

WELLCOME HISTORY OF MEDICINE PRIZE AND MEDAL

The Prevention of Smallpox in the Eighteenth and Nineteenth Centuries and the Consequent Demographic and Economic Effects.

Smallpox has afflicted the face of the earth probably since the earliest times. Its origins are obscure, as the early clinical descriptions of the disease are poor and often ambiguous. Its origin has been traced to a whole population and caused the disease to be introduced. It was described as the first of the diseases which eighteenth century Europe was afflicted by as well as in five died of the disease before the age of ten.

Through a long period of the disease, preventive measures have been taken. The Chinese, the Arabians of India, the Arabians and the Africans all knew from earliest times that the inoculation of matter from a mild case of smallpox often produced a slight form of the disease, which would protect the individual against a severe attack. The method preferred by the Chinese was to insert matter from a cowpox into the nostrils, through the disease was communicated through the respiratory tract. (Inoculation by vaccination) was in early use in India and the districts of Scotland.

Submitted by Michael E. Richardson 1758

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Smallpox has scourged the face of the earth probably since the earliest times. Its origins are obscure, as the early clinical descriptions of the disease are poor and often ambiguous. Its ravages have decimated whole populations and caused whole cities to be abandoned. It was described as the most virulent disease with which eighteenth century Europe was afflicted; an estimated one in five died of the disease before the age of ten.

Through a fearful dread of the disease, preventive measures have arisen. The Chinese, the Brahmins of India, the Arabians and the Africans all knew from earliest times that the inoculation of matter from a mild case of smallpox often produced a slight form of the disease, which would protect against a severe infection. The method preferred by the Orientals was to insert smallpox crusts into the nostrils, whereby the disease was communicated through the respiratory tract. Inoculation (or variolation) was in early use in Wales and the Highlands of Scotland.

In Western Europe the medical efforts were directed not towards prevention but towards treatment. In England in the seventeenth century, and indeed well into the eighteenth, the orthodox treatment for smallpox comprised of isolation of the patient, rest in bed in a hot, ill-ventilated room, frequent blood-lettings, and overdrugging. In essence, a regime not too compatible with survival. Sydenham, who rejected this belief that the disease was contagious - for the scourge was so universal that some believed it to be

congenital - proposed the "cooling method". There were no fires allowed in the patient's room, windows were opened and bedclothes were "laid no higher than the waist". Under this mild treatment his patients did well, but few doctors adopted it, feeling his treatment was essentially to do nothing.

In the early eighteenth century inoculation was regularly practised in Turkey. In 1713 Dr. Emmanuel Timoni, a Greek physician in Constantinople, gave an account of this to the Royal Society in London. In 1716 Sir Hans Sloane M.D., F.R.C.P., the President, described the practice of inoculation in Turkey in the "Philosophical Transactions". His information was obtained from Dr. James Pylarini, who had published a dissertation on the subject in the previous year. In 1717 Lady Mary Wortley-Montague (1689-1762), the wife of the British Ambassador at Constantinople, had her son inoculated by Dr. Charles Maitland. On her return to this country she informed King George I of the method and urged its adoption in England. Contrary to many historical accounts, this was not the first English child to be inoculated. Two sons of the secretary to Sir Robert Sutton, the previous ambassador, returned to London in 1716 bearing the marks of the operation. These cases, however, were less publicized.

Contemporary evidence makes it necessary to revalue the importance of the several of the earliest individuals associated with the practice. It is clear that Lady Wortley-Montague's enthusiasm, and the inoculation of her daughter in London in April 1721, would have been insufficient to propel the practice - just as isolated inoculations in Germany and Hungary during the same year did not initiate the practice there. Much more important was the intense

interest of Sir Hans Sloane, prominent Fellow of the Royal Society and physician to the King, who used his powerful position at court and as scientific interlocutor among domestic and foreign correspondents to promote inoculation.

In 1722 six condemned criminals in Newgate were offered their freedom if they could be experimented upon. As there could be few worse fates than Newgate, they not unnaturally consented. The inoculations and tests performed by Dr. Maitland, with Dr. Mead and others in attendance, were successful. Dr. Mead, both eminent and influential in the medical world, was later to publish his "De Variolis et Morbillus" in which he strongly favoured inoculation. The practice was quickly to spread from the criminals to the Royal Family. Amyand, the Serjeant Surgeon, then inoculated the King with Maitland standing by. In the same year Queen Caroline, the Princess of Wales, and her two daughters were inoculated; and in 1724 the King sent Maitland to Hanover to inoculate his grandson, Prince Frederick.

The practice now had the support of the medical profession and royal approbation, which helped allay much of the opposition to the method. In 1746 a hospital for the inoculation of the poor was established in London; and in 1754 the College of Physicians considered inoculation "to be highly salutary to the human race".

The procedure was concurrently gaining adoption in the American colonies. The Reverend Cothan Mather in Boston was pressing the cause for inoculation with the co-operation of Dr. Zabdiel Boylston. In 1721 the latter inoculated his son and two negro slaves successfully - though this act and Mather's subsequent publications precipitated near riotous reactions.

Two most important figures in securing the successful practice of inoculation were the brothers Robert and Daniel Sutton - both without medical qualifications. They combined their inoculation technique which, by 1765, had been so perfected that "it well nigh attained the status of a modern preventative injection", with the Sydenham "cooling treatment". They claimed to have inoculated 20,000 persons without a single fatality.

Another inoculator, Adams, succeeded in obtaining a very attenuated virus, which usually gave rise to only one vesicle at the site of the puncture and a very mild form of smallpox.

A noteworthy inoculator was Thomas Dimsdale M.D. (1712-1800), Extra-Licentiate of the College of Physicians, London. He published in 1767 the "Present Method of Inoculating for the Smallpox" which enjoyed a great vogue and made his reputation. He successfully inoculated the Empress Catherine of Russia and her son, the Grand Duke, in 1768 - thus serving to disseminate the practice to Russia.

The adoption of inoculation was secured in three phases. It was first introduced and accepted by the upper classes, refinements then occurred in its technique, and this was followed by its general adoption amongst the lower classes. At first the procedure was drastic, exhausting and expensive for the patient. From 1720 to 1740 it is unlikely that the practice spread from the intelligentsia to include any of the poorer classes. Although the medical profession supported inoculation throughout the eighteenth century, from 1740 onwards it was largely promulgated outside the profession. Many unqualified laymen took up the inoculating lancet, with little more than a financial

incentive. They had the big attraction that they were much less expensive than the medical practitioners. Refinements occurred in the techniques which allayed many of the septic complications and the dangers of transmitting such serious diseases as tuberculosis, syphilis and erysipelas. The refinements, reduction in costs and the host of new inoculators allowed the practice to be applied to a much wider population group.

Controversy over inoculation was of three types; medical, social and religious. Medical questions asked whether the mild attack of smallpox induced did, in fact, produce immunity to further attacks and whether other diseases might not also be transmitted at inoculation. The defence rested its case on actual experience and the demonstration of mortality rates. Other diseases must inevitably have been transmitted. The mortality from the induced smallpox depended largely on the individual inoculator, and was probably around one in five hundred.

The social objections, voiced more loudly as the practice spread, centred on the hazards which inoculation brought to the whole community by maintaining foci of disease, which might lead to unsought infection. In rural districts, however, attempts were made to inoculate whole communities at once to avoid this. But, where urban populations were concerned, this was impossible, so that the practice undoubtedly harboured the disease within the towns. Yet the disease was so prevalent it is hard to imagine that the recently inoculated persons contributed significantly to its spread.

The religious objections, which probably worried the greater number of people, questioned how far man was to take

an active role in directing medical events in his life; whether it was a sin to make oneself ill deliberately; whether illness itself was not part of a providential plan, sent for the education and chastisement of mankind, and whether man should, therefore, interfere in the ways of God. These were all spontaneous and logical doubts arising inevitably from the current state of medical knowledge and accustomed religious thought. However, the contention that the resistance to inoculation for religious reasons was an example of the retarding influence of the Church on scientific progress must be revised. It is both true and natural that there was some clerical opposition to the practice. On the other hand, much of the leadership of the campaign was in the hands of well-educated clergy aware of their responsibility towards the lives and welfare of their charges. For example, Cotton Mather in Boston and Isaac Maddox, Bishop of Worcester, and, in fact, men of all religious persuasions were actively engaged in promoting the practice.

The opposition to the practice, though loudly voiced, did little to hamper its general acceptance. The opposition would have had to cite a much stronger case to overcome the people's dread of the disease. Fear of smallpox was the principal motivating force for inoculation, both for its introduction and continuance as a valid medical procedure. The antecedent history of smallpox shows an increasing terror of the disease which accelerated efforts to control it. The controversy around variolation helped reorientate public thinking and allowed a ready acceptance of vaccination. Variolation had called forth a unique and extensive trial, the logical sequence of which was vaccination.

The milkmaids of several pastoral areas of England were well aware that an attack of cowpox could protect them from

smallpox, though this was held by many to be merely a folk legend. The first to inoculate cowpox against smallpox was Benjamin Jesty, a farmer of Yeominster in Dorsetshire who himself had had cowpox by contagion. In 1714 he inoculated his wife and two sons with cowpox. His wife and family remained proof against smallpox inoculation and contagion.

In 1791, in Holstein, a Peter Platt inoculated his employer's three children with cowpox matter, and when an epidemic occurred in their area the children were the only ones unattended by the disease. Both Platt and Jesty were contented with their isolated success. It was left to Edward Jenner who, by careful observation and conclusive experiments, was able to render what was regarded as a legend into an immortal service.

Edward Jenner was born on 17th May 1749, third son of the Reverend Stephen Jenner, Vicar of Berkeley in Gloucestershire. His devout father died in 1754 and the young Jenner was cared for by his affectionate brother, the Reverend Stephen Jenner.

Very much at home in his rural surroundings he interested himself as a child in the natural history of the district. Following a brief schooling, he went to Sodbury near Bristol where he was instructed in the elements of surgery and pharmacy by the eminent practitioner Mr. Ludlow. He was then referred to the celebrated John Hunter in London to pursue further his medical studies. He spent two years under Hunter. The latter was an original thinker - vigilant in observation and scrupulously accurate in examination. He was surely one of the first real scientists in Medicine. Indeed, in an age when any form

of scientist was sorely lacking, his boldness and independence of thought and character must have had a profound effect on Jenner. He did well enough under Hunter for the latter to recommend him for a fellow lectureship and an appointment of naturalist to Captain Cook in 1772. Fortunately for the world he declined both, forsaking wealth and distinction for his beloved countryside.

On his return to Berkeley, Jenner built up for himself a large, busy and quite lucrative practice - at the same time maintaining an active epistolary intercourse with Hunter. The subjects were mainly on natural history and they delved avidly into the mysteries of cuckoos and hedgehogs - both writing many treatises for the Royal Society. It was concerning hedgehogs that Hunter gave his memorable and most valuable advice to Jenner "... why think, why not try the experiment".

In the face of bitter criticism from his colleagues he set out to establish the prophylactic value of cowpox inoculated into a human subject. They felt his pursuits were doomed to failure, ridiculed him for showing so much interest in what was only a rumour, and even threatened to exclude him from further membership of his local medical society should he address any more papers on the subject of cowpox. In the face of this scepticism, he was forced to keep many of his thoughts secret, though he not infrequently alluded to his ideas in letters to dearest friends. It is unlikely, however, that Jenner spent the thirty years prior to the publication of his "Inquiry" in unmitigated devotion to the subject - as his biographer, Baron, would have us believe.

On 14th May 1796 he was, at last, presented with the opportunity to perform his first vaccination for smallpox. He transferred the cowpox from Sarah Nelmes, who had been

infected from milking diseased cows, into the arms of a healthy young eight year old, James Phipps. Jenner on the following 1st July then tried to inoculate the lad with smallpox. He tells the story to his friend Gardner:

"But now listen to the most delightful part of my story. The boy has since been inoculated for the smallpox which, as I ventured to predict, produced no effect. I shall now pursue my experiments with redoubled ardour".

When the cowpox again returned to the diaries in 1798 he made further vaccinations, publishing the results of his experiments in his famous "Inquiry into the Causes and Effects of Variolae Vaccinae". He proposed that the disease "grease" afflicting horses was the origin of cowpox. He maintained that only the true cowpox virus gave protection from smallpox. He called other eruptive lesions on the cows' teats "spurious cowpox". He felt that the protection afforded was life-long, though he was later shown to be wrong in this. As evidence of the efficacy of his discovery he gave twenty-three case histories.

In 1799 he issued an account of his "Further Observations" and in 1800 he published a "Continuation".

Although his discovery was soon widely adopted, controversy raged. Unlike the arguments that had centred round the introduction of inoculation, the arguments presented against vaccination were largely unfounded. Jenner managed to rise above the unworthy scorn of his opponents in the safe knowledge of his own convictions of truth. His public image was never marred, which cannot be said for the majority of his opponents.

Some of the first trials were conducted in the most

unsuitable environment imaginable: the Smallpox Hospital. The vaccination lymph was inevitably contaminated with variola virus and the result was not the solitary pustule characteristic of vaccination, but a mild general eruption of smallpox. Jenner detected the error immediately and there is little evidence that Dr. Woodville, and others of the Smallpox Hospital, distributed any of the contaminated lymph. Jenner himself sent lymph to De Carro in Vienna, Stromeyer in Hanover, Waterhouse in America and also to the Barbados and Newfoundland. In 1802 Parliament granted Jenner £10,000 and reported on the utility of his discovery. Contrasting it with inoculation they concluded that "it introduces a milder disorder, which is not capable of being communicated by contagion". A further grant of £20,000 was made in 1807, in order to offset Jenner's expenses incurred by devoting so much time to vaccination. Many honours were bestowed on him from all over the world, amongst them the freedom of the City of London and of Edinburgh. In 1821 he was appointed Physician Extraordinary to King George IV.

In 1808 Parliament called upon the College of Physicians to inquire into vaccination methods and to organize a Central Institution for the practice of vaccination and the distribution of lymph. Within the first quarter of the nineteenth century Jenner heard many encouraging reports on the utility of his discovery - both from the old and new worlds. He laboured incessantly to disseminate the practice from his first successful vaccination in 1796 to the hour of his death. This great benefactor of mankind died of a cerebral haemorrhage on 26th January 1823.

After Jenner, the supply of vaccine lymph was continued by the National Vaccine Establishment until 1861 when its

powers were taken over by the Privy Council. The supervision, standardization and distribution of the lymph was directed by the Privy Council until 1871. The Local Government Board undertook the responsibility from 1871 until 1919, and then its successor, the Ministry of Health, took over the work.

Before the end of the century another great name was to appear in the history of the prevention of smallpox. Sydney Arthur Monckton Copeman - born on 12th February 1862 at Norwich, son of the Reverend Canon Copeman - was appointed a medical inspector of the Local Government Board in 1891. It was on this board that he did his outstanding work on variola and vaccinia; for which he received many distinctions, including the Cameron Prize of the University of Edinburgh. At that time it was common for arm-to-arm vaccination to be practised. This introduced the dangers of possible attenuation of the virus and also the transmission of other diseases such as syphilis and erysipelas. Sepsis was another hazard from lack of aseptic precautions.

Copeman, investigating the properties of lymph, was the first to demonstrate the selective germicidal action of glycerine on the extraneous bacteria of calf vaccine lymph. Suitable techniques were then devised for preparing the glycerinated lymph.

In 1897 Dr. Copeman, visiting the major European capitals, found that since the publication of his work vaccination with glycerinated calf lymph had become universal. Following Copeman's researches, the Vaccination Act of 1898 stipulated that all vaccine lymph should be derived from the calf and be distributed in glycerinated preparations in air-tight tubes. This effectively abolished arm-to-arm vaccination, and made the technique much more simple and safe.

Although vaccination was made available to the poor in 1840 at the expense of the ratepayers, and by 1853 was compulsory for those under three months, a high proportion of children were not protected. The Public Health Act of 1858 attempted to provide adequate powers for the enforcement of compulsory vaccination, as did the Act of 1871 - and after 1871 a very high rate of vaccination was achieved. However, in 1898 an Act allowed conscientious objectors to be excused vaccination - an act which was interpreted very liberally by the public. The result was a decline in the protection rate of children from around 80% to 41.5% between the years 1898 and 1946.

As well as doing important experimental work and developing calf lymph, Copeman was a notable authority on alastrim and post-vaccinal encephalitis. The history of smallpox shows that no vaccine is absolutely safe. The complications of our present vaccination procedures are extremely rare. They include benign and malignant post-vaccinal encephalitis, vaccinia gangranosa, eczema, septicaemia and sepsis. It must be noted that the introduction of glycerinated calf lymph at the end of the nineteenth century greatly diminished septic complications - another outstanding tribute to Copeman's work. This great man died at Hove on 11th April 1947.

An assessment of the effects of inoculation and vaccination upon the epidemiological picture of smallpox is often regarded as indeterminable, at least until 1837. This is because of the lack of adequate statistics and proper controls. Until 1801 there was no official census in England, and prior to 1837 there was no national registration of births and deaths. Many economic historians have therefore chosen to analyse population trends for the eighteenth century from the London

Bills of Mortality. However, these tables are both full of inaccuracies and are unlikely to be representative of the material trend. For, even as late as 1801, only a fifth of the population lived in towns of over 10,000 people.

What is known is that there was an increase in national population in the eighteenth century beginning around 1740. The causes of this population explosion must be accounted for. Evaluation of statistical evidence prior to registration is doubtful and perhaps more reliable is a qualitative assessment of the sensitivity of the birth and death rates - and their relative effectiveness in promoting a population growth when both rates were high.

Some economic historians hold that an increase in the birth rate was the all-important factor in the rise in population. This is the neo-Malthusian view - that there was an increased birth rate due to expanding employment opportunities and a rise in the general standard of living associated with economic advances, encouraging earlier marriages. However, there is evidence to suggest that marriage age, marriage rate and fertility were relatively constant throughout the eighteenth century. It is now quite clear that the birth rate was more or less constant and that from 1740 onwards there was a sharp fall in the death rate.

The high mortality rates of the eighteenth and nineteenth centuries were largely due to infectious diseases, e.g. typhus, typhoid, tuberculosis, scarlet fever and smallpox. The factors that might favourably affect the death rate from these diseases are environmental improvements; a decreased virulence of the microorganisms; a rise in host resistance and specific curative or preventive medicine. There is little evidence that any of these, apart from prophylactic medicine,

played a part in reducing mortalities.

To dismiss them all individually, there is no evidence that any sociological changes were effective prior to the latter half of the nineteenth century. In many ways environmental conditions deteriorated. Likewise there was neither changes in host resistance nor bacterial virulence (except in the case of  $\beta$ -haemolytic streptococci in the nineteenth century, which is not the present concern). Specific curative medicine in eighteenth century England was known to be even less scientific than it is today.

Having eliminated all other factors which are likely to substantially contribute to a fall in the death rate, all that remains is specific preventive medicine. The only measures introduced in the eighteenth and early nineteenth centuries were inoculation and vaccination. However, to attribute the whole of the population increase to these two factors would be, of course, an oversimplification. The myriad of other marginal factors, too small to assess individually, might well combine and together play a decisive role in causing the population explosion.

For an account of the demographic and economic effects of inoculation and vaccination, the countries of Western Europe and the American Colonies afford the most reliable data. England and Ireland provide excellent examples of the contrasting economic effects of smallpox prevention.

So far the evidence given that inoculation was mainly responsible for the decline in the death rate is largely negative. It has consisted of eliminating all other possible causes so that whatever remains, however improbable, is the

truth. There is, however, a bulk of largely uncovered positive evidence. The chronology of the adoption of inoculation amongst the upper and lower classes fits in with the population increases in these groups.

Recent studies for the aristocracy and gentry (Hollingsworth, 1964) indicate that there was a marked drop in mortality, especially among younger age groups, during the middle of the eighteenth century. Such a population group must be largely unaffected by quantity of food supplies; rises in per capita incomes - thus it is fair to surmise that the introduction of inoculation against smallpox might well account for the drop in mortality.

It is much more difficult to account for the whole of the population rise in terms of inoculation. The statistics may be used to lend support to a multitude of opinions, and hence conclusions would be better rested on the credibility of qualitative argument. For the population as a whole inoculation only became popular after 1765, when the Suttons perfected their much safer technique. The great population increase occurred after 1770 which fits in well with the chronology of the spread of inoculation.

Most economic and medical historians have postulated that any advantages derived from inoculation in the individual were negated by the practice causing perpetuation and spread of the disease. Yet, after 1765, attempts were made to do inoculations on a large scale - especially when epidemics threatened. By inoculating all those in a community who had not had a previous natural or induced attack of smallpox, the dangers of the contagious disease conferred were overcome. The dangers of contagion were also overcome

by strict quarantine regulations, as were observed by the aristocracy and members of the American colonies. Of course, vaccination was the only completely effective measure in that it conferred non-infectious immunity. It is for this reason that vaccination was so very effective in abolishing smallpox - especially from towns, where inoculation largely failed.

Inoculation in large towns was doomed to failure. The magnitude of the problem prevented mass inoculation, and hence isolated inoculations, though beneficial to the individual, were detrimental to the population as a whole. For, as was often the case, the inoculated individual was not strictly isolated and served to disseminate the disease, causing further mortalities. This is possibly why the London and Carlisle tables show such consistently high mortalities from smallpox throughout the eighteenth century. The towns were further unrepresentative of the community as a whole in that the overcrowding and social intercourse abetted spread of the disease; and lack of hygiene and personal well-being caused complications of the disease, thus increasing mortalities.

Inoculation was carried on extensively in Ireland during the latter half of the eighteenth century. By the turn of the century it was practically universal, so that when in 1807 the Dublin College of Physicians were asked their opinion of vaccination they replied "By the frequency of inoculation throughout Ireland, smallpox is rendered a much less formidable disease, and hence parents object to the introduction of vaccination, rather than not recur to that mildness and safety with which they are well acquainted". Fine praise indeed for a practice slandered by so many. The activities of the itinerant Irish inoculators are noted

as late as 1851. The exact decline in smallpox during the late eighteenth and early nineteenth centuries is impossible to trace, there being no statistical information in Ireland during this period. Except for mild outbreaks in 1827 a survey of smallpox epidemics mentions none after 1776. It can be concluded, therefore, that inoculation and vaccination must have been most effective in reducing smallpox mortalities and the overall death rate. Hence the population increase from 1740 to the early nineteenth century may be explained as the result of the gradual elimination of smallpox, and therefore mainly independent of contemporary economic changes.

Why then were the economic effects in England and Ireland so different, if the demographic effects were so similar? For Ireland's population expansion ended in famine and ruin, whereas it allowed England to become the world's first Industrial country. The answer is complex and involves consideration of a wide range of social, political and economic factors. The multitude of factors important in such an issue make any theory an over-simplification.

The population expansion in England, first seen in the aristocracy, resulted in an earlier expansion of the market for quality goods. The consumption of silk and wax candles increased rapidly after 1755. High quality white glass nearly quadrupled its production between 1747 and 1801. The mortality among the poorer classes did not fall significantly until after 1765, and it was not until the end of the century that the home market for poorer quality goods expanded - when the consumption of beer and production of tallow candles and common bottles increased. Beginning probably during the 1770's

there was a considerable expansion of the home market for cheap woollens and cottons - due almost entirely to an increase in population rather than a growth in per capita incomes. The great upsurge of population after 1770 affected every branch of social and economic life - growth of canals, improvement of roads, enclosure of land, development of the factory system - in short, the Industrial Revolution. Although increasing exports and the raised demand of the wealthy led to a growth of production, these were not the foundations of the change. They helped to maintain the real incomes of the mass of the population, and therefore helped to translate increased needs - from an enlarged population - into effective demand, which raised prices and stimulated economic growth. The price of wheat rose from £1.15. 5 per quarter to £2. 2. 6 between 1714 and 1788. Only a radical expansion of mass markets could provide sufficient conditions necessary for the fundamental transformation of the economy, that is, the growth of the new factory capitalism. This is the economy as it developed in England. She was fortunate in that there were, prior to the population explosion, all the potentials that would allow industrialisation: the existence of provincial capital markets and a growing commercial centre in London, a social structure encouraging enterprise and providing a potential mass market, a progressive agriculture, sufficient technical innovation and a thriving textiles industry.

Ireland had none of these potentials for industrialisation and derived no economic benefits. She relied entirely upon a subsistence economy of peasant cultivation. When her potato crop failed, the expanded population was unable to survive. Widespread famine and ruin were the results.

By the beginning of the nineteenth century , vaccination was gaining universal acceptance throughout Europe and the American Colonies. It resulted not only in the decline of the practice of its antecedent, inoculation, but also a marked decline in smallpox mortality and morbidity.

For its effects in Western Europe in the first quarter of the nineteenth century, Sweden offers both a good example and the most reliable statistics. Sweden's annual average smallpox mortality from 1774 to 1801 was over two per thousand of the population. When vaccination was introduced in 1801 there was an immediate fall in mortality - becoming great after 1809, when the level reached one per thousand in one year only. After 1816 it fell to often 0.1, and in one year reached 0.04 per thousand.

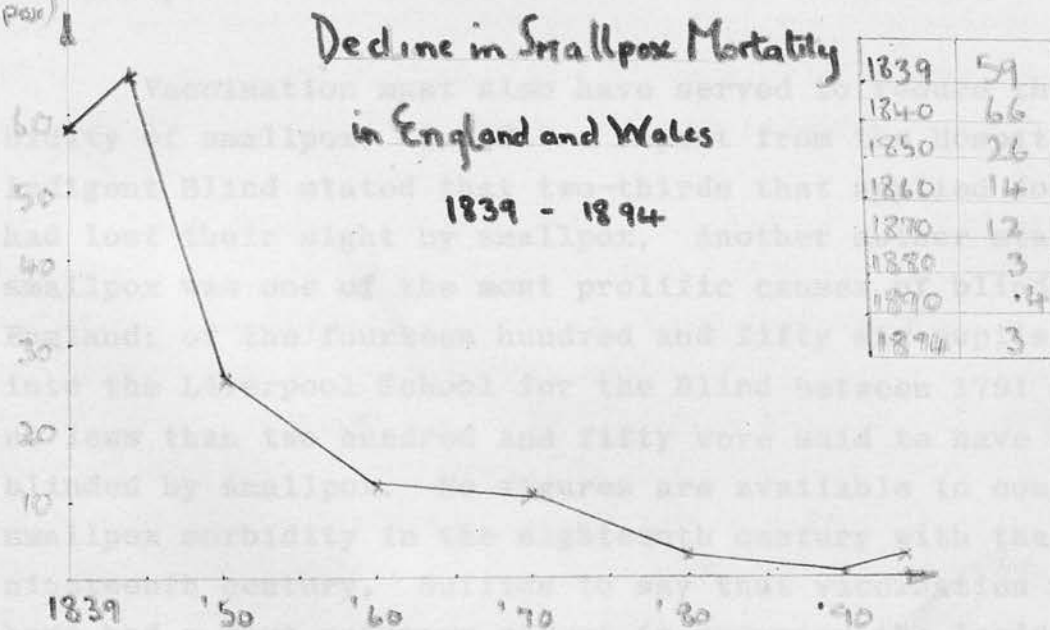
The most exact records of Copenhagen showed smallpox to be prevalent up to 1801, and then a sudden decline - and no deaths were recorded from it between 1810 and 1824.

A similar picture to this sudden decline in smallpox was seen in England in the first twenty five years of the century. However, after this there was both a decline in the prevalence of smallpox and the practice of inoculation. This left an increasing number of the community dependent on vaccination for immunity. Thus the amount of vaccination adequate to afford a great protection in the earlier years ceased to be adequate in later years. It was partly due to this that the incidence of smallpox mortality increased towards the middle of the century and had to be combatted by legislation making vaccination compulsory in 1840.

In 1837 the present system for registration of births

and deaths commenced in England, giving more exact statistics for smallpox. In Scotland a similar system was initiated in 1885, and not until 1864 in Ireland - though information for Ireland can be derived from the decennial census commenced in 1841. Vaccination had, since the beginning of the century, seen widespread adoption in England. Throughout the century there was a marked, though irregular, decline in deaths from smallpox. This is seen in the graph below. The figures relate to deaths returned from smallpox in England and Wales. The irregularities in the decline are most noticeable opposite the years 1840 and 1871. This coincides with the introduction of compulsory vaccination in 1840 and the effective measures to ensure it taken in 1871.

Deaths from smallpox  
(+ chicken pox)



\* Deaths from chicken pox are included with those from smallpox, but they may justifiably be regarded as negligible in comparison and constant throughout.

It is unlikely that any factors other than vaccination played a significant part in causing the decline. However, for reasons essentially unknown, the prevalence of many viral diseases is associated with a natural waxing and waning. Whether there was a natural waning of the disease at this time is unlikely to be determined. Another possible cause of the decline would have been a change in the virulence of the variola virus - but there is little evidence for this. No numerical statement can be made as to the proportion of the total population that had at some time been vaccinated - though it may be inferred that it grew from 1840 onwards and was greater around 1871. It is known that between 1871 and 1878 over 80% of all children born were vaccinated. With these high levels of infant vaccination it is quite probable that vaccination accounted for the whole of the decline of smallpox mortality.

Vaccination must also have served to reduce the morbidity of smallpox. In 1819 a report from the Hospital of Indigent Blind stated that two-thirds that applied for relief had lost their sight by smallpox. Another author states that smallpox was one of the most prolific causes of blindness in England: of the fourteen hundred and fifty six pupils received into the Liverpool School for the Blind between 1791 and 1860, no less than two hundred and fifty were said to have been blinded by smallpox. No figures are available to contrast smallpox morbidity in the eighteenth century with that in the nineteenth century. Suffice to say that vaccination must have had a most salutary effect in reducing the incidence of mental disease, blindness and other sequelae of smallpox.

A similar picture of smallpox in the latter half of the nineteenth century was seen in Scotland and, indeed, throughout Europe. Vaccination was made compulsory in Scotland in 1864 and from then the numbers vaccinated at birth steadily



grew. With the growth in vaccinations, smallpox mortality and morbidity fell - though the decline was very irregular.

Jenner had believed that a single successful inoculation of vaccine matter secured absolute immunity for the future against smallpox. In this he had overrated the effect of vaccination. It is now known that it is not absolute, and that revaccinations are necessary. That he should have overestimated it is not to be wondered at when the tendency to be unduly sanguine, which besets any discoverer, is borne in mind. The concept of immunity conferred by vaccination waning took many years to be fully appreciated. During this time infants protected at birth were being allowed to grow up without revaccination to boost their dwindling immunity. Smallpox was thus able to attack the older age groups. Also, fewer adults were now immune from inoculation or a previous attack of smallpox. The introduction of vaccination thus caused a gradual change in the epidemiological pattern of smallpox.

This is seen in the following figures. The burial registers for the graveyards of St. Cuthbert's, Canongate, and Buccleuch Street, Edinburgh, show that during 1764-1783 the proportion of deaths from smallpox in those below ten years of age was 993 to every thousand deaths from that disease at all ages. Between 1855 and 1859 the proportion of deaths in those below the age of ten (in England and Wales) per thousand deaths was, due to infant vaccination, down to 763. Between 1890 and 1894 it had further dropped to 338. In marked contrast to this, deaths per thousand in those over forty five years of age climbed steadily from near zero in 1783 to thirty one in 1855 and up to 173 in 1894.

The necessity for revaccination was appreciated by

the Germans who, in 1874, made revaccination compulsory. The waning immunity of the population had been reflected in the increased mortality rates just prior to 1874. Revaccination resulted in a dramatic decline in mortalities. In the seven years after 1874 the mortality rate dropped by a factor of 70!

Another important characteristic of vaccination appeared in the nineteenth century. It was found that although the protection it afforded was not absolute it did modify the nature of an attack of smallpox in the vaccinated individual. It usually produced a much milder clinical disease with a less fatal outcome. There are very few reliable statistics to show this as many of those supposedly vaccinated, who later caught smallpox, might possibly not have been successfully vaccinated. However, in a survey conducted in England in 1881 the ratio of deaths from smallpox in those unvaccinated to those vaccinated was 44 to 1. Hence Jenner was right on the cardinal point - the vaccinated individual enjoys a much safer position in society in relation to smallpox than does the unvaccinated.

The beneficial effects of vaccination in the nineteenth century may be summarized as follows. It caused a drastic reduction in smallpox mortality and morbidity; it allowed a much milder disease in those already vaccinated and it also caused an alteration in the incidence of the disease in different age groups - this favoured the saving of many young lives. This must have been most beneficial to the new factory system, whose economy was dependent on a plentiful supply of young labour.

Its effect on the overall death rate of the latter half of the nineteenth century was small in comparison with the reduction in deaths from other causes. Effective improvements in sanitation, clothing, housing, plumbing and nutrition com-

pletely altered the earlier picture of the infectious diseases. The reduction in deaths from smallpox was overshadowed by a decline in deaths from, notably, tuberculosis, but also typhus, typhoid, scarlet fever, dysentery and cholera. The proportion of lives saved which was attributable to smallpox was around 6% compared with 47% from tuberculosis. This 6% represents the contribution of smallpox to the reduction in mortality for which the infectious diseases as a whole were responsible between 1851 and 1891. To attempt to assess this relatively small figure in terms of specific economic effects is impossible.

It must be concluded that the full consequences of the works of men like Sir Hans Sloane, the Sutton brothers, Edward Jenner and Sydney Arthur Monckton Copeman is beyond assessment. They rest from their labours, but their works follow them and adorn the name of British Medicine.

They all strove towards the annihilation of smallpox from the face of the earth. It remains endemic still in large areas of Asia, Africa and South America, but active eradication programmes are being followed along the lines they laid out. It is surely the finest tribute to these great men that smallpox, once the scourge of our country, is now essentially unheard of. What a change from its terrible endemicity two and a half centuries ago, which caused Pope to equate the inevitability of smallpox with that of old age.

"Oh! if to dance all night and dress all day  
Charmed the smallpox or chased old age away,  
Who would not scorn what housewives' cares produce  
Or who would learn one earthly thing of use?"

(Rape of the Lock,  
Canto V)

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