The Milroy Lectures ON HALF A CENTURY OF SMALL-POX AND VACCINATION.

DELIVERED BEFORE THE ROYAL COLLEGE OF
PHYSICIANS OF LONDON.

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INTRODUCTORY.

In beginning these lectures I crave permission to strike a personal note. It happens to be just fifty years since I entered on the study of medicine at the old College of Glasgow. The pandemic of small-pox which had started before, but was greatly favoured by the Franco-Prussian war, reached Glasgow in 1871. At first some cases of the disease were treated in the Fever House of the Royal Infirmary, so that students had opportunity of seeing small-pox in the wards, though spread of infection among patients soon caused its exclusion. In 1873-74 the epidemic reached the town of Kilmarnock in Ayrshire, where I had just begun practice and where the outbreak could be watched from beginning to end. A few years later my interest was stimulated by the discovery of a local register of mortality covering the period 1728 to 1764. Publication of the facts as to the ravages of small-pox revealed in this record led to further discussion of the whole subject, which again resulted in my giving lengthy evidence before the Royal Commission on Vaccination. Also, as Medical Officer of Health for Kilmarnock and subsequently for the counties of Stirling and Dunbarton, various opportunities of dealing with the disease, especially from the preventive and administrative sides, fell to my lot, and now my thanks are due to the Royal College of Physicians for giving me the opportunity, through the Milroy Lectureship, of endeavouring to sum up the opinions or conclusions which have formed themselves in my mind in the course of these fifty years.

It will be convenient to treat the subject in three sections:

- I. Small-pox as it was and is.
- II. Vaccination as it was and is.
- III. Control of small-pox in the present day.

I. SMALL-POX AS IT WAS AND IS.

How does the small-pox of the present compare with the small-pox of the past in respect of (a) fatality, (b) infectivity, and (c) prevalence?

(a) FATALITY.

The literature of small-pox in the days before vaccination depicts it as a disease of normally high fatality, with occasional outbreaks of a very mild character. Wagstaffe's statements: "There is scarcely, I believe, so great a difference between any two distempers in the world as between the best and worst sort of small-pox"; and "there is one sort in which a nurse cannot kill, and another which even a physician can never cure,"¹ may no doubt be explicable on the supposition that he did not distinguish between variola and varicella. Even Sydenham's reference to variolous fever without eruption might be attributed to his theory of epidemic constitution of the atmosphere having caused him to regard febrile illness during an acknowledged small-pox epidemic as due to the existing atmospheric constitution. Such terms as windpox, waterpox, stonepox, swinepox, and niplepox, may often have meant small-pox much modified, though not absolutely prevented by previous inoculation. There is, however, unquestionable evidence of exceptional mildness of type in the small-pox of 1789, which Jenner proposed to utilize for establishing a mild sort of inoculation, milder even than the Suttonian then in vogue. Also, in 1806, Adams of the Small-pox Hospital in London gave the name pearl-pox to a much modified variety which then prevailed.

Prior to the Acts for notification of infectious diseases (adoptive in 1889, compulsory in 1899) fatality rates in modern times are to be learned mainly from hospital practice, and those which I am about to give include both vaccinated and unvaccinated. Until the pandemic

of 1870-73, for hospital statistics in this country we have to depend on the London Hospital for Small-pox and Vaccination, which originated in 1746 as the Hospital for Small-pox and Inoculation.

In 1836-51 Marson at that hospital had 5,982 cases with 1,279 deaths, or 21.38 per cent.

This period includes the first of the two greatest epidemics of the nineteenth century—those of 1837-41 and 1870-73. Marson's predecessor, Dr. George Gregory, records for the epidemic year 1838 694 cases with 188 deaths, or 27.1 per cent.²

The European Pandemic of 1870-73.

By 1870-73 the practice of vaccination in Britain had greatly extended, and affected the gross fatality rates.

The first hospital of the Metropolitan Asylums Board was opened at the end of 1870, and the following rates are given for the metropolitan area in 1870-72:

Number of cases, 13,721; deaths, 2,557=18.6 per cent.
Glasgow in 1871-74³ had 4,328 cases, with 786 deaths=18.1 per cent.

In Cork Street Hospital, Dublin, in 1871-73 there were 746 cases, with 162 deaths=21.6 per cent. In the same institution in four years beginning April 1st, 1876, the figures were: 2,404 cases, 523 deaths=21.7 per cent.

Between the pandemic of 1870-73 and the epidemic of 1892-95 about to be considered, mention may be made of two local epidemics:

Sheffield, in 1887-88, had 4,677 cases, with 474 deaths=10.1 per cent.

Bristol, in the same period, with 327 cases, had 37 deaths=11.3 per cent.

The epidemic of 1892-5 was of wide extent. In the Metropolitan Asylums Board's institutions there were in 1893-94: 3,493 cases, with 282 deaths=8.1 per cent. If the four years 1892-95 be taken instead of the two years 1893-94, the fatality rate is almost identical: 4,759 cases, 381 deaths=8 per cent.

The following figures relate to outbreaks in various places in the provinces. The disease prevailed chiefly in Lancashire and Yorkshire, but also further south.

TABLE I.
Small-pox Fatality Rates.—Provinces.
Epidemic 1892-95.

Place.	Time.	Cases.	Deaths.	Percentage.
Middlesbrough ...	1893-4	115	11	9.6
Liverpool ...	1892	191	15	7.7
Manchester ...	1892-4	936	68	6.8
Salford ...	1892-5	173	22	12.7
Warrington ...	1892-3	598	60	10.0
Oldham ...	1894	163	22	13.5
Halifax ...	1892-3	513	44	8.6
Bradford ...	1893	935	100	10.7
Hull ...	1893-4	205	12	5.9
Leeds ...	1893	585	30	5.1
Brighouse ...	1892-3	150	18	12.0
Sheffield ...	1892-4	157	9	5.7
Keighley ...	1893	72	7	9.7
Derby ...	1893 and 1895	135	15	11.1
Nottingham ...	1893	53	6	11.3
Leicester ...	1892-3	347	21	6.1
Hinckley ...	1894	116	10	8.5
Birmingham ...	1893-5	3,153	248	7.9
Aston Manor ...	1893-4	315	29	9.2
Walsall ...	1893-4	945	83	8.8
Willenhall ...	1894	842	47	5.6
Bristol ...	1893-4	366	36	9.8
St. Albans ...	1893	58	6	10.4
Edinburgh ...	1892-5	697	73	10.5
Glasgow ...	1892-5	750	58	7.7
Dundee ...	1892-5	22	2	9.1
Rest of Scotland ...	1892-5	443	34	7.7
Dublin (H) ...	1894-5	795	96	12.1
		13,899	1,182	8.5

The fatality rates in London and the provinces are so approximately equal in the early nineties as to show that the same general type of disease prevailed throughout the country as a whole. This was the first extensive epidemic since the seventies, and small-pox showed itself a much less fatal disease.

The Epidemic of 1902-5.

We come now to the most recent extensive prevalence of small-pox in Britain, and that is so long ago as 1902-5.

Summarizing the London statistics from 1870 to 1902

the Metropolitan Asylums Board has recorded for the sphere of its own operations fatality rates as follows:

1870-72	...	...	18.8 per cent.
1876-78	...	...	18.2 "
1879-83	...	...	16.5 "
1884-85	...	...	15.9 "
1892-93	...	...	8.0 "
1901-2	...	...	16.8 "

The data on which these rates are based are:*

Period.	Cases.	Deaths.
1870-72	13,721	2,557
1876-78	13,208	2,410
1879-83	14,558	2,329
1884-85	12,509	1,992
1892-93	3,493	282
1901-2	9,659	1,629

It will be at once observed that the progressive decline in fatality which had gone on from 1870-72 to 1892-93 was abruptly broken in 1901-2 in London. The data are: 9,659 cases, 1,629 deaths = 16.8 per cent.

In Middlesex in 1901-2 the disease was of the London type, thus: 1,868 cases, 301 deaths = 16.1 per cent.

In the Provinces.

At this time the Local Government Board were obtaining from London and from nearly all provincial towns of over 25,000 inhabitants, as well as from others of smaller population, weekly returns of notifications, and issuing a weekly statement to the medical officers of the towns taking part in the scheme. The aggregate population thus dealt with altered as the returns increased, but the total (including London) was between 19 and 20 millions of the 32 millions in England and Wales. In the provinces in 1902-6 inclusive the cases thus reported were 23,883 and the deaths 1,649, or 6.9 per cent.

Turning now to detailed statistics of the provinces for this epidemic, I have gathered from various sources the data of many outbreaks from 1900 to 1905, according to

TABLE II.
Small-pox Fatality Rates.—Provinces.
Epidemic 1901-5.

Place.	Time.	Cases.	Deaths.	Percentage.
Newcastle ...	1903-5	628	28	4.5
Tynemouth...	1902-5	328	17	5.2
Chester-le-Street ...	1903-4	106	6	5.7
Wigan ...	1902-3	70	1	1.4
Blackburn ...	1902-3	141	5	3.5
St. Helens ...	1902-5	66	3	4.5
Sunderland ...	1902-3	66	4	6.1
Liverpool ...	1902-3	2,280	159	7.0
Manchester ...	1902-4	563	33	5.9
Salford ...	1902-4	262	12	4.6
Preston ...	1904-5	172	8	4.7
Macclesfield ...	1903-4	69	5	7.2
South Shields ...	1902-5	272	14	5.1
Oldham ...	1902-3	413	32	7.7
Chadderton ...	1902-5	144	5	3.5
Stockport ...	1902-4	159	15	9.4
Warrington ...	1903	86	4	4.7
Heckmondwike ...	1904	91	5	5.5
Batley ...	1904	103	6	5.8
Dewsbury ...	1904	552	57	10.3
Bradford ...	1901	28	0	0.0
Hallifax ...	1903	141	6	4.3
York ...	1902-4	39	7	17.9
Leeds ...	1902-5	690	35	5.1
Hull ...	1903-4	184	10	5.4
Sheffield ...	1902-4	141	5	3.5
Derby ...	1903-4	255	5	2.0
Nottingham ...	1903-5	479	17	3.5
Bristol ...	1903-6	125	4	3.2
Birmingham ...	1902-5	364	17	4.7
Leicester ...	1902-4	731	30	4.1
Cardiff ...	1901-5	96	5	5.2
Swansea ...	1902	187	33	17.1
Portsmouth ...	1902-5	20	1	5.0
Ilford ...	1900-4	82	9	11.0
County Palatine of Lancaster	1902-6	2,502	118	4.7
Derham County ...	1902	35	1	2.9
West Riding (including Dewsbury)	1903-4	3,296	215	6.5
Northamptonshire ...	1902-3	44	9	20.5
Ossett Union ...	1902-5	519	61	11.8
Nottinghamshire ...	1903-5	376	14	3.7
Edinburgh ...	1900-4	191	16	8.4
Glasgow ...	1900-2	2,255	283	12.5
Dundee ...	1903-4	1,158	88	7.6
Rest of Scotland ...	1900-4	175	12	6.9
Dublin (H) ...	1900-4	2,844	235	8.3
	1903-4	243	33	13.6

* If 1870-73 be taken instead of 1870-72 the figures are: 16,080 cases, 3,024 deaths = 18.8 per cent.; and if 1892-95 be taken instead of 1892-94 the statistics are: 4,759 cases, 381 deaths = 8.0 per cent. There is a slight discrepancy as to the 1870-72 rate; the data give 18.6 not 18.8 per cent.

the spread of the disease in different localities. Table II records the figures. It will be seen that, as contrasted with London's reversion to a higher fatality rate, there was a further and appreciable decline from 1892-95, many of the rates being round about 5 per cent., and several well below that figure—even 2, 3 and 4 per cent.

These facts, with due reservation for vaccination and diagnosis, show unequivocally a milder epidemic type in the provinces at this period than had been known since reliable statistics on any extensive scale became available.

In the metropolitan area itself in 1903 there was some prevalence, not, however, by extension from 1901-2, but by infection from the provinces and elsewhere. The cases were 355, and, allowing for a few remaining in the wards at the end of the year, the fatality rate was only 3 per cent. In Middlesex at this time the disease was no less mild, there having been in 1903-5, 185 cases with 5 deaths, or 2.8 per cent.

Clinical Observation of Small-pox.

The tables of statistics which I have submitted do no more than support clinical observation of the change that has taken place in small-pox. They are a convenient method of setting forth broadly what every physician whose experience of the disease goes back far enough has with his own eyes seen of the contrast between past and present. And even so, some small reservation as to change of type has to be made in accepting the teaching of the statistics. Comparison of fatality rates at the present day with those of (say) only twenty or thirty years ago must be affected by the fact that systematic contact hunting brings out many very slight cases which but for the hunting would not be discovered at all. In these days such cases are notified and go to hospital, and increase the quantum of mild cases. Similarly, the contact hunting produces a large number of cases vaccinated just too late for complete protection, but greatly modified by the vaccination after exposure. This must now be a common experience where sporadic groups are being dealt with in towns and in factories and workshops. The result is also to increase the total of the mild cases in hospital, and so affect the fatality rates.

Two Types—Severe and Mild.

Concerning the sources of the two different types of small-pox occurring simultaneously in Britain in the epidemic years following the beginning of the twentieth century, it is necessary to look abroad for enlightenment. Fortunately, since I began to prepare these lectures, the Local Government Board has published an invaluable collection of statistics by Dr. Bruce Low relating to small-pox in many parts of the world, and so I am able to put aside in favour of his authentic official figures much material which I had been laboriously collecting.

European or African Type.

Dr. Bruce Low's report (p. 26) shows that in France after a period of comparative quiescence in 1897-99, small-pox became active in the years 1900-1903. In Paris in 1900-1 there were 4,505 cases, with 758 deaths, or 16.8 per cent. This happens to be exactly the London fatality rate of the same period, and in his report for 1902 to the London County Council Sir Shirley Murphy says (p. 28): "In summary it may be stated that during 1900 and 1901 small-pox had been frequently introduced into London from abroad, especially from Paris." Paris and Marseilles were the chief centres for spread of infection in France at this time, there having been in 1899-1900 more than 1,000 deaths in Marseilles. Spain also was heavily attacked by small-pox in 1900-1903. Madrid had 1,566 deaths in 1900-1, but the number of cases is not recorded. In Italy in the four years 1901-4 there were 60,532 cases of small-pox, with 14,951 deaths, or 24.7 per cent. These three countries, Spain, France, and Italy, with their extensive Mediterranean seaboard, are constantly under risk of infection from North Africa, where small-pox is very prevalent. There is every probability that the London small-pox of 1901-2 had the origin indicated by these facts, and the type of disease supports that view.

American Type.

In searching for a source of the much modified small-pox which prevailed in the provinces in the same period,

we have to look to the New World. In Trinidad in 1902-3 mild small-pox was imported from Venezuela, and in 5,256 reported cases there were only 28 deaths, or 0.53 per cent. For a time there was much difference of opinion as to the nature of this disease, but it appears ultimately to have been accepted as variolous.⁴ In the United States small-pox of a very mild type has prevailed for many years. Returns are incomplete, as some States do not furnish reports, but the following comprise the records for the years with which we are dealing at the moment:

Year.	Cases.	Deaths.	Percentage.
1901	48,206	1,085	2.3
1902	55,857	2,111	3.7
1903	40,581	1,382	3.4

How this American type may have reached this country is illustrated in the following note addressed to the *Lancet* and *BRITISH MEDICAL JOURNAL* in 1901 by Dr. Boobhyer on an outbreak of small-pox at Mormon head quarters in Nottingham.

Small-pox has recently been introduced into the Mormon head quarters in this city, apparently by letters or other fomites from Salt Lake City. The first of our cases appears to have had a very mild attack and slight rash about February 1st; the second, also a very slight one, had a rash commencing about February 21st. The third and fourth were somewhat more severe than the preceding, but still very slight, and their rashes dated from about March 24th. The fifth, another extremely mild case, began to develop a rash on April 14th, at which date I first became aware of these facts, and at which also the entire household were removed to our isolation hospital. . . . I regret to say that the outbreak has been the means of communicating small-pox to Leicester, Loughborough, Derby, Sheffield, Liverpool, and probably some other places, though in single cases only, I believe, in each instance up to the present. The special cause of this latter general dissemination was in a small Mormon conference held in Nottingham on March 24th, at which date the rashes of the third and fourth local cases were developing.

The first case among the Mormon missionaries occurred about twelve days after receipt by them of a parcel from Salt Lake City. Mormon activities, it may be mentioned, are asserted also to have been responsible for New Zealand small-pox in 1913-14, a Mormon missionary being the reputed agent.

In 1901 Dr. Meredith Young had a very mild case in Stockport, infected from raw cotton exported from Texas, and, in reply to inquiry, the State medical officer explained that small-pox was quite prevalent, but so mild as to need no medical attention nor cessation of work.

In the United States this much modified small-pox has continued, and the fatality rates are even lower than those of 1901-3. In fact, from 1906 to 1915 (the latest year of Dr. Bruce Low's statistics), the rate has not in any year reached 1 per cent. of the cases, so that the Trinidad experience has been repeated. In the States the disease in this form is now looked on as endemic, occurring here and there like scarlet fever, and comparatively little heed is given to it.

In Canada also benign small-pox has been the type in recent years. In Ontario, in 1912-15, in 2,446 cases there were 11 deaths, or 0.45 per cent.—that is, only one death in 222 cases.⁵

New South Wales has shared in the mild American type of the disease. In 1913-14 there were 1,661 cases, with only two deaths. Infection is supposed to have been imported from Vancouver, where the same type prevailed.⁶ Recent facts relating to small-pox in this country still show a mild type of disease.

Intercurrent Severity.

Intercurrently with this modified small-pox there have been in the United States local outbreaks of high severity. Pittsburg in 1912 had 33 deaths, or 27.3 per cent., in 121 cases, and other local rates of 25.6, 25.0, and 28.6 are mentioned. New York City in 1901-2 had 3,480 cases with 720 deaths, or 20.7 per cent. Similarly Ontario had, a few years before the low fatality rates above mentioned, a very different kind of small-pox. Dr. Hodgetts, secretary

to the Provincial Board of Health, writing on mild small-pox (Toronto, 1905), gave the following figures for certain outbreaks in different parts of the province:

Year.	Cases.	Deaths.	Percentage.
1881	202	67	33.0
1885	146	16	10.9
1889	49	13	26.5
1899	30	9	30.0

In our own country in 1899-1900, just before the mild epidemic began, the city of Hull had a considerable epidemic of a severe type. The total cases were 943, and the deaths 163, or 17.3 per cent. With regard to possible origin, the medical officer writes in his report for 1899:

The great emigrant traffic through this city and port, especially from Southern Russia, may, in spite of the vigilance of the authority, have contributed a source of infection, for among the emigrants, persons had been frequently recognized as having recently had small-pox, and possibly the means of their disinfection had not been altogether efficient.

In 1903-4 Hull had a share in the then prevailing epidemic, and the type of the disease was that occurring generally throughout the provinces. The cases were 184, and the deaths 10, or 5.4 per cent.

Glasgow had a somewhat similar experience. An epidemic began there in April, 1900. The first case was that of a seaman on a vessel which arrived in Glasgow on March 18th from Bombay. The disease was confluent small-pox, and on discovery the symptoms indicated that his attack was well advanced towards the end of the second week. The effects of this source of infection did not extend beyond August, 1902. The fatality of the disease originating thus in 1901-2 was comparatively high—12.5 per cent. For more than a year from August, 1902, there was practically no indigenous small-pox in Glasgow. In September, 1903, however, a fresh epidemic began, the disease being introduced by navies from the Talla Water-works in Peeblesshire, and the fatality rate for 1903-4 was 7.6 per cent.

Bristol in 1908 had an introduction of small-pox of a severe type, from the Sea of Azov in Eastern Europe: the cases numbered 61, with 12 deaths. Again in 1915 a case introduced from Spain to the port of Bristol gave rise to an exceptionally severe outbreak of 32 cases, with 7 deaths. (Spain, as noted above, is apt to be infected from North Africa.)

Dr. Franklin Parsons⁷ relates that:

In one town in Lancashire there were outbreaks from two sources concurrently; one could be traced to the cases imported from America, of a mild type, while another was traceable to the infection which had come across from Paris via London, and that was severe.

Mainly, however, small-pox in this country has been attenuated in type in quite recent years. Cardiff in 1916 had 51 cases with 3 deaths. In March and April, 1918, an outbreak amounting to 33 cases occurred in the East of London. Air raid shelters played a part in the spread of infection. The medical officer of the Local Government Board reports that "the type of the disease in this outbreak was very mild and no patient died except the presumed first one." Much vaccination and revaccination resulted in the locality.

The remarkable change in the type of small-pox from severe to mild, as recorded above, has occurred on the whole somewhat suddenly. It is true that the Metropolitan Asylums Board figures already quoted show some diminution between 1871-2 and 1884-5, but the drop from 15.9 in 1884-5 to 8.0 in 1892-3 is the first really striking change, and, except in London, there is a further appreciable fall in 1901-5.

Improved hospital accommodation and medical treatment and nursing and diagnosis cannot account for the change in this country, still less for the Trinidad, American, Canadian, and New South Wales experiences.

It is common knowledge that when small-pox is absent vaccination diminishes, and the occurrence of extraordinarily low fatality rates during and after a period of years in which vaccination has been less practised testifies further to the mildness of type of the existing disease.

Relation of Types.

The question naturally occurs whether these two different types of small-pox—the African and the American—are really the same disease or whether they have some relation to each other more or less analogous to that which exists between typhoid and paratyphoid. It is safe to say that vaccination supplies the answer. So far as I have seen, the great bulk of the evidence is to the effect that vaccination prevents the mild type just as it prevents the severe type. The relationship of vaccinia to the two types appears to be identical, and Jenner's conviction, which originally was much disputed, that variola and vaccinia are essentially the same disease, is now almost universally accepted. Evidence similar to that of the preventive power of vaccination against the mild and the severe infections has its parallel in evidence that the one infection prevents the other—the severe preventing the mild and vice versa. The conclusion, therefore, is that both infections are variolous. As Chapin said when mild small-pox was spreading in America:

The crucial test of the identity of the two forms is, however, to be found in their immunity relation. Persons who have had small-pox or who have been successfully vaccinated are at least as immune to the mild as to the severe type. It is also found that persons who have had the mild type are equally immune to vaccination.⁶

When the mild disease first showed itself prominently it was naturally regarded as a "sport" of small-pox, the sport being the exceptional form. If, however, it should now gradually displace throughout the civilized world the severe form, then by and by the severe form would have to be regarded as the sport and the mild form as the normal—but that is a speculation which would carry us far into the future.

What are the conditions which cause small-pox to assume high virulence in one part of the world at one time and attenuation in another part of the world at another time, is a question of much epidemiological and practical interest, and is well worthy of study, say, by the Medical Research Committee. Comparison could be made of the conditions in Africa on the one hand, and in Venezuela and Trinidad on the other hand. Quite probably, high aggregation of cases in houses, or hospitals or towns, or such overcrowding and misery as existed in Paris at the time of the siege in 1870, may have favoured development of virulent or septic types, while opposite conditions may have the opposite tendency.

FATALITY OF NATURAL SMALL-POX.

The statistics which I have given include vaccinated and unvaccinated, so that the gross figures for individual towns with differing amounts of vaccination, if compared with each other, are somewhat fallacious. Taken broadly, however, and looking to the very considerable number of places included in the tables, they do not, I think, contain any important error, when applied to the country as a whole, in showing the fatality rates at successive periods. It is obvious, too, that the remarkably attenuated or American type of small-pox, which has so extensively replaced the severe or African type in recent years, is a reality, independent of statistics. And these lectures are addressed to a medical audience, which does not require to be convinced of the protective value of vaccination.

All the same, the epidemiological question of the fatality rate of natural small-pox at one period and another is of much interest. There being no vaccination in the eighteenth century, fatality rates,* so far as they exist, relate to natural small-pox only. Unfortunately, reliable data for that century are scanty, as the great majority of records are of deaths and not of cases. For the rest, it is necessary to eliminate the influence of vaccination since its introduction at the beginning of the nineteenth century, and to take note only of the fatality rates in the unvaccinated. But the age incidence of small-pox has an important influence on the fatality rate in any given epidemic. It is a very fatal disease in infancy, the fatality diminishes rapidly to a minimum in the third quinquennium of life—the age period 10 to 15 years being the most resistant to death by variola—then the rate increases during the remainder of life. The fatality rate, therefore, of natural small-pox, assuming the type of the disease to

be fairly constant, would yet vary with the interval between epidemics. If the intervals were only about five years the rate would be high, because the cases would be mainly those of children under 5. If, on the other hand, an epidemic took place after an interval of, say, fifteen or twenty years, the fatality rate would be lowered by the fact that many of the cases would be at the most resistant period of life.

Notwithstanding these difficulties, it does seem worth while to utilize such data as exist in endeavouring to discover what has been the course of natural small-pox in respect of fatality.

The Eighteenth Century.

When small-pox inoculation first came into vogue about the year 1720, various statistics were published to show the difference between the fatality rate of natural small-pox and of inoculated small-pox. The principal authority was Dr. Jurin, secretary to the Royal Society, and the general statements made are to the effect that the rate of natural small-pox was about 16 or 17 per cent. Such rates are mentioned by various writers, but how far they follow Jurin's authority, and how far they had observed for themselves, it is difficult to say. I suspect the validity of Jurin's figures because of his curious assumption that all deaths under two years of age are to be put under such headings as overlaid, chrysoms and infants, convulsions, etc., but not small-pox, so that the cause of death is really unstated. We know that small-pox in pre-vaccination times was largely a disease of children, and that early childhood is a time of high fatality. With that reservation, and the further reservation as to the possibility of some chicken-pox being regarded as small-pox, there is little choice but to accept for what it is worth Jurin's figure of 16 or 17 per cent. as the fatality rate of the period between 1720 and 1730, to which the data refer.

The next available figures relate to the London Hospital for Small-pox and for Inoculation, and it is recorded that in the period 1746 to 1763 there were 6,456 cases and 1,634 deaths, a fatality rate of 25.3 per cent. In the last quarter of the eighteenth century—say 1775-99—it is stated that the rate in that institution was 32.5 per cent. It will be noted, therefore, that the rate was increasing three-quarters of a century before vaccination began.

The Nineteenth Century.

In 1836 to 1851, 2,654 unvaccinated cases in the same hospital had 996 deaths, or 37.5 per cent. In the epidemic year 1838, there were 387 unvaccinated cases with 155 deaths, or 40.1 per cent.* But Marson, who gives these figures, points out that these rates were somewhat higher than natural small-pox ought to yield, because severer cases were often sent to the hospital, and it was sometimes overcrowded.

1870-73.—The next figures are more certain, and relate to the epidemic of 1870-73. Dr. Seaton, in his report on that epidemic to the Local Government Board published in 1875, gives the fatality rate in the hospitals of the Metropolitan Asylums Board as 44.8 per cent.—say 45 per cent. This rate, like those already mentioned, is based on so large a number of cases as to make it fairly reliable, and it appears to indicate the maximum virulence in respect of epidemic fatality to which small-pox has reached in this country during the past 200 years. This view of the extraordinary virulence of the small-pox of 1870-73 does not depend merely on statistics. Dr. Munk and Mr. Marson, the medical officers to the Small-pox and Vaccination Hospital (which was still in use at this time after the institutions of the Metropolitan Asylums Board had been opened) refer to

the severity of the disease, and especially to the number of cases of malignant small-pox, the proportion of which to other cases has been very largely in excess of anything within the previous experience of either of your medical officers.⁹

Dr. Seaton writes:

The ratio in the hospitals of provincial and foreign towns generally has ranged from 40 to 50 per cent. among the unvaccinated and from 8 to 10 or 11 per cent. among the vaccinated—enormous rates, and attributed everywhere to the same cause—namely, the unusual proportion of malignant, black, and haemorrhagic cases. . . .

In hospitals at Berlin "the mortality among the unvaccinated was 81.25 per cent. and among the vaccinated

* There was no statistical confusion, so far as I have read, between natural and inoculated small-pox.

* Gregory (loc. cit.) gives 396 cases with 157 deaths in 1838.

14 per cent." In the hospital at Leipzig "the mortality among the unvaccinated was 71 per cent. and among the vaccinated (including doubtful cases) between 9 and 10 per cent."

The years 1873-84 in the metropolitan hospitals show a rather lower rate of 38.6 per cent., based on 2,169 cases and 838 deaths. (Gayton.)

1892-95.—Disregarding smaller or localized outbreaks, and turning to the next extensive epidemic in this country, that of the early nineties, the Royal Commission states that in London in 1892-93, among 409 unvaccinated cases there were 99 deaths, or 24.2 per cent. If "doubtful" cases are included the number is increased to 580, with 127 deaths, or 21.9 per cent. For the provinces I have taken out the figures for a large number of populous places with considerable prevalence of the disease in 1892-95, and find that in 2,550 unvaccinated cases there were 662 deaths, or 26.0 per cent. In various outbreaks the reports distinguish between the doubtful and the unvaccinated. The figure just given includes the doubtful. Of these there were 261 cases, with 42 deaths. If they be deducted the particulars are 2,289 cases, with 620 deaths, or 27.1 per cent. (See Table III.)

1901-5.—Coming now to the latest epidemic of any extent—1901-5—I find that in 1,305 unvaccinated cases in the provinces there were 247 deaths, or 18.9 per cent., and that if doubtfuls are deducted the cases are reduced to 1,088 with 198 deaths, or 18.2 per cent. (Table IV). In the Metropolitan Asylums Board's hospitals in 1901-2 the Continental or African type of small-pox caused a fatality rate of 33.1 per cent. in the unvaccinated—2,278 cases, and 753 deaths.

With regard to all these rates the reservations that require to be made have already been indicated. I would be glad to see a closer and fuller collection and analysis of all available data, which quite likely would make some alteration in details, but the figures at least give some support to the thesis just indicated, namely, that beginning with the year 1720, in the absence of comparable data for any preceding period, natural small-pox gradually became throughout the eighteenth century, and up to the epidemic of 1870-73, a more virulent and fatal disease, its maximum fatality being on a large basis of facts 45 per cent., and since then it has irregularly, yet persistently, diminished in fatality until we come to the epidemic of 1901-5 with its unvaccinated rate of 19.3 per cent.

Since 1901-5 the disease has been so little prevalent as to furnish no sufficient material for a further statement of reliable fatality rates, but such figures as exist, broadly looked at, continue to point in the same direction. Indeed, if the American type of disease be regarded as having

TABLE III.
Provincial Small-pox Fatality Rates in the Unvaccinated.
(Including Doubtful Cases.)
Epidemic 1892-95. All ages.

Place.	Time.	Cases.	Deaths.
Dewsbury	1891-2	300	94
Warrington	1892-3	68	21
Leicester	1892-3	158	19
Liverpool	1892	24	9
Birmingham	1892-4	457	127
Aston Manor	1893	15	5
Brighouse	1892-3	36	11
Manchester	1892-4	155	34
Salford	1892-3	35	12
Halifax	1892-3	84	36
Leeds	1893	88	17
St. Albans	1893	10	4
Keighley	1893	41	6
Bradford	1893	229	61
Walsall	1893-4	239	73
Nottingham	1893	12	4
Hinckley	1891	19	3
Willenhall	1894	89	30
Bristol	1892-4	41	11
Oldham	1894	48	14
Derby	1895	27	8
Dublin	1891-5	201	60
		2,550	632 = 26.0%
Deduct doubtfuls...		261	42
		2,289	620 = 27.1%

* I argued similarly in *Vaccination Vindicated* in 1887, and pointed out that Dr. Munk had advanced the same view in 1881.

TABLE IV.
Provincial Small-pox Fatality Rates in the Unvaccinated.
(Including Doubtful Cases.)
Epidemic 1901-5. All ages.

Place.	Time.	Cases.	Deaths.
Ossett Union	1902	133	37
Eccles	1902-3	3	2
Leeds	1902-5	185	18
Nottingham	1902-3	24	3
Newcastle	1903-5	138	14 (or 1902?)
Stockport	1902-4	40	6
Bradford	1900-1	8	0
St. Helens	1903	4	0
County Palatine of Lancaster	1901	125	11
Cardiff	1901 and 1903	14	1
Swansea	1902	16	7
Halifax	1903-4	40	5
Wigan	1902-3	12	1
Salford	1903	31	3
Oldham	1902-3	140	11
Tynemouth	1902-3	54	2
Felling-on-Tyne	1903-4	41	2
Glasgow	1900-1	168	88
	1903-4	155	37
Dublin	1902-4	67	21
		1,368	275 = 19.8%
Deduct doubtfuls...		217	49
		1,171	226 = 19.3%

replaced the small-pox of former days, the pestilence has been reduced to a mere shadow of its old self in respect of its ability to kill those whom it attacks. We must never forget, however, that intercurrently the African type of the disease appears every now and then, even in areas where the attenuated strain is so well established as to be considered endemic; and we dare not prophesy, but can only hope that the mild may ultimately displace the more virulent form of variola.

(b) INFECTIVITY.

Two factors go to make up the inherent capacity of a case of small-pox to convey infection to persons within the range of its influence. One is the character of the infecting organism which, reasoning by analogy, is assumed to be the *causa causans* of the disease. The other is the amount of the *materies morbi* in a given case. In a word, the two factors are quality and quantity.

Quality.—Unfortunately, bacteriology has not yet conclusively identified the organism. In this respect small-pox resembles measles, whooping-cough, and typhus, but differs from diphtheria, enteric fever, and tuberculosis. By observation, however, we know that those infections whose organism is undiscovered differ from each other in the certainty of their infecting power. I do not myself recollect ever seeing a sporadic case of measles. A single case means an outbreak. Whooping-cough is not so readily kept under observation by the health officer, but my impression is that it must be almost as certainly infectious as measles. In respect of scarlet fever the position is very different. It often occurs sporadically, and a single case does not necessarily portend an epidemic. Either the disease may die out, or dropping cases may continue to occur for weeks or months before there is any epidemic. In diphtheria, whose organism has been studied, Dr. Davies of Bristol found that a marked increase of infectivity, under which sporadic cases were supplanted by epidemic prevalence, was accompanied by a definite change in the characters of the organism.¹⁰

Small-pox has more resemblance to scarlet fever than to measles in respect of the possibility of sporadic cases. In Kilmarnock in the eighteenth century (where it should be observed, however, that only deaths and not cases are recorded) there were, in inter-epidemic periods, occasional deaths which formed no part of an outbreak. In well-defined epidemics occurring every four or five years in a town with a probable population of over 4,000 the deaths ranged from 45 to 84, but between some of the epidemics there was an occasional sporadic death, and in one year a straggling prevalence over seven months yielded 8 deaths without attaining the dimensions of an epidemic. In Glasgow I have heard of a man with a fully developed and abundant eruption being discovered seated in a place

of public resort (George Square), and it was found that for about a week he had been freely exposing himself whilst in this condition. Yet not a single case of small-pox resulted from this missed case. That was a most exceptional occurrence, but seems to show an absence of infective quality in that particular case. Such occurrences are more likely during the decline than during the rise of an epidemic. After the pre-epidemic period referred to in the next paragraph has passed, the small-pox of a rising epidemic seems more infectious, and with more carrying power, than that of an epidemic which has passed its meridian. Commonly, but by no means invariably, rise and decline are associated with respective periods of the year, prevalence rising from about December to May and falling from about June to October.

Small-pox epidemics sometimes begin very slowly, and sometimes break out very suddenly. In Kilmarnock in the eighteenth century there were instances of both sorts, but most of the outbreaks were pretty sudden. Deaths, not cases, of course are the criterion in prevaccination times. Dr. Seaton in 1868 called attention to this feature of slow onset of epidemics which had occurred in Cardiff and Sheffield in 1857. He regarded it as characteristic of all small-pox epidemics.

In London in 1901 the epidemic spread was very slow. At the beginning of the year there was one case in hospital, and the following were the monthly admissions:

January ...	2	July ...	14
February ...	1	August ...	82
March ...	0	September ...	167
April ...	0	October ...	272
May ...	1	November ...	438
June ...	5	December ...	761

Taking May as the onset, it was not till August that the dimensions of the outbreak became very noticeable.

The Gloucester epidemic of 1895-6 had a similar slow onset. Here are the figures:

Month of Outbreak.	Cases.	Month of Outbreak.	Cases.
1st ...	1	10th ...	604
2nd ...	—	11th ...	733
3rd ...	3	12th ...	283
4th ...	1	13th ...	122
5th ...	3	14th ...	13
6th ...	7	15th ...	—
7th ...	12	16th ...	—
8th ...	52	17th ...	—
9th ...	145		
		Total	1979

On the other hand, Edinburgh furnished an example of a small-pox outbreak which developed quickly. Owing to dispersion of navvies from Talla Waterworks (in the county of Peebles), where small-pox existed, four cases occurred in Edinburgh in December, 1903, and the monthly progress of the outbreak was as follows:

December, 1903 ...	4	June ...	10
January, 1904 ...	34	July ...	4
February ...	63	August ...	nil
March ...	32	September ...	nil
April ...	14	October ...	1
May ...	10		

Quantity.—Leaving now what, after all, is mainly conjecture as to the quality of the contagium vivum of small-pox, I turn to the much clearer question of the influence of quantity. It is an accepted fact that the eruptive material of small-pox, both cutaneous and buccal, is the infective agency, and there is no need to refer to the proof which inoculation affords of the truth of the proposition that small-pox vesicles and pustules and crusts are the *materies morbi* of the disease. So far, therefore, as quantity is concerned, the amount of the eruption, not merely on the skin, but also on the mouth and throat, in any given case is a measure of its inherent capacity for spreading infection, if opportunity be given by the infective material coming into due relationship to susceptible subjects. In the vaccinated, however, an originally copious eruption sometimes aborts remarkably, with corresponding effect on the amount of infective material.

It is not necessary to search through detailed reports of hospitals and of health officers to demonstrate that there has been in recent years a great diminution in the total average amount of eruption per case of natural small-pox. Broadly speaking, eruption and fatality rate go hand in

hand. Confluent, discrete, and sparse eruption are accompanied by characteristic differences in case mortality, and this is so obvious that the proposition need not be laboured. It has been shown above that the fatality of small-pox is greatly reduced in recent years. Therefore the amount of eruption must have been greatly reduced, and in the same proportion the amount of infective material has been lessened. Small-pox, therefore, has been and is a much less infectious disease than it was half a century ago.

(c) PREVALENCE.

Fatality being reduced, and infectivity being reduced; it follows that, other things being equal, prevalence must also have diminished, and Dr. Bruce Low's report gives abundant evidence that this is the case.

In England and Wales the deaths have remarkably diminished. In five successive decades they have been:

1867-76 ...	58,614
1877-86 ...	18,026
1887-96 ...	4,892
1897-1906 ...	4,763
1907-16 ...	139

The total notified cases in the years 1911-17 have been only:

	1911.	1912.	1913.	1914.	1915.	1916.	1917.
Totals notified ...	295	123	115	65	90	149	5
Of which in port towns ...	20	72	48	10	31	55	2
In port sanitary districts ...	30	12	25	7	12	14	1

These are very striking figures, showing that in the seven years small-pox has obtained almost no hold in the country, even when repeatedly introduced at seaports. In London the notifications since 1905 (after the epidemic had terminated) have only been in successive years to 1916 inclusive, 74, 31, 8, 4, 21, 7, 72, 6, 4, 21, 3, and 1. In Liverpool from 1904 to 1916 inclusive there have been only 144 cases with 4 deaths, and the last three years of this period have had only two cases, neither fatal. In Edinburgh and Glasgow in the five years 1912-16 inclusive there has not been a single notification, and in the twelve years 1905-16 the total cases in the two cities have been 37, with one death. In Ireland in the twelve years 1906-17 there has been one death.

On the Continent the Scandinavian countries have shared in Britain's remarkable freedom from small-pox, and so also has Holland. Sweden had only 18 deaths in the twenty-two years 1895-1916. Norway in the sixteen years 1899-1914 had 376 cases with 27 deaths, or 7.2 per cent. Denmark had 18 deaths in the twenty-five years 1892-1916. Its cases were about 300, so that the fatality rate was about 6 per cent. Holland had 124 deaths in the twenty years 1897-1916. The number of cases is not stated. Belgium has had much small-pox, but it has greatly diminished since an epidemic early in the present century, culminating in 1903, in which year there were 1,630 deaths in cases estimated at 10,000, which gives a fatality rate of over 16 per cent.—very similar to the rates in Paris and London in the same epidemic.

In France there has been no such complete disappearance of small-pox, though the deaths in the six years 1908-13 (the latest available data) were only 939. For Paris the figures are known up to 1916 inclusive, and in the four years 1913-16 the cases were 103 and the deaths five. In the Paris epidemic of 1900-1 it has already been noted that the fatality rate was the same as London's, 16.8 per cent. In subsequent years it has been much less, the cases having been 4,773 and the deaths 399, or 8.4 per cent. In Marseilles there has been very considerable prevalence, and in 1906-7 the fatality rate appears to have been very high, but there have been few cases from 1908 to 1915.

In Spain there has been much small-pox, but details are vitiated by small-pox and chicken-pox being classified together. Portugal also has had much small-pox. In Switzerland prevalence has diminished since 1905, though the fatality rate has been 13 per cent, the cases having been 345 and the deaths 45. In 1900-1 there were 567 cases and 67 deaths, or 11.8 per cent.

In Italy the disease has been very prevalent and the fatality high. In the twenty-nine years 1888-1916 there

Dr. Gillick Millard, in his Leicester report for 1902, mentions two or three cases of the sort.

were 320,161 cases and 81,289 deaths, or 25.3 per cent. In the last three years of this period, however (these being war years as it happens), prevalence was much less and the fatality rate low—2,126 cases and 57 deaths, or 2.6 per cent.

Small-pox in Germany will be considered in the next lecture.

In Austria up till 1900 there was heavy prevalence with fatality rates of 20 to 40 per cent. From 1901 to 1914 inclusive the disease was at a low ebb, with fatality rates much below the previous level, but in 1915 and 1916 there have been nearly 50,000 cases, though the deaths are not stated.

Hungary, like Austria, had much small-pox, but there has been very regular diminution from 15,470 deaths in 1887 to 81 deaths in 1912, the last year for which figures were obtained. It is probable that the disease has had some prevalence during the war, though Budapest is the only town of which that can be said with certainty.

In Russia there is a great deal of small-pox, with apparently a very high fatality rate, though there is probably some fallacy owing to incomplete returns of cases.

The above facts as to the continent of Europe, taken from Dr. Bruce Low's report, show that while in some of the countries there has been much less small-pox in recent years, in others there is still a high prevalence, and the constant intercourse between the United Kingdom and the Continent maintains a degree of risk which prevents any sense of security against successful invasion by the disease. Also, there is always a minor risk of small-pox by cotton from America, and by paper or other textile fabrics, as exemplified in Dr. Macewen's reports on outbreaks in cotton mills in Lancashire.

But, reverting to our own country, during the last half-century there has been, with the exception of the metropolitan epidemic of 1901-2, a great diminution in the fatality and the infectivity and the prevalence of small-pox. This diminution has progressed at an increasing rate of speed. In the latter part of the half-century, and in particular since the mild epidemic of 1901-5, the country has shown unparalleled freedom from the disease, not merely in respect of fatality, but also in respect of prevalence.

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FUNCTIONAL PARALYSIS OF THE DIAPHRAGM IN TWO CASES WITH ACCELERATION OF RESPIRATION.

BY

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ATTENTION has been directed recently to the rapid, shallow type of breathing in late cases of gassing, and Haldane has associated the condition with an exaggeration of the Hering-Breuer reflex. The condition has also been observed in cases in which nervous symptoms have developed as the result of shell shock or other disturbance.

The observations made upon two cases at Oakbank Military Hospital seem to indicate that a paresis or paralysis of the diaphragm, the result of functional disturbance of the centre of the phrenic nerves, may account for the acceleration in breathing in some cases.

CASE I.

Pte. J. (nine months' service), admitted to hospital with a diagnosis of debility. He was a thin, undersized man, easily excited and nervous when spoken to. The respirations were rather rapid (28), the breath sounds somewhat feeble all over the chest, with a few moist râles at bases of lungs; he had neither cough nor sputum, the pulse rate was 80, and, beyond a localized basal bruit, there was no other abnormality of the heart. On the seventh day after admission he showed marked tremors of the hands and legs, specially severe in the right sartorius muscle. The knee-jerks were slightly exaggerated,

with occasional slight ankle clonus in the right leg. Tactile and thermal sensation and eye reflexes were normal. On the eighth day it was noticed that the respirations were becoming gradually more rapid and fluctuating very much in rate (50 to 80). Ten days later the respirations were still very variable and usually extremely rapid. The breath sounds were much more harsh than formerly, but no râles were audible. The pulse was also very variable in rate (usually about 100), and he developed a transient albuminuria, which lasted three days. Observations on the thirty-fourth day show that the legs as a whole were now extremely tremulous, and the tremor of the right sartorius was merged in the more general one. The knee-jerks were much exaggerated, but no ankle clonus could be elicited, and the plantar reflexes were sluggish. No change in the condition of the chest was observed, but the respirations were more continuously rapid and less variable in rate (80 to 90). Careful charting of the rate showed that the increased rate was only present during the day, and practically disappeared during sleep.

CHART I.—Respirations in Case I.

By the 106th day, although the patient was allowed up and could go about the ward quite freely, the high respiratory rate with a fall to normal during sleep still continued; the tremors of the hands and legs were still very marked, and the former condition of reflexes was maintained. As the patient showed no tendency to improve, he was transferred to a special hospital for neurasthenics, and unfortunately no further information has been obtained.

CASE II.

Pte. Y., admitted to hospital from France, where he had been for five weeks, gave a history of fits as an infant, intermittent otorrhoea since childhood, acute rheumatism and acute pneumonia six years ago during the same winter. He had been rejected for the army in 1915, owing, he says, to neurasthenia, but was accepted in 1917.

On admission he complained of difficulty in breathing, especially when lying down, discomfort in the cardiac region, and of occasional attacks of pain in the arms and legs. The condition was of gradual onset, and became noticeable about three weeks before admission—that is, about two weeks after going to France. He was described on that date as a very pale man of moderate physique with enlargement of the area of cardiac dullness—apex beat in fifth space in nipple line. No thrill. No bruit. Second sound slightly accentuated. Rhythm regular. Tachycardia, but not extreme—96. Respirations very laboured, numbered 50 per minute, and in consequence had great difficulty in expressing himself in speech. There was a slight prolongation of respiratory movements in a small area close to the edge of the sternum in the third right inter-space, and the sounds in this area were rather moist, but no dullness on percussion could be appreciated. There was no sputum and no pyrexia. There were no tremors. The pupils were moderately dilated. Reflexes normal. Patient was a very heavy cigarette smoker, and his smoking was drastically curtailed on his first admission to hospital. During his residence little change was noticed in his condition; the rapid breathing persisted, and was present both while awake and asleep. The tachycardia still continued, and the following chart shows graphically the state of matters:

CHART II.—Respirations in Case II. Plain line = respirations. Dotted line = pulse.

He was transferred to a special hospital for neurasthenic cases, and has since been discharged from the army on account of "functional nerve disease." The respiratory movements are still rapid, but he is able to move about slowly.

At the request of Professor Noël Paton graphic records of the chest and abdominal movements were taken. This