there are general agencies which are of some value for all. Among these fresh air supply and sufficient air space are the most important. The high barracks-like buildings in which the people of Glasgow live give infectious diseases like smallpox and scarlet fever easier opportunity for spread than do separate single dwelling-houses scattered over a wide area. Prevention of overcrowding and abundance of ventilation are therefore in their measure useful against smallpox. Yet the striking distance of smallpox is so much greater than that of typhus fever that the housing reform which has done so much to stamp out the latter disease has had infinitely less effect on the former.

Hospital Isolation.

We come now to consider very briefly the value of isolation in smallpox prevention. In places where vaccination and re-vaccination are fully resorted to, hospital isolation is practically not required. In Germany the city of Berlin, with its two million inhabitants, has only twelve beds for smallpox in a general hospital within the city. But in London, with its five millions, where re-vaccination is not compulsory, and where primary vaccination is in default to an extent which in some recent years has approached 20 per cent., there are kept in regulated readiness for smallpox about 2500 hospital beds, not in the city, but well away from it in sparsely populated rural areas. But if vaccination and re-vaccination were entirely wanting in London, even this great amount of hospital accommodation would be quite insufficient. In a wholly unprotected community persons nursing smallpox would themselves be attacked. They in their turn would infect others, and so the disease would spread unchecked in ever-widening circles. Smallpox hospitals, therefore, are needless where vaccination and re-vaccination are universal, and they are powerless where vaccination and re-vaccination are entirely absent. It is in the intermediate condition that they are of value. In a partially vaccinated community hospital isolation of cases, and systematic observation of contacts, together with thorough disinfection, frequently make it possible to check an outbreak at the beginning, or to limit the disease even where it is not prevented. If the smallpox patient is sent to hospital, and his nurses and attendants and all who have been in contact with him are at once vaccinated, the disease may perhaps go no further. In this way smallpox hospitals are under present conditions most valuable in Britain.

Their Dangers.

But in order to get the full benefit of them, experience shows that they should be situated not in the heart of cities, but away in the country, where there is very little population and the air is pure. In London, when it was visited by the pandemic of the early seventies of last century, intra-urban hospitals were largely used, and did a great deal to spread the disease. The subject was investigated by Mr. W. H. Power, at first in relation to Fulham Hospital, with results which may be summarised as follows:

(1) When smallpox was not being received into the hospital there was no special incidence of the disease in the one-mile area around it, nor was there any regularity of distribution in quarter-mile zones within the mile area of such smallpox as did exist.

(2) When the hospital came into operation for smallpox its surrounding mile area became specially affected, and at the same time the subdivisions of the area were affected relatively to their propinquity to the hospital.

(3) These phenomena were observed with remarkable regularity in one epidemic after another.

(4) London parishes in which smallpox hospitals were completed in 1871 or afterwards had their smallpox

prevalence altered relatively to that of the parishes which did not contain these hospitals, so that some parishes which previously had been comparatively exempt from the influence of smallpox epidemics came under that influence to a very remarkable extent, and displaced other parishes which formerly had headed the list.

(5) The positions in this list of the parishes containing smallpox hospitals varied according as these were closed or in active operation.

(6) Houses in the chief thoroughfares leading to the hospital were not exceptionally affected.

(7) Smallpox prevalence in the special area was greater after acute cases in the hospital were beginning to increase rapidly, the statistics being made up fortnight by fortnight, so as to allow for incubation of the disease in infected persons.

(8) The special area around large hospitals devoted to convalescent smallpox cases showed no exceptional prevalence of smallpox, and reception of convalescent cases was not followed by any such surrounding prevalence.

Attempts were made by strict regulation of hospital traffic, by minimising the ingoings and outgoings of the staff, and by attention to every administrative detail, to prevent this evil influence of the hospitals; but all these efforts failed, and when the disease again became epidemic the hospitals again became centres of infection. Endeavour was next made to prevent this untoward result by strictly limiting the number of acute smallpox patients to be admitted to each hospital, but repeated limitations were found to be powerless. Finally, in 1886, the treatment of smallpox in these London hospitals was entirely given up, hospital ships were established in the estuary of the Thames, and to them London smallpox cases were removed. The hospital ships were situated about half a mile from the north or Essex shore, where there were certain villages and a scattered country population. And it was next found that when smallpox prevailed in London, and the ships became occupied with many acute cases, the disease broke out in this Essex population, and that this recurred in epidemic after epidemic.

A very well-defined difference of opinion exists as to how such facts are to be interpreted. Many hold (myself among them) the best or only explanation of many of the observed facts to be that the poison of smallpox is conveyed aerially, and I observe that Drs. Welch and Schamberg, who were sceptical to begin with, have been forced to accept this conclusion by the experiences of smallpox hospital isolation in Philadelphia. Others hold that infection from hospitals is always due to personal communication. It is impossible to do more than mention the matter in these lectures, and all I want to say is that, whatever be the explanation, the obvious lesson follows that smallpox hospitals for acute cases should be well isolated. Convalescent hospitals show no such power of spreading the disease.

Hospital Management of Smallpox.

Intercourse being one possible means of spread of smallpox in and from a hospital, no matter where situated, efforts must in every case be made to minimise that risk. If, under any circumstances, it becomes necessary to treat smallpox in an hospital to which other infectious diseases are admitted, very special precautions have to be taken.

It is assumed that the vaccination of nurses will in all cases be duly attended to. The vaccinal condition of every patient should be examined, and wherever necessary consent for vaccination should be asked. In my own experience, consent has been hardly ever refused, but sometimes a patient may be too ill for vaccination. So long as smallpox is under treatment in the hospital, no patient suffering from any other infectious disease should be admitted, unless he has already had smallpox, or his vaccination is satisfactory, or will be permitted if unsatisfactory. Difficulty may occur where vaccination is refused on behalf of a patient really requiring it, whose isolation is essential for the protection of the public against infection by the disease from which he is suffering.

The hospital population being rendered insusceptible to smallpox infection, it is necessary to take all possible measures towards preventing spread of the disease around the hospital by intercourse direct or indirect. Visitors should only be admitted if they are in a proper vaccinal condition and if patients are very ill. The usual waterproof overalls and caps should be kept for all persons entering the wards. Smallpox patients should be treated in a pavilion by themselves, quite apart from the rest of the hospital. Their airing ground should be separated by two unclimbable fences, with space enough between to make contact with the outside impossible. The pavilion should be self-contained in respect of cooking and of sleeping accommodation for the staff. Nothing should be sent to the laundry which has not already been thoroughly steeped in a reliable disinfectant solution. As regards contact with the outside, while the dangers of indirect infection from hospitals by journeyings of the staff or visits of tradesmen have perhaps been exaggerated, yet all contact risks should be reduced to the minimum degree consistent with efficient hospital management. Fever nurses are often very willing to take the opportunity to gain experience of smallpox, and will sometimes consent to intermit all outside leave for six weeks or three months at a time, after which other nurses can be employed on similar terms. This has been done in Edinburgh and in Stirlingshire. Telephonic communication from the hospital is valuable in minimising intercourse. Orders to tradesmen can be sent by telephone, and reports on the condition of patients can be similarly telephoned to the health office and thence forwarded by letter to patients' relatives. Hospital supplies should, as far as practicable, be left at the gate lodge, and thence brought in by the hospital porter. In large hospitals there should be a separate entrance for goods and for patients. All tradesmen sending goods to the hospital should be informed that only re-vaccinated messengers are to be employed, and the vaccinal condition of messengers set apart for such work should be examined by the medical officer. Ambulance vans should, of course, be disinfected after use, and there should be no avoidable contact or communication during journeys. The above precautions, of course, apply to all hospitals where smallpox is treated, whether or not they are wholly devoted to that disease.

As regards injurious results from vaccination, the Royal Commission made very careful search and caused medical enquiry to be made into alleged injuries reported during its seven years' sittings. Their conclusion was as follows:

Vaccinal Injuries.

'A careful examination of the facts which have been brought under our notice has enabled us to arrive at the conclusion that, although some of the dangers said to attend vaccination are undoubtedly real and not inconsiderable in gross amount, yet considered in relation to the extent of vaccination work done they are insignificant. There is reason further to believe that they are diminishing under the better precautions of the present day, and with the addition of the further precautions which experience suggests will do so still more in the future.' This was written at a time when arm-to-arm vaccination was practically universal in England. Now calf lymph is equally universal, and it is obvious that diseases to which the calf itself is not liable cannot be conveyed by calf lymph. In addition, the most careful antiseptic and aseptic precautions are now used by public vaccinators. Nothing in this world is absolutely free from risk, but vaccination is in itself very safe, and its evil effects are a mere droplet as contrasted with an ocean of benefit.

In England objection to compulsion in the matter of vaccination has been much greater than objection to vaccination itself, but it is easy to see how the former has increased the latter. Questions of personal liberty are viewed very differently in Germany, America, and England, and I do not propose to enter on their discussion here. But the protection afforded by the Jennerian prophylaxis, duly renewed, especially where smallpox exists, is such that no one who chooses to make full use of vaccination need have the slightest fear of smallpox. He can live safely through the most virulent epidemic.

He can reside in a smallpox hospital and freely inhale an atmosphere loaded with infection. He can so protect his children as safely to bring them into a smallpox ward and have them photographed by the bedside of smallpox patients, or along with vaccinated babies safely suckling at the breasts of smallpox-infected mothers. Jenner's work was much greater than Jenner, and it is not too much to claim for him that by promulgating vaccination he has directly saved more lives and prevented more suffering than any other man in the past history of medicine, if not in the past history of the human race.

LECTURE X

THE PREVENTION OF TUBERCULOSIS

THE prevention of tuberculosis is by far the most important public health problem of the present day. That it is a public health problem at all is only a modern discovery. Thirty years ago consumption was looked on, popularly and even professionally, as a physical curse, passing on from one generation to another, sometimes loosening, but never letting go, its hereditary grip of the families which, in some unknown way, had come within the wide sphere of its evil influence. Nothing could be relied on to prevent attack, and the science of medicine could, as a rule, only prolong life and palliate suffering. For the afflicted families the outlook was indeed gloomy, and it had become all the darker with the advance of civilisation, with increased appreciation of the value of human life, and with the freer play of natural affection which had accompanied a lessening of the keenness of the struggle for the mere necessaries of existence. Into this gloom Koch's discovery of the tubercle bacillus came as a ray of light nearly a quarter of a century ago. The public, indeed, did not fully appreciate its significance; but it raised high hopes in the breasts of medical men. Later came the sanguine expectation of an inoculative cure for phthisis, followed by a natural reaction of disappointment. And now, at length, we have the whole civilised world deeply interested, to some extent even engaged, in the prevention of tuberculosis.

The bacillus of tubercle is an immotile rod without flagella. It is often irregularly segmented. In the sputum and in the tissues it may be branched and in thread forms. The way in which it resists destruction by desiccation suggests the belief that it is a spore-forming microbe, though this has not been actually demonstrated. Its growth is favoured by a temperature between 85° F. and 108° F., the optimum being 98.6°-100.4°, but it always grows slowly in artificial media, and does not grow in the absence of oxygen. At first it was believed that it could not live outside the body of its host—that it was a true parasite—but this, unfortunately, is an error. It may find entrance into the human body by two principal gateways—the air passages and the alimentary canal. There is much reason to believe that primary infection of the lung in most cases is by way of the alimentary rather than the respiratory tract. In addition, it can be received through a wound in the skin.

Bacteriology.

Into the air passages and the alimentary canal it can find admission either as dust of dried sputum or as spray from coughing or speaking. The spray of ordinary coughing probably does not carry more than three feet from the patient, but it has been found that a man speaking from a platform in a public hall or church gives forth a fine spray, which carries as far as forty feet. Dr. Mervyn Gordon, following Flügge's experiments, took Petri dishes containing nutrient broth, and exposed them in various parts of a room in which loud speaking was afterwards practised. It was found that the Streptococcus brevis, which abounds in saliva, was carried through the distance already stated, and then fell on the Petri dishes, and could be tested there by the streptococcus producing a definite change of colour in neutral red broth under anaerobic conditions. In spray the bacillus of tubercle has been found alive after three days in the light and after eighteen days in darkness. That observation bears on the important fact that sunlight is very destructive to the bacillus.

The bacillus is not present in the sputum until the lung begins to break down, and until it is discovered there can be no more than suspicion of the disease. Even when the bacillus does become capable of detection, at first it may be present in the sputum only occasionally, so that specimens for examination should represent a whole day's coughing, and even then repeated samples should be taken at intervals. In the laboratory of Edinburgh University, as stated by Professor Hunter Stewart, both the ordinary methods of examination are followed—one by liquefaction of the sputum, and separation of its contents by centrifugal action, the other by making films directly from visible caseous specks. Six films are made from different parts of the sample, and all are tested. Of 105 specimens in which the bacillus was obtained, only seven did not show it in the first film, and only one did not show it in either first or second. The practice in the Glasgow Corporation laboratory is to make a composite film on a slide, by taking about half-a-dozen particles from different parts of the sputum, spreading them in narrow streaks side by side, and drying and staining in the ordinary way. When several negative results are obtained in a patient with very suspicious symptoms, a biological test is made.

The fact of the tubercle bacillus being acid-fast, so that stained specimens resist decolouration even by 25 per cent. strength of sulphuric acid, does not necessarily distinguish it from various so-called pseudo-tubercular bacilli which are practically identical both morphologically and in withstanding acid. But there exists between the pathogenic and non-pathogenic acid-fast bacilli the usual difference of cultivation temperature: room temperature, or 60° F., is enough for the latter, whilst the disease germs require blood heat, and even then the bacillus grows slowly. Dr. A. C. Coles also holds that there is an appreciable difference in the degree of acid-fast quality. The bacillus of tubercle, when stained for seven minutes, withstands decolouration by even sixteen hours' exposure to 25 per cent. strength of sulphuric acid, whilst the pseudo-bacilli are entirely decolourised by such exposure.

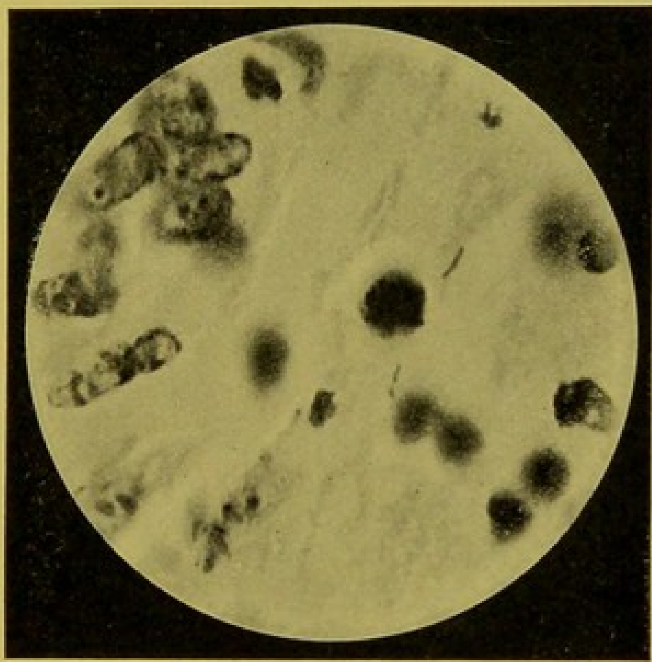
As regards invasion by the digestive tract, the chief agency, of course, is food. In the bovine disease the muscle itself is practically not attacked by tubercle, but only the organs, glands, and membranes. I need not recall how, in 1901, Koch startled the medical world for the third time with regard to tuberculosis. The first occasion was when he announced his discovery of the bacillus, the second when he advocated tuberculin as a cure, and the third when he declared his belief that bovine tubercle is so different from human tubercle that man cannot be infected by the cow disease.

Bovine Tuberculosis.

Koch fed young cattle with human tuberculous sputum for seven or eight months. He caused others to inhale the spray of water loaded with bacilli, and he tried various other means of setting up tuberculosis in cattle by injection of sputum or of cultures, subcutaneously or into the peritoneum or into the jugular vein. All failed. There were neither symptoms nor post-mortem appearances. Control experiments by the use of bovine tubercle succeeded, on the other hand, in quickly setting up the disease in other cattle. The cattle used had all been previously tested by injection of tuberculin. Another experiment consisted in trying to infect some swine by means of human tubercle, and others by bovine tubercle. The former attempt failed, while the latter succeeded.

In enquiring whether the bovine disease could affect human beings direct experiment was, of course, impossible, but Koch reasoned that meat and milk so often contain bovine tubercle as to make it certain that primary tubercular disease of the intestine must frequently result if the infection be communicable, and such cases, he held, were really very rare.

The publication of Koch's views led to immediate investigation by Royal Commissions in both Germany and Britain. Though even yet the British Commission has not completed its work, it issued in 1904 an interim report quite opposed to Koch's conclusions. The Commission introduced human tuberculous matter into twenty cows, and found that seven of them were at once attacked by acute tuberculosis, and that all the others except two were affected to a less extent, the disease in these spreading from the seat of inoculation to the lymphatic glands, with at the most some small amount of tubercle in organs like the lungs and spleen. But even in these slight cases the tuberculous disease so established could be introduced into other bovines or into guinea pigs. Still further, and



BACILLUS TUBERCULOSIS IN UDDER OF COW.
×1,000. (Buchanan.)

very important, when cows were inoculated from the guinea pigs they developed general tuberculosis of an intense character. This disease set up in the bovine animal by material of human origin was quite indistinguishable from that set up in similar animals by matter of bovine origin.[1]

[1] The Royal Commission have now (January, 1907) issued a Second Interim Report, in which they conclude "There can be no doubt but that in a certain number of cases the tuberculosis occurring in the human subject, especially in children, is the direct result of the introduction into the human body of the bacillus of bovine tuberculosis; and there also can be no doubt that in the majority at least of these cases the bacillus is introduced through cows' milk. Cows' milk containing bovine tubercle bacilli is clearly a cause of tuberculosis

Other investigators have arrived at similar conclusions, and as regards Koch's contention that the virus, if swallowed, should first attack the bowel, Martin and Hamilton have found that animals fed on tubercular sputum often develop tuberculosis without the intestinal or mesenteric glands being at all infected.

I have now mentioned, in the light of bacteriology, the principal means by which tuberculosis may be spread. The next question is, how may it be prevented?

Statistics—Diminution.

The answer may be best approached by enquiring whether in the past it has to any extent already been prevented. The reply is a most emphatic affirmative. The following are the figures for all forms of tuberculosis in England and Wales in the past four decades, stated per million of population:

1861-1870	1871-1880	1881-1890	1891-1900
3239	2862	2429	2010

If phthisis alone be taken, the improvement is even more striking. Thus:

1861-1870	1871-1880	1881-1890	1891 1900
2545	2190	1775	1391

and of fatal tuberculosis in man. Of the sixty cases of human tuberculosis investigated by us fourteen of the viruses . . . contained the bovine bacillus. . . . Of the total sixty cases investigated by us twenty-eight possessed clinical histories indicating that in them the bacillus was introduced through the alimentary canal." Of these, thirteen contained the bovine bacillus. "These facts indicate that a very large proportion of tuberculosis contracted by ingestion is due to tubercle bacilli of bovine source. A very considerable amount of disease and loss of life, especially amongst the young, must be attributed to the consumption of cows' milk containing tubercle bacilli. The presence of tubercle bacilli in cows' milk can be detected, though with some difficulty, if the proper means be adopted, and such milk ought never to be used as food. There is far less difficulty in recognising clinically that a cow is distinctly suffering from tuberculosis, in which case she may be yielding tuberculous milk. The milk coming from such a cow ought not to form part of human food, and indeed ought not to be used as food at all. Our results clearly point to the necessity of measures more stringent than those at present enforced being taken to prevent the sale or the consumption of such milk."

For tubercular meningitis at all ages the figures are:

1861-1870	1871-1880	1881-1890	1891-1900
310	284	234	216

But tubercular meningitis is mainly a disease of childhood, and in each million of children under five years old the following have been the deaths:

1861-1870	1871-1880	1881-1890	1891-1900
2233	1908	1456	1320

At later ages the registrations from tubercular meningitis have rather increased, probably owing to improved diagnosis.

Diminution in tubercular peritonitis and tabes mesenterica has not been so great, the rates per million in the four decades having been

1861-1870	1871-1880	1881-1890	1891-1900
266	285	257	217

It will be noted that only in the last decade has there been a very definite improvement. Other tubercular diseases of glands, bones, skin, and other tissues cause only a small total of deaths, but such as they are they show an increase, thus:

1861-1870	1871-1880	1881-1890	1891-1900
118	103	163	186

Perhaps change of nomenclature, the substitution, say, of caries for such an indefinite term as bone disease, may explain this apparent anomaly.

For the same four decades in Scotland the rates were as follows:

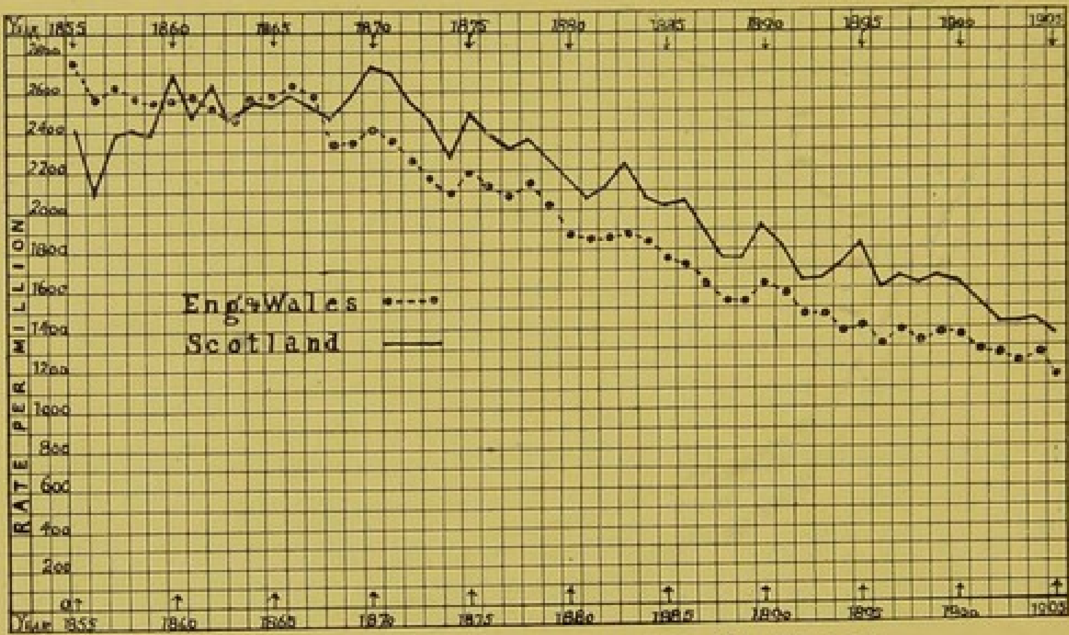
	1861-1870	1871-1880	1881-1890	1891-1900
All Tubercular Diseases, -	3620	3470	2750	2370
Phthisis alone, - - -	2560	2390	2000	1690

The following chart shows the reduction in the phthisis death-rate for England and Wales, and for Scotland.

For the counties of Stirling and Dunbarton the figures are given at p. 22.

How, then, has this great improvement been accomplished in Britain? On the continent of Europe I believe it is attributed to what they call the English method. That is as high a compliment as could be paid to local government in Britain. It will be observed that diminution in mortality has been going on all through the forty years, and had made good

The English Method.



PHTHISIS—DEATH-RATE PER MILLION, 1855 TO 1905.
England and Wales. Scotland.

progress long before bacteriology gave us its most valuable aid, and long before we even knew phthisis as an infectious disease.

The English method, as usually understood, means general sanitation, in the sense of better air, better food, better water, better houses on better sites, better drainage, and greater individual and domestic and municipal and national cleanliness.

Improved house accommodation is perhaps the chief of these agencies. Drier sites; damp-proof courses in walls; houses raised higher above the ground level; larger windows, opening more freely and more freely opened; the restricted use of bedrooms without fireplaces and chimneys; open iron bedsteads, instead of shut-in and curtained recesses; smooth wall-papers, easily dusted and washed; carpets not reaching to the wall, but convenient for lifting and cleaning, or small rugs instead of carpets, and closely-boarded, polished floors—all such items are included in improved house accommodation.

One cause of such means having been so successful is to be found in the nature of the disease itself. In all zymotics there are two main factors, the seed and the soil. In measles the seed is all-important. It can grow on any soil which has not already been exhausted by it. But in tuberculosis the soil is infinitely more important than the seed. If the poison of tubercle were as infective as that of measles, it would almost depopulate the world. But the bacillus tuberculosis is a very inactive microbe, and will not grow unless under very favourable conditions. By the sanitary and social progress of the past forty years, including the diminution of poverty, these favourable conditions have been greatly diminished.

It is obvious that the same fresh air and cleanliness which strengthen the individual to resist the disease weaken the invading micro-organisms. In the laboratory, by artificial processes, the functions of pathogenic organisms may be strengthened or weakened or altered or suspended. When the animal tissues are invaded by the bacillus, a struggle is at once set up between the body cells and the microbe, and the difference between the cells of a healthy, well-fed man living a cleanly life in a cleanly environment, and a man who has been under opposite influences, must continually make all the difference between victory and defeat in the momentous warfare.

Such have been the main features of the English method as generally understood in England itself. But in addition, it has been cogently urged by Dr. Newsholme that increased resort to segregation of advanced cases has played an important and insufficiently recognised part in diminishing phthisis. He contends, indeed, that it has been the principal agency, and he has given statistical

Isolation of Cases.

evidence to show that in recent years far more phthisical patients than before have spent the last and most infectious period of their illness in poor law infirmaries or other public institutions. Such institutional treatment was not to any appreciable extent, at least until lately, resorted to with the definite aim of preventing spread of infection, but rather for administrative poor law or humanitarian reasons, and within most of the infirmaries there may have been little attempt to separate phthisical from non-phthisical cases. Yet, just as general sanitation has aided in lowering the prevalence of phthisis, though not specifically adopted for that purpose, so has increased isolation of advanced cases; and the same lesson of the profit of perseverance in well-doing is deducible from both experiences, and is applicable for future guidance in both directions.

Though good health plays so large a part in the prevention of phthisis, it is by no means the only agency, and has to be supplemented by other measures. These now claim our attention.

Smoke Prevention.

In the first place, practical effect should be given everywhere to the knowledge which we possess of the remarkable influence of sunlight in the destruction of the tubercle bacillus. The influence of sunlight on bacteria is well illustrated by a method devised by Professor Buchner of Munich. An agar plate was thickly sown with the micro-organisms of Asiatic cholera and exposed to direct sunlight for $1\frac{1}{2}$ hours. Black paper letters of the word 'Cholera' were attached to the under surface of the plate, which was then placed in the sunshine bottom upwards. After a period of exposure, the plate was placed in the dark at a suitable temperature. It will be observed from the accompanying picture that the growth has only taken place in those parts of the jelly shielded from the sunshine by the black paper.[1]

While every corporation should pay reasonable heed

[1] The plate is taken from Dr. P. F. Frankland's *Our Secret Friends and Foes*, p. 198

to the interests of manufacturers, perseverance and activity in the detection and prosecution of offenders in the matter of smoke production is a manifest duty. There is constant talk of the harassment to which great industries are subjected by legislation regarding factories and workshops and the prevention of rivers pollution and the abatement of smoke. But when necessity for improvement arises through enforcement of the law, it is astonishing how

problems which appeared impossible of solution are solved, and how the utilisation of waste products tends to repay outlays which had been incurred under prophecy of financial disaster and of the encroachments of foreign competitors who, it is always alleged, are subject to no comparable restrictions. Factory and workshop chimneys, however, are not the only offenders. Domestic smoke yields a large total of atmospheric pollution, though the individual items are so trifling, and sanitary authorities should ask for a measure of control to be used judiciously in accordance with advancing knowledge of methods of smoke prevention. It is hardly necessary to point out how the prevention of tubercle by this particular means coincides with what is and ought to be public policy, altogether independently of tuberculosis.

The Spitting Nuisance.

In the next place, practical effect should be given to the knowledge that so long as the microbes of infectious disease are kept in a liquid medium, other than drinking water or liquid food, such as milk, they remain perfectly harmless. It is mainly when carried by the air, or by direct contact, that danger is to be feared from ordinary infectious diseases. In phthisis the infection is conveyed not by the breath of the patient, but chiefly by dried sputum borne on the air as dust. As a result partly of gradual improvement in public manners, and partly of bye-laws for public conveyances, spitting in cars and streets and public places is gradually diminishing. Yet a huge amount of sputum is discharged on the pavements of popular working-class parades on Saturday and Sunday evenings in large towns. In dry weather even a Monday morning washing of the principal pavements would make a very appreciable diminution of the infective material to which the public is exposed. Of course abundant rainfall would sometimes render any such measure unnecessary.

Thirdly, with regard to measles, I have already urged the great importance of air space and ventilation in elementary schools. It is perhaps even more important in preventing consumption. Artificial or mechanical ventilation should be the rule here, and in large schools the cost is by no means prohibitive.

Tuberculous Meat.

The measures already mentioned have to do mainly with the prevention of infection from human sources. We come now to the bovine disease. Though muscle is little affected by tubercle, and though thorough cooking is a reliable remedy, yet the value and practicability of regular meat inspection in every city is not open to question. In Berlin where, owing to the German practice of imperfect cooking, the question is a very important one, a large staff of veterinary surgeons is occupied in the meat inspection service. So far, however, as concerns the recognised sale of tuberculous flesh for human consumption, after careful sterilisation, of course, I doubt whether in Britain or America we are ever likely to follow the Berlin example. Sentiment plays a large part in the acceptance or rejection of food, and our working classes are fortunately in a better position than Berlin artisans to give heed to sentiment. With us it is hardly likely that meat, even rendered thoroughly safe by treatment, would find a ready sale if labelled tuberculous.

Tuberculous Milk.

Fifthly, the cow is dangerous much more as a milk giver than as a meat giver, and the cow's health should be conserved on the same lines as the health of human beings, mainly by making its home healthy, by having sufficient cubic space in cowsheds, by their proper ventilation, by daily cleansing and periodical lime-washing, and by causing the cows to lead an outdoor life as far as the climate and circumstances of the locality will permit. Into cowsheds also sunlight should be allowed to enter freely. It is for dairy purposes the cheapest and most easily provided of all sanitary agencies. There is no reason why by means of roof windows, byres should not be as well lit as dwelling-houses are by windows in the walls. Sunlight not merely kills the tubercle bacillus, but also forces into notice dirt and dust and cobwebs which would otherwise remain unobserved, and thus stirs the cowkeeper into cleanly activity, and makes admonition by the dairy inspector less needful and less insistent.

Authority should also be exercised over the sale of milk. Cleanliness in every detail of its production should be insisted on and constantly supervised. It is well known that cooling greatly diminishes and checks the abundance of microbic life in milk, apart from any question of tubercle conveyance. Cooling of milk, therefore, should be compulsory, not merely in order to make it keep during a long railway journey from the country to the town, but even in town dairies where the milk is sold soon after it comes from the cow. A further question is whether milk which has not been duly sterilised should be permitted to be sold. Some municipalities have established milk depots, where they themselves trade in milk specially prepared for infants who are not breast fed, but that provision relates not so much to the prevention of tuberculosis as of infantile diarrhoea.

In phthisis, so far as public safety is directly concerned, early recognition is of less importance than in the acute infectious diseases, because in its first stages there is very little danger to the public. But for the welfare of the individual it is of great consequence, as the prospect of cure is closely linked with early diagnosis, and in this way it also affects the public by diminishing the sources of infection.

Notification.

It is now frequently suggested that notification of the existence of tubercle in human beings be made compulsory, as in the case of ordinary infectious diseases like scarlet fever and enteric fever. To that proposal perhaps the commonest objection has been that the accompaniment of notification would be isolation in hospital. The objection is groundless. Systematic notification must undoubtedly be useful independently of removal to hospital. If a phthisis-infected house is open to visitation by the public health officials, unsatisfactory conditions of overcrowding and want of ventilation or cleanliness can be dealt with, instruction can be given as to precautionary measures, general supervision can be exercised, disinfection can be carried out when needed, and a register of infected houses and streets and localities can be kept, which might throw much light on the natural history of the disease. There are difficulties in the way of compulsory notification, but these are quickly disappearing. The first duty of a medical man is to his patient, and by some patients the intimation of phthisis might be looked on as a death warrant. Their fear of the disease might be such that the mental anxiety and depression consequent on the announcement would have a bad effect on their prospects of recovery. As consumption comes to be less dreaded in respect of incurability this objection lessens in weight, and I believe that in Sheffield, where compulsory notification has been adopted, no practical difficulty is experienced. The malady is, indeed, already less feared than of old, so far as its fatality is concerned. The difficulty about notification can be largely got rid of by a proviso that the sanitary authority shall take action only in co-operation or after consultation with the medical man notifying the case. Many a man with a bad lung is yet quite capable of leading a useful life, and of following his occupation in factory or workshop. All he has to attend to is the sputum and the spray in the act of coughing, and it might be very necessary to explain to his neighbour working at the same bench that, due care being taken by the consumptive, no infection need be feared.

Voluntary notification, where the medical man intimates only cases to which objections do not apply, is a step in the right direction. Compulsory notification, as just noted, is already in force in one town in England, and the Scottish Local Government Board have recently intimated that they will be prepared to consider favourably proposals by local authorities for compulsory notification where proper arrangements have been made for dealing with the disease when notified.

Examination of Sputum.

Under either voluntary or compulsory notification, the sanitary authority should undertake bacteriological examination of samples of sputum sent by medical practitioners, for the purpose of aiding in the recognition of doubtful cases. Infected houses should be visited, their sanitary condition examined, and any defects remedied. If the case is to be kept at home, detailed instructions should be given as to the hygienic management of the disease, so as to minimise risk of infection of others in the family. If the dwelling is in the country—say a cottage with a garden—a movable shelter can easily be constructed, and an open-air life begun. Or if the patient has relatives in the country who can give him accommodation, a similar arrangement may be made. Pauper consumptives belonging to urban districts might even be boarded out in the country, as suitable pauper imbeciles often are in Scotland.

Poor patients should be provided with spit bottles and other necessary appliances. The members of every infected household should be medically examined and dealt with as indicated by the examination. They also are to be instructed in the measures to be taken for their own welfare and that of the patient. If the patient is still able to work, he is to be told how to manage his sputum and cough-spray so as to protect his fellow-workmen. The sanitary condition of his workshop is to be ascertained and attended to, but special discretion is required here to prevent the man losing his employment or his fellow-workmen being needlessly alarmed.

The instructions above referred to should be printed, as well as verbally enforced. Cards for the purpose are in very general use. The following is an example:

PRECAUTIONS FOR CONSUMPTIVE PERSONS.

Consumption is, to a limited extent, an infectious disease. It is spread chiefly by inhaling the expectoration (spit) of patients which has been allowed to dry and float about the room as dust, or by directly inhaling the spray which may be produced when a patient coughs.

Do not spit except into receptacles, the contents of which are to be destroyed before they become dry. If this simple precaution is taken there is practically no danger of infection. The breath of consumptive persons is free from infection, except when coughing.

The following detailed rules will be found useful, both to the consumptive and to his friends:—

(1) Expectoration indoors should be received into pieces of old newspaper or small paper rags and burnt immediately, or into any convenient receptacle—such as a cup, or mug, or spittoon—containing a little water. The receptacle is to be emptied down the drain daily and then washed with boiling water. The spit should never be allowed to dry on the sides of the receptacle.

(2) The patient should always hold a piece of paper over his mouth when coughing, and this should be immediately burnt, even if the cough is not accompanied by expectoration.

(3) Expectoration out of doors should be received into a suitable bottle, to be afterwards washed out with boiling water. If a paper handkerchief is used, this must at once be placed in a waterproof bag, the contents subsequently burnt, and the bag washed daily.

(4) Ordinary handkerchiefs, if ever used for expectoration, should

be put into boiling water before they have time to become dry, or into a solution of a disinfectant, as directed by the doctor.

(5) Daily wet cleansing of rooms, particularly of bedrooms occupied by sick persons, should be substituted for "dusting" and sweeping. A damp cloth should be used for furniture and woodwork, and wet tea leaves or wet fragments of old newspapers, or damp sawdust, should be sprinkled on the floor before sweeping.

(6) The pillow covers and sheets on the patient's bed should be changed weekly, and boiled. Blankets should be washed monthly, after being steeped for two hours in disinfectant solution.

(7) The patient must have a separate bed, and, if at all practicable, a separate bedroom.

(8) Sunlight and fresh air are the greatest enemies of infection. Every patient should sleep with his bedroom window open top and bottom, a screen being arranged, if necessary, to prevent direct draught.

N.B.—The patient himself is the greatest gainer by the above precautions, and his recovery is retarded and frequently prevented by renewed infection derived from his own expectoration.

(9) The patient should live out of doors as much as possible, at the same time avoiding chill and over-exertion.

(10) Persons in good health have little reason to fear the infection of consumption. Over-fatigue, intemperance, bad air, dusty occupations, and dirty rooms favour consumption.

(11) The earlier the disease is recognised, the greater is the prospect of recovery. Any one suffering from cough and debility should consult a doctor at once and get the spit examined.

It is desirable to present such instructions in a popular and attractive form, so that the print will not be immediately thrown away. Dr. W. G. Stevens, of Renfrew, has very successfully done this by means of an illustrated calendar, containing local views, of which I am enabled to submit a copy reduced to post-card size.

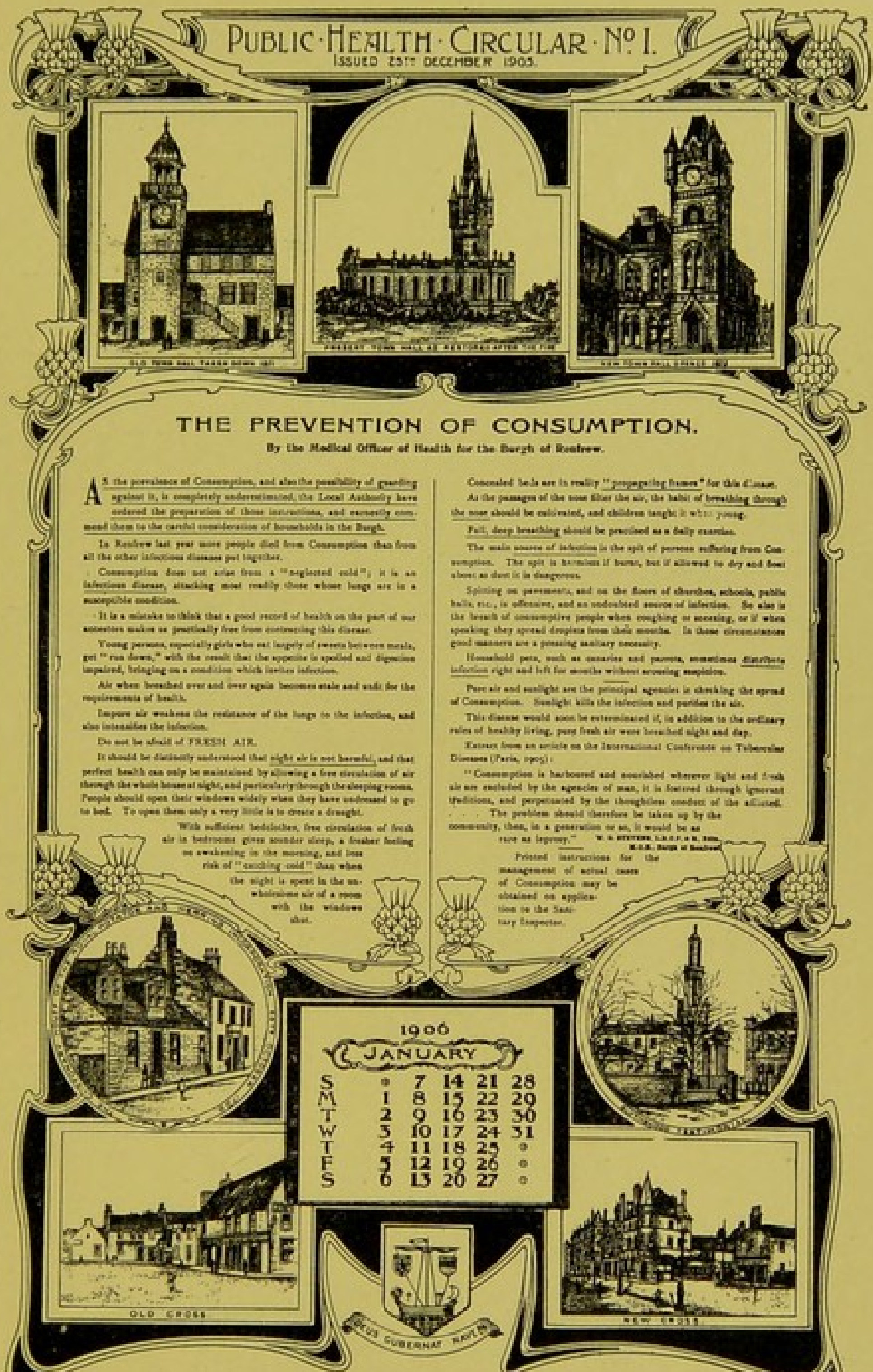
In addition to these cards of instructions for the patients, longer tracts or pamphlets may be issued for general information. (See Appendix.)

Lastly, we come to the very important question of the provision of sanatoriums for consumptives. And, to begin with, a word of warning is necessary.

Sanatoriums.

The public conscience has been stirred by statistics showing the enormous mortality from phthisis, and impulsive benevolence has rushed into the building of sanatoriums. Sanatoriums are excellent. But of themselves they are quite insufficient to minimise the ravages of phthisis, and if in any case the provision of a sanatorium comes to be regarded as fulfilling public duty in the matter, and stays the undertaking of a complete scheme of prevention, more harm than good will have been done. A sanatorium attempts, with a very considerable degree of success, to nurse back into health consumptives who, under proper conditions, should never have been attacked by the disease. In this matter the primary duty of a health authority is to prevent the disease, not to treat its victims. One means of prevention may, and probably must, consist in isolation of advanced cases with abounding discharge of infectious material. But in any logical sequence of sanitary organisation the first stage is the production and maintenance of conditions which will hinder the occurrence of infectious cases. That, however, is a counsel of perfection, and it is impossible to say that sanitary conditions such as would abolish the disease will ever be achieved. Sanatoriums, therefore, will always be useful, but even accepting the existing inevitability of phthisis, they are merely one section of any proper system of control.

Sanatoriums may be provided either by public or individual benevolence, or out of the rates. The isolation of advanced and very infectious cases for protection of the community is more obviously a duty of the ratepayer than the cure of cases in the early stages, but both measures are in the long run profitable to the country which adopts them. In the evolution of many well-recognised public duties, both local and national, there has been a transition period in which private benevolence has held the place to be ultimately taken by systematic general assessment. In this matter of sanatoriums we are passing through that stage, and, looking to the progress of public opinion, it is safe to prophesy that a time will come when sanatoriums for consumption will be provided out of either local rates or imperial taxes. But I trust that before that time arrives every local authority will have been compelled to do its duty in striking at the roots of the disease, so that by efficient sanitary control we shall as quickly as possible



PUBLIC·HEALTH·CIRCULAR·No I.
ISSUED 25TH DECEMBER 1905.

THE PREVENTION OF CONSUMPTION.

By the Medical Officer of Health for the Burgh of Renfrew.

As the prevalence of Consumption, and also the possibility of guarding against it, is completely underestimated, the Local Authority have ordered the preparation of these instructions, and earnestly commend them to the careful consideration of households in the Burgh.

In Renfrew last year more people died from Consumption than from all the other infectious diseases put together.

Consumption does not arise from a "neglected cold"; it is an infectious disease, attacking most readily those whose lungs are in a susceptible condition.

It is a mistake to think that a good record of health on the part of our ancestors makes us practically free from contracting this disease.

Young persons, especially girls who eat largely of sweets between meals, get "run down," with the result that the appetite is spoiled and digestion impaired, bringing on a condition which invites infection.

Air when breathed over and over again becomes stale and unfit for the requirements of health.

Impure air weakens the resistance of the lungs to the infection, and also intensifies the infection.

Do not be afraid of FRESH AIR.

It should be distinctly understood that night air is not harmful, and that perfect health can only be maintained by allowing a free circulation of air through the whole house at night, and particularly through the sleeping rooms. People should open their windows widely when they have undressed to go to bed. To open them only a very little is to create a draught.

With sufficient bedclothes, free circulation of fresh air in bedrooms gives sounder sleep, a fresher feeling on awakening in the morning, and less risk of "catching cold" than when the night is spent in the unwholesome air of a room with the windows shut.

Concealed beds are in reality "propagating frames" for this disease.

As the passages of the nose filter the air, the habit of breathing through the nose should be cultivated, and children taught it when young.

Full, deep breathing should be practised as a daily exercise.

The main source of infection is the spit of persons suffering from Consumption. The spit is harmless if burnt, but if allowed to dry and float about as dust it is dangerous.

Spitting on pavements, and on the floors of churches, schools, public halls, etc., is offensive, and an undoubted source of infection. So also is the breath of consumptive people when coughing or sneezing, or if when speaking they spread droplets from their mouths. In these circumstances good manners are a pressing sanitary necessity.

Household pets, such as canaries and parrots, sometimes distribute infection right and left for months without arousing suspicion.

Pure air and sunlight are the principal agencies in checking the spread of Consumption. Sunlight kills the infection and purifies the air.

This disease would soon be exterminated if, in addition to the ordinary rules of healthy living, pure fresh air were breathed night and day.

Extract from an article on the International Conference on Tubercular Diseases (Paris, 1905):

"Consumption is harboured and nourished wherever light and fresh air are excluded by the agencies of man, it is fostered through ignorant traditions, and perpetuated by the thoughtless conduct of the afflicted. . . . The problem should therefore be taken up by the community, then, in a generation or so, it would be as rare as leprosy."

W. S. STEVENS, L.R.C.P. & S. Edin.,
M.O.H., Burgh of Renfrew.

Printed instructions for the management of actual cases of Consumption may be obtained on application to the Sanitary Inspector.

1906
JANUARY

S	◦	7	14	21	28
M	1	8	15	22	29
T	2	9	16	23	30
W	3	10	17	24	31
T	4	11	18	25	◦
F	5	12	19	26	◦
S	6	13	20	27	◦

diminish the number of cases requiring either treatment or isolation.

The provision of sanatoriums has made much more progress in Germany and in America than in Britain, and on this subject, as in many others, one comes to

America rather to learn than to teach. But, indeed, all over the civilised world medical men and the public are in the meantime only in the learning stage with regard to sanatoriums. There has recently been evidence of very considerable doubt and disappointment, both public and professional, as to the results of sanatorium treatment. Such doubt and disappointment are the fruits of the high expectation originally indulged in. Just as when Koch introduced his tuberculin treatment the world went mad over the apparent prospect of curing the disease, and its subsequent disappointment was as great as its hopes had been, so with sanatoriums; far too much has been expected from them, and we are now rather in the stage of reaction.

Results of Sanatorium Treatment.

The results of sanatorium treatment are stated very differently by different authors, and that is not surprising, because the conditions vary so much. The best figures I have seen are those of the German Central Committee for the Erection of Sanatoriums in their report for 1905, as quoted by Dr. F. R. Walters in the *Lancet*.[1] The statistics refer to 3420 cases spread over seven or eight years. Of cases regarded as fit for work on dismissal the following are the numbers who remained fit at different periods after dismissal:

At the end of	one year,	79 to 86	per cent.
,,	two years,	63 to 76	,,
,,	three years,	54 to 67	,,
,,	four years,	45 to 58	,,
,,	five years,	44 to 54	,,
,,	six years,	40 to 45	,,
,,	seven years,	37	,,

Figures intended to show the result of sanatorium treatment are given by another writer as follows:—Of cases received in the first stage of the disease 28 per cent. were cured and 31 per cent. were nearly cured on dismissal. In the second stage of the disease only 7 per cent. were

[1] The *Lancet* of 6th Jan., 1906, contains a most suggestive series of short articles on Sanatoriums by physicians of the highest standing in Britain.

cured and 15 nearly cured, whilst in the third stage only one per cent. were cured and 2 per cent. nearly cured.

Dr. Letham makes a comparison between modern experience and that recorded in a work on phthisis published by Dr. Pollock in 1865. At that time, when there was no sanatorium treatment, the disease usually lasted between two and three years before the fatal termination came. In Germany, on the other hand, it has been found that of 100 workmen dismissed from the sanatorium as being fit for work 31 per cent. are still fit at the end of five years, and in the State Railway service the percentages are 43 and 53, whilst the statistics of phthisical German workmen who do not go to sanatoriums for treatment are very unfavourable.

The higher of the percentages given above regarding those who still remained fit for work at different periods after dismissal refer to more recent years, and indicate the more recent improvement in sanatorium methods, and the surprising fact is stated that the treatment which produced these results averaged less than three months' duration. The results, of course, refer only to cases dismissed as fit for work, not to patients who were sent out as incurable. There never can be anything magical in sanatorium treatment. A good sanatorium can provide a pure atmosphere, proper feeding, rest when rest is required, and skilled medical supervision constantly controlling all that is done.

Ideal Schemes.

In an ideal scheme sanatoriums should be supplemented by hospitals for consumption, convalescent homes, farm colonies, model villages, and an administrative bureau to direct and guide the whole. And even besides all these, if any country determines to do the very best that can be done for minimising tubercular diseases within its bounds, a system of national insurance of the working classes against sickness will also be required. Up till now, excepting in Germany, public action on the whole subject has been fragmentary and unsystematic.

Going into a little more detail, the following points may be mentioned :—Consumption hospitals should be used for cases too ill to benefit by sanatorium treatment. Even in these hospitals the cases should be classified and grouped according to their condition. Many of the patients may be so far improved as to become fit for transference to sanatoriums. Others, on the contrary, will go from bad to worse until death brings relief. Where acute infectious diseases are concerned there is little use in sending one case to hospital and leaving another at home; but from the public health point of view every tuberculous patient removed to hospital means a public gain, each patient having been more or less of a danger to some other members of the general community. In particular, the advanced cases, with large discharges of sputum loaded with the infective bacillus, are a menace to the inmates of the house in which they live, at least if the house is small and crowded and ill-ventilated and dirty, and if the other members of the family are themselves poor and ill-clad and uncleanly in their habits. Consumption is so often associated with pauperism that poor law authorities have a great opportunity of taking an important share in preventing spread of the disease by isolation of patients in their infirmaries. But so far as avoidable the stigma of pauperism should not attach to a man whose poverty is the direct result of his disablement for work by phthisis.

An Outdoor Life.

The cases to be sent to sanatoriums should, of course, be those capable of benefit by the treatment there. The life is as nearly as possible an outdoor life. In Nordrach, and in institutions following the Nordrach example, the principle of outdoor life is carried to this length, that weather conditions are regarded as affording no justification for remaining under cover. Rain-storms and snow make no difference. This manifestly must cause a good deal of personal discomfort to patients, and any omission or delay in following the rules with regard to change of clothing or bathing after the exercise is over may lead to very serious results.

But on the whole question of exercise in sanatoriums there are two great divisions of opinion and practice. The disciples of Dettweiler combine exposure to fresh air with long rest and high feeding. Rest is given in covered shelters, and the feeding is forced, so that there is very great addition to the bodily weight. Continuance of the disease in the lung is not infrequently consistent with this artificial fattening. The other system is practised by the followers of Brehmer, of whom perhaps the best known is Dr. Otto Walthier, at Nordrach. Instead of rest they insist on exercise, which, in fact, is one of the essentials of their treatment. The exercise is carefully graduated. In Britain the Nordrach system is followed at various sanatoriums, of which perhaps the best known is Heatherside Sanatorium at Frimley in connection with the Brompton Hospital for Consumption. Exercise begins with slow walking, slightly uphill, for from two to ten miles daily. The second stage is the performance of very light tasks—the gathering of fir cones, and the carrying to a stack of a half basket weighing about eleven pounds. The third is the carrying of a full basket of cones and firewood; the fourth, half a basket of gravel and stones, weighing about twenty-one pounds, from a gravel pit to paths in the grounds of the sanatorium; the fifth, the carrying of a full basket of about thirty-eight pounds weight; the sixth, the rolling of grass or gravel with a garden roller; the seventh, the digging of ground which has been already broken; the eighth, the working of a lawn mower; the ninth, the digging of unbroken ground for four hours daily; and the tenth and last, the digging of such ground for six hours daily. This system has attached to it both risks and advantages. The risks are those due to over-fatigue. A consumptive patient will readily be made worse and a fatal termination brought on if he is asked to do work beyond his strength. Very careful and skilled supervision is therefore required for the proper carrying out of the Frimley scheme.

Rest and Exercise.

On the other hand, when wisely followed, it is most beneficial in several directions, and the advantages appear greatly to excel the risks. If a man who has been engaged in manual toil from his youth is sent to a sanatorium where he leads an absolutely idle life he is very apt to become a lazy loafer, who can hardly be induced to enter again on useful work. It is indeed said that in Germany an incidental disadvantage of universal insurance against sickness is, that when insured patients are sent to sanatoriums maintained or subsidised by insurance companies, they refuse to work, and hold that no one can compel them. Independently of prevention of habits of indolence, it is manifest that a system of graduated labour naturally leads up to return to a useful life after sanatorium treatment is over. At Heatherside there is a regular labour test before dismissal of cases, the test for those who require to return to manual toil being capacity for digging unbroken ground for six hours a day for three weeks, while for clerks and shopmen three weeks' lawn mowing or digging of unbroken ground for four hours a day is regarded as sufficient.

Difficulties.

A great practical difficulty in the sanatorium system, at least in Britain, is that most working men come too late and wish to leave too soon. Some time ago I read that in America the former of these difficulties is not experienced, and that workmen can be got to submit themselves to treatment from the very beginning of their disease. Of course the reason why they leave too soon is their family responsibility. If a man has a wife and children to maintain at home, and feels his strength returning, he gets restless and anxious; he thinks that, after all, the medical attendant is wrong as to the likely risks of return to work. Unfortunately it is the best and most conscientious class of workmen who are most apt to make this mistake.

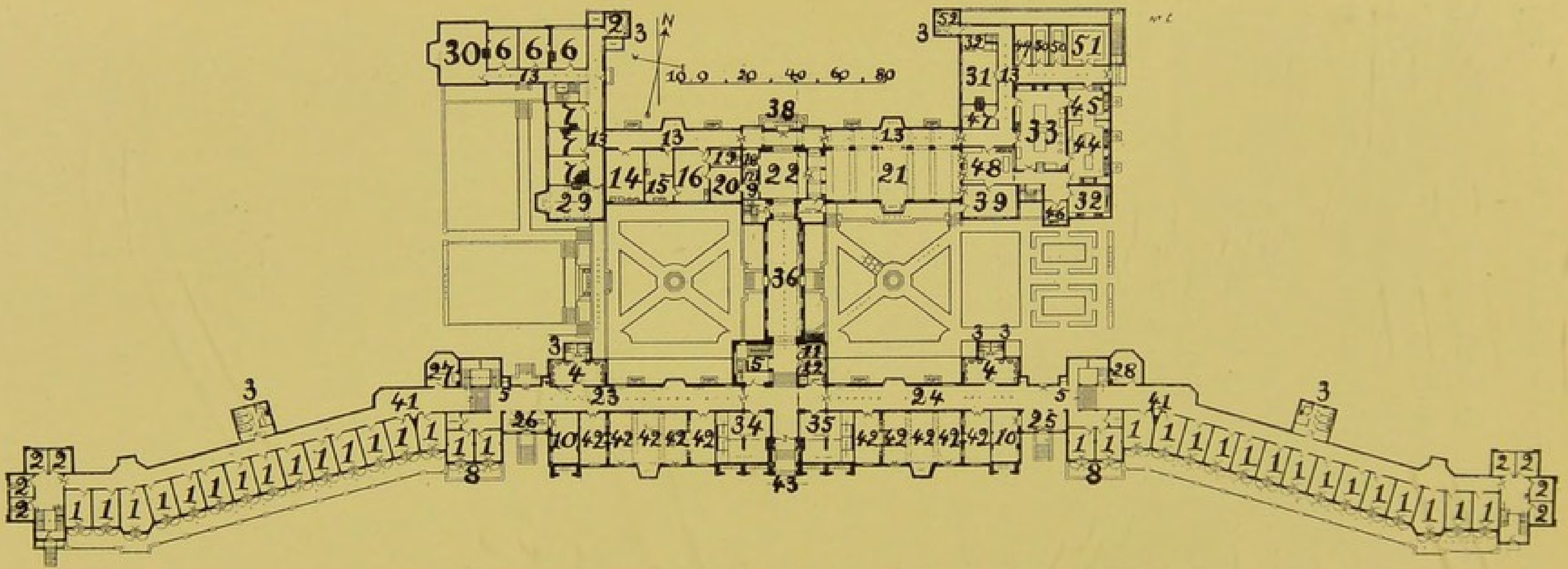
One deterrent in getting patients removed to ordinary hospitals for infectious diseases need not apply to sanatoriums for consumption. The risks of infection are not such that visitors require to be excluded. They can safely be admitted and hold communion with their friends under treatment, and this is all the more desirable because the stay in the sanatorium is so prolonged. In admitting cases to a sanatorium it would be a good rule, if its enforcement were possible, to accept only those coming under a definite and binding obligation not to leave until the physician gives permission.

Re-infection.

In the management of sanatoriums due care is to be exercised to prevent re-infection of the patient. No doubt medical men and nurses in these institutions are seldom attacked by the disease, and it is sometimes urged that this proves that patients themselves are not likely to be re-infected. But the argument is fallacious. Doctors or nurses who belong to a family liable to attack by consumption will not choose sanatorium duty. It may be assumed that the opsonic index of the staff of a consumption sanatorium is high. On the other hand, a patient comes into the institution with a naturally low resisting power, made still lower by the presence of disease. If, half-way to recovery, he is re-exposed to infection, his last state may be worse than his first. That, however, is no reason for failing to send him to a sanatorium. It is only a reason for managing the sanatorium properly. As already explained, the carrying distance of sputum from a coughing consumptive is only about a yard, though the finer spray from loud speaking will go much further. The simple precaution of compelling every patient who coughs to place a handkerchief to his mouth, and to cough into it, is almost of itself sufficient to prevent real risk. Any patient infringing the rules of the institution should be unhesitatingly dismissed. Whether in hospital or sanatorium, the more advanced cases should be separated from those in the introductory stage of the disease.

Supervisory Committee.

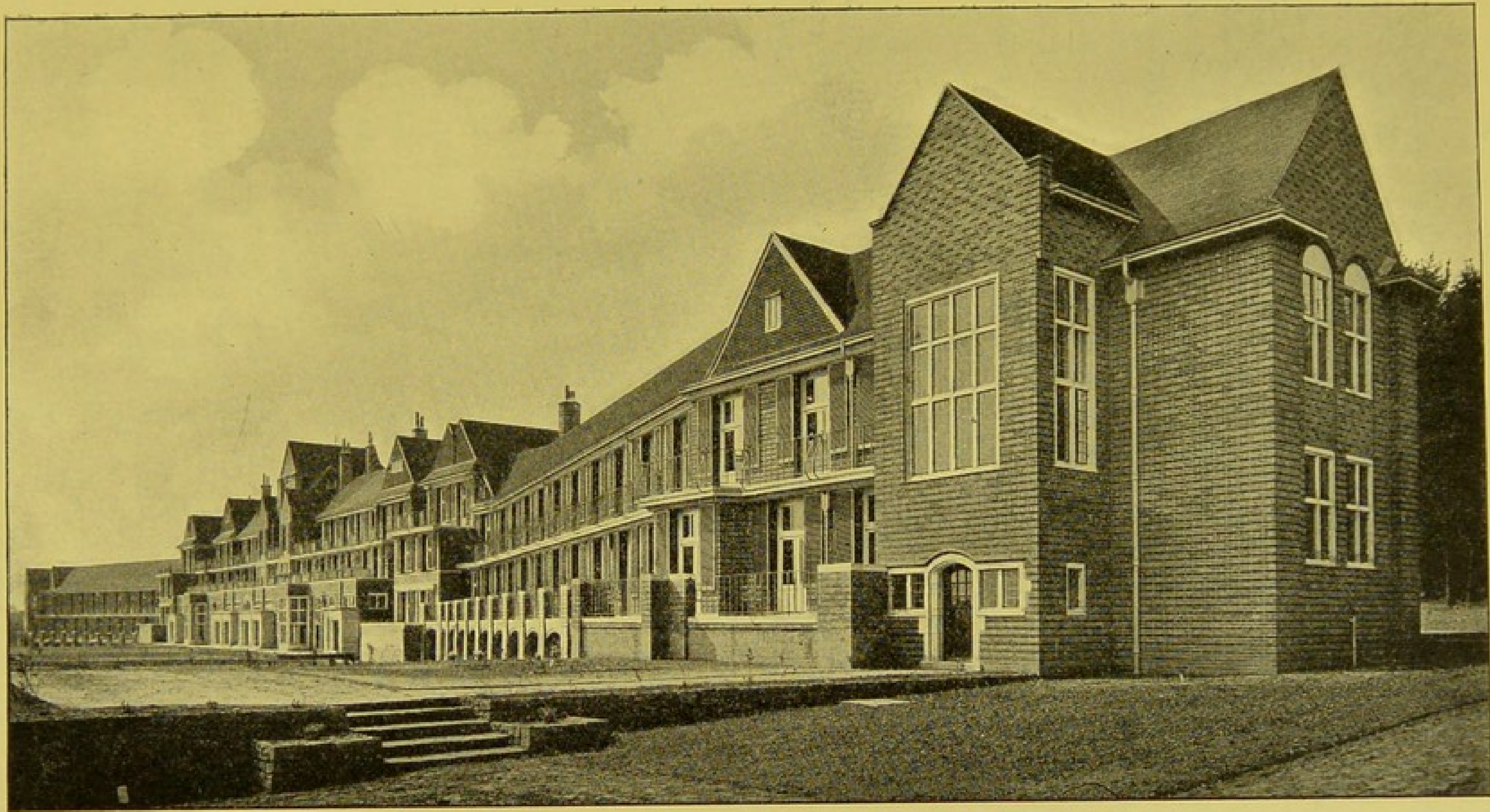
But the sanatorium system is deplorably incomplete unless there is connected with it some society or organisation for providing suitable employment for a patient when he leaves the institution. He was originally attacked by consumption because of his weak resisting power to infection by tubercle, and because, also, the conditions of his life



THE KING EDWARD VII. SANATORIUM, MIDHURST—GROUND FLOOR PLAN

(By permission of *Architectural Review.*)

1. Bedrooms.
2. Bathrooms.
3. W.C.'s.
4. Lavatories.
5. Lifts.
6. Medical officers' bedrooms.
7. Medical officers' sitting-rooms.
8. Balconies.
9. W.C. Lobbies.
10. Cloakrooms.
11. Cloakroom (well-to-do male).
12. Cloakroom (well-to-do female).
13. Corridors.
14. Operative Theatre.
15. Dispensary.
16. Consulting-room.
17. Telephone.
18. Porter.
19. Dark room.
20. Waiting-room.
21. Dining-hall.
22. Entrance hall.
23. Male necessitous corridor.
24. Female necessitous corridor.
25. Female necessitous patients' entrance.
26. Male necessitous patients' entrance.
27. Nurses' room.
28. Nurses' sitting-room.
29. Committee-room.
30. Medical library.
31. Servants' hall.
32. Pantries.
33. Kitchen.
34. Male hydropathic room.
35. Female hydropathic room.
36. Connecting corridor.
37. Small dining-room.
38. Principal entrance.
39. Dining-room.
40. Linen.
41. Hydrants.
42. Recreation rooms.
43. Well-to-do patients' entrance.
44. Scullery.
45. Vegetable scullery.
46. Nurses' pantry.
47. Nursekeeper's room.
48. Servery.
49. Cook's room.
50. Larders.
51. Storeroom.
52. Pails and brooms.



THE KING EDWARD VII. SANATORIUM, MIDHURST. FRONT.
(By permission of *Architectural Review.*)

favoured attack by the bacillus. Even if, when he is sent out from the sanatorium, he is absolutely well and free from the disease, yet his diathesis remains. His opsonic index with relation to tubercle was originally low, and when he leaves the sanatorium it necessarily remains low. His natural condition is simply one of exceptional susceptibility to tubercle, and in view of the superabundance of infective material which everyone must meet with in ordinary daily life, such a man will very readily succumb once more to the invading microbe. Also, if he returns to an overcrowded workshop, where ventilation is bad and dirt abounds, he is called on to fight the bacillus in those conditions which are exactly most suitable for strengthening his enemy.

Employment for recovered Patients.

Obviously, therefore, there has been little gained even by really curing such a man of phthisis and sending him back to be once more overcome. How can this difficulty be avoided or minimised? Only by a carefully thought-out and organised system of dealing with occupations. A bureau or committee should have charge of this work, and should act in conjunction with sanatorium authorities. There should be in connection with sanatoriums farm colonies for those patients who are suited for farm work. They may have been brought up to some other kind of occupation, but in the system of graduated exercise in the sanatorium it will soon appear whether an agricultural life will suit them; and they can be trained there for that life, and afterwards employed accordingly.

In farm colonies in Germany it is said that success has not been very great, owing to injury by overwork, but in many German sanatoriums graduated exercises are not practised, and if a man is discharged from such an institution, immediately placed on a farm colony, and expected to do much work, he may readily be over-fatigued, and suffer accordingly. But in any such scheme there are numerous practical difficulties to face. The case of a young unmarried man is the easiest to solve. He has no family responsibilities to bear, and can readily give up the trade to which he has been apprenticed and adopt an agricultural life. Many patients, however, may be unsuited for such a life. If a man's work has been light and easy, perhaps clerking or accounting in an office, the bureau could look out for him an opening as clerk in some healthy town or country village and in a healthy office there. In some sanatoriums note is taken of the capacity of individuals for work, and if their previous employment has been very unsuitable they are trained in some new work, such as photography. Many light occupations will readily suggest themselves for such training. Even country life does not need to involve the heavy labour of a ploughman. Fruit cultivation may be open to one, and to another some other occupation not involving work in a great factory in a crowded city. If I mistake not, dairying, the production of milk and butter for the market, has been mentioned as light and healthful, but I doubt whether people would care to purchase dairy produce from cured consumptives living even in a model village. All this system would involve large expenditure of money, and it is most unlikely that the earnings of the workers would pay the outlay, so that such a scheme could best be wrought along with a system of national or compulsory insurance of workmen. As all these measures continued to be practised they would gradually reduce the prevalence of tuberculosis throughout the nation which adopted them, and in the end, though not in one generation, the investment would reap a rich reward.

Educative Value.

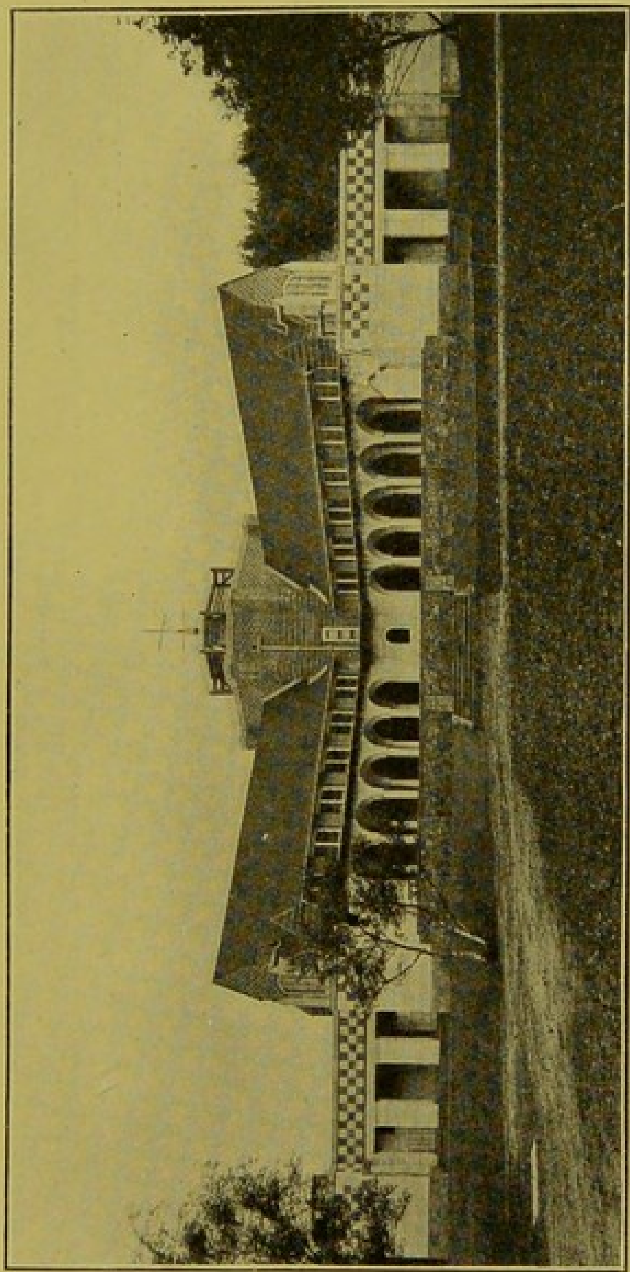
One advantage in sanatorium life must not be lost sight of. It is a most valuable college of hygiene, and when a patient leaves it, even if, unfortunately, he is among those who have to be sent out as incurable, he will be much less of a danger to his friends. One writer declares that a sanatorium is one part hospital and three parts school. In the management of such institutions it is, of course, necessary to see that they are used to the advantage of the greatest practicable number. If, after reasonable probation, a patient is still unfit to begin the sanatorium routine of graduated work, he may have to be sent home, or, still better, to a hospital for consumptives, and his sanatorium bed used for someone else.

Isolation in Fever Hospitals.

In Britain spare wards in fever hospitals are in some places now being used for consumptives, not necessarily for prolonged treatment, but for four or six weeks' education, so that when sent back to their homes they may practise what they have been taught, and diminish the risk within the household. One authority objects to this system on the ground that during the period of treatment and education the number of bacilli in the body may be greatly reduced, but that those which remain may be of a virulent and active type, may breed and multiply after the discharge of the patient, and so may kill the man sooner than if he had stayed at home. I do not myself think that this largely theoretical suggestion is at all sufficient to prevent resort to the education system. Fever hospitals differ from other hospitals in the fact that in non-epidemic times many of their wards may be empty, and so it seems both suitable and economical that these empty wards should be used for the temporary accommodation of phthisis. The system has been very successful in Brighton, where it was begun on the recommendation of Dr. Newsholme.

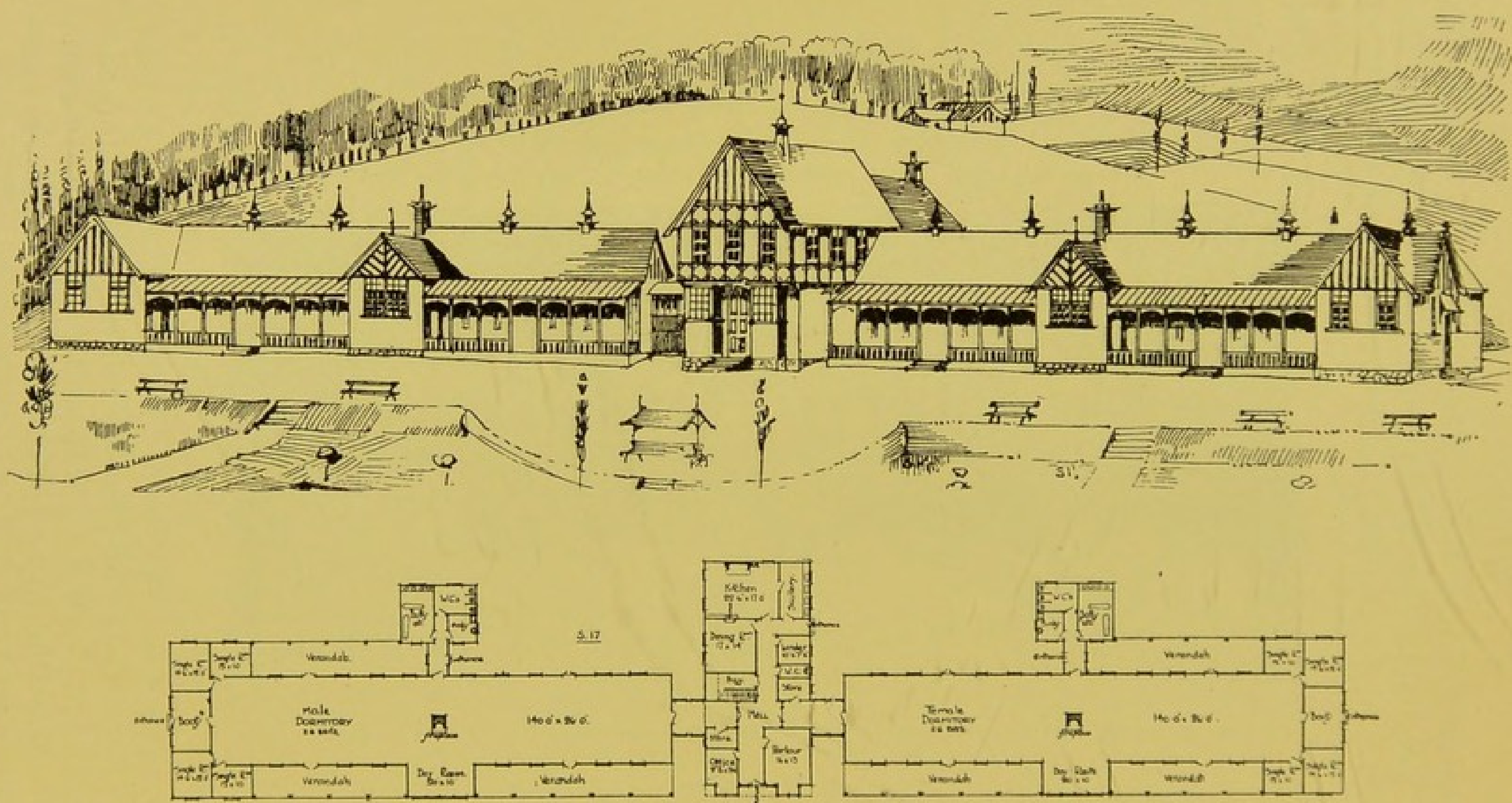
National Insurance in Germany.

Mention has been made of the German national insurance system, and a word may be said in explanation. Every workman with less than 2000 marks a year must insure against sickness or incapacity for work. He pays two-thirds of the premium and the employer the remaining one-third. When such a man applies for relief he is medically examined, and if phthisis is suspected he is sent to a convalescent home. If the diagnosis is confirmed he goes to a sanatorium. Otherwise he returns to work. If the disease is phthisis his whole family is examined at a dispensary. If his case is hopeless, or if it becomes so, he is educated before dismissal to prevent spread of infection. When dismissed he has the choice either of going to a special home or of getting aid for a year from the insurance companies. These insurance companies find it profitable to make grants both to hospital dispensaries and to building societies engaged in erecting



THE KING EDWARD VII. SANATORIUM, MIDHURST. OPEN AIR CHAPEL.
(By permission of *Architectural Review.*)

healthy houses for workmen. Examination of the man's whole family is not compulsory, but if it is not allowed no sick benefit is given. In England a national association for the establishment of sanatoriums for workmen suffering from phthisis is now being organised.



SANATORIUM AT GARTLOCH ASYLUM OF GLASGOW PARISH COUNCIL.

Messrs. Spiers & Co., Structural Engineers, Glasgow.

In Britain the latest important institution of the sort is the King Edward VII. Sanatorium, recently inaugurated by the King. It is illustrated in the accompanying plan and views.

The King Edward VII. Sanatorium.

But sanatoriums do not all need to be built so expensively. Cheap structures of wood, or wood and iron, make most useful institutions, and where money is difficult to raise very fair provision can be made at comparatively little cost. I append a sketch of the sanatorium at Gartloch Asylum, which belongs to the Glasgow Parish Council. A large building of the same sort has been erected at Barrasford, in Northumberland.

In conclusion let me once more urge that sanatoriums without a sanitary organisation to co-operate with them are of comparatively little value, and that, independently of sanatoriums, a great deal can be done for prevention of spread of phthisis by good public health administration, and by supervision of the home management of the disease.

APPENDIX

TRACT ON THE PREVENTION OF CONSUMPTION[1]

Preliminary.—There was a time when efforts at the prevention of consumption were efforts without guidance; the source of the disease was unknown and its manner of attack obscure. Yet even then general sanitary measures, though not specially directed against consumption, had, wherever used, an immense influence in diminishing its ravages, and the death-rate from tubercular diseases was already being steadily lowered before Koch's great discovery of the tubercle bacillus illuminated the field in which sanitation had been darkly groping. The new knowledge is alike a stimulus to continuance of work on the old lines, and an incentive to additional and special preventive action. The origins of consumption having been accurately investigated by laboratory methods, resistance to its spread may be organised with detailed precision. In brief, consumption is definitely preventable, and should be prevented.

There are still every year many thousands of deaths from tuberculous diseases. These include consumption of the lungs, consumption of the bowels, tubercular meningitis, "water in the head," and scrofulous diseases of the glands, bones and joints, and skin. The number of existing cases of the disease at any time is roughly about five times the annual number of deaths. The subjects are mainly people at the most useful and responsible period of life—young men and women, many of them married and with children to support and rear. Independently of sentiment, the economical loss due to consumption is tremendous. It is when the working time of life has come—when the baby has been nursed into school age, when the schoolboy has become an apprentice, when the apprentice has learned his trade, and has entered on the years when he should begin to repay all that parental care and rate-supported education have done for him—it is then that he is struck down by consumption. In England and Scotland more than one-seventh of all deaths are due to tuberculous maladies. In Scotland

[1] Most of this Tract was written for me by Dr. J. R. Currie.

the deaths from these diseases are about 10,000 annually, of which about 6000 are from consumption of the lungs. Manifestly, consumption is a malady whose prevention is of immense importance.

It is the purpose of these pages to promote a sound knowledge of this disease, to indicate the results of experimental inquiry into its nature, and to explain the circumstances which control its spread. The Local Authority hope that the people of the district, weighing these matters in their minds, will co-operate in carrying the discoveries of science to their practical conclusion—a resolute attempt at the prevention of consumption.

The Nature of the Disease.—The infectious disease which is known as consumption, phthisis, or tuberculosis of the lungs, is produced by the growth in the lung of the tubercle bacillus. The tubercle bacillus is a germ or microbe, one of the lowest forms of organic life, appearing as a short rod under a high power of the microscope. It is a sluggish organism, which grows and multiplies very slowly. The range of temperature within which it can grow is from about 84 degrees F. to about 108 degrees F. The temperature of the human body (98.4 degrees F.) suits it admirably, and so also does the slightly higher temperature of the cow. By artificial means the bacillus can be induced to grow outside the animal body, and here also moisture and darkness are important. In less favourable conditions, though it ceases to *multiply*, it *survives* for many months. It is quickly killed by exposure to sunlight and pure air.

Not men only, but certain lower animals also, are subject to the group of diseases of which consumption is one.

The life history of the tubercle bacillus as the agent of consumption may be thus narrated. Entering by the mouth, for the most part, and penetrating at a vulnerable area, the bacillus effects a lodging within the body, though not necessarily in the lung first of all. Established in the lung it multiplies at the cost of the lung cells, destroys their vitality and disintegrates their substance. Suppurative bacteria prey on the weakened lungs, and the wrecked tissues, teeming with micro-organisms, are detached by the act of coughing. Thus the sufferer as he coughs spreads danger broadcast in the surrounding air, partly in minute drops of spray which are the carriers of tubercle bacilli, partly in the spit or expectoration, which, falling here and there, dries and floats off as infective dust. The droplets, or the dust, enter by the mouth of another person, and so the cycle is complete. It may be said of the disease that it comes by the mouth and goes by the mouth.

Every case of tubercle has come by infection, direct or indirect, from a previous case. Every case prevented or cured or properly controlled and guarded diminishes the opportunity of spread of the disease.

The Conditions which Control the Spread of Cases.—In order that consumption may be established, two conditions are essential—the tissues must be ready for infection, the bacillus must be apt to infect.

The interdependence of these factors notably influences the spread of consumption.

The proneness of tissues to infection raises at the outset the question of the hereditary transmission of phthisis. The view held in the past, that consumption is constantly hereditary, was founded on ignorance of the fact that apparent heredity is due to infection in childhood or adolescence. It is within modern knowledge, indeed, that tuberculosis has been transmitted, but such transmission is a curiosity of medicine, an episode so rare as to be without significance for the matter in hand. Infection is constantly from without. Susceptibility may be handed down by parents, but with all the susceptibility in the world there can be no consumption in the absence of the tubercle bacillus.

Further, with regard to the proneness of tissues to infection, it might be supposed, in view of the great prevalence of tuberculosis among human beings, that man is peculiarly vulnerable by the tubercle bacillus. That is not so. Man is resistant rather than otherwise, and there is reason to believe that normal man escapes unharmed when exposed to a moderate degree of infection. Why, then, the prodigious death roll? The reasons are these—the persons infected are not normal, the infection is not moderate, and the one condition is reinforced by the other.

The *persons infected* are not normal when their vitality and tissue resistance are depressed by want or debauchery, by living in rooms which are damp and sunless and ill-ventilated, by working in workshops which are crowded or ill-ventilated—in brief, by exposure to that order of conditions which is associated with absence of light and air. Houses which are close set or built back to back have a special incidence of consumption; those who live in such houses, even if comparatively well-to-do, provide more cases of the disease than poorer persons in more spacious surroundings. Consumption is essentially not a disease of the poor, but of the packed. It is by these aids that a natural or hereditary liability to consumption is artificially exaggerated, and that the disease seizes on and gets firm hold of multitudes who in better circumstances would have all their lives remained free from it, or would have overcome it if attacked.

The *infection* is not moderate where a phthisical patient is housed or employed with his fellows under the conditions which have just been described. In a room which is close, either by defect or fixation of windows, bacilli which are launched by coughing hang thickly in the still air, infective as they hang, or they settle invisibly in the dust of the roof, walls, and floor, and await the opportunity of further mischief. In houses which are damp and dark the organism holds tenaciously to life, and experiment justifies the belief that on the sodden effluvium-tainted wallpaper of damp and crowded rooms the bacillus is able not only to survive, but also to grow and multiply.

In the unfavourable surroundings described, if a patient, in addition, is indifferent to the precepts of personal cleanliness, above all if he practises the vice of promiscuous spitting, the body of infection is rendered massive, and the risk of communicating disease becomes extreme.

A *reinforcement* effect is produced when a person of weak resistance is exposed to a massive charge of infection. This is the two-fold action of unwholesome living conditions. It has been most active in the spread of phthisis.

Whatever makes for good health is embraced in the term sanitation as applied to human beings. But the agencies which promote good health in man are exactly those which make for bad health in the tubercle bacillus. Human sanitation is bacillary insanitation. Bacillary sanitation is human insanitation. The bacillus flourishes in dirt and darkness and foul air. In these conditions man pines and dies. The man thrives and strengthens in cleanliness and sunlight and pure air, but the bacillus pines and dies.

These are the principles of phthisis prevention.

The General Policy of Prevention.—An appreciation of the natural history of consumption and of its bacillus, as above recorded, points to the certainty that an improvement in the living condition of the people with a reduction in the volume of infective material will be efficacious in checking the disease. This policy, betterment of living with control of infection, must be a policy of intelligent co-operation, a policy in which administrative bodies, the medical profession, and the public must each play their part.

It is the part of the Sanitary Authority to approve and help all procedure which tends to the advancement of the public health. It is their part to offer adequate disinfection in cases of this and other diseases, to take such measures as may from time to time seem advisable and practicable to aid by institutional isolation or by home precautions in preventing the spread of infection from person to person, to secure the dryness of subsoil for building, to further good drainage and the sanitary construction of houses, schools, workshops, and the like, reasonably to promote measures towards the disclosure of tuberculous meat and milk, to educate the public as to the dangers and control of consumption, and to foster every influence which makes for moral well-being, which dissipates ignorance, and which widens knowledge. As regards the provision of isolation, the Poor Law Authority may perform a very useful function in providing accommodation for advanced cases of phthisis in pauper subjects, but it matters little to the public whether the immediate cost of such isolation is paid by a public health rate or by a poor rate, and, in either case, the same ultimate pecuniary profit is to be looked for in the diminution of infection, a smaller number of disabled adults, and a consequent lessening of pauperism.

It is the part of the *medical profession* to continue their efforts of past years to combat and to cure the malady. Their hands will be strengthened by the provision by the Sanitary Authority of facilities for gratuitous examination of phthisical sputum. The importance of this provision can scarcely be stated too highly. Examination of sputum for the tubercle bacillus enables a diagnosis to be made precisely at that stage in the course of the disease when a diagnosis is of the greatest urgency. So long as the bacillus, in most cases, is persistently absent from the expectoration, the disease, if present, is following a course of a certain mildness. When once the bacillus has shown itself in force the patient's fate hangs in the balance, for the disease is assuming a new and more virulent form, and special treatment must be begun forthwith. Further, the appearance of the bacillus in the sputum marks the onset of the period when the patient becomes a source of danger to his friends. It indicates the time when precautions for the check of infection must be actively called into play.

Both for the patient, therefore, and for his friends examination of sputum is valuable—for the patient because it indicates the need for treatment, for the friends because it shows the necessity for precaution.

Also, by a system of phthisis notification, it is desired that the profession intimate to the Sanitary Authority the existence of cases of the disease, so that such action may be taken as the circumstances of cases may require.

It is the part of the *people* to pursue with zeal the objects set forth in the following sections, of which one is concerned more especially with the control of infection in the immediate presence of a patient, the other with the betterment of living conditions with a view to the increase of tissue resistance; yet the subjects, as already indicated, are so closely associated in fact, that it is neither useful nor convenient to separate them rigidly in discussion.

The Direct Control of Infection.—As phthisis comes by one channel, the mouth, so also it goes by one channel, the mouth. The danger is in the spit or sputum, and in the droplets of spray, both of which find egress through that channel. In care of the *spit* and the *spray* control of infection lies. The measures are within the reach of all—they do not necessarily require the isolation of the patient or exclude him from the company of his fellows; he need not in all cases abandon his employment, though some modification in this regard may frequently be essential—he may live and move among his friends in the quiet assurance that he is not exposing them to risk, provided he assiduously observes the precautions now to be detailed.

The precaution in the case of the *spit* or sputum-mass proper is to receive it in a suitable vessel, to prevent its drying and spreading in the form of dust, and to destroy it by burning or otherwise. The precaution in the case of the *spray* is to arrest the droplets as they issue from the mouth, to prevent their escape into the air, and to destroy them by burning or otherwise. These objects may be attained by the simplest means.

The Spit.—While *indoors* the patient is to spit into a spittoon or vessel of some kind containing a little water. The spittoon is to be kept covered lest flies should carry the infection. Twice a day or oftener the contents of the spittoon are to be destroyed by burning, by burying, or by pouring into a drain. Twice a day the spittoon is to be scalded with boiling water; *or*, the patient is to line his spittoon with paper, removing the paper with its charge of sputum several times a day and burning it in the fire; *or*, the patient is to spit into a cut square of paper at each time of coughing, and is to burn the paper forthwith. After coughing the lips are to be wiped with paper, and this paper also is to be burned immediately.

While *out of doors* the patient is to spit into a portable spit bottle which will be provided to poor persons by the Sanitary Authority. The contents of the bottle are to be destroyed by burning, burying, or pouring into a drain twice in each day or oftener. Twice a day the bottle is to be scalded with boiling water; *or*, the patient is to carry in one of his pockets cut squares of paper—ordinary newspaper will suffice—and spit into these, and another pocket of the clothing is to be lined with detachable waterproof, forming a bag in which the used squares of paper are to be carried till an opportunity of burning them arrives. The waterproof lining is to be removed daily and swabbed with a cheap disinfectant; *or*, the patient is to spit into the grating of a drain. He is to abstain wholly from the atrocious habit of promiscuous spitting on pavements or floors of public places. After coughing the lips are to be wiped with paper, which is to be carried after use in the waterproof pocket till an opportunity of burning offers.

The principle throughout is clear—the sputum is to remain moist till the moment of destruction. If moist it cannot get into the air in the form of dust.

The Spray.—When a patient is out of doors in a solitary place droplet infection may on occasion be disregarded. Within the house, however, it is among the most active agents of infection, for its invisible particles carry the bacillus of tubercle in the most virulent form. Yet the remedy is simplicity itself. The patient is to hold one of the cut squares of paper before his mouth during the acts of coughing which precede the expulsion of the sputum-mass, and the flying spray will adhere to the paper. Whether the sputum-mass is ultimately expelled or not, the square of paper is to be folded and burned forthwith.

It will be noted that the handkerchief has not been mentioned as playing its part in the remedy. The omission is by design. The handkerchief is to be avoided. Danger lurks in it, for sputum or droplets received in the handkerchief dry and are shaken off in the air as imperceptible but infective dust. If the handkerchief is used it is never to dry; it is to be carried in a moist state in a waterproof pocket; and it is to be carefully boiled.

Few consumptives, for the sake of their friends and companions, will neglect the simple measures which are now being described. Yet it must be studiously borne in mind that these precautions safeguard the patient also, for they act as a defence against reinfection. When the patient is careless he himself suffers first. The air which he breathes is thronged with bacilli, and the organisms which are warring on his lung are constantly reinforced from without.

Further, the consumptive patient is to employ his own table utensils. He is not to kiss on the mouth. He is to be diligent in the washing of face and hands. He is not to swallow his sputum; to swallow the sputum is to incur the risk of infecting the organs of digestion.

The consumptive patient is to *sleep* in a bed by himself. No personal precautions can obviate the risk to any one sleeping with a consumptive patient. The consumptive, besides, is to have a *bedroom* to himself, if this can by any possibility be procured; and whether he has a bedroom to himself or not, the windows of the room in which he sleeps are to be widely open day and night. During the half-hours of dressing and undressing only is it permitted to close the windows. If the breeze through the widely open windows is at any time too strong for comfort it may be tempered by the use of screens. But nothing surprises a patient in a sanatorium more than the freedom with which he can sleep in a bedroom of which the windows are wide open. He expects to catch a cold, but, in fact, he does not, and he soon gets to regard the open windows as almost a necessity of existence.

The floor of the patient's bedroom is to be uncarpeted; it is to show the boards or be covered with linoleum. A rug in addition is permitted. The walls of the room are to be clear of hangings, and the window curtains are to be light and washable.

The patient's bedroom is to be freed from dust by the use of a *damp* duster once a day. The duster is to be boiled. Wet tea leaves, scraps of wet newspaper, or the like, are to be employed in the process of sweeping the floor. It is important that the process should be a damp one in either case. The object is to remove infective dust, not to redistribute it through the room.

If the patient should happen to have a choice of bedroom, the following details are to influence his choice:—A spacious outlook free from obstructive trees or buildings, a sunny exposure, an absence of damp, the possibility of through ventilation from window to window or from window to fireplace, as the case may be. A fireplace with a good chimney is to be looked on as essential, and the damper of the grate is to be kept open. No merit of a room in other directions compensates for defect in ventilation.

If *children* are present in a house with a consumptive patient the most scrupulous household cleanliness is particularly necessary. Young children who creep or play in a room are in closer contact with floor dust than persons in the erect position. If the dust is infective, bacilli are readily transferred by the hands of the children from the floor to their mouths. Young children are to be excluded from the consumptive's room and presence as far as possible.

The Betterment of Living Conditions.—A healthy life amid healthy surroundings raises the tissue resistance of the individual and makes him refractory to attack by the tubercle bacillus. The same conditions are powerful in the direct control of infection. This is the two-fold action of wholesome living as opposed to the two-fold action of unwholesome living, to which reference has already been made. In promoting a healthy life in healthy surroundings the Sanitary Authority and the public are brought into line. It is needful that people should lead a good life so far as in them lies, and that they should support with their good will all effort at the improvement of their living conditions.

Their attention is drawn to the following final recommendations :—

Apart from the actual known presence of a phthisical patient, much may be done to check the disease by the regulation of life and conduct.

Cleanliness of the person is to be carefully maintained. It favours mental and physical fitness; it raises the standard of tissue health and renders infection difficult.

Over-indulgence in alcohol, which diminishes alertness of mind and body, is a fruitful cause of tuberculosis. This vice is to be entirely avoided.

True comfort of living is to be striven for, so far as wages and circumstances in general permit. Money is to be judiciously expended in the purchase of suitable clothing and simple but nourishing food, not squandered in the pursuit of trivial amusement which confers no lasting benefit. Food is to be wisely selected. Oatmeal porridge should be a daily diet, and tea and its concomitants only sparingly used. Food is not only to be of sound quality; it is also to be thoroughly cooked. The last precaution meets the possibility of tuberculous infection by means of meat.

The unclean and useless habit of promiscuous spitting is to be resolutely suppressed. Notices in its disfavour are already to be seen in public places; already, perhaps, it is on the wane; but many persons persist in it with unabated offensiveness. Not only is the spitter physically repulsive; he is a dangerous social pest. Careless whether his sputum or saliva is infective, he spits freely in public places. The risk of heedless spitting may be inferred from the circumstance that a recent investigation of railway carriage dust disclosed tubercle bacilli in one-sixth of the samples examined.

More, perhaps, than any other single factor the state of the *dwelling* determines the issue of the conflict between the tubercle bacillus and the human subject. According as the dwelling is wholesome or the reverse, the onset of the micro-organism is reinforced or impeded. In a room which is unvisited by air and sun the bacillus outside the animal body can survive for long, or even multiply. Tuberculosis is a pestilence that walks in darkness.

Let people therefore promote the free access of air and sunshine to their dwellings; let the outlook from their houses be spacious and ample; let dwellings be avoided where neighbouring buildings curtail the sunlight or deflect the wind. Let windows be widely opened that the air may move to and fro unhindered in rooms and passage ways, bringing out-of-door freshness with it, driving off dampness, diluting infective material, destroying it in its place, or blowing it clear away. Let sunlight be admitted to dark places, flooding through open windows or brightly polished glass, not filtered sparingly through heavy curtains or dimly penetrating dusty panes. The walls of dark lobbies should be pierced with windows. Not only is sunlight the implacable foe of the tubercle bacillus and of all such degraded life; it has the merit of showing the house as it really is, not as the housewife may fondly imagine it to be. Minute, yet important, defects are brought to the light of day, and the gospel of cleanliness is preached from an illuminated text.*

There should be no overcrowding of dwellings or workshops; their cleansing and ventilation should be frequent and thorough. Broken interior walls should be repaired; a rough surface cannot be kept clean. There should be no accumulation of unwashed linen in living rooms or bedrooms; this produces an impure atmosphere.

And so every excursion into detail leads back to the two cardinal virtues of the dwelling—fresh air and sunshine.

* "We would preach the gospel of cleanliness, fresh air, and sunshine, from a new text."—Dr. J. B. Russell "On the Prevention of Tuberculosis."

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