Charles Creighton's
Article for Encyclopædia Britannica
on
VACCINATION
(first published 1888; second edition typeset 5/30/2023)

VACCINATION (from Lat. *vacca*, a cow), the name given in France to the Jennerian practice of cowpoxing, shortly after the practice began in England (1799). The procedure was based almost exactly on the earlier practice of inoculating the smallpox, the matter being inserted under the skin of the arm by a lancet point; also the continuance of the same stock from arm to arm through a series of cases was an idea taken from some of the more adroit variolators. To replace smallpox inoculation by cowpox inoculation under certain specified circumstances was Jenner's tentative project. The history of the introduction of cowpoxing, given the article JENNER (vol. xiii. p. 623), is here supplemented from the point of view of historical criticism.

It is right to say that the views expressed in the present article diverge in many points from the opinions generally received among medical men, and must be regarded not as the exposition of established and undisputed doctrine, but as the outcome of an independent and laborious research.

Jenner's originality consisted in boldly designating cowpox as *variolævaccinæ* or smallpox of the cow, and in tracing cowpox itself back to the grease of the horse's hocks. The latter contention was at length set aside by prctical men as a crude fancy; the former designation is just as arbitrary and untenable. It was elaborately shown by Pearson in 1802, and has often been confirmed by subsequent writers, that the vesicle of inoculated cowpox, even while it remains a vesicle, is quite unlike a single pustule of smallpox. But it is only for the vesicular stage of cowpox that there is even an allegation of likeness to variola; the vesicle of natural or unmodified cowpox is only the stage of the disease before it becomes an ulcer, either inflammatory or indurated. Inoculated horse-grease has the same vesicular stage; and so also has the venereal pox when it is inoculated experimentally on the skin.[1] These three very different infections have the same kind of vesicle, in every case unlike a smallpox pustule, and the same natural termination in a phagedendic or indurated sore.

Jenner's originality in starting vaccination in practice is for the most part misunderstood. When he published his *Inquiry* in June 1798, he had twice succeeded in raising vaccine vesicles by experiment,—the first time in 1796 with matter from a milker's accidental sore, and the second time in March 1798 with matter direct from the cow. The first experiment was not carried beyond one remove from the cow; the second was carried to the fifth remove, when the succession failed. A third experiment, in summer of 1798, failed from the outset; and his fourth and last experiment, in November-December 1798, led to nothing but extensive phagedendic ulceration in two cases out of six vaccinated.

In this posture of affairs Woodville of the inoculation hospital, London, succeeded in January 1799 in starting a succession of arm-to-arm vaccinations from a London cow, which were exceptionally free from the ulcerative termination. From that source Jenner himself was supplied with lymph in February, while more than two hundred practitioners both at home and abroad were supplied some three weeks later. There was a quarrel with Woodville in due course, and and attempt to set up an authentic Jennerian lymph independent of the London stock. But the merits of this claim (which otherwise rests on the vague evidence of Marshall) may be judged of by the fact that Ring's application to Jenner in September 1799 for genuine lymph

[1] See Ricord, *Traité Complet*, 1851, plate i. figs. 6 and 7 and ii. 7, 8, and 9; also H. Lee, *Med. Chir. Trans.*, xliv. p.238, 2nd plate, fig. 2.

was answered by the latter with a supply of matter which was none other than Woodville's own stock, after six months' use in the country. Woodville's stock was used all over the world down to 1836. By that time there were numerous complaints that the lymph was degenerating, and a widespread feeling that it was necessary to "go back to the cow." Apart from the numerous original cases of cowpox alleged to have been found in Würtemberg, the first new authentic source was the Passy cow of 1836. From the accidental vesicles on the milkers's hand Bousquet, the director of vaccination in Paris, started a new stock, which partly superseded Woodville's lymph hitherto in use in France. In 1836 Estlin of Bristol, after several years' vain endeavours, heard of original cowpox in Jenner's own parish of Berkeley (Gloucestershire), where the disease was so far forgotten that the milkers were for several days unaware that the vesicles on their hands had been contracted from cows. Estlin's new geniture is one of the most fully recorded in the history of vaccination. In the same year, and the two following years (1838-41), Ceely of Aylesbury found some half-dozen distinct occurrences of cowpox in the dairy-farms of his district, and cultivated lymph from them. His account of the natural history of cowpox in the cow, and of the effects of primary lymph when inoculated on the human arm, is by far the most comprehensive and candid that has ever been given; without it we should hardly had understood the real nature of cowpox. Bousquet, Estlin, and Ceely are the chief writers who have authentically described the establishment of new stocks of cowpox lymph since Woodville's original report of 1799. There are numerous other references, less detailed, to the original cowpox in the cow, and to vaccinations therefrom, in England, on the Continent, and in the United States; some of these came to light in the inquiry of the Epidemiological Society in 1852. One of the best-known cases of comparatively recent times is the Beaugency cow of 1866, which has been the source of much of the calf-lymph of the Dutch, Belgian, and other vaccine "farms." Another French case occurred in the Gironde in November 1881, and is described in the *Bulletin* of the Academy of Medicine (p.17, 1882). In England the editors of the *Veterinarian* inserted a notice in the number for August 1879, making a request to their readers for lymph "from vesicles on the teats of cows in the cases of so-called natural cowpox." The only answer to it hitherto has been an intimation in June 1880 that there was a case of cowpox at Halstead in Essex, which was visited by Ceely and others and pronounced by the former to be of the nature of eczema. In 1876 the disease was found at a farm nead Reykjavik in Iceland, where it had never been seen before; it was of the old type, producing sores on the milkers' hands, and causing much alarm by its unfamiliar character.[2]

The so-called calf lymph is as remote from the cow as ordinary humanized lymph; it differs from the latter merely in the circumstance that the calf (on its shaven belly) becomes the vaccinifer, instead of the child, and that the cycle of the disease is very much abbreviated or contracted in the calf: the vesicles are distended with lymph about the fourth of fifth day, instead of the seventh or eighth, and are almost unattended by areolar redness and constitutional disturbance, the animal being able to support fifty to a hundred or more vesicles without the smallest inconvenience. On the child's arm the vesicles after calf-lymph are slower in development than in the calf, and are attended by areola, &c.

Under the influence of theory, "vaccine" lymph has been got from two sources that have absolutely nothing to do with cowpox; and, oddly enough, the matter from these sources has

[2]Cowpox of the original ulcerating type still occurs, but is now hardly recognized as such. The inquiry into an outbreak of scarlet fever in December 1885, traced to a dairy at Hendon (Middlesex), elicited the fact that the inculpated cows, as well as seventy or eighty at two other farms, were affected with what the dairymen called "cowpox" (see Cameron, *Trans. Epid. Soc.*, April 1886). A similar outbreak in November 1887, involving 160 cows and 7 milkers at four farms in Wiltshire, was cearly proved by Crookshank to be the historical cowpox of Jenner and Ceely, by the evidence of identity in the sores on the cows' teats and in the sores or vesicles on the milkers' hands or faces, and by the production of correct vaccine vesicles in calves inoculated with lymph from a vesicle on the face of a milker (*Brit. Med. Journ.*, 17th December 1887 and 21st January 1888).

been so managed as to produce correct vesicles on the child's arm. One source is the grease of the horse's hocks and the other is smallpox itself.

The grease of the horse was known to produce vesicles and subsequent ulcers on the hands almost indistinguishable from those of accidental cowpox. There was also a tradition (which breaks down when tested by facts) that accidental infection with the grease protected from smallpox. Jenner held that all "genuine" cowpox came from horse-grease; and, after he had raised vaccine vesicles on the arms of children by matter from the cow's teats, he proceeded to try whether he could not raise the same kind of vesicle experimentally by matter once removed from the horse's hocks. The experiment succeeded, just as the accident had done. The vesicle (represented in plate 2 of the *Inquiry*) ulcerated, and the boy died of what is vaguely termed a "fever" in one place and a "contagious fever" in another. The same kind of inconsequent logic suggested the experiment of inoculating the matter of horse-grease upon the skin of the cow's teats, the object being to prove the identity of cowpox with the grease. That too succeeded in the hands of Loy of Whitby. Loy also inoculated children with the same matter, and raised vesicles on their arms, which were, of course, the same as the accidental vesicles (compared to the blister raised by a burn). Sacco of Milan actually used the equine matter on a large scale, instead of cowpox matter; and De Carro of Vienna "equinated" many persons in that city with lymph sent him by Sacco. Baron prints a memorandum of Jenner, dated to 23d July 1813, relating to "equine virus which I have been using from arm to arm for these two months past, without observing the smallest deviation in the progress and appearance of the pustules from those produced by vaccine," and a second note, dated 17th May 1817, in which Jenner says he "took matter from Jane King (equine direct) for the National Vaccine Establishment. The pustules beautifully correct." This is not a place to enter upon the pathology of horse-grease; and, as a matter of fact, equination has not been much practiced on the whole. According to Jenner's own data, it was an occasional constitutional disease of the horse's hocks in wet seasons, which was communicable to the hands of men in the form of large whitish vesicles, ending in corroding and painful open sores (see the case reported to him by Fewster, *op. cit.*, ed. 1800, p.96).

The other anomalous source of "vaccine" is human smallpox. Jenner having succeeded in passing off his doctrine that cowpox is smallpox of the cow, it occurred to some persons about forty years after to prove the doctrine by experiment, the proof being to variolate the cow on the udder. This was accomplished in 1838, after much trouble, by Thiele in Kazan (Russia), who inoculated several thousands of persons with the variolous matter "passed through the system of the cow." Within a few months of that experiment, the same thing was attempted by Ceely of Aylesbury, who succeeded, after many failures, in raising a large variolous pock, not on the udder of the cow, but on the mucous membrane of the vulva. The first experiment with the matter of this pock was undesigned; his assistant pricked his hand with the lancet which had just been dipped into the large pustule, and in due course had an attack of smallpox. Ceely preserved with his experiments (having meanwhile variolated another heifer at five places on the vulva), and in due time "managed" his matter as to produce vesicles on the human arm (without general eruption on the skin), which were regarded at Cheltenham and other places as on the whole better than the cowpox vesicle of the period. But the real practical application of this idea was reserved for Badcock, a dispensing chemist at Brighton. It does not appear that any authentic or fully detailed account of Badcock's experiments has been published;[3] but he thus summarized the results some forty years later (*Pall Mall Gazette*, Jan. 23, 1880):—"By careful and repeated experiments I produced, by the inoculation of the cow with smallpox, a benign lymph of a non-infectious and highly protective character. My lymph has not been in use at Brighton for forty years, and is at the present time the principle stock of lymph

[3]See Hodgeson, *Brit. Med. Journ.*, 26th November 1881.

employed there, being that exclusively used by the public vaccinators." At Boston, U.S., the same kind of lymph was raised and put in use in 1852. But at Attleborough, Mass., the same experiment had in 1836 led to disaster. Smallpox was inoculated on a cow's udder, and the product used to vaccinate about fifty persons. The result was an epidemic of smallpox, a panic, and the suspension of business.[4] On the face of it this method was simply variolating the cow (on a mucous membrane if the hairless or shaven skin failed) and inoculating the human subject with that curiously disguised smallpox matter. However, it was thought necessary to hold an experimental inquiry upon it, and in 1865 a commission of the Lyons Society of Medicine reported that, "in vaccinating according to the method of Thiele and Ceely, we are merely practising the old inoculation, rendered uniformly benign, it may be, by the care taken to inoculate only the first product (*l'accident primitif*), but preserving for certain all its risks in respect to contagion."[5] A negative result was come to by Klein in 1879, in an inquiry for the Local Government Board, wherein he had Ceely's cooperation. In 1879 the Irish Local Government Board prevented the use of similar variolous lymph by threatening to prosecute under the Act making the inoculation of smallpox penal. Notwithstanding the common sense of the case, and these three experimental proofs, the official view taken by the medical department in 1857, that Thiele, Ceely, and Badcock had established the correctness of Jenner's doctrine of variolæ vaccinæ, is still held very tenaciously by the profession. It is too simple and attractive to be soon given up; but perhaps the best way to get rid of it is to state in plain terms what cowpox itself really is.

Although there is no difficulty in drawing up a complete natural history of cowpox, thanks to the laborious and exact studies of Ceely, yet the attention has been so much diverted to side issues that the facts to be stated in this section will come before most readers with the aspect of novelty. The original authorities besides Ceely are Jenner himself, Pearson (who collected information by circular in the months following Jenner's *Inquiry*), Bousquet (1836), Estlin (1838), and Crookshank (1888). The Würtemberg inquiry, published by Hering (Stuttgart, 1839), is made up of very indifferently authenticated or incomplete statements, which have not the same value as the rest, and are at variance with them on the most essential points.

Cowpox as an infective disease arises in cow-houses here and there, and at wide intervals of time, out of a common physiological or constitutional eruption of some particular cow, usually a heifer in her first milk, very often in the spring season or at some other crisis of the year or of the animal's life-history. It never arises except in milch cows; it occurs nowhere in the cow but on the teats, or, by infection on adjoining parts of the udder. All the characters by which we know it distinctively as cowpox are associated with the fact of milking, or with the inevitable traction on teats that are the subject of an otherwise unimportant eruption. The primary disorder, as Ceely describes it, is an eruption of a few pimples, the size of a vetch or larger, hard and solid at first, but at length slightly vesiculated on the summit. It is only rarely that a series of events ensues on this basis which constitute cowpox as we know it; they ensue in some one animal out of many in the same byre, and years may elapse before the event happens again. The pimples on the teats are made to bleed by what Ceely calls "the merciless manipulations of the milkers"; the blood forms crusts, which are dislodged every six hours; and indurated ulcers form on the sites of the original pimples. The process being thus made inveterate owing to the incessant interference of the milker's hands, it becomes communicable to other cows. The milkers can usually point out some one cow in which the disease began; and it spreads slowly through the byre, taking sometimes as long as three months to go the round of the animals. An animal already infected at one or more places on its teats may become infected at other places on the teats and body of the udder, either by the traction of milking

[4] *Bost. Med. and Surg. Journ.*, 1860, p. 77.
[5] *Vaccine et Variole*, Paris, 1865, p.101.

of by the contact of parts when the cow is lying down.

The ulcers heal sometimes slowly, sometimes more quickly; they may heal under crusts, or as open sores; induration and rounding of the edges are distinctive, along with much thickening of the base. The scars are also indurated, rounded and elevated at the edges, and smooth or puckered on the surface; they are often as large as a walnut. It is not easy to see a vesicular stage of the disease even in the cows infected from the initial spontaneous case; and Ceely had for the most part to be content with the coagulated matter of crusts to vaccinate with. The process is, in fact, bound up from the first to last in the most intimate and essential manner with the operation of milking. Cowpox "undisturbed by the milker's hands" has no existence in the originating cow; it is the persistent irritation that makes it a pox. It is communicable, also, to the hands of the milkers themselves, and by their filthy hands to their faces. Jenner mentions a good many such cases; Pearson has collected several; and Ceely gives three in very full detail. As in the inoculated venereal pox, the infection proceeds for a time under the skin, making a bluish-white vesicle; it eats away the tissues round the margin, where the fluid makes the skin bulge out into the characteristic tumid ring. After the fourteenth day, the vesicle will have become an eschar, the average size of a sixpenny piece, which comes away of the infection in the milker's hand. Various regions of the face get infected by contact from the hands: Jenner mentions the case of "a poor girl who produced an ulceration on her lip by frequently holding her finger to her mouth to cool the raging cowpox sore by blowing upon it"; another of Jenner's cases had the sore on the wing of the nose; one of Ceely's cases had an ulcer on the temple three-quarters of an inch long; in a case observed by Crookshank there was a very large vesicle and subsequent sore over the left cheek-bone. The local infection is accompanied by constitutional disturbance, more of less severe, including headache, pains, pains in the loins, vomiting, and sometimes delirium. The axillary glands become painful, usually about the fourth day, and remain hard for some time. Eruptions occurred, but there is little said about them.

As might have been expected, the effects of experimental infection with cowpox matter were the same as the accidental. They are spoken of as the effects of "primary lymph," that is to say, lymph direct from the cow's teats or from the milker's sore hand, or in the earlier removes from these sources. Jenner's experience of primary lymph was very much the same as Bousquet's, Estlin's, and Ceely's forty years later. Woodville's, on the other hand, was exceptionally reassuring;[6] had it not been so, it is not likely that cowpoxing on the large scale would have ever survived the initial discouragements entailed by the use of primary lymph. The process on the child's arm was on the whole the same as on the milker's hand, allowing for the more deliberate mode of inoculation and for different texture of the skin. The vesicle grew to a great size up to the fourteenth day, and often became an ulcer, either excavated under the crust or absolutely open. Estlin did not entirely get rid of the ulceration until after the twenty-ninth remove from the cow. The constitutional disturbance was often severe in infants: axillary tenderness and swelling were somewhat constant, and eruptions were especially frequent about the second to fourth week, including macular roseola, lichen, and pemphigoid bullæ. At each successive remove from the cow the cycle of the process became more contracted, and the constitutional disturbance, *cæteris paribus*, became less. Bousquet gives a plate which shows by parallel series of figures the differences between the vesicles of the old lymph (Woodville's, nearly forty years old) and the lymph from the Passy cow. The new lymph induced a process more protracted at every stage: the vesicle continued to enlarge at the periphery for several days after the common vaccine vesicle of the period would have ceased to extend. It was not at its maximum until about the end of the second week, and it then became an eschar

[6]But Addington (*On the Inoculation of the Cowpox*, Birmingham, 1801), who got his lymph from Woodville, was not equally fortunate: of eleven cases at the beginning of his series five ended in ulceration; after that the cases all ended in a "dry scab."

and a sore. Bousquet confesses that he first understood "les frayeurs de Jenner" when he saw the ulcerative and other effects of primary lymph. After a certain number of removes from the cow the cycle became so contracted that the vesicle was full at the eighth or ninth day; the abbreviation of its life-history enabled it to heal without ulcerating. It thus becomes the ordinary vaccine vesicle as we know it, which heals under a scab, and leaves the peculiar punctuated scar of subcrustaceous repair. The abbreviation or mitigation is effected by taking lymph from each successive vaccinifer at as early a period as it can be got, until the golden mean of safe vaccination, namely, maturity at the eighth day, is reached. That corresponds to Jenner's rule of taking the matter for vaccination before the areola appears; if the vesicle be emptied after that period, the lymph from it is apt to cause ulceration, or, as Ceely puts it, we have "all inconveniences of primary lymph." It is this clear that humanized cowpox might be easily cultivated back to its original type; and, as a matter of fact, it has sometimes been so cultivated back by misadventure, with serious consequences to the vaccinated.

The risks of vaccination may be divided into the risks inherent to cowpox infection and the risks contingent to the puncture of the skin. Of the latter nothing special requires to be said; the former will be discussed under five heads of (1) erysipelas, (2) jaundice, (3) skin eruptions, (4) vaccinal ulcers, and (5) so-called vaccinal syphilis.

(1) A slight degree of erysipelas was recognized by Jenner himself, and even postulated by him, as part of the natural history of cowpox in man; and it is so recognized by the more unbiased writers of recent date.[7] The usual time for it corresponds to the appearance of the areola (eighth or ninth day), that efflorescence round the pock being normally a slight erysipelas. It may start, however, from the puncture or scratch in the skin, after a day or two's interval; but that form of it (the "early erysipelas" of German writers) is much rarer than the erysipelas of the areola, of "late erysipelas." Primary lymph, or lymph in the first removes, is most apt to exite an extensive and spreading areolar redness. In the ordinary course of vaccination remote from the cow the intensity of the superficial redness and deep infiltration would seem to depend mostly on the child's constitution, or on whatever concurrence of circumstances serves to recall the "inconveniences of primary lymph." The registrar-general's tables of mortality for England and Wales have contained an entry of "erysipelas after vaccination" from 1855 to 1881, when the entry was changed to "cowpox and other effects after vaccination," the numbers at the same time nearly doubling. The fatal cases of erysipelas in infants under one year referred to vaccination are but a small fraction of the whole mortality from erysipelas at that age, a mortality which is far greater that at any other period of life. It is quite certain that in foundling hospitals, such as that of St Petersburg, the erysipelas of vaccination has been the starting-point of disastrous epidemics of erysipelas affecting the inmates generally. There is no means of knowing whether the same has been the case among the population at large. In Table I. the column of deaths from erysipelas in general, among infants of the first year in England and Wales, is given side by side with the column of deaths from erysipelas after vaccination.

[7] Bohn, *Handbuch der Vaccination*, Leipsic, 1875, p.174.

	Erysipelas after Vacci--nation.	Erysipelas.		Erysipelas after Vacci--nation .	Erysipelas.
1855	0	583	1870	20	685
1856	5	610	1871	22	716
1857	0	421	1872	16	617
1858	0	599	1873	19	675
1859	5	569	1874	27	867
1860	2	514	1875	36	796
1861	2	492	1876	21	700
1862	3	458	1877	26	667
1863	7	612	1878	35	582
1864	11	618	1879	31	561
1865	10	579	1880	32	618
1866	9	527	1881	562	644
1867	3	467	1882	652	696
1868	8	647	1883	512	641
1869	19	589	1884	492	618

The post-vaccinal inflammation sometimes takes the form of phlegmon; but there is no separate entry for that as a special sequel of vaccination. Many of the alleged deaths from erysipelas after vaccination have been the subject of coroner's inquests; the verdict is often an open one, and even such cases as those near Gainsborough in 1876 and Norwich in 1882 were found to have been returned (all but one) by the certifying medical practitioners as due to erysipelas merely. It may be assumed that "after vaccination" is not certified unless the case has left no doubt in the minds of the jury or of the certifying medical attendant. The increase in the first columm from 0 in 1855 to 32 in 1880 is probably in appearance only, and due to more correct diagnosis.

(2) It is only within the last few years that jaundice has been regcognized as a post-vaccinal effect; and at present there is only one accepted instance of it on the large scale. This was the epidemic among re-vaccinated adults in a large shipyard at Bremen from October 1883 to April 1884. Owing to an alarm of smallpox, 1289 workmen were re-vaccinated between the 13th August and 1st September with the same humanized lymph preserved in glycerin; of these 191 had jaundice at various intervals down to the month of April following. Circumstantial evidence (agreement and difference) clearly traced the epidemic to vaccination.[8] In future an outlook will be kept for this effect of vaccination; at present it has no intelligible theory. It may be noted that the lymph which caused the Bremen epidemic was mixed with glycerin.

(3) The eruptions that follow vaccination are proper to cowpox infection. Although little is said about them in the accidental infection of milkers, they were very common in the practice of Estlin, Ceely, and others with primary lymph. The eruption is a kind of exanthem, or "secondary" of the local infection, and does not ordinarily appear before the second week. One of its commonest forms is a patchy rose-rash, or macular roseola, not easily distinguishable from the macular roseola of syphilis.[9] Another form is lichen or dry papules, apt to scale; it may also occur as a vesicular eruption, and in the form of pemphigoid bullæ or blebs. In one of Ceely's cases the eruption extended to the whole mucous membrane of the mouth and throat. A peculiarity of the exanthem is that it may come and go several times before it finally disappears; and, like other skin eruptions, specific or non-specific, it may become inveterate. The widespread belief that much of the eczema of childhood dates from vaccination is not by

[8]See Lürman, *Berl. klin. Wochenschrift*, 1885, p.20.
[9]Parrot, *La Syphilis Héréditaire*, 1886, p.33.

any means to be dismissed as a mere fancy. The skin-disorders that followed vaccination in the first years of the practice were declared by Birch and others to be new in type. At present the vaccinal eruption, especially on the scalp, is sometimes distinguished by the size and form of the crusts, and by scars remaining for a time.

(4) Ulceration of the vaccine vesicle, or of the site of it, is one of the commoner forms of "bad arm." It is a return to the native or untamed characters of cowpox on the cow's teats, or on the milker's hands or face, or in the child's arm after experimental inoculation with primary lymph. It crops out not unfrequently in everyday practice, and is probably dependent for the most part on the lateness at which the lymph was taken for vaccination, or on retardation of the process in the vaccinifer, or on emptying the latter's vesicles too much; however, it may result from picking the scab or otherwise dislodging it. The ulceration usually proceeds to some depth in the form of a crater under the crust, and is attended with induration and rounding of the edges and induration of the base. According to Bohn (*op. cit.*, p. 166), it may alarm practitioners by its resemblance to syphilis. In other cases the crust is wanting and the ulceration has the distinct type of phagedena. The destruction of tissue in either case may be very extensive, going "down to the bone" and having as much as an inch or more of superficial area. Healing is frequently an affair of weeks, and may be aided by mercurial treatment. There are no statistics of this sequel of vaccination; but the frequency or infrequency of it may be learned in conversation with any intelligent chemist whose shop is resorted to by the poor, or with a medical practitioner of average experience.

(5) It has been proved by many experiments, undesigned or otherwise, in Paris (1831 and 1839), Vienna (1854), and elsewhere, that an infant with congenital syphilis develops correct vaccinal vesicles, provided its skin be clear of eruption and the lymph have been taken at the usual time; also that the lymph taken from the correct vesicles of a syphilitic child produces correct vesicles in its turn, but does not produce syphilis in the vaccinated child. The congenital taint is, in fact, irrelevant to the course of cowpox infection. So far as experiment and casual experience can prove anything, that has been proved; the recent attempt to disprove it by an officer of the Local Government Board (*Report* for 1882, p. 46) is vitiated by fallacies, and has no value against the overwhelming testimony collected thirty or forty years ago. What, then, is the meaning of the numerous outbreaks of syphilis in groups of children or adults vaccinated or re-vaccinated with lymph from one source?

A careful examination of these cases shows that syphilis at the source of the vaccine matter was in all cases an after-thought, that in most of the cases there was no evidence for it, and that in the remaining cases the evidence was so far-fetched as to be unlikely (apart from the known *a priori* improbability), or that the traces of constitutional infection found in the vaccinifer were subsequent to vaccination, and therefore capable of being explained as an effect concurrent with the more obvious symptoms in those vaccinated therefrom. The effects, however, were very much the same as in the venereal pox. The vaccine vesicle either became an indurated or phagedenic sore, as described in the foregoing section on vaccinal ulcers, or the scar opened into an indurated sore after the usual subcrustaceous healing was complete, or became indurated without opening. The axillary and cervical glands were often indurated. In most of the epidemics there were a certain number of cases in which the effects were purely local, or confined to one only of the seats of puncture; if these had not occurred along with others in a group, they would have been counted as ordinary vaccinal ulcers. But there were often secondary symptoms as well, including the roseolar, lichenous, or (rarely) pemphigoid eruption, and not unfrequently condylomata *circa anum et genitalia.* In some epidemics (but not in all) there were, in a small minority of the cases, mucous patches on the tonsils, tongue, or lips, tending to ulcerate; and in some of the Italian outbreaks the infection spread among the mothers and other members of the households in the form of specific sores of the nipples,

with or without constitutional symptoms. Affections of the bones and viscera do not seem to have followed; fatalities were not very common.

It will be hard to persuade medical authorities that these secondary effects are not the result exclusively of the venereal pox. The evidence, however, does not allow us to assume any other specific infection than that of cowpox, which, as we know, has its proper secondary exanthem in the form of macular roseola, lichen, or pemphigus; the eruption has even been known to affect the mouth and throat. The evidence from epidemics of vaccinal sore arms teaches us that condylomata, mucous patches of the tonsils, tongue, and lips, and even iritis, are also possible, although far from invariable, among the "secondaries" of the primary vaccinal ulcer. The most general fact that comes out in these epidemics is that the lymph was taken late from the vaccinifer, or that the vesicles of the vaccinifer were drained dry to vaccinate a large number, or that the same vaccinifer was used for arm-to-arm inoculation on two successive days. It is not difficult to see how, in those circumstances, the abbreviated cycle of humanized cowpox may be departed from and the native or untamed characters of cowpox infection reverted to. Cowpox, indeed, is parallel with the venereal pox, both in the circumstances of its becoming an infective ulceration (indulated or suppurating) and in its secondary or constitutional manifestations as an infection in man. But the "bad" lymph has hardly ever been used beyond the second remove; and there the parallel fails.

The following is a list of the so-called syphilitic epidemics after vaccination, including those that have been considered spurious, because they were either anomalous in type from the point of view of syphilitic infection or had no obvious causal connexion with that disease.

Udine, 1814 (see Viennois, in *Syph. Vaccinale*, p.221). Cremona, 1821 (see Depaul, "Projet de Rapport," in *Syph. Vacc.*). Grumello, 1841 (*ibid.*). Coblenz, 1849 (Wegeler, in *Preuss. Vereinz-Ztg.*, 1850, No. 14; abstract in *Schmidt's Jahrb.*, vol. lxvii., 1852, p.62). Upper Franconia (the Hübner case), 1852 (*Intelligenzbl. der Bayr. Aerzte*, 1854; Bohn, *loc. cit.*). Lupara (Italian prov. Molise), 1856 (see Depaul, *loc. cit.*). Dispon near Pesth, 1855-57 (*Oester. Zeitschr. für prakt. Heilk.*, 1862; Bohn, *loc. cit.*, p.322). Rivalta (Piedmont), 1861 (Pacchiotti, *Sifilide Transmessa per Mezzo della Vaccinazione in Rivalta presso Acqui*, Turin, 1862). Torre de' Busi near Bergamo, 1862 (see DePaul, *loc. cit.*). United States (troops on both sides in the Civil War), 1861-65 (Jones, *Circular II.*, *Louisiana Board of Health*, Baton Rouge, 1884). Argenta near Ferrara, 1866 (Gamberini, in *Gaz. des Hôpitaux*, 1870, p.505). Morbihan (neighbourhood of Vannes and Auray), 1866 (DePaul, *Bull. de l'Acad. de Méd.*, xxxii., 1866-67, p. 201; Bodelio, *ibid.*, p.1033). Cardaillac (Lot), 1865 (*Bull. de l'Acad. de Méd.*, 28th February 1867). Schleinitz (Styria), 1870 (Kochevar, *Allgem. Wiener Med. Ztg.*, 1870, Nos. 21 and 24; abstract in *Arch. für Dermatologie und Syph.*, 1870). London (two series), 1871 (Hutchinson, *Med. Chir. Trans.*, liv., 1871). Switzerland, 1878 (*Bull. de la Soc. de la Suisse Romande*). Algiers, 1880-81 (*Journ. d'Hygiène.* 25th Agust 1881). Lyck (East Prussia), June 1878 (Pincus, *Vierteljhschr. f. gericht. Med.*, 1879, p. 193). Aspriéres (Aveyron), March 1885 (P. Brouardel, *Rapport*, Paris, 1886).

Attention was drawn to these cases because they occurred in groups varying in number from 10 to 100 or more, which made considerable stir, especially in country districts. It is unlikely that all cases have been reported. In the third *Report* of the clinical hospital of Manchester, Whitehead states the results of his inquiries on post-vaccinal illness in children. Setting aside most of the cases of illness vaguely alleged by the mothers to have been the consequence of vaccination, he admits as truly post-vaccinal 34 cases of syphilis or pseudo-syphilis; of these he enumerates only 14 in his table of 63 cases of children's syphilis of all kinds, the other 20 cases being omitted, it would appear, not because there was any doubt of their being post-vaccinal, but because they were not of the perfect type of infantine syphilis. Such was the experience of a competent observer at a single hospital during a period of 20 months. Whitehead's *Report* was

published in 1859; but, when Hutchinson published his first series of London cases in 1871, the subject was considered to be quite new. Here again it was the concurrence of some ten cases in a group that helped the reluctant assent of the profession. The first group of London cases had hardly begun to be talked of when one of Hutchinson's colleagues was led by two cases of skin disease at a hospital to follow up the traces of another group, the very existence of which was unsuspected by the public vaccinator or general practitioners in whose district the eleven patients with vaccinal ulcers and occasional secondaries resided.

In the registrar-general's tables of mortality for England and Wales about one-half of the deaths from "cowpox and other effects of vaccination," or nearly thirty per annum, may be put down to effects of vaccination other than erysipelas; but there is nothing to show that these were fatal cases of vaccinal ulcers with constitutional symptoms or marasmus. On the other hand, the table of deaths from syphilis shows and enormous and steady increase in the number of deaths of infants under the age of one. In the first year of compulsory vaccination (1854) the deaths suddenly increased by one-half, and the increase has gone on steadily since then (see Table II.) The interpretation of the fact is by no means easy or free from fallacies. There are doubtless other and better reasons for the increase besides vaccination; and it is significant that the tables for Scotland show the mortality to be chiefly in the first three months of life, whereas the statutory limit for vaccination in that country is six months.

Infantine Death-Rate from Syphilis (*England and Wales*).

	Infants under One Year.	All Other Ages.		Infants under One Year.	All Other Ages.
1847	255	310	1868	1364	522
*1852	380	243	1869	1361	498
*1853	380	242	1870	1422	436
*1854	591	373	1871	1317	425
1855	579	368	1872	1410	421
1856	579	300	1873	1376	467
1857	656	301	1874	1484	513
1858	684	322	1875	1554	580
1859	778	311	1876	1580	554
1860	767	300	1877	1550	524
1861	798	379	1878	1647	535
1862	867	378	1879	1493	536
1863	983	403	1880	1588	571
1864	1089	461	1881	1540	557
1865	1155	492	1882	1666	561
1866	1180	482	1883	1813	500
1867	1241	457	1884	1733	547

*The proportion assigned to the first year of life is calculated from the specimen table for 1852 (females only) and from the tables of the London mortality.

In the polemical writings of anti-vaccinists, such diseases as scrofula, tubercle, hooping-cough, diarrhœa, and other common causes of infantine mortality are alleged to have increased owing to vaccination. There is little or no reason, in theory of in experience, to suspect that tuberculous or scrofulous infection is ever communicated by vaccine lymph. As regards the

above and other infantine maladies, vaccination may predispose the child to fall into them, in so far as it produces, or ought in theory to produce, a considerable constitutional disturbance and presumably a loss, for a brief period, of the natural power to resist the various noxious influences by which the age of incancy, especially among the poor, is beset.

The value of cowpox as a protection against smallpox may now be judged of apart from the fanciful doctrine of variolæ vaccinæ by which it was originally recommended. It has been put to a test extending over eighty years; and in some circumstances it has been possible to apply the logical methods of agreement and difference with a good deal of cogency. The besetting fallacy of all vaccination logic is that of *post hoc ergo propter hoc*; and the only way to escape it is to hold intelligent views of the history, the natural history, and the epidemiology of smallpox. This will necessitate a brief excursus.

Smallpox, which is really a tropical skin disease of the nature of lichen turned pustular, or of ecthyma, must be judged according to what we know of foreign pestilences in general. Perhaps we are safest to take a line through the behavior of the plague. Plague in western Europe had the start of smallpox by a good many years, if we speak only of prevalence on the large scale. "Throughout the 16th century," says Hirsch, "the plague was a permanent form of disease on the continent of Europe. ... During the first two-thirds of the 17th century we still meet with it over an equally wide area and equally often. But in the last thirty years of that century, the plague was observed to be retreating gradually from the soil of Europe." It was not only in London after the fire of 1666 but also in Denmark and Sweden, in Italy, in Holland and Belgium, in Switzerland, in France, in western Germany, and in Spain that the years 1660-1680 saw the last of plague; it lingered only in the Levant, in Poland, and in other parts of north-eastern Europe, with occasional epidemic visits, such as those of Messina and Marseilles. Now it has left the Levant and Egypt, has abandoned even Mesopotamia and Arabia, and retreated to a few poor villages on the Perso-Armenian frontier. Or, take the example of leprosy, which owed its existence rather to the widespread or national concurrence of the same causes in various countries than to the travelling of an infection: Italy had it first and lost it first, and nearly every other country in Europe saw its rise, its general prevalence, its decline, and its extinction, the northern countries keeping it longest. Again, typhus fever was a standing disease so long as Europe was the theatre of protracted wars and all of their consequences; but, like other infections, typhus gradually declined and has almost disappeared since the conditions on which it depended ceased.

Leaving these parallels and coming to the facts of smallpox itself, it rose to prominence in western Europe in the 16th century, and in England in the 17th.[10] From the early part of the 18th century a remission was noted; but the latter half of that century saw a considerable extension of the area of the disease, for which the practice of inoculation has been blamed. It is a mistake to suppose that smallpox has shown a tendency towards a universal infection; for all its chances it has kepts within moderate limits of age and place, and extended only by repeated provocation. Thus, Hirsch says of the western hemisphere, "A still more terrible source for America was the importation of Negro slaves, so much so that in after years, particularly in South America and the West Indies, not only the first appearances of smallpox, but every fresh outbreak of it, could be traced to importation from Africa,"—the African continent being then, as now and always, one of the principal native seats. In Europe it has been peculiarly a disease of infancy and of the most crowded parts of cities. It has had victims among the upper classes, just as cholera has had; but, like that disease, its habitat is among the crowded poor; and it

[10]The first known use of the term "small pocks" is in Holinshed's *Chronicle* (1577), an epidemic of *pestis* in 1365 being so rendered, although it was probably the ordinary bubo-plague of the period. The pox of Elizabethan writers was the French pox or great pox (syphilis), which overran Europe as an epidemic in 1494. Its prominent character at its first appearance was the loathsome affection of the skin (especially the face); hence when variola came on the scene it was called the lesser pox, or smallpox.

would have touched the well-to-do-classes less in former times if there had always been spacious west-end quarters in cities or the modern "passion for clean linen," personal ablutions, and fresh air. Tenement houses and ill-ventilated courts or alleys have been the natural harbourage of smallpox; in proportion as these have been demolished the disease has disappeared or been circumscribed in its area. It is fallacious to estimate its prevelence now in ratio of the whole population; for a just comparison of one period with another, we have to take into account, not the death-rate per million living, but the death-rate per million still living under the old-world conditions. From the earliest period of its history in Europe, the disease has had its seasons of quickening or revival, with long intervals of quiescence; only in the most crowded parts of Western cities has it ever been endemic from year to year. These epidemic outbursts have varied much in intensity and in area, the conditionsof variation being mostly unknown. In that respect it need hardly be said, smallpox is like other epidemic diseases.

During the early years of the 19th century there was a marked remission of the epidemic outbursts of the disease in most parts of Europe. The amount of vaccination during those years was inconsiderable; in particular it hardly touched the poor. Thus, at the time of the Norwich epidemic of 1819, it was estimated (by Cross) that only one-fourth of the inhabitants were vaccinated, and these almost exclusively the well-to-do. At the same time the practice of inoculating smallpox, which was with good reason blamed for keeping the contagion generally diffused and active among the non-inoculated, began to be discontinued and soon ceased altogether. Undoubtedly there was a marked decline in smallpox during the first fifteen years of the century, but the associated circumstances are as complex as the fact itself is simple. We have to bear in mind the old law of periodic exacerbation and dormancy, the cessation of a practice (inoculation) which almost certainly interfered with the natural tendency of smallpox as a foreign pestilence to die out, and other displacing or substitutive factors in the death-rate. To what extent vaccination was a factor will have to be decided by the experience of a period when the practice was much more generally in vogue. For that purpose we may here restrict the inquiry to England and Wales, premising that the experience of other European countries where vaccination has been equally practised is not different.

The following table (III.) begins with the year 1847; the registration reports go back to 1838, but there is a break in the tables for five years near the beginning.

Deaths from Smallpox from 1847 to 1884, with the numbers among Children under five.

Year.	Total of All Ages.	Children under Five.	All other Ages.	Year.	Total of All Ages.	Children under Five.	All Other Age.
1847	4227	3114	1113	1866	3029	1662	1367
1848	6903	4782	2121	1867	2513	1370	1143
1849	4644	3146	1498	1868	2052	1234	818
1850	4665	3265	1400	1869	1565	892	673
1851	6997	4869	2128	1870	2620	1245	1375
1852	*7320*	*5076*	*2244*	*1871*	*23126*	*7770*	*15356*
1853	3151	2164	987	1872	19094	5758	13336
1854	2808	1659	1149	1873	2364	587	1777
1855	2525	1323	1202	1874	2162	543	1619
1856	2277	1299	978	1875	950	271	679
1857	3936	2335	1601	1876	2408	612	1796
1858	*6460*	*3585*	*2875*	*1877*	*4278*	*1056*	*3222*
1859	3848	2247	1601	1878	1856	472	1384
1860	2749	1544	1205	1879	536	130	406
1861	1320	723	597	1880	648	170	478
1862	1628	931	697	*1881*	*3098*	*740*	*2358*
1863	5964	3267	2697	1882	1317	275	1042
1864	*7684*	*4294*	*3390*	1883	957	226	731
1865	6411	3262	3149	1884	2234	503	1731

The Italic numerals indicate the periodic maxima.

In the first years of the table the deaths from smallpox of children under five were to those of all other ages in the ratio of 3 to 1 or of 5 to 2 (at Norwich in 1819 there were 530 deaths, of which half were in infants under two and all the rest save ten were in children under ten years); the disproportion lessened gradually, until about 1864 it was nearly 4 to 3; in 1870 the proportion was nearly equal; and from that time onward the preponderance leaves the age of infancy and childhood, so that in 1884 the deaths under five were three times fewer than those at all other ages. The great epidemic of 1871-72 brought out that remarkable change of incidence most decidedly. Taking the mortality of 1871 as an instance, the significance of the changed incidence on the periods of life is that the 7770 deaths under the age of five would, in pre-compulsion times, have had a complement of no more than 2500 deaths in the later periods of life, or that the actual mortality of 15,356 above the age of five would have had a complement of some 40,000 or 45,000 deaths below that age. (In British India in 1884 of 333,000 deaths 72 per cent. were of children under 12 in Bengal, and 64 per cent. in Madras.) Apart from the changed incidence of smallpox, Table III. shows merely the caprices of the disease as an epidemic. After every epidemic outburst the disease declines and sometimes looks as if it were about to die out altogether. The alarm attenending each severe epidemic has induced the legislature to make the vaccination law more stringent and vaccinators to insert more of the virus, so that the periodic subsidence has corresponded to, and has seemed to be owing to, the better enforcement of the practice; but there have always been alternating periods of quiescence and exacerbation, irrespective of any prophylactic. Moreover, smallpox being a foreign contagious skin disease lurking in congenial haunts, it would be quite according to precedent that it should one day cease absolutely in a community where sanitary progress had advanced so far as to take the ground from under the feet of the pestilence; such absolute

cessation would have no more necessary connexion with almost universal vaccination than the alternating quiescence and recrudescence of epidemics have been conected with each new Act of Parliament. The epidemic of 1871-72 was one of the worst in the whole history of European smallpox; and it may be that it was one of the last flickers of a slowly expiring flame. The universal practice of cowpoxing, however, is based upon the assumption that this contagious skin disease imported from the tropics is a thing that Europe must reckon with for an indefinite time. On the other hand, the teaching of epidemiology is that a foreign pestilence never stays unless it finds quarters suited to its existence, and that it may even take its departure capriciously, as in the case of the plague, after it has had a certain career, or on being displaced by some congener such as typhus. Vaccination is considered to have turned smallpox in great part aside from the early years of life and thrown it more than ever upon the later ages, while measles and other maladies proper to childhood have at the same time increased.[11]

Thus far as regards the utility of vaccination to the state; we have now to consider its utility to the individual. Do the vaccinated escape in an epidemic? or, if they do not escape an attack of smallpox, do they escape death from it? The answer to the first question, apart from the familiar negative experience of everyone, we have the statistics of smallpox hospitals, which relate to the poorer classes and probably do full justice to the fact of non-vaccination, inasmuch as the unvaccinated residue is mostly to be found in those slums and tenements of the poor where smallpox (now as always) is apt to linger. At the Eastern Metropolitan Hospital (Homerton) from its opening early in 1871 to the end of 1878 there were 6533 admissions for smallpox, of which 4283 had vaccination marks, 793 had no marks although vaccinated, and 1477 were unvaccinated, giving a proportion of 0.29 unvaccinated. In the epidemic hospitals of Liverpool, Glasgow, and Dublin the proportion was 0.25 during the same period. For some of the German states the proportion of unvaccinated cases comes out a good deal less than one-fourth; thus in Bavaria in 1871 of 30,742 cases 29,429 were in vaccinated persons, or 95.7 per cent., and 1313 in the unvaccinated, or 4.3 per cent.[12] In some of the small local outbreaks of recent years the victims have been nearly all vaccinated (*e.g.*, at Bromley in 1881, a total of 43 cases, including sixteen confluent, all vaccinated).[13] In the army and navy, where vaccination and re-vaccination are absolutely without exception, the proportion is accordingly 0. It would thus appear that the rather excessive proportion of cases among the small residue of unvaccinated in the civil population must have other associated circumstances besides non-vaccination; and these are not far to seek.

The next question is the death-rate among the vaccinated and unvaccinated respectively. The total death rate from smallpox in modern times is almost the same as it was in the 18th century; large aggregates collected by Jurin and others in pre-vaccination times show a mortality of 18.8 per cent., and corresponding aggregates in English and American hospitals, mostly since 1870, show a mortality of 18.5 per cent. It has, however, to be borne in mind that the division into discrete, confluent, and malignant smallpox is an old one; that a mild type was quite common in the 17th and 18th centuries, and was now and then characteristic of whole epidemics, just as in the case of scarlatina; and that the vaccinated are at present liable to be attacked by the confluent and malignant disease as well as by the discrete. But are the vaccinated liable to the fatal forms of smallpox in the same proportion as the unvaccinated? It is only since 1879 that the registrar-general's tables for England and Wales have attempted to

[11] See Farr, *Reg. Gen. Report* for 1867, p.213: "To operate on mortality, protection against every one of the fatal zymotic diseases is required; otherwise the suppression of one disease-element opens the way to another" (p.219). He quotes Watt (1813) to show that the decrease of smallpox mortality among infants in Glasgow from 1783 to 1812 was balanced by a great increase in the infantine deaths from measles. See also Guy, *Journ. Statist. Soc.*, 1882, p. 430.

[12] Majer, *Vierteljahrschrift für gericht. Med.*, xxii. 355.

[13] Nicolson, *Lancet*, 27th August 1881.

supply data bearing on this; and it will be seen from the following abstracts (Tables IV.-VII.) that the data are still far from being sufficient:—

Table IV. — Deaths from Smallpox, showing the Numbers of the Unvaccinated.

Year.	Total Deaths.	Unvaccinated.	Vaccinated.	Not stated.	Year.	Total Deaths.	Unvaccinated.	Vaccinated.	Not stated.
1879	536	231	117	188	1882	1317	325	176	816
1880	648	282	121	245	1883	957	162	78	717
1881	3098	1068	652	1378	1884	2234	595	493	1146

Table(V.),—Same for the Provinces (Metropolitan Deaths deducted).

Year.	Total Deaths in Provinces.	Unvaccinated.	Vaccinated.	Not stated.	Year.	Total Deaths in Provinces.	Unvaccinated.	Vaccinated.	Not stated.
1879	86	20	9	57	1882	887	143	66	678
1880	171	43	14	114	1883	821	111	35	675
1881	731	133	90	508	1884	1336	282	239	815

Table VI.—Deaths from Smallpox in Infants under One Year.

Year.	Total Deaths.	Unvaccinated.	Vaccinated.	Not stated.	Year.	Total Deaths.	Unvaccinated.	Vaccinated.	Not stated.
1881	319	144	14	161	1883	126	32	1	93
1882	129	43	2	84	1884	254	118	7	129

Table (VII.),—Same for the Provinces (Metropolitan Deaths deducted).

Year.	Total Deaths in Provinces.	Unvaccinated.	Vaccinated.	Not stated.	Year.	Total Deaths in Provinces.	Unvaccinated.	Vaccinated.	Not stated.
1881	66	13	1	52	1883	108	21	1	86
1882	90	20	1	69	1884	146	56	5	85

These figures may be made to prove anything, according to the bias of the individual; the column of "not stated" commands the situation. The official figures[14] for Bavaria in 1871 are ore precise: among the 29,429 cases of smallpox in vaccinated persons there were 3994 deaths, while among the 1313 unvaccinated cases there were 790 deaths; of the latter no fewer than 743 deaths were of infants in their first year. The mortality among both the vaccinated and the unvaccinated is always excessive for infancy. Feeble health, as well as non-vaccination, is a factor in the very excessive smallpox mortality at that tender age.

The returns from special smallpox hospitals make out a very small death-rate (6 per cent.) among the unvaccinated. The result is doubtful *qua* vaccination, for the reason that in pre-vaccination times the death rate (18.8 per cent.) was almost the same as it is now in the vaccinated and unvaccinated together (18.5). At the Homerton Hospital from 1871 to 1878 there were admitted 793 cases in which "vaccination is stated to have been performed, but without any evidence of its performance"; the deaths in that important contingent were 216,

[14]Majer, *op. cit.*

or 27.2 per cent., but they are not permitted to swell the mortality among the "vaccinated."[15] Again, the explanatory remarks of the medical officer for Birkenhead in 1877 reveal to us the rather surprising fact that his column of "unvaccinated" contained not only cases that were admittedly not vaccinated, but also those that were "without the faintest mark"; of the 72 cases in that column no fewer than 53 died. His column of "unknown" contained 80 per cent. of patients who protested that they had been vaccinated (28 deaths in 220 cases or 12.7 per cent.). Those who passed muster as veritably vaccinated were 233, of whom 12 died (5.1 per cent.). With reference to this question of the marks, it has to be said that cowpox scars may betemporary, that their "goodness" or "badness" depends chiefly on the texture of the individual's skin and the thickness or thinness of the original crust, and that the aspect of the scar, or even its total absense some years or even months after, may be altogether misleading as to the size and correctness in other respects of the vaccine vesicle, and of the degree of constitutional disturbance that attended it. This was candidly recognized by Ceely,[16] and will not be seriously disputed by anyone who knows something of cowpox and of how it has been mitigated, and of the various ways in which the tissues of individuals may react to an inoculated infection. In confluent cases the marks on the arm would be less easily seen.

The following statistical table (VIII.) shows death from smallpox to be comparatively rare where the marks are many and "good."

Table VIII., showing the Number and Kind of Arms ¡arks in 379 Fatal Cases of Smallpox at Homerton Hospital, 1871-80 (Gayton)

Vaccinal Marks	Admissions.		Deaths.		Mortality per cent.	
	Under 10 Years.	Over 10 Years.	Under 10 Years.	Over 10 Years.	Under 10 Years.	Over 10 Years.
4 good	56	247	0	4	0.0	2.5
3 good	44	388	0	12		
2 good	41	528	1	19	2.4	4.1
1 good	43	422	1	20		
4 imperfect	91	317	3	17	3.0	6.9
3 imperfect	107	545	3	43		
2 imperfect	142	930	17	92	12.5	12.6
1 imperfect	138	820	18	129		

The practice of re-vaccination was first recommended in England by G. Gregory, and in Germany for the army by Heim (1829). It has been more or less law in Prussia since 1835:[17] "re-vaccination of school pupils at the age of twelve is an integral part of the vaccination law." Notwithstanding the fact that Prussia was the best re-vaccinated country in Europe, its mortality from smallpox in the epidemic of 1871 was higher (69,839) than any other northern state. The efficacy of re-vaccination is sometimes sought to be proved by the immunity of nurses in smallpox hospitals. The experiment of not re-vaccinating the nurses was tried at the smallpox hospital of South Dublin Union in 1871-72; 29 out of the 36 attendants had not been re-vaccinated, and these all escaped smallpox as well as the other seven.[18] But nurses are not rarely chosen from among those who have had smallpox, and cases of smallpox in re-vaccinated nurses are not unknown.[19] The evidence as to the re-vaccination on a large scale comes from the army. According to a competent statistician (A. Vogt), the death rate from smallpox in

[15] *Parliamentary Return*, 24th February 1880.
[16] *Trans. Prov. Med. and Surg. Assoc.*, viii., 1840.
[17] Horn's *Medicinal-Wesen in Prussen*, ed. Eulenberg, Berlin, 1873-74, pp. 160 and 215
[18] *Med. Press and Circ.*, 27th March 1872.
[19] Sweeting, *Rep. Fulkan Hosp.*, 1881.

the German army, in which all recruits are re-vaccinated, was 60 per cent. more than among the civil population of the same age; it was ten times greater among the infantry than among the cavalry, and sixty times more among the Hessians than among the Würtembergers. The Bavarian contingent, which was re-vaccinated without exception, had five times the death-rate from smallpox in the epidemic of 1870-71 that the Bavarian civil population of the same ages had, although re-vaccination is not obligatory among the latter.

The susceptibility to cowpox infection diminishes with age; among the pupils of twelve years in Prussian schools it fails in about one-fourth of the attempts, and at later periods of life the proportion of failures is still greater.

It is often alleged that the unvaccinated are so much inflammable material in the midst of the community, and that smallpox begins among them and gathers force so that it sweeps even the vaccinated before it. Inquiry into the facts has shown that at Cologne in 1870 the first unvaccinated person attacked by smallpox was the 174th in order of time, at Bonn the same year the 42d, and at Liegnitz in 1871 the 225th.

State-supported facilities for vaccination began in England in 1808 with the National Vaccine Establishment. In 1840 vaccination fees were maid payable out of the rates. The first compulsory Act was passed in 1853, the guardians of the poor being intrusted with the carrying out of the law; in 1854 the public vaccinations under one year of age were 408,824, as against an average of 180,960 for several years before. In 1867 a new Act was passed, rather to remove some technical difficulties than to enlarge the scope of the former Act; and in 1871 the Act was passed which compelled the boards of guardians to appoint vaccination officers. The guardians also appoint a public vaccinator, who must be duly qualified to practise medicine, and whose duty is to vaccinate (for a fee of one shilling and sixpence) any child resident within his district brought to him for that purpose, to examine the same a week after, to give a certificate, and to certify to the vaccination officer the fact of vaccination or of insusceptibility. The Local Government Board awards a considerable sum in premiums for totals of successful vaccination, at a higher scale of one shilling for each case, and a lower scale of sixpense. The vaccination officer sees that all infants are vaccinated, either publicly or privately, before they are three months old (in Scotland six months), unless there is reason for postponing the operation. He acts also as registrar of vaccinations. Parents refusing to obey the summons taken out by the vaccination officer are liable to a penalty of twenty shillings for each offence. In 1880 the president of the Local Government Board brought in a bill to repeal the part of the Act relating to cumulative penalties; but the bill was withdrawn owing to protests from the medical profession. In a number of populous unions of England, a majority of the guardians are decided not to prosecute under the Vaccination Act; in other unions prosecutions are not unfrequent, the convictions having amounted in 1885 to the upwards of two thousand, and having usually led to distraint of goods (rarely imprisonment) in default of paying the fine. In England about two-thirds of all infants are vaccinated at the public expense.

Vaccination was made compulsory in Bavaria in 1807, and subsequently in the following countries:—Denmark (1810), Sweden (1814), Würtemberg, Hesse, and other German states (1818), Prussia (1835), Roumania (1874), Hungary (1876), and Servia (1881). It is compulsory by cantonal law in ten out of the twenty-two Swiss cantons; in an attempt to pass a federal compulsory law was defeated by plebiscite in 1881.

In the following countries there is no compulsory law, but Governmental facilities and compulsion on various classes more or less directly under Governmental control, such as soldiers, state employés, apprentices, school pupils, &c.:—France, Italy, Spain, Portugal, Belgium, Norway, Austria, Turkey.

In only a few States or cities of the American Union is there a vaccination statute; in Canada there is none. Vaccination has been compulsory in South Australia since 1872, in Victoria since

1874, and in Western Australia since 1878. In Tasmania a compulsory Act was passed in 1882. In New South Wales there is no compulsion, but free facilities for vaccination. Compulsion was adopted for Calcutta in 1880 and since then at eighty other towns of Bengal, at Madras in 1884, and at Bombay and elsewhere in the presidency a few years earlier.

Re-vaccination was made compulsory in Denmark in 1871 and in Roumania in 1874; in Holland it was enacted for all school pupils in 1872. The various laws and administrative orders which had been for many years in force as to vaccination and re-vaccination in the several German states were consolidated in an imperial statute of 1874.

Authorities.—Jenner, *Inquiry*, London, 1798, and *Further Observations*, 1799; G. Pearson, *Inquiry concerning the History of Cowpox*, London, 1798; Woodville, *Reports of a Series of Inoculations for the Variolæ Vaccinæ or Cowpox*, London, 1799; Baron, *Life of Edward Jenner, M.D.*, 2 vols., London, 1838; Bousquet, *Sur le Cow-pox, découvert á Passy*, Paris, 1836; Estlin, in *Lond. Med. Gazette*, 1838-39; Ceely, *Trans. Prov. Med. and Surg. Assoc.*, viii. (1840) and x. (1842); Hering, *Ueber Kuhpocken an Kühen*, Stuggart, 1839; Vienois and others, in *Syphilis Vaccinale*, Paris, 1865; Bohm, *Handbuch der Vaccination*, Leipsic, 1875; E.C. Seaton, *Handbook of Vaccination*, London, 1868; *Reports on Sanitary Measures in India, 1884-85*; W. White, *Story of a Great Delusion*, London, 1885; M'Vail, *Vaccination Vindicated*, London, 1887; Lotz, *Pocken und Vaccination*, 2d ed., Basel, 1880; G. Fr. Kolb, *Der heutige Stand der Impffrage*, Leipsic, 1879; A. Vogt, *Der alte u. d. neue Impfglaube*, Bern, 1881; and Creighton, *Natural History of Cowpox and Vaccinal Syphilis*, London, 1887. (C.C.)

A Note About This Second Edition of Creighton's 1888 Article: The text of Charles Creighton's work has been copied to the best of the ability of the editor. No intentional changes were made to the text, with the following exception: In the original, footnotes were numbered such that the footnote counter would reset with each page; in this version, the footnote counter continues to increase even from page to page. Since the page numbers in the original don't line up with the page numbers of this version, it wouldn't actually even make sense to keep the original footnote numbers.

Additionally, the original text contained a footnote that read,

> [2] Cowpox and other effects of vaccination.

but there was nothing in the body of text that actually pointed to this footnote. This was probably an error on the part of whoever typeset the original document. To give the reader an idea of where this footnote would have been in the text, this footnote came between footnote 7 and footnote 8 of this document.

For the reader's reference, the text of this document comes from a pdf posted to the internet by the National Library of Scotland. The National Library of Scotland's website that hosts this document can be found at this link. The reader will have to scroll down to Volume 24, where the reader can load the document either an ebook or a pdf. Readers who go to the original pdf will find that it takes forever to load. Part of why I decided to retypeset this article is because that pdf was taking forever to load just because of how large that document was, even though I was only really interested in the seven pages that had to do with vaccination. For those readers who are interested in examining that original version, the article on vaccination is on pages 23 through 30 of the book or pages 35 through 42 of the pdf file.

I've done my best to check over all the numbers in all the tables, but just to be safe, if the reader is interested in quoting any tables from this second edition, it would be wise to double check with what Creighton's original document said. Cheers.

—Joko