

English vaccination and small pox statistics : with special reference to the report of the Royal Commission, and to recent small pox epidemics / by Noel A. Humphreys.

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ENGLISH VACCINATION and SMALL POX STATISTICS; with special
REFERENCE to the REPORT of the ROYAL COMMISSION, and to
recent SMALL POX EPIDEMICS. By NOEL A. HUMPHREYS.

[Read before the Royal Statistical Society, 16th February, 1897.
A. E. BATEMAN, Esq., C.M.G., Vice-President, in the Chair.]

FEW will be disposed to under estimate the importance at the present time of sound information and conclusions on the "effect" of vaccination in reducing the prevalence of and the mortality "from small pox." This was the first of the five questions submitted to the Royal Commission on Vaccination, on the 29th of May, 1889, for inquiry and report. After a laborious inquiry extending over more than seven years, at a cost of more than 13,000*l.*, the Royal Commission issued their final report in August last. This report, which can scarcely fail to serve as the basis of further legislation on the subject of compulsory vaccination, contains an almost exhaustive amount of information on the nature and history both of small pox and of vaccination. Abundant materials for the formation of sound conclusions on the vexed question of the influence of vaccination on small pox, whether viewed from a political, medical, or purely public health point of view, may be found in the various volumes of report and evidence issued by this Commission during the past seven years.

The determination of the real influence and effect of vaccination as a protection against small pox appears to be to so large an extent a statistical problem, that I have felt justified in asking the Royal Statistical Society to devote an evening to the consideration and discussion of this paper, which deals mainly with the statistical evidence given before the Royal Commission, with special reference to the statistics of recent small pox epidemics. My object has been to present these statistics in such a manner as to facilitate the formation of sound conclusions on the subject, and with as much impartiality as the nature of the facts and figures permits.

If vaccination confers the protection against small pox that has been attributed to it, the steady increase in the adoption of the practice which has been maintained throughout the greater part of this century should have resulted in a marked diminution of the mortality from small pox during that period. It is therefore in the first place necessary to supply an answer to the question which at the outset of the inquiry presented itself to the Commissioners: Does the history of small pox mortality since vaccination was introduced afford warrant for a belief in its protective effect?

The rate of mortality from small pox prior to the discovery of vaccination is beside the present inquiry, and it is not until 1837, when the civil registration of deaths commenced, that any really useful or trustworthy statistics of small pox mortality in England are available.

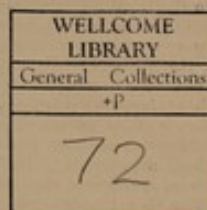
Vaccination Legislation.

Before, however, considering the Registrar-General's statistics of small pox mortality since 1837, it is desirable to note the various legislative enactments dealing with vaccination. Although the House of Commons made grants to Jenner in 1802 and in 1806, and annual grants to the National Vaccine Establishment, which was founded by royal warrant in 1807, the first Act dealing with vaccination was "An Act to Extend the Practice of Vaccination," which received royal assent on the 23rd of July, 1840. By this Act poor law guardians throughout England and Wales were empowered and directed to contract with their medical officers, or with any legally qualified medical practitioners, for the vaccination of persons resident within each union or parish, payment being authorised for all successful primary vaccinations. This Act moreover declared the inoculation of small pox illegal, and the use of it was made penal. In the following year this first vaccination Act was amended, and the expenses of carrying out the original Act was charged on the poor rates; it was further provided that "the vaccination or surgical or medical assistance" incident to the vaccination of any person resident in any union "or parish, or of any of his family, should not be considered "parochial relief." Under these two Acts vaccination remained voluntary; they only provided the public vaccinator, whose services were available to all who might come to him for the purpose of vaccination.

In 1853, at the suggestion of the Epidemiological Society, which had recently been founded, Lord Lyttleton introduced into the House of Lords "an Act to extend and make compulsory the "practice of vaccination," which afterwards was passed and became law without opposition or division. By the provisions of this Act each union, or parish if not in union, was divided into vaccination districts, in order to increase the facilities for the vaccination of the poor. Vaccination stations were appointed, at



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which the public vaccinator would attend, at fixed hours, to vaccinate and to inspect the result of previous vaccinations. This Act provided that the registrar should at the registration of the birth, or within seven days of such registration, send to the parents a scheduled notice that the infant must be vaccinated; and the Act imposed a fine of 20s. upon any parent who, after such notice, did not cause the child to be vaccinated, and to be inspected on the eighth day after the vaccination. In order to facilitate proceedings under the compulsory clauses, an Act was passed in 1861 giving permission to guardians and overseers to appoint vaccination officers to institute and conduct proceedings for the purpose of enforcing obedience to the Vaccination Acts. This Act, moreover, distinctly enacted that proceedings might be taken at any time during which the parent remained in default. This provision was due to a legal decision that under the compulsory Act of 1853 a defendant, having been once convicted and fined, could not be convicted and fined a second time for the same offence, as failure to take a child to be vaccinated within three months of its birth was held to be a single definite offence. In 1867 an Act consolidating previous vaccination Acts was passed, and although some not unimportant changes were introduced into this Act, they do not need special notice here, except (1) that for the first time provision was specifically made for the encouragement of re-vaccination, and (2) that the machinery for securing the registration of vaccinated children, and for dealing with cases of neglected vaccination, was much improved.

No further legislation respecting vaccination occurred until the Vaccination Act of 1871, which came into force on 1st January, 1872. This Act resulted from the report of a select committee appointed to inquire into the working of the Consolidating Act of 1867. The most important modification of the law effected by this Act was that the appointment of vaccination officers to enforce the compulsory provisions of the Act of 1853, which had previously been permissive only, was made obligatory upon poor law guardians. Some other changes were made by this Act, but they are comparatively unimportant for the purposes of this paper. It should be noted, however, that the superintendence, direction, and inspection of vaccination, which was by the earlier Acts vested in the Privy Council, was in 1871 transferred to the Local Government Board, in which it is still vested. Such are the principal statutory enactments affecting vaccination in England. We have seen that gratuitous vaccination was first provided by the Act of 1840; it was made compulsory in 1853; the permissive power to appoint paid vaccination officers was given to guardians in 1861; and as this permissive power was not put in force in a large number of unions, the appointment of vaccination officers was subsequently made compulsory by the Act of 1871.

Statistics of Vaccination.

With a view to judge correctly of the effect of this legislation upon the mortality from small pox, it is in the first place important to have evidence of the effect of this legislation on the proportion of infants successfully vaccinated. Unfortunately, although there is no reason to doubt that, at any rate during the first three-quarters of this century, a constantly increasing proportion of children was vaccinated in infancy, no satisfactory records of successful infant

TABLE I.—Statistics of Primary Vaccination of Infants, 1872-94, derived from the Annual Reports of the Local Government Board.

Year.	Births Registered during Year.	Of the Children whose Births were Registered during the Year given in Col. 1, by the 31st January in the Year next but one following Year there were				Percentage of Children not finally vaccinated for (including cases postponed).
		Successfully Vaccinated.	Certified as incapable of Vaccination; had Small Pox or Died Unvaccinated.	Vaccination postponed by Medical Certificate.	Remaining.	
1872	821,856	698,137	81,192	42,527		5.1
'73	816,508	704,606	81,540	4,264	36,038	4.8
'74	814,787	727,065	85,341	5,677	35,704	4.8
'75	810,154	722,466	87,549	5,914	34,225	4.7
'76	817,694	763,277	85,885	5,528	33,004	4.3
'77	817,947	766,824	80,541	6,081	33,503	4.5
'78	821,741	760,982	81,840	6,475	35,466	4.7
'79	810,211	756,835	78,146	6,670	37,471	5.0
'80	811,651	750,203	88,166	5,920	37,253	4.9
'81	811,744	765,162	77,569	6,302	33,711	4.5
'82	819,081	763,525	81,516	7,598	35,423	4.8
'83	820,780	762,080	81,060	8,110	37,440	5.1
'84	808,881	764,975	91,578	8,693	41,335	5.5
'85	824,165	757,714	85,006	9,323	42,220	5.8
'86	803,846	754,069	91,072	10,187	47,528	6.4
'87	815,198	738,980	89,410	12,382	62,701	8.5
'88	829,813	719,103	85,187	13,366	74,627	9.9
'89	815,900	707,161	90,755	13,615	85,571	11.3
'90	877,188	682,560	91,444	13,823	108,973	13.4
'91	914,079	693,117	98,166	13,278	119,201	14.9
'92	890,695	662,607	94,499	13,845	133,324	16.1
'93	914,557	661,513	105,875			

vaccinations in England and Wales exist prior to 1872. Such statistics, issued by the Local Government Board, would appear to have been first made possible by the improved registration of vaccinations provided for by the Act of 1871. The annual per-

centage of children born and not finally accounted for as to vaccination, including cases of postponement, was almost stationary during the twelve years 1872-83, and only ranged between 5.1 in 1872, and 4.3 in 1876. After 1883 the percentage unaccounted for rose steadily; at first slowly to 9.9 in 1889, and more rapidly after the appointment of the Royal Commission, to 11.3 in 1890, 13.4 in 1891, 14.9 in 1892, and 16.1 in 1893. It may here be noted that the proportion of cases of children in Scotland whose vaccination was not finally accounted for, has since 1872 been constantly and considerably lower than in England, and has shown a very slight increase in recent years—affording ground for the conclusion that the opposition to vaccination, which has caused so large a decline in the proportion of vaccinations in England, does not exist, or has been comparatively inoperative in Scotland.

Official Statistics of Small Pox Mortality in England.

Let us now examine the English official statistics of small pox mortality, commencing with 1838, the first complete year of civil registration. Unfortunately the causes of death in England and Wales in the four years 1843-46 have never been classified, which makes it necessary to omit all reference to those years. During

TABLE II.—*Annual Rate of Mortality per Million Living from Small Pox in England and Wales, 1838-96.*

[Dr. Ogle's table, "First Report," p. 114.]

Year.	Deaths.	Year.	Deaths.	Year.	Deaths.	Year.	Deaths.
1838	1,064	1852	401	1867	116	1881	124
'39	589	'53	171	'68	93	'82	54
		'54	151	'69	70	'83	39
1840	661	'55	114			'84	87
'41	400	'56	119	1870	116	'85	107
'42	168	'57	204	'71	1,015	'86	13
'43	?	'58	332	'72	824	'87	21
'44	?	'59	195	'73	101	'88	40
'45	?			'74	91	'89	4
'46	?	1860	118	'75	40		
'47	245	'61	66	'76	103	1890	4
'48	397	'62	80	'77	128	'91	5
'49	264	'63	189	'78	79	'92	19
		'64	167	'79	25	'93	51
1850	263	'65	103			'94	31
'51	389	'66	141	1880	39	'95	10

Notes.—The deaths in this table include those referred to chicken pox. The facts are not available for the four years 1843-46.

the twelve years 1838-42, and 1847-53, for which official records exist, prior to vaccination being made compulsory, the annual death-rate from small pox averaged 408 per million, and ranged between 1,064 in 1838, and 168 in 1842. It may be stated that there is good ground (based upon the statistics for London) for believing that the mean small pox death-rate in the four years 1843-46, for which no tabulated records exist, somewhat exceeded the mean rate in the twelve years 1838-53, for which the Registrar-General has published the results. Compulsory vaccination came into operation in 1854, and although no effectual means of enforcing the obligation existed until after the Act of 1871 took effect, there is conclusive evidence that a marked increase of primary vaccination took place in 1854. During the forty-two years of compulsory vaccination the annual death-rate from small pox averaged 126 per million, although this period included the remarkable epidemic in 1871-72; indeed, during the twenty years 1877-96, the mean annual rate has been only 42 per million. The range of mortality during this period of forty-two years was from 1,012 and 821 per million in 1871 and 1872, to 0.8 and 0.6 per million in 1889 and 1890. Thus, judged by the whole available statistics of the Registrar-General, the mean mortality from small pox declined from 408 per million in the twelve years prior to compulsory vaccination, to 126 per million in the forty-two years since vaccination was made compulsory, notwithstanding the epidemic of 1871-72; showing an average decline of more than two-thirds, or 69 per cent.

Dr. William Ogle, in his valuable evidence before the Royal Commission, subdivided the period of compulsory vaccination into two:—(1) "Vaccination obligatory but not efficiently enforced, 1854-71;" and (2) "Vaccination obligatory, but more efficiently enforced by vaccination officers, 1872-87." Those who impartially study the evidence given before the Commission, and the statistics of the subject, can scarcely avoid the conclusion that the passing of the Act of 1871 marks a decided epoch in the inter-relation of small pox and vaccination, not only on the ground of the compulsory appointment of vaccination officers, but also because of the marked improvement in the machinery for securing the effective action of these officers, which provided the means for a satisfactory registration of successful vaccinations, and of cases unaccounted for. Dr. Ogle's subdivision drew the line after the year 1871, because the Act of that year did not take effect till 1872, and thus included this year of heaviest small pox mortality in the period of inefficiently enforced obligation, 1854-71. Dr. Ogle with his evidence gave a table showing that in these eighteen

TABLE III.—*Mean Annual Rate of Mortality from Small Pox at all Ages and at Six Age-Periods in Three Groups of Years, selected with reference to Optional and Obligatory Vaccination.*

[“First Report,” p. 114.]

1	2	3	4	5	6	7	8
Period.	All Ages.	0-5.	5-10.	10-15.	15-25.	25-45.	45 and upwards.
(1.) Vaccination optional, 1847-53*	305	1,617	337	94	109	66	22
(2.) Vaccination obligatory, but not efficiently enforced, 1854-71	223	817	243	88	163	131	52
(3.) Vaccination obligatory, but more efficiently enforced by vaccination officers, 1872-87	114	242	120	69	122	107	47

* In this table the period of optional vaccination begins with 1847, not with 1838, because the deaths were not abstracted in combination with ages until 1847.

years 1854-71, the mean annual mortality from small pox was 223 per million, whereas under more efficiently enforced compulsion the mean rate fell in the sixteen years 1872-87 to 114 per million. The Commissioners in sympathy with anti-vaccinators naturally took exception to Dr. Ogle's subdivision, and the witness was subjected to very severe cross-examination with a view to show that he had undervalued the effect of the Act of 1867, by which guardians were empowered, but not compelled, to appoint vaccination officers. The real object was apparently to throw the year 1871, with its remarkable and fatal small pox epidemic, into Dr. Ogle's later period of enforced compulsion, and thus to lessen the reduction of small pox mortality attributed to increased vaccination. Although there appears to be no valid reason for doubting that Dr. Ogle's subdivision was fully justified by the facts of the case, it is unnecessary to insist upon it here, as the two simple periods of voluntary vaccination and compulsory vaccination give a sufficiently striking contrast, namely, mean annual rates of 408 and 126 per million respectively, although the compulsory period by this arrangement includes the epidemic of 1871-72.

Mortality from Small Pox in different Age-Periods.

We must now consider the varying rates of small pox mortality at different age-periods in successive years. It should in the first place be stated that prior to 1848 the ages and causes of death were not classified by the Registrar-General in combination. The Commissioners' Report gives a table, which is here reproduced, showing the mortality per million from small pox at six age-periods, during the seven years 1848-54, and in the four succeeding decennia ending in 1894.

TABLE IV.—*Mean Annual Death-Rate from Small Pox per Million Living at Six Age-Periods.*

[“Final Report,” p. 48.]

Years.	Mean Annual Rate per Million Living.					
	Under 5.	5-10.	10-15.	15-25.	25-45.	45 and upwards.
1848-54*	1,514	323	91	110	69	24
'55-64	789	210	69	119	88	36
'65-74	783	333	142	267	221	88
'75-84	128	63	46	82	77	34
'85-94	50	15	11	24	32	19

* The figures for this period include the deaths attributed to chicken pox as well as those from small pox.

The main feature of this table is the marked decline of mortality under 5 years of age, namely, from 1,514 per million in 1848-54 to 50 in 1885-94. Under this arrangement, which is an entirely arbitrary one, the first year of compulsory vaccination is included in the first or seven-year period, but the marked decline under 5 years of age in the next ten years, nearly equal to 50 per cent., is very striking, taken in conjunction with the actually increased rate at ages over 15 years. The next ten years, 1865-74, is governed by the epidemic of 1871-72, and the mean rate showed a marked increase, compared with that of the preceding decennium, at each age-period above 5 years, but under 5 years there was a slight decline, notwithstanding the effect of the epidemic. This is the more remarkable and suggestive when we bear in mind the legislation of 1867 and 1871, which was passed with a view to increase the amount of infant vaccination. In the next ten years, 1875-84, during which the Acts of 1867 and 1871 were in full operation, the rates under 5, and from 5 to 10, fell from 783 and 333 to 128 and 63; while in the last decennium, 1885-94, the rates at these periods further fell to 50 and 15 respectively. Above 10 years of age small pox rates showed, as has been pointed out, a very largely increased death-rate during the decennium 1865-74, owing to fatal effect of the epidemic in 1871-72 upon the adolescent and upon adults; in this period the rate per million rose to 142 in the 10-15 age period, 267 at the ages 15-25, 221 at 25-45,

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 data are not normally distributed.

TABLE I			
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and 86 among persons aged upwards of 45 years. At each of these periods the rate successively fell in a marked manner in each of the two following decennia, and in 1885-94 the mean rates were only 11, 24, 32, and 19 respectively, being in each case far below the rates in the first period of seven years 1848-54, although the fall did not approach those recorded under 5, and from 5 to 10, which were apparently due to the influence of increased infant vaccination. Comparing the rates under 5 and from 5 to 10 in 1885-94 with those in 1848-54, given in this table, they show a decline to $\frac{1}{2}$ and $\frac{1}{3}$ of the rates that prevailed forty years before, when vaccination was optional.

The marked fatality of small pox in 1871-72 among persons above the age of childhood, judged by recent statistics, was mainly the result of the exhaustion of the protective influence of infantile vaccination, and of the neglect of re-vaccination. Unfortunately no satisfactory evidence exists which would justify even an estimate of the proportion of the population above the age of childhood that has been re-vaccinated, although it is safe to assume that since the epidemic of 1871-72 the number and proportion of the re-vaccinated have very considerably increased.

The Age-Incidence of Deaths from Small Pox.

Time and space forbid any discussion of such statistics as exist showing the age-incidence of fatal small pox in pre-registration periods. It may be stated, however, that there is good ground for believing that formerly small pox was to a far greater extent than is now the case mainly a disease of childhood. For instance, from evidence handed in to the Commission by Sir John Simon, formerly medical officer to the Local Government Board, it appears from an analysis of nearly 7,000 fatal cases of small pox recorded in Geneva between 1580 and 1760, that more than 96 per cent. occurred among children aged under 10 years, including 81 per cent. under 5 years of age. Dr. McVail, in his valuable analysis of Kilmarnock small pox statistics in 1728-64, pointed out that the death-rate under 5 years of age was thirty-five times greater than it now is, and that the mean age at death from small pox was only 2½ years in the last century, whereas it is now about 20 years. Bearing on this change of age-incidence and its cause, much evidence was given before the Commission with a view to elucidate the relative protection conferred respectively by an attack of small pox and by vaccination. To this point it will be necessary to refer. It will suffice here to discuss the change in the age-incidence of small pox as exhibited by English official statistics since 1848, when ages and causes of deaths were first published by the Registrar-General in combination. A table in the appendix, reprinted from the Commissioners' final report, gives the proportion of 1,000 deaths from small pox occurring in each year from 1848 to 1895 at each of seven groups of ages. From this table it appears that of 1,000 deaths from small pox in 1851-60, 239 occurred under 1 year of age, and in 1881-90 only 119; between 1 and 5 years the proportion declined from 363 in 1851-60, to 93 in 1881-90. Thus in the first year of life, during only a portion of which are any infants protected by vaccination, the proportional number of fatal cases of small pox declined 50 per cent. between 1851-60 and 1881-90, whereas in the period 1-5 years the decline was equal to 75 per cent. Calculated in the same manner, the decrease in the proportion of small pox deaths occurring between the ages of 5 and 10 years was from 134 in 1851-60 to 64, equal to about 50 per cent. Above the age of 10 years the proportion of fatal small pox cases was higher in 1881-90 than in 1851-60. Thus of 1,000 deaths in 1851-60, 35 occurred between 10 and 15, 103 between 15 and 25, 99 between 25 and 45, and 28 among persons aged 45 and upwards; whereas these proportions had increased to 52, 222, 328, and 124 respectively. To summarise these figures, of 1,000 small pox deaths in 1851-60, 735 were of children under 10 years of age, and 265 of persons aged upwards of 10 years; while thirty years later, in 1881-90, when vaccination had been made compulsory, and the compulsion enforced by the Acts of 1867 and 1871, the proportions were more than reversed, for only 277 were of children under 10 years of age, and 723 were of persons aged upwards of 10 years.

The following table, reproduced from the final report of the Commissioners, throws additional light upon this most important change of the age-incidence of small pox:—

TABLE V.—*Proportion of Deaths from Small Pox, at each of Six Age-Periods, to 1,000 Deaths from Small Pox at all Ages.*
[“Final Report,” p. 47.]

	Under 5.	5-10.	10-15.	15-25.	25-45.	45 and Upwards.
1848-54	677	130	33	75	67	18
'55-59	559	144	37	117	111	31
'60-64	550	108	41	128	133	44
'65-69	545	103	33	126	145	48
'70-74	312	110	58	200	214	66
'75-79	241	113	71	218	264	90
'80-84	135	98	68	216	286	97
'85-89	193	54	51	229	344	129
'90-94	283	50	46	131	338	172

This table shows that of 1,000 deaths from small pox, 677 occurred among children aged under 5 years of age in 1848-54, while the proportion in this age-period steadily declined in subsequent groups of five years to 91 in 1885-89, and rose again to 283 in 1890-94, under the influence of the decrease of infant vaccination, due in great measure to the delay in the issue of the Report of the Commission. On the other hand the proportional numbers of small pox deaths among persons aged upwards of 15 years steadily rose from 160 per 1,000 in 1848-54 to 704 in 1885-89, and fell again to 641 in 1890-94. To what can this complete *bouleversément* of age-incidence be attributed if not to the undoubted increase in the proportion and efficiency of infant vaccination during the thirty years between the two periods we have compared? Much ingenious sophistry was brought to bear upon this point by some of the Commissioners in cross-examining some of the witnesses, notably Dr. Ogle and Dr. Thorne Thorne, who prominently brought out this fact in their evidence, and also by some of the anti-vaccination witnesses in their evidence. The facts, however, remain unchallenged, and inexplicable on any other suggested hypothesis than that the change of age-incidence is due to increased infant vaccination. It is, moreover, very noteworthy that in the minority report of Dr. Collins and Mr. Picton, no explanation of this change of age-incidence is attempted, although attention is called to the fact that in the nine years 1872-80, under the influence of compulsory vaccination, "at every age over 10 years the chance of dying of small pox was greater" than it had been in the six years 1848-53, when vaccination was voluntary. It would be interesting to know why Dr. Collins and Mr. Picton confined their comparison to the nine years ending with 1880, and to the ages above 10 years. It is, at any rate, worth noting that if they had enlarged the period to a more recent date, still more if they had compared 1848-53 with say 1888-93, the result of the comparison would have been very different.

Before leaving this branch of the subject, namely, the evidence of the effect of infant vaccination upon child mortality from small pox, it is necessary to refer to the important statistics given in the Commissioners' Report relating to the age-incidence of the fatal cases of small pox recorded at each of the six epidemics that occurred at Sheffield, Warrington, London, Dewsbury, Leicester, and Gloucester between 1887 and the present time. These statistics are here tabulated:—

TABLE VI.—*Child Mortality from Small Pox in relation to the Neglect of Vaccination in Six Towns which have recently suffered from Small Pox Epidemics.*

[“Final Report,” pp. 50 and 176.]

1	2	3	4	5
Town.	Date of Epidemic.	Total of Small Pox Deaths.	Percentage of Deaths under 10 to Total Deaths from Small Pox.	“Unaccounted for” as to Vaccination.
Warrington	1892-93	64	22.5	4.8
Sheffield	'87-88	589	25.6	4.5
London	'92-93	184	36.8	9.9
Dewsbury	'91-92	110	51.8	12.5
Gloucester	'95-96	443	64.5	67.6
Leicester	'92-93	21	71.4*	68.1

* Excluding the deaths of 3 patients in a scarlet fever ward in close proximity to the small pox hospital, this proportion would be reduced to 66.6 per cent.

The figures in this table show that in the ten years preceding the epidemic in Warrington, only 5 per cent. of the children born were unaccounted for as regards successful vaccination; in London the mean proportion of children not accounted for was 10 per cent.; in Dewsbury this proportion of unvaccinated children was 32 per cent., and both in Gloucester and Leicester it was so high as 68 per cent. If, as statistics previously dealt with suggest, the proportion of deaths from small pox among children depends upon the proportion that has been vaccinated, the age-incidence during these six epidemics should show wide variations. This expectation is abundantly fulfilled. In the well vaccinated towns of Warrington and Sheffield only 23 and 26 per cent. respectively of the deaths occurred among children under 10 years of age; but this proportion was 37 per cent. in London, 52 in Dewsbury, 65 in Gloucester, and 71 in Leicester. These figures corroborate in a remarkable manner the evidence afforded by other statistics, and seem to forbid disbelief in the assertion that small pox mortality, at any rate among children, is directly governed by the proportion of successful vaccinations. It is true that the intensity of the mortality from small pox also varied very widely in these six epidemics, and it is noteworthy that Dr. Collins and Mr. Picton endeavour to discredit vaccination by pointing out that in Leicester and Dewsbury, in which towns vaccination had been so persistently neglected, the rate of mortality from the disease was much lower than in Sheffield and Warrington, in which vaccination had been well carried out. Is the inference suggested that the mildness of the type of the disease in Dewsbury and Leicester was due to the neglect of vaccination? It is still more noteworthy that Dr. Collins, when dealing with the statistics of these epidemics,

The first part of the paper is devoted to a discussion of the general principles of the theory of the structure of the atom. It is shown that the structure of the atom is determined by the laws of quantum mechanics, and that the laws of quantum mechanics are determined by the laws of the special theory of relativity. The second part of the paper is devoted to a discussion of the structure of the atom, and the third part to a discussion of the structure of the nucleus.

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Year	1921	1922	1923	1924	1925
Population	1,000,000	1,100,000	1,200,000	1,300,000	1,400,000
Area	100,000	110,000	120,000	130,000	140,000
Population per square mile	10	11	12	13	14

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makes no reference to, much less attempts to explain, the remarkable evidence they afford of the relation between infant vaccination and child mortality from small pox.

What is the true lesson to be learned from this changed incidence of small pox mortality? If we accept infant vaccination as the explanation of the decreased mortality of small pox in childhood, and no other reasonable and tenable explanation was suggested by any of the witnesses before the Commission, we are bound also to accept the same explanation of the increased fatality of the disease among adolescents and adults. Small pox has long since ceased to be mainly a disease of childhood, and notwithstanding the marked decline of the aggregate mortality from this disease, there has been until quite recently no actual decline in its rate of mortality among adults. Much speculation, and some evidence on this point was submitted to the Commission, and may be found in their reports. The only conclusion dictated by common sense, and admitted by most of the best informed witnesses, is that infant vaccination does not afford a protection from small pox equivalent to that conferred by an attack of small pox. The opinion has been expressed, by those who have carefully weighed such evidence on the point as exists, that in pre-vaccination times nearly all children had small pox during some period of childhood, and thus were protected from attack in after life, just as the majority of children now suffer from measles, scarlet fever, and whooping cough, from which no protecting operation equivalent to vaccination has been discovered.

It is much to be regretted that the medical profession so long hesitated to admit that Jenner was over sanguine and mistaken in declaring that infant vaccination conferred life long protection from an attack of small pox. The hesitation and delay in making this admission appears to have added much force to the anti-vaccination agitation. It appears to have been a mistaken policy, which feared that such an admission would weaken the arguments for the continued compulsory practice of vaccination, as accumulated evidence of the protective effect of vaccination during childhood cannot be gainsaid.

As to the relative value of vaccination and an attack of small pox as a protection from the disease, this is a speculative problem, on the solution of which statistics do not, and in the nature of the case cannot, afford much assistance. Dr. Ogle, in the forty-third annual report of the Registrar-General, expressed the opinion that "the immunity derived from vaccination is both less perfect and less permanent than that conferred by small pox itself." Dr. Gayton, in his evidence before the Commission, after quoting the opinion of Jenner that the protection by vaccination was tantamount to that of an attack of small pox, said "proofs are abundant already, and will continue to accumulate, to disprove these statements." Mr. Sweeting, and in fact all the most experienced authorities, hold the same opinion.¹ It seems possible, however, that the apparent inferiority of vaccination to an attack of small pox as a protection from that disease may be due to the fact that while the mean age at which vaccination takes place in England is probably under 4 months, the mean age at which children used to be protected by an attack of small pox was between 2 and 3 years. It might happen that if infant vaccination were postponed until the third year of life, that its protective effect would be both increased and prolonged, and might then equal that conferred by an attack of small pox. This is, however, mere hypothetical speculation. That the increased proportion of adult mortality from small pox is due to the fact that the adult population is in some way more susceptible to small pox infection since the protection of children by infant vaccination, and not by an attack of small pox, seems to be beyond doubt or controversy.

The Value of Re-vaccination.

The undoubted fact of the increase in the proportion of adult small pox mortality, concurrently with the decline of child mortality from this disease, might well raise a doubt as to the balance of advantage derived from this changed age-incidence, unless good ground existed for believing in the efficacy of re-vaccination as a means of protecting adults from the disease. Much information was given before the Commission bearing upon the degree of protection conferred by re-vaccination. No one really now questions the fact that the protective influence of infant vaccination diminishes with the lapse of years. The value of re-vaccination is obviously, therefore, a subject of great importance. Unfortunately there are no available statistics showing the amount or proportion of re-vaccination in this country. Except under the influence of panic arising from the epidemic presence of small pox, the proportion of the adult population that has been re-vaccinated is probably not large. In those towns that have suffered from epidemic small pox in recent years, careful attempts have been made to obtain information on this point. Dr. Barry, during his inquiry concerning the Sheffield epidemic in 1887-88, ascertained

¹ It should be noted, however, that the investigation of the statistics of the recent epidemics in Sheffield, Dewsbury, Warrington, and Leicester disclosed 15 cases of small pox occurring among persons who had suffered from a previous attack of this disease, 5 of which proved fatal, showing a case-mortality of 14.2 per cent., which considerably exceeds the average case-mortality among vaccinated persons. These numbers are, however, it must be allowed, small.

the most common of all diseases, and is often the result of a
poor diet, and a sedentary life.

The first symptom of this disease is a general feeling of
weakness, and a loss of appetite. This is followed by a
sore throat, and a difficulty in swallowing. The next
stage is a general swelling of the body, and a
feeling of heat. This is followed by a
fever, and a general prostration of the system.
The disease is often fatal, and is
one of the most common causes of death.

The disease is often fatal, and is
one of the most common causes of death.

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and reported that 64,431 re-vaccinated persons were enumerated, and that after careful inquiry into 352 cases of re-vaccinated persons said to have been attacked with small pox, he only found 27 cases in which small pox supervened after successful re-vaccination, and only one of these proved fatal, 19 being of an extremely mild character. It is needless to point out that it is as necessary to differentiate between successful and unsuccessful re-vaccination as it is between successful and unsuccessful primary vaccination; for it is not held that any protection is conferred by unsuccessful re-vaccination, and one unsuccessful attempt at re-vaccination should not, we are told, be accepted as proof of insusceptibility. Dr. Barry's figures showed an attack rate among re-vaccinated persons of only 0.04 per cent., whereas the attack rate among once vaccinated persons aged above 10 years was 5.2, and among unvaccinated persons 54.2 per cent. In the same inquiry Dr. Barry enumerated 18,292 persons in Sheffield who had had small pox prior to 1887, of whom 23 had a second attack in 1887-88. These figures showed an attack rate considerably higher than among the re-vaccinated; and the proportional mortality was also higher. Those, however, who have studied the report and evidence issued by the Commissioners, will remember that this part of Dr. Barry's report was subjected to severe criticism, and that some doubt was thrown upon the success of his attempt to enumerate the numbers of the vaccinated, re-vaccinated, and unvaccinated in the Sheffield population. There were in Sheffield at the time of this epidemic 830 troops of all ranks, all of whom should, in accordance with regulations, have been re-vaccinated. Twelve men, however, or 1.4 per cent. of the total strength, were attacked with small pox, and of these one died; it was, however, proved to the satisfaction of the Commissioners that not one of these 12 soldiers had been *successfully* re-vaccinated, and that in fact although the soldiers mingled freely in the town during the epidemic not a single *successfully* re-vaccinated soldier was attacked by small pox in Sheffield. Of the Sheffield police who, to the number of 372, were necessarily, in the course of their ordinary duties, brought into close relation with infected persons and things, only ten cases of small pox occurred. These ten policemen had been vaccinated in infancy, but not one had been re-vaccinated. Not one of the 290 men and boys employed on the permanent staff of the Post Office, who by the regulations must be re-vaccinated before engagement, contracted small pox, although many of them must have been in contact with infection.

The report contains much similar information relating to the stated numbers of re-vaccinated persons attacked by small pox during the epidemics in Leicester, Warrington, and Dewsbury, and to the result of the cases. It does not appear desirable, however, to refer to this class of statistics at greater length, as mere statements as to re-vaccination are at the best more or less unsatisfactory, and are obviously difficult to support by proof.

It seems desirable, therefore, to depend mainly upon the statistics of small pox hospital nurses and attendants submitted to the Commission, for conclusive evidence of the value of the re-vaccination of adults as a protection from small pox. Dr. Gayton stated that 366 persons were employed on the staff at Homerton Small Pox Hospital between 1st February, 1871, and the end of 1877. The whole of these, with one exception, were re-vaccinated on commencing duty, and this accidental exception was the only case of small pox attack among the 366 hospital attendants. Subsequent to 1877 Dr. Gayton was unable to state the precise number of the staff employed at the Homerton hospital, but was of opinion that the number was equal to that in the previous period. Among these there was again only one case of small pox, a case in which the nurse had not been re-vaccinated. In the small pox hospital ships of the Metropolitan Asylums Board, during

TABLE VII.—*Number and Proportion of Attendants, &c., who contracted Small Pox in the Metropolitan Asylums Small Pox Hospital Ships in the Twelve Years 1884-95.*

[“Final Report,” p. 85.]

Year.	Number of Attendants Employed, either Temporarily or otherwise, in the course of the Year.	Of whom there contracted Small Pox during the Year.	
		Number.	Proportion. Per Cent.
1884.....	283	4	1.4
'85.....	240	0	0
'86.....	110	0	0
'87.....	55	0	0
'88.....	45	0	0
'89.....	53	0	0
'90.....	64	0	0
'91.....	64	0	0
'92.....	138	2	1.4
'93.....	140	6	4.3
'94.....	289	0	0
'95.....	274	0	0

the twelve years 1884-95, the hospital staff, including doctors, nurses, and servants, varied from about 50 to rather more than 300 per annum. The only cases of small pox among this large staff occurred in 1884, 1892, and 1893. In 1884 there were 4 cases

among 283 attendants; in 1892, 2 cases among 138; and in 1893, 6 cases among 320. No cases occurred in any of the nine other years. Of these 12 cases of small pox, 1 occurred within three days of commencing duties in the hospital ship, 1 within nine days, 4 within ten days, and 4 others within from twelve to fifteen days' service. It is further stated that none of these 12 recorded cases in the twelve years had been successfully re-vaccinated prior to the commencement of the incubation period, although the operation was in all cases attempted. Similar statistics were given by Mr. Sweeting with reference to the staff employed at the Western Small Pox Hospital at Fulham. Mr. Marson, the well known surgeon to the Highgate Small Pox Hospital, gave evidence to the select committee in 1871, to the effect that during the preceding thirty-five years no nurse or servant at the hospital had been attacked with small pox. Since 1871 only 1 case, that of a gardener, has been attacked. Of the 137 nurses and attendants who have been engaged since 1883, 30 had had small pox, some having been patients in the hospital, engaged as nurses or ward maids after their recovery; all the others were re-vaccinated upon entering the service, except the gardener referred to above, who took the disease. Thus at this hospital there was only 1 case of small pox among the hospital staff during sixty years.

At the Sheffield Small Pox Hospital, of 62 attendants who had only been vaccinated in infancy, 6 contracted small pox, while of the 80 who had been re-vaccinated not one was attacked. At Warrington 2 of the hospital staff were attacked, being the only two who had not been re-vaccinated at the commencement of the outbreak. Six of the attendants at the Leicester Hospital refused to be re-vaccinated, five of whom contracted small pox and one died; there was only one case of the disease, a mild one, among the larger number who had been re-vaccinated, that of a nurse re-vaccinated ten years before. Dr. Grimshaw, Registrar-General for Ireland, stated that in the Cork Street Hospital in Dublin, with which he was formerly connected, all the officers and servants were re-vaccinated, with the exception of one resident pupil, who refused to be re-vaccinated, and who died from small pox. It seems useless to multiply this kind of evidence, which, so far as it relates to English hospitals of a more or less public character, is practically identical. While it cannot be asserted that the staff at small pox hospitals, even if re-vaccinated, enjoy absolute immunity from the disease, the cases of attack have been so rare and exceptional as not substantially to modify the conclusion that re-vaccination affords practically complete protection even to nurses in personal attendance on small pox patients. With regard to the exceptions, it is a well known fact that there are both individual cases of exceptional susceptibility and individual cases of insusceptibility to small pox. I personally knew a case of a young woman who was insusceptible both to vaccination and small pox, who nursed several members of her family who were suffering from small pox without taking the disease, and who later in life acted more than once as a small pox nurse without any ill effects.

With a view to depreciate this evidence derived from English hospitals, the attention of the Commissioners was called to some evidence of a different character from other hospitals, notably to the experience at the Bicêtre Small pox Hospital at Paris, and to a statement made by Mr. Porter, who was a short time medical officer to the South Dublin Union Hospital in 1871. In neither of these cases, however, did the evidence stand the test of cross-examination, and the Commissioners came to the conclusion that it did not materially affect the weight of the evidence derived from the hospital experience in this country.

Before quitting the discussion of the value of re-vaccination, it appears desirable to call attention to the accompanying Table VIII, reprinted from the "Final Report" of the Commissioners, showing the annual rate of mortality from small pox in

TABLE VIII.—Annual Rate of Mortality from Small Pox per 100,000 living, in Prussia and Austria in the Twenty Years 1862-81.

[“Final Report,” p. 91.]

Years.	Prussia.	Austria.	Years.	Prussia.	Austria.
1862	21.06	31.14	1872	26.17	18.91
'63	33.80	53.10	'73	35.65	11.16
'64	46.25	84.78	'74	9.52*	11.19
'65	43.78	45.51	'75	3.60	27.71
'66	62.00	35.85	'76	3.14	19.28
'67	43.17	74.08	'77	6.34	51.18
'68	18.81	33.27	'78	6.71	60.59
'69	19.44	35.18	'79	1.25	50.83
'70	17.52	30.30	'80	2.60	64.31
'71	44.21	19.28	'81	3.42	82.67

* Re-vaccination was made compulsory in Prussia in 1874.

Prussia and Austria during the twenty years 1862-81. It will be seen that re-vaccination was made compulsory in Prussia in 1874, a logical result of the almost universal epidemic of small pox in 1871-72. The striking contrast between the comparison of the Prussian and Austrian figures before and after 1874, affords conclusive evidence of the value of re-vaccination.



It has been urged by the anti-vaccinators that the real explanation of the exceptional immunity from the disease enjoyed by the staff of small pox hospitals is not the effect of re-vaccination, but is due to long and gradual exposure to the poison, by which the human frame becomes insusceptible to its effect. The Commissioners declare that facts do not support this theoretical explanation. In the first place, the exposure to the poison in a small pox hospital cannot be described as gradual, and this theory, moreover, affords no explanation of the phenomenon that among the hospital attendants, very nearly all the re-vaccinated escape the disease, while those not re-vaccinated are attacked in such far larger proportions. Moreover, as the Commissioners state in their final report, "the experience of almost certain immunity from the disease in the case of successfully re-vaccinated attendants in small pox hospitals has no parallel in the case of the staff in hospitals in which other contagious or infectious diseases are treated."

At the London Fever Hospital a large number of typhus patients were treated during the ten years 1862-71, and the staff of attendants (including laundry women) averaged about 100; the average number of cases of typhus among the staff was 19·2 per annum. The medical staff suffered severely during this period. In 1862 two medical officers caught typhus; in 1863 four medical officers successively caught typhus; in 1864 and 1865 a medical officer in each year contracted the disease; and in 1866 the resident medical officer died from the disease. It is evident that exposure to the influence of typhus poison does not protect the doctors and nurses from the disease; it is therefore only reasonable to prefer the theory that small pox attendants are protected by re-vaccination, and not by "exposure to the influence of small pox poison."

TABLE IX.—*Number and Proportion of Attendants, &c., who contracted Infectious Diseases* in the Metropolitan Asylums Fever Hospitals in the Nine Years 1887-95.*

[*"Final Report,"* p. 85.]

Year.	Metropolitan Asylums Board's Fever Hospitals.		
	Number of Attendants Employed, either Temporarily or otherwise, in the course of the Year.	Of whom there contracted Scarlet Fever, Diphtheria, or Typhoid during the Year.	
		Number.	Proportion.
1887.....	1,103	37	For Oct.
'88.....	—	25	3·4
'89.....	—	42	—
'90.....	1,311	53	4·0
'91.....	1,460	68	5·9
'92.....	1,624	121	7·3
'93.....	1,175	121	5·6
'94.....	2,182	111	5·1
'95.....	2,514	116	4·6

* Scarlet fever, diphtheria, or typhoid fever.

Before leaving this branch of the subject, it may be pointed out by way of contrast, that more than 5 per cent. of the attendants in the Metropolitan Asylums Board Fever Hospitals contracted either scarlet fever, diphtheria, or typhoid fever during seven years ending with 1895; whereas among the attendants employed temporarily or otherwise in the Metropolitan Asylums Board Small Pox Hospitals Ships during the twelve years 1884-95, the proportion who contracted the disease only amounted to 0·6 per cent. Thus the attendants in the Fever Hospitals appear to be more than eight times as liable to infection from scarlet fever, diphtheria, and typhoid fever than are the re-vaccinated attendants on the Small Pox Hospital Ships, although adults are, re-vaccination apart, far more likely to be infected by small pox than by the diseases treated in the Fever Hospitals.

Proportional Mortality from Small Pox among Vaccinated and Unvaccinated.

The six last local epidemics of small pox in England, to which reference has before been made, were specially investigated by Local Government Board Inspectors or by medical men selected by the Commission, who made careful analyses of all the available statistics. Disregarding the incredulity of the opponents of vaccination of this class of statistics, it is necessary to refer to the evidence on this point afforded by the reports on these six epidemics. If the figures for the six towns are aggregated they afford more trustworthy results because they are larger. The number of unvaccinated cases of attack was 2,321, of which 822, or 35·4 per cent. proved fatal; the 1,449 cases under 10 years of age gave a mortality of 36·0 per cent., and 872 above that age a mortality of 34·3 per cent. The close agreement between the proportional mortality among unvaccinated cases under and over 10 years of age is very noteworthy. Excluding the 2,321 unvaccinated cases, from the 11,065 cases of attack recorded during the six epidemics, the remaining 8,744 gave 461 deaths, showing a mortality of only 5·2 per cent. Thus the total cases of attack, 1,065, showed a fatal percentage of 11·5; the 8,744 vaccinated cases, including all the doubtful cases, namely those stated to be vaccinated but bearing no marks, showed a mortality of 5·2 per

When the first of the above mentioned conditions is not fulfilled, the system is not in equilibrium. In this case, the system will evolve towards a state of equilibrium. The evolution of the system is determined by the second and third conditions. The second condition states that the system must be closed. This means that there is no exchange of matter or energy with the surroundings. The third condition states that the system must be isolated. This means that there is no exchange of energy with the surroundings. If both the second and third conditions are fulfilled, the system is in equilibrium. In this case, the system will remain in a state of equilibrium indefinitely.

Table 1	
Time (s)	Temperature (°C)
0	20.0
10	21.5
20	23.0
30	24.5
40	26.0
50	27.5
60	29.0
70	30.5
80	32.0
90	33.5
100	35.0

The data in Table 1 shows that the temperature of the system increases over time. This is consistent with the second and third conditions of equilibrium. The system is closed and isolated, and therefore, the temperature will increase until it reaches a state of equilibrium. The rate of increase in temperature is constant, which is also consistent with the conditions of equilibrium.

The data in Table 1 also shows that the temperature of the system increases linearly with time. This is consistent with the second and third conditions of equilibrium. The system is closed and isolated, and therefore, the temperature will increase linearly until it reaches a state of equilibrium. The rate of increase in temperature is constant, which is also consistent with the conditions of equilibrium.

cent. while the 2,321 unvaccinated cases showed a mortality of 35.4 per cent. The Commissioners in their final report pertinently ask, "how is this to be accounted for?" They ask whether this marked difference in the mortality of cases classed as vaccinated and unvaccinated can be a mere freak of chance. In reply they say that it is scarcely possible to believe that it can be so, more especially when it is found that the same contrast is exhibited on comparing the figures for each of the six towns. The Leicester epidemic was marked by a remarkably low case mortality, and the proportional fatality of the unvaccinated cases under 10 was only 14 per cent.; but then there was not a single death among the vaccinated cases under 10 years.

Even admitting the possibility of mistakes in the classification of individual cases, "it cannot be doubted," says the report, "that the great majority of the one class were vaccinated, whilst the great majority of the other class were unvaccinated."

There was nothing new about the evidence afforded by these six recent epidemics, except that they were investigated by special inspectors chosen by the Commissioners or by the Local Government Board. The evidence, however, fully corroborated previous small pox hospital statistics. Mr. Marson's observations during thirty-two years at the small pox hospital, based upon 19,467 cases, showed a fatality of 36.5 per cent. among the unvaccinated, while the highest fatality among those bearing vaccination marks was 12.8 per cent. among cases with only one cicatrix. Dr. Gayton gave evidence concerning 10,403 cases at the Homerton Hospital between 1873 and 1884, showing a mortality of 10.5 per cent. among the vaccinated, including all doubtful cases said to be vaccinated but without marks, while among the unvaccinated the mortality was 45.4 per cent. Mr. Sweeting's statistics of 2,584 cases at the Fulham Hospital in 1880-85 showed a total mortality of 16.5 per cent.; among the vaccinated and doubtful cases the percentage was 11.4, whereas among the unvaccinated it was 46 per cent. Eliminating the doubtful cases from Mr. Sweeting's figures, the mortality of the vaccinated class is reduced from 11.4 to 8.9 per cent.

This class of statistics has been subjected to much adverse criticism by the opponents of vaccination, on the ground that the case mortality of the unvaccinated shown thereby very far exceeds that of recorded small pox prior to the introduction of vaccination. These objections are mainly founded on some small pox statistics collected by a Dr. Jurin, which showed a case mortality of 16.5 per cent., and upon Bernoulli's figures, which are said to represent the case mortality of natural small pox during the eighteenth century. Much doubt, however, was thrown upon the trustworthiness of these foreign statistics by evidence and cross-examination before the Commission, and while there is abundant and recent evidence of wide variations of case mortality in different epidemics, it is beyond question that the records of the London Small Pox Hospital show a mortality of 25.3 per cent. during the years 1746-63, and that during the last twenty-five years of that century the mortality was 32 per cent. We are bound, however, to base our conclusions mainly upon recent statistics, which are abundant and as a rule beyond suspicion.

It has, moreover, been urged that the marked difference between the case mortality of vaccinated and unvaccinated cases is not due to the protective effect of vaccination, but to the fact that the unvaccinated are mostly to be found among the poorer and more neglected classes of the population. This assertion may be accepted as to a certain extent true, inasmuch as it is a fact that small pox mortality is in the main confined to the working classes. It is equally true, however, that the neglect of vaccination is also mainly confined to the same classes. The special reports on the six epidemics, moreover, conclusively show (especially the Warrington report) that the vaccinated and unvaccinated cases were not only of the same class, but were in fact to a very large extent members of the same families living in the same houses.

It has also been suggested that the excess of mortality among the unvaccinated is due to the inclusion among this class of those cases in which vaccination has been postponed on medical grounds, which cases consist, it is asserted, mainly of children of delicate constitution. The Commissioners, however, point out that the proportion of postponed cases is in the aggregate too small materially to affect these statistics, that postponement does not necessarily prove that the child is of a delicate constitution, and that a considerable proportion to the children whose vaccination is postponed are afterwards vaccinated.

Small Pox Attack Rate among Vaccinated and Unvaccinated.

The medical experts selected to investigate and report upon five of the six recent epidemics to which reference has so often been made, endeavoured to collect statistics with a view to show the small pox attack rate among the vaccinated and unvaccinated. This involved the necessity for ascertaining the numbers of vaccinated and unvaccinated persons exposed to risk in the several towns. The difficulties in the way of collecting such information are obvious, and these statistics were subjected to much adverse criticism by some of the Commissioners. It should be borne in

mind, however, that the attack rate of small pox depends primarily upon the liability to contact with sources of infection, and that there is a source of fallacy in the attempt to calculate attack rates on the whole vaccinated and unvaccinated population of a large town. The *bona fides* of the investigations being, however, beyond question, it seems desirable to refer briefly to these statistics, although from a pro-vaccination point of view they are far outweighed in importance and conclusiveness by the figures previously dealt with showing the almost absolute immunity from attack enjoyed by successfully re-vaccinated nurses and attendants in small pox hospitals.

Dr. Barry arrived at the conclusion that Sheffield at the date of the epidemic, contained 266,797 vaccinated and 7,315 unvaccinated persons of all ages, and that the small pox attack rate in these two classes of the population were 1.6 and 7.5 per cent. respectively. For reasons stated above, the value of these statistics is somewhat doubtful. No similar objections can be urged against Dr. Barry's statistics of the attack rate of the vaccinated and unvaccinated inmates of houses invaded by small pox. These houses contained, it is reported, 4,419 children under 10 years of age stated to be vaccinated, of whom 353 or 7.9 per cent. were attacked; while of the 337 unvaccinated children of the same age, 228 or 67.6 per cent. were attacked. Above 10 years of age the attack rate among the vaccinated and unvaccinated did not differ so widely, being 28.3 and 51.6 per cent. respectively, proving, what now needs no proof, that the protective effect of infant vaccination decreases with the lapse of years. Dr. Savill shows that in 437 houses infected with small pox in Warrington, the attack rate was 4.4 per cent. among vaccinated, and 54.5 per cent. among unvaccinated children aged under 10 years; above 10 years of age the attack rate was 29.9 and 57.6 among the vaccinated and unvaccinated respectively. Very similar results were reported concerning the attack rate in invaded houses at the epidemics in Dewsbury, Leicester, and Gloucester; the figures will be found in the following table:—

TABLE X.—Small Pox Attack Rate of Vaccinated and Unvaccinated Persons under and over 10 Years of Age, in Five Towns in which Small Pox Epidemics have recently occurred.

[“Final Report,” p. 65.]

1 Towns.	2 Date of Epidemic.	3 Attack Rate under 10.		4 Attack Rate over 10.	
		Vaccinated.	Unvaccinated.	Vaccinated.	Unvaccinated.
Sheffield	1887-88	7.9	67.6	28.3	51.6
Warrington	'92-93	4.4	54.5	29.9	57.6
Dewsbury	'91-92	10.2	50.8	27.7	53.4
Leicester	'92-93	2.5	35.3	22.2	47.8
Gloucester	'95-96	8.8	46.3	32.2	50.0

In view of these figures relating to invaded houses, it appears impossible to avoid the conclusion arrived at by the Commissioners, that the vaccinated at all ages are far less liable to be attacked by small pox than the unvaccinated, and that the advantage in this respect enjoyed by vaccinated children under 10 years of age is greatly in excess of that enjoyed at a more advanced period of life.

Severity of Type of Small Pox among Vaccinated and Unvaccinated.

Nearly all English small pox hospital statistics during the past fifty years have shown that the type of small pox suffered by the vaccinated is, as a rule, far less severe than that to which the unvaccinated are liable. That small pox differs greatly in the degree of its severity is a well known fact; sometimes it is a comparatively trifling ailment, in other cases it is a very serious illness entailing the gravest after consequences. The most severe forms of the disease are known as malignant or hæmorrhagic; the confluent type is less severe, but still of a very serious character. Milder types have been described as coherent and discrete, and the mildest as varioloid or simply “mild.” Much statistical information derived from the reports on recent epidemics was given to the Commissioners, bearing on the varying types of disease suffered respectively by vaccinated and unvaccinated patients in the small pox hospitals. It will only be possible here to refer very briefly to these statistics. Of 825 vaccinated cases in the Sheffield Borough Hospital in 1887-88, 85.5 per cent. were mild or discrete, 13 per cent. coherent, and only 1.5 per cent. confluent; the 280 unvaccinated cases included no varioloid or mild cases, 17.9 per cent. discrete, 62.5 per cent. coherent, and 19.6 per cent. confluent. All the 27 vaccinated children under 10 years suffered from the varioloid or discrete type; while 74.6 per cent. of the 67 unvaccinated children had the disease of the coherent, and 6 per cent. of the confluent type. Thus the proportions of severe and mild forms of the disease among the vaccinated and unvaccinated were practically almost exactly reversed. No explanation of these ratios except the fact of previous vaccination or otherwise of the patients suggested itself to the Commissioners. In Dewsbury the vaccinated cases showed 8.2 per cent. of the confluent type, while 60.2 per cent. among the

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unvaccinated cases were of this severe type. It is needless to refer to these figures in greater detail. The following table gives a summary of these statistics for the epidemics in Sheffield, Dewsbury, Leicester, and Warrington:—

TABLE XI.—*The Incidence of Mild and Severe Cases of Small Pox on Vaccinated and Unvaccinated Persons attacked during Five recent Small Pox Epidemics.*

[“Final Report,” pp. 69 and 70.]

Local Epidemics.		Mild.	Severe.
London	vaccinated	89.0	11.0
	unvaccinated	35.2	64.8
Sheffield	vaccinated	82.8	17.2
	unvaccinated	18.5	81.5
Dewsbury	vaccinated	82.0	18.0
	unvaccinated	23.1	76.9
Leicester	vaccinated	81.4	18.6
	unvaccinated	27.2	72.8
Warrington	vaccinated	78.2	21.8
	unvaccinated	29.4	70.6

It should be noted that the classification of the London cases differed somewhat from that adopted in the other towns, but the figures show very similar results. The main feature of the table is the practical agreement between the returns from the several towns. Thus the proportion of mild cases among vaccinated persons only ranged from 78.2 in Warrington to 89.0 in London; while among the unvaccinated the range was from 18.5 per cent. in Sheffield to 29.4 in Warrington and 35.2 in London.

It appears therefore that as regards the attack rate, the type of disease, and the fatality of small pox, the vaccinated enjoy marked advantages when compared with the unvaccinated. The Commissioners ask, “what is to be said when it is found that apart from the fatality of the disease, its type in the two classes (vaccinated and unvaccinated) also differs, and perhaps even more widely than its fatality does, and that the milder type distinguishes the same class which exhibits the smaller fatality?” This cannot be mere chance coincidence, especially as the phenomenon is uniform in the case of epidemics in five different towns. The facts afford, it is admitted by the Commissioners, strong corroboration that the classification was on the whole accurately made, and that the cause of the different manner in which small pox behaved to the two classes was vaccination. There was no material difference between the two classes except that one contained, with some possible exceptions, only unvaccinated persons, while the other consisted, certainly for the most part, of vaccinated persons.

Quality of Vaccination Tested by the Number and Nature of Marks.

This branch of the subject was fully investigated by the Commissioners. All the small pox hospital authorities from Marston to the present time, appear to have been convinced that

TABLE XII.—*Proportional Mortality of Cases of Small Pox treated in the Highgate Small Pox Hospital, under the observation of Mr. Marston, in 1836-51 and 1852-67, among Patients bearing one or more Vaccination Marks.*

[“Final Report,” p. 76.]

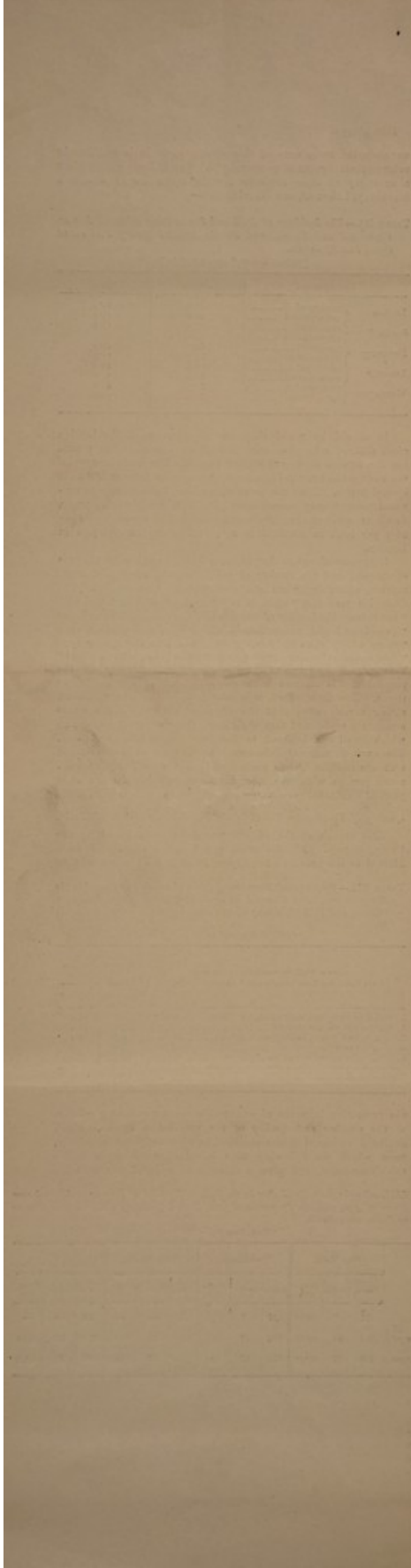
Cases of Small Pox classified according to the Vaccination Marks borne by each Patient respectively.	Percentage of Deaths in each Class respectively.	
	1836-51.	1852-67.
1. Stated to have been vaccinated, but having no cicatrix	21.7	39.4
2. Having one vaccine cicatrix	7.6	13.8
3. “ two “ cicatrices	4.3	7.7
4. “ three “ “	1.8	3.0
5. “ four or more vaccine cicatrices	0.7	0.9
Unvaccinated	35.5	34.9

the protective influence of vaccination bears a constant relation to the number and quality of the vaccination marks. Much evidence in support of this assertion, based upon recent experience, from which the following table is selected, was given before the Commission, and after a detailed analysis of this evidence

TABLE XIII.—*Deaths from Small Pox in the Fulham Hospital of Persons under and over 10 Years of Age, with the Proportional Case Mortality among Patients with One or More Vaccination Marks.*

[“Final Report,” p. 75.]

	One Mark.			Two Marks.			Three Marks.			Four and over Four Marks.		
	Cases.	Deaths.	Death-rate.	Cases.	Deaths.	Death-rate.	Cases.	Deaths.	Death-rate.	Cases.	Deaths.	Death-rate.
	—	—	—	—	—	—	—	—	—	—	—	—
Under 10 years of age	21	1	4.76	29	1	3.45	37	—	—	53	—	—
Over 10 years of age	384	41	10.68	509	46	9.04	459	37	8.06	296	19	6.42
All ages	405	42	10.37	538	47	8.73	496	37	7.45	449	19	4.23



the Commissioners state that it points to the "conclusion that the greater the number of marks the greater is the protection in relation to small pox enjoyed by the vaccinated person," and that the statistics show a marked contrast between the protection afforded by three or four marks, as compared with one or two. It is pointed out, moreover, that the figures given in the Sheffield, Leicester, and London reports indicate that the disease varies in its severity inversely with the number of the vaccination marks. The Commissioners declare that the evidence as to the influence of foretation and of the area of vaccination marks upon the amount of protection conferred by vaccination, was on the whole insufficient to enable them to draw any weighty conclusions.

The Injurious Effects of Vaccination.

This was naturally one of the subjects submitted for the inquiry and consideration of the Royal Commission. The opponents of vaccination not only deny its utility as a protection from small pox, but assert that mischievous effects directly and indirectly result therefrom, causing injury and loss of life. The Commissioners declare that if vaccination may lead in certain cases to personal injury or even to death, this would afford no conclusive argument against its use if its practice has been productive of substantial benefit in limiting the ravages of small pox. The objectors to vaccination have adopted two lines of attack with a view to prove that it causes disease and death. Speciously arranged Parliamentary Returns have been asked for, showing the concurrent increase of vaccination and of deaths referred to different diseases; and public attention has been directed to individual cases in which injury or death has been attributed to vaccination. Much evidence was taken with a view to throw light upon these charges. With regard to Mr. Hopwood's return, which was intended to show the malign influence of vaccination, Dr. Ogle gave some valuable evidence, showing that of the fourteen diseases dealt with in the return, some had increased and some had decreased in mortality. He pointed out that the line of reasoning which had been considered by some to justify the assertion that vaccination has produced in those who have been subjected to it serious diseases, would equally justify the assertion that it has rendered them largely exempt from other diseases no less serious. He showed for instance that the mortality from phthisis, pneumonia, and convulsions, among other diseases, has markedly declined since vaccination has been more generally practised. The Commissioners point out that Dr. Ogle does not, of course, suggest that vaccination has caused this decline, but he asks, and they think the question a pertinent one, why vaccination should be debited with the increase of diseases which have increased, and not credited with the decrease where the mortality has diminished. It is beyond question that the mortality of infants from all causes has not only not increased with the increased practice of vaccination, but it has considerably declined. With regard to the mortality from specific diseases, that of infants attributed to syphilis has undoubtedly increased in the last twenty years, and this is not the place to discuss whether the increase is a real increase, or the result of improved diagnosis of cases of congenital disease. This increase of infantile syphilis has been persistently attributed to vaccination, but the Commissioners were convinced by the evidence given on this point that the increase was considerably greater under the age of 3 months, when it could not have been caused by vaccination, than it was in the later part of the first year of life. It was moreover given in evidence that the increase of fatal infantile syphilis, based upon a comparison of the years 1863-67 with 1883-87, was far greater in Leicester, where the practice of vaccination had been practically disused, than in England and Wales generally. The increase in the mortality of infants aged under 1 year from syphilis (in the above mentioned period of twenty years), which was 24.7 per cent. in England and Wales, was equal to 69.3 per cent. in Leicester. This does not of course imply any connection between the disuse of vaccination and the increase of infantile syphilis, but it conclusively rebuts, as the Commissioners point out, the attribution of the increase of mortality from syphilis to vaccination.

Similar attempts to attribute increased mortality from cancer, erysipelas, tabes mesenterica, scrofula, pyæmia, bronchitis, diarrhoea, and skin diseases to vaccination were investigated before the Commission with similar results. Upon this branch of the inquiry the Commissioners summarise in the following words: "Upon the whole we think that the evidence is overwhelming to show that in the case of some of the diseases referred to, vaccination cannot have produced any effect upon the mortality from them, and that it has not in the case of any one of them increased the mortality to a substantial, we might even say an appreciable, extent."

With regard to the evidence of personal injury or death resulting from vaccination, the Commissioners admit that it is beyond doubt that such cases have occurred. The recent returns of the Registrar-General contain a heading, "cow pox and other effects of vaccination," and Dr. Ogle gave evidence to the effect that during the nine years 1881-89, 476 deaths were classed to this heading, showing a proportion of one such death to 14,159 primary vaccinations. To this heading is classed every death the medical

certificate relating to which assigns vaccination as the cause or the contributory cause of death. There is abundant proof that in many cases the association of vaccination with the cause of death was not intended by the certifying practitioner to indicate that the disease which ended fatally was due to vaccination. On the other hand, however, cases came to the knowledge of the Commissioners in which, although the fatal illness was engendered by vaccination, this circumstance was not referred to in the medical certificate. The evidence did not enable the Commissioners to decide which of these two classes of cases were the more numerous. About half the deaths attributed to the effects of vaccination were caused by erysipelas, and if the cases of pyæmia, septicæmia, and blood poisoning be added, they together account for two-thirds of the cases. There is conclusive evidence that most of the deaths assigned to "the effects of vaccination" occur among the lower grades of the working classes, and are frequently attributed by the certifying practitioner to neglect, want of cleanliness, and in fact to the filthy surroundings of the infant. It may be noted that of the 43 deaths referred to "cow pox and the effects of vaccination in 1891," 36 were of the infant children of mechanics, artisans, or labourers, or of the illegitimate children of domestic servants; 4 were described as the children of shopkeepers or of shop assistants, 2 as children of commercial clerks, and 1 as the child of a farmer. Not one occurred among those classes in which due and intelligent care of infants can, as a rule, be assured.

The conclusion at which the Commissioners arrived on this branch of the subject, after a careful examination of the facts and consideration of the evidence, is stated in the following words: "Although some of the dangers said to attend vaccination are undoubtedly real, and not inconsiderable in gross amount, yet when 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." In another place the Commissioners say: "In our opinion if the precautions we have suggested were adopted, untoward incidents of vaccination, already rare, would become much rarer."

Proposed Means, other than Vaccination, for diminishing the Prevalence of Small Pox.

This subject was specially referred to the Commission for inquiry and report, and the final report contains an interesting summary of the evidence on this point, which is only indirectly connected with vaccination and small pox statistics. The opponents of vaccination not unreasonably point to the results of the Leicester epidemic of 1892-93, as affording evidence that effective notification and prompt isolation exercises a powerful influence in the control of a small pox epidemic. To such an assertion no one will be inclined to take exception, although there appear to be no grounds for attributing the exceptionally low rate of case mortality in Leicester to the energetic measures adopted by the Sanitary Committee for coping with the epidemic. The Commissioners, however, on the general question state that they can see nothing to warrant the conclusion that in this country vaccination might safely be abandoned, and replaced by a system of isolation, and that if such a change were made in our method of dealing with small pox, it is impossible to contemplate the probable consequences without dismay. While they are very far from underrating the value of isolation, they point out that what it can accomplish as an auxiliary to vaccination is one thing, and whether it can be relied on in its stead is quite another.

The Minority Report of Dr. Collins and Mr. Picton.

Having read with careful attention this minority report, I fail to discover therein any serious attempt to combat the important conclusions at which the large majority of the Commission arrived respecting the influence of vaccination as a protection against small pox. It is mainly a summary of all the most damaging statements that have been made by the opponents of vaccination, without too critical a regard to the source or entire credibility of these statements. For instance, on page 171 it is stated that "In 1828 a severe epidemic broke out at Marseilles, and 2,000 vaccinated persons caught the disease." No authority is given for this statement, and no further information as to the total number of cases is given; indeed it might be assumed that the epidemic only attacked the vaccinated. Then paragraph 72 states "The vaccinated, nowadays, generally constitute the majority of the patients in small pox hospitals, and in certain limited outbreaks only vaccinated persons have been attacked." Such statements may be verbally correct, but they are certainly not judicial in tone, and are liable to be misunderstood and misused. It is, however, to the illogical use of statistics that special notice of this minority report seems called for in this paper. The dissentients assert that "in proportion as the ratio of the vaccinated to the unvaccinated in the hospitals approximates to that obtaining outside (assuming the admissions to be a fair sample of the whole cases) we must regard the protection of small pox as approximating to nil." Let us imagine the existence of so perfect

a system of infantile vaccination that the whole population had been vaccinated in infancy. According to present information such a condition (without re-vaccination) would not prevent small pox epidemics, but all the inmates of small pox hospitals would necessarily be vaccinated, and they might then include no children under 10 years of age. Dr. Collins and Mr. Picton assert that such a state of things would prove that the protective influence of vaccination was nil. This fallacy underlies all the attempts to prove that the increased proportion of vaccinated cases of small pox since the increased practice of vaccination proves the uselessness of the operation. Then paragraph 90 says, "Whatever influence vaccination may exert against small pox, then, would appear to lie somewhere between none at all on the one hand, and very considerably less than that of a previous attack of small pox on the other." What about the protection of childhood, should it have been ignored? Again, it is stated that "when large figures are taken, the fatality of small pox now, with a large majority of the cases protected by vaccination, is about the same as it was last century, when none of the cases had received any protective rite." The fact is we have very little information as to the case mortality of small pox in the last century, and that little appears to be of doubtful trustworthiness. It is probable that we shall find much of this minority report quoted and used in anti-vaccination literature, but we doubt whether it will exert much influence upon expert opinion.

The dissentients are perfectly logical in recommending the repeal of the compulsory clauses of the Vaccination Acts, perhaps more logical than the majority of the Commissioners, who conclude a report teeming with evidence of the value of vaccination, by recommending a course of action which would practically make the compulsory clauses a dead letter, without repealing them.

The Gloucester Epidemic.

Before proceeding briefly to summarise the conclusions to be deduced from the vaccination and small pox statistics contained in the reports and evidence issued by the Royal Commission, it seems desirable to call attention to a few of the more salient features of the quite recent remarkable epidemic at Gloucester. The facts are partly derived from the excellent report issued by the committee appointed by the Board of Guardians, under the advice and superintendence of Dr. Bond, and partly from other sources. In February, 1887, the Gloucester Board of Guardians by a majority of 12 to 10 out of 30 present, resolved to take no further steps to enforce the compulsory clauses of the Vaccination Acts. The result of this resolution was that although 14,212 births were registered within the Union of Gloucester during the nine years 1887-95, only 1,285 or 9.7 per cent. were recorded as successfully vaccinated. The epidemic broke out in the latter part of 1895, and speedily assumed alarming proportions after the beginning of 1896; 51 cases were notified in January, 142 in February, 628 in March, and the maximum monthly number, 779, in April. Under the influence of the panic caused by the epidemic, the public vaccinators towards the end of January had their hands full, and private practitioners were equally active. The pressure at the public stations became so great that two deputy public vaccinators had to be appointed, and some of the public elementary schools, which had been closed owing to the epidemic, were used as vaccination stations. Measures were taken by the Town Council to appoint six qualified practitioners to go from house to house and to vaccinate as many as could be induced to submit to the operation. This visitation commenced on the 6th of April, and on the 21st of the same month a special vaccination committee was appointed for organising and carrying out this house to house vaccination. Dr. Bond, who was invited to undertake the organising and superintendence of the work, selected Dr. Ernest Carter, of Cheltenham, to act as his deputy. The guardians, moreover, on the 24th March, had rescinded their resolution not to enforce vaccination, and after due notice a few prosecutions were sufficient to secure the vaccination of most of the children that remained unprotected after all powers of persuasion on their parents had failed to produce the desired effect. The public elementary schools were re-opened on the 1st June to all children who had been vaccinated. No fewer than 4,800 children under 10 years of age were vaccinated in Gloucester during the five months ending on the 31st May. When this systematic house to house visitation, and the accompanying wholesale vaccination and re-vaccination was completed, the epidemic rapidly died out. Gloucester, which in the year 1892 headed the record of badly vaccinated communities in England and Wales, showing a percentage of 86.9 of children born in that year but not accounted for in the vaccination returns, is now, probably both in regard to its child and adult population, one of the best vaccinated towns in the kingdom. It is now necessary to point out the cost of life and suffering at which this wonderful conversion has been effected.

The first cases of small pox were notified in May, 1895, but they were very few until the close of the year. The total cases reported up to the end of July (when the epidemic ceased) in the city and suburbs was 2,036, of which 1,981 occurred within the city. The total number of deaths, according to the local

report was 443,² showing a total case mortality of 21.2 per cent. This affords striking contrast to the case mortality at other recent epidemics, which ranged from 5.8 in Leicester, to 9.7 in Sheffield, and 10.7 in Dewsbury. Of the 2,036 cases in Gloucester only 730 were admitted to the Isolation Hospital, the remainder being treated on the premises in which they occurred. The case mortality was 27.2 per cent. in hospital, and 18.6 per cent. among those cases treated at home. The 199 deaths in the hospital included 125 or 62.9 per cent. of unvaccinated children under 10 years of age. The case mortality of all cases under 10 years of age (all but one of the 279 deaths being of unvaccinated children) was 39.2 per cent.; while the case mortality between 10 and 20 (at which ages the vaccinated were more than five times as numerous as the unvaccinated) was under 7 per cent. Between 20 and 30 the case mortality was 9.5 per cent.; between 30 and 40 it was 15 per cent.; and over 40 it was 19 per cent. These figures afford a trustworthy indication of the decreasing effect of infantile vaccination on the protection of adult life from fatal small pox. The age incidence of the cases of attack are noteworthy. Only 2 per cent. of the vaccinated cases were under 10 years of age; whereas of the unvaccinated cases no less than 88 per cent. were of children under 10 years of age. Among the fatal vaccinated cases less than 1 per cent. was of patients under 10 years of age, while of the unvaccinated the proportion was 85 per cent. Dr. Bond in his report, from which many of these figures are taken, calls special notice to the fact that in his classification "vaccinated" only means vaccinated in infancy, and points out that the measure of success which has attended the attempts of anti-vaccinators to discredit vaccination among ill-informed persons is to a great extent due to the fallacy of assuming that the word "vaccinated" has in all cases a precise and uniform meaning. This fallacy makes it comparatively easy to misinterpret the lesson which vaccination statistics, if correctly appreciated, teach. "Vaccinated" may indeed mean anything, as Dr. Bond says, from the fleeting protection given by a single poor vesicle, to the almost perfect and long-protracted immunity which is, as a general rule, conferred by three or four good vesicles.

It should, moreover, be noted that the 2,036 cases of attack during the Gloucester epidemic did not include a single case of a person who had been successfully re-vaccinated within ten years, and not less than one month previous to exposure to infection. With reference to the influence of vaccination in modifying the severity of the disease, Dr. Bond points out that the inspection of a hospital ward full of small pox cases, with information as to their vaccination antecedents, converted many doubters in Gloucester who had been proof against other forms of evidence.

It is very much to be regretted that the information given in the medical certificates relating to the vaccination or otherwise of the 447 fatal cases of small pox registered within Gloucester registration district during the epidemic was singularly incomplete. Of these, 39 were described as vaccinated, including 6 cases in which vaccination had taken place during the incubation period; 96 were returned as unvaccinated, and the remaining 312 were "not stated" as to vaccination, although it is evident from Dr. Bond's report that information on this point was available.

In the special reports on all recent small pox epidemics it has been abundantly proved that deaths from small pox are in the main confined to the lower strata of society. Anti-vaccinators sought to convince the Royal Commissioners that this fact was a natural result of low sanitary condition. The more probable explanation is, however, that anti-vaccination agents meet with greater success in advocating their doctrine among the so-called working classes, who are necessarily ill informed on the subject, and whose natural prejudice to the operation on their children is the more easily excited. It is an undoubted fact that vaccination is almost universally practised among the educated classes.

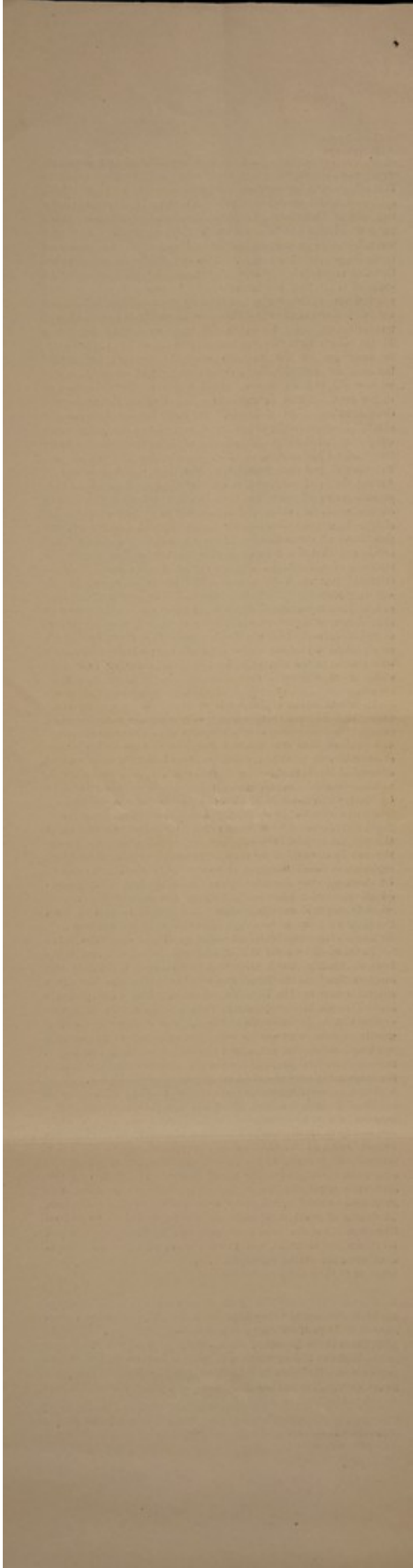
The Gloucester death register has been examined with a view to ascertain the rank or occupation of the 447 persons whose deaths resulted from small pox in 1895-96. Three cases were of adult females aged 32, 40, and 55, one the wife of a minister of the Gospel, and two described as of independent means, but not a single child belonging to the professional or upper middle classes died from small pox during the epidemic. The deaths of two commercial clerks and of one school teacher were recorded, and 40 deaths of small shopkeepers or assistants or their children. The remaining 401 fatal cases included 178 of dock or general labourers, 168 of artisans, mechanics, &c., 39 of railway employes, 5 of domestic servants, and 11 of persons of unknown occupations, or of their children respectively.

Summary of Conclusions.

With due regard to the figures dealt with in this paper, and of the source from which they have been derived, it appears impossible to avoid the following conclusions:—

1. That the mean annual death-rate from small pox at all ages in England and Wales, which was 408 per million in the twelve years for which records exist prior to compulsory vaccination, fell to 126 per million in the forty-two years since vaccination was

² It should be noted that 447 deaths from small pox were registered within Gloucester Registration District during the eight months from December, 1895, to July, 1896, both included.



made compulsory, which period includes the world-wide epidemic of 1871-72.

2. That the main part of this decline of mortality occurred among children under the age of 10 years, who may be presumed to have been principally affected by the increase of infant vaccination.

3. That the age of incidence of fatal small pox has entirely changed under the influence of increased infant vaccination; and that small pox from being mainly a disease of childhood, is now proportionately more fatal to adults.

4. That judged by the statistics of the six last principal local small pox epidemics, the proportion of deaths of children bears a constant ratio to the proportion of children officially returned "unaccounted for" as regards successful vaccination.

5. That efficient infant vaccination confers a practically complete immunity from fatal small pox during the first 10 years of life.

6. That the increase in the proportion of adult deaths from small pox must be attributed to the waning of the protective effect of infant mortality; this hypothesis being corroborated by the steady increase in the proportional case mortality in recent epidemics at successive age-periods above 10 years.

7. That both the small pox attack-rate and the case-mortality is far lower at all ages among those who have been vaccinated in infancy than among the unvaccinated.

8. That the type of disease suffered by small pox patients is far more severe among the unvaccinated than among the vaccinated; and that the severity of the type appears to vary with the number and quality of the vaccination marks.

9. That judged by the statistics of small pox hospital nurses and attendants, successful re-vaccination affords practically complete protection to adults, even to those brought into actual personal contact with the worst forms of the disease.

Suggested Amendment of the Vaccination Acts.

It is impossible, in conclusion, to omit a brief reference to some of the recommendations signed by eleven of the thirteen Commissioners. At the end of the Report, which terms with admissions of the efficacy of vaccination as a protection from small pox, and immediately following a paragraph in which the Commissioners express the hope that their report "will stimulate belief in the efficacy of vaccination, that it will remove some misapprehensions, and reassure some who take an exaggerated view of the risks connected with the operation, as well as lead to a more ready enforcement of the law by local authorities," it is actually suggested that a statutory declaration made by a parent to the effect that he entertains an objection to the practice of vaccination, should be allowed to bar any proceedings under the compulsory clauses of the Vaccination Act. It may be, and possibly is true, that the opposition to vaccination has been stimulated by repeated prosecution of persons who pose as martyrs to compulsory vaccination, but, in view of such statistics as have been published by this Commission, it may well be doubted whether the State would be justified, in deference to the opposition of mistaken and misguided persons, however honest, in imperilling the lives of thousands of children who would remain unvaccinated as a result of the proposed relaxation of the law. With a view to evade the necessity for the prosecution of the small minority who remain unconvinced of the value of vaccination, it might be expedient to allow, subject to such restrictions as would exclude the merely indolent and careless parents, an extension of the power of postponement of vaccination for limited periods, renewable on formal application. In order, however, to counterbalance the effect of a probable large increase of such postponements, it would appear to be necessary to give statutory power to some local authority to examine all children on admission to any public elementary school, and to prosecute the parent of any child then unvaccinated. This examination would prove of incalculable value, by affording an opportunity to promote the re-vaccination of all children, at the public expense, before the conclusion of the school period.

With the various suggestions for changes in the practice of vaccination, in order to minimise the risks of vaccination, and to reduce as far as possible the prejudice against the operation, it is impossible but to sympathise and to endorse the opinion of the Commission, that if carried into effect they would probably tend to reduce the organised opposition to infant vaccination. To one of these suggestions special reference may be made, namely, that the period during which vaccination is voluntary should be extended. It may be noted that the age for compulsory vaccination in Scotland is six months, and in Germany the operation may be postponed until the end of the second year of life. The evidence bearing upon the practice of compulsory vaccination under these conditions in Scotland and in Germany, where practically no organised opposition exists, seems to point to the conclusion that if the period of voluntary vaccination in England were extended to six months, or even to one year (except in the presence of epidemic prevalence of small pox), the opposition in this country would be reduced to a minimum.

If this Paper should, to ever so slight an extent, decrease the probability of the adoption of the dangerous experiment of offering facilities to the ill informed parents, who constitute the main opponents of vaccination, for finally evading the vaccination of their children, I shall consider that it has not been written in vain.



APPENDIX.

TABLE XIV.—Proportional Deaths from Small Pox at each of Six Age-Periods to 1,000 Deaths from that disease at all Ages in each of the Years 1848-95.

["Final Report," p. 154.]

Year.	Under 1.	1—	5—	10—	15—	25—	45 and upwards.
1848	235	457	130	37	72	58	11
'49	250	437	145	35	65	69	18
1850	268	432	133	35	65	55	14
'51	258	439	131	33	68	59	12
'52	267	426	122	32	75	62	16
'53	273	413	123	31	71	70	19
'54	263	388	128	31	108	107	35
'55	194	321	135	31	135	143	41
'56	231	329	122	40	134	108	36
'57	243	345	164	31	94	98	25
'58	234	319	173	39	105	106	24
'59	252	327	126	44	116	104	31
1860	232	324	112	42	121	132	37
'61	242	295	108	47	125	126	57
'62	231	328	110	45	122	125	39
'63	236	308	105	37	129	140	45
'64	243	312	105	37	119	140	44
'65	233	272	102	41	134	163	55
'66	222	320	99	32	130	146	45
'67	239	298	86	31	133	169	53
'68	239	351	102	31	115	123	39
'69	221	327	125	30	111	136	49
1870	179	284	143	38	140	170	46
'71	135	109	149	56	181	221	59
'72	137	162	164	66	191	214	66
'73	132	99	138	62	224	258	87
'74	129	100	107	70	263	258	73
'75	106	101	108	80	261	254	90
'76	119	135	108	67	214	286	71
'77	102	145	112	72	216	270	83
'78	119	135	117	77	213	255	84
'79	114	127	119	63	187	265	123
1880	120	142	117	76	196	267	82
'81	103	136	109	68	205	276	103
'82	98	111	77	61	226	325	102
'83	131	104	95	62	239	261	107
'84	114	116	92	71	214	302	91
'85	120	120	79	63	185	312	115
'86	113	80	65	40	189	313	200
'87	121	73	61	61	283	328	73
'88	119	81	63	49	230	329	129
'89	86	43	—	43	261	437	130
1890	188	61	—	—	188	373	188
'91	246	102	61	61	82	285	163
'92	117	148	77	9	132	359	158
'93	141	142	66	30	110	305	205
'94	140	133	45	28	143	367	144
'95	—	—	63	27	139	327	161

Note.—The deaths for the years 1848-54 unavoidably include those referred to chicken pox.

TABLE XV.—Death-Rates from Small Pox per Million Living at all Ages and at Six Age-Periods in each of the Years 1848-95.

["Final Report," p. 155.]

Year.	All Ages.	Under 5.	5—	10—	15—	25—	45 and upwards.
1848	197	2,090	439	135	140	86	23
'49	154	1,364	326	86	90	59	26
1850	164	1,400	298	86	89	54	18
'51	189	2,065	438	121	139	86	25
'52	471	2,117	420	119	158	93	34
'53	171	892	180	50	64	45	17
'54	151	675	165	44	86	61	28
'55	131	512	151	39	93	70	28
'56	115	491	122	44	82	47	22
'57	201	801	283	59	100	75	27
'58	310	1,364	489	121	185	132	42
'59	191	835	208	82	119	76	31
1860	135	561	130	54	87	67	27
'61	64	256	59	28	43	30	19
'62	78	322	73	33	50	37	16
'63	185	1,153	255	101	198	151	67
'64	164	1,590	325	126	232	193	83
'65	101	1,127	260	117	217	187	86
'66	139	558	117	41	102	78	33
'67	114	453	82	33	82	69	31
'68	91	396	78	27	56	43	18
'69	67	271	71	19	40	35	17
1870	111	388	136	40	86	74	27
'71	1,012	2,502	1,205	529	934	869	306
'72	841	1,815	1,130	603	851	676	279
'73	98	167	114	57	119	98	44
'74	88	148	79	57	125	87	34
'75	15	54	32	26	49	35	16
'76	99	185	89	62	113	108	37
'77	173	316	161	116	201	189	76
'78	74	139	72	53	85	73	33
'79	21	38	21	12	21	22	14
1880	15	49	24	18	26	26	11
'81	119	210	107	75	130	127	65
'82	50	78	32	28	60	63	27
'83	16	64	28	20	46	36	20
'84	83	145	63	54	93	95	40
'85	104	197	69	60	101	123	63
'86	15	15	5	4	10	12	11
'87	18	28	9	10	27	23	7
'88	16	58	19	16	44	45	25
'89	1	1	—	—	1	1	1
1890	1	1	—	—	1	1	1
'91	4	5	1	1	1	2	1
'92	15	32	10	1	10	20	12
'93	49	105	26	12	26	65	49
'94	17	61	11	7	20	38	21
'95	7	17	4	2	5	9	6

Note.—The rates for the years 1848-54 unavoidably include the deaths referred to chicken pox.

