Les conditions sanitaires des populations du passé.
Environnements, maladies, prophylaxies et politiques publiques
Sous la direction de Isabelle Séguy, Monica Ginnaio, Luc Buchet
Éditions APDCA, Antibes, 2018

Inoculation, vaccination and public hygiene against smallpox

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Abstract
We are giving here an historical view of the fight against smallpox. It starts from the beginning of the XVIIIth century, when the medications prescribed by Rhazes from 910 were still applied. However an approach by inoculation, which was supposed to permit everybody to avoid the contagion, begins to develop. We show its evolution in England, New-England and France. This evolution followed very different paths, going for the entire acceptation in New-England till 1750, to the unconditional reject, in France during the reign of Louis XV. At the end of the XVIIIth century a new approach, this time by vaccination, was proposed by Jenner. Even if the population was reticent at its beginning, it quickly accepted this practice and permits its dissemination worldwide during the XIXth century. However some voices would have preferred a more hygienic approach during this century. During the XXth century the World Health Organization undertook the complete eradication of this disease from 1967, and declared in 1980 that the disease had been wiped off the face of the Earth. To accomplish this, it used not only mass vaccination but in numerous cases, when it was insufficient, a strategy founded on hygiene procedures and isolation of patients to break the contagion chain.
Keywords: History, Eradication, Epidemic, Public Health, Population Reaction.

Inoculation, vaccination et hygiène publique face à la variole
Résumé
Nous présentons ici une vue historique des progrès dans la lutte contre la variole. Elle part du début du XVIIIe siècle, où les médications déjà présentées par Rhazes dès 910 sont toujours appliquées. Cependant une approche par inoculation, qui devait permettre de soustraire à la contagion, commence à se développer en Europe. Nous en montrons l'évolution en Angleterre, en Nouvelle-Angleterre et en France. Cette évolution suit des parcours divers allant de la pleine acceptation en Nouvelle-Angleterre dès 1750, au rejet inconditionnel sous la France de Louis XV. À la fin du XVIIIe siècle une approche, cette fois-ci par vaccination, est proposée par Jenner. Bien que réticente au début, la population finit par accepter cette pratique qui se diffuse dans le monde entier au cours du XIXe siècle. Cependant certaines voix lui préfèrent une approche plus hygiéniste pendant ce siècle. Au XXe siècle l'Organisation Mondiale de la Santé entreprend l'éradication complète de cette maladie dès 1967, et la déclare totalement éradiquée en 1980. Elle a utilisé

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pour ce faire non seulement la vaccination de masse mais, dans de nombreux cas où elle ne suffisait pas, une stratégie fondée sur des mesures d'hygiène et d'isolation des malades pour briser la chaine de transmission du virus.
Mots-clés : histoire, éradication, épidémie, santé publique, réactions populaires.

The magnitude of smallpox epidemics in time and space is worth recalling. Outbreaks occurred in different parts of the world for at least two thousand years. The "Antonine plague" that struck the Roman Empire under the reign of Marcus Aurelius in 166 C.E. was probably, in fact, a smallpox epidemic. Another terrible episode called the Mecca epidemic in 572 C.E. spread to Europe as a result of the Arab invasions. The scourge then spread worldwide, notably among the American Indian populations from the earliest European conquests in 1518. De la Condamine (1759) describes the illness thus :

> A horrible and cruel disease, whose germ we carry in our blood, destroys, mutilates or disfigures one-quarter of the human race. (De la Condamine, 1759, p. 615)

How, then, was one supposed to combat such a disease ?

Rhazes[1] (circa 910) was the first physician to clearly diagnose the smallpox, to differentiate it from measles, and to propose different modes of treatment of this disease. He first proposes, before the appearance of the disease, a kind of public hygiene : to follow a healthy detailed meal plan, to wash and bath in cold water, etc. He said[2] :

> And by this means the small-pox is entirely repelled from one who is in such condition that it can be repelled. (Greenhill, 1848, p. 43)

However when the symptoms of the disease occur, this regimen is no more useful :

> When you perceive symptoms of the smallpox [...] : then take from him a large quantity of blood, even until fainting comes on. [...] In order more effectually to perform this extinction, let the patient drink water made cold in snow to the highest degree [...] (Greenhill, 1848 p. 44-45)

However, if the eruption of smallpox cannot be prevented, he proposes to quit this mode of treatment and accelerate this eruption :

> [...] by well raping the patient up in clothes, and rubbing his body [...] you will have then to use these medicines which promotes the eruption. (Greenhill, 1848, p. 46)

Finally, he proposes to ripen and dry the pustules and then to take away the eschars and dry scabs with different preparations. However he recognizes that the disease may be often fatal and presents the different signs of death.

1. Muhammad ibn Zakariya al-Razi (known by his Latinized name Rhazes) was born in 865 in the ancient city of Ray, near Teheran. He is regarded as the greatest physician of Islam during the Middle Ages. He also made his mark in alchemy, chemistry, metaphysics and philosophy. He died in Ray in 925.
2. We are using here the English translation of this book by Greenhill (1848).

His book has been translated in Latin from 1279, in Greek from 1548, in French from 1566, in English from 1717 and in German from 1762. His diagnosis and treatment were followed by the major part of European physicians almost till the XVIII[th] century.

More than seven centuries later, Helvetius[3] in 1722 presents the same ways to fight this disease : he always proposes as the main treatment bleeding, and to use medicines in order to promote eruptions.

However there are other ways not only to prevent and combat but more importantly to defeat this decease. This paper[4] will show how inoculation was introduced in various countries, with a relative failure. Then it will develop how vaccination became compulsory during the XIX[th] century. However some voices rise against vaccination proposing a more public-health-centered theory. The complete eradication of smallpox was effective in 1967, not entirely through mass vaccination, but mainly by isolating patients during the contagion period.

The relative failure of inoculation

The origin of inoculation is hard to trace beyond the seventeenth century. We shall therefore rely primarily on known sources from early eighteenth-century Europe.

For example, De la Motraye (1727) describes an inoculation that he had seen Circassians perform in 1712 :

> As I did not see anyone scarred by smallpox, it occurred to me to ask if they had some secret for protecting themselves from the damage caused by that enemy of beauty among so many Nations. They told me yes, and gave me to understand that [the secret] consisted in inoculating it, or communicating it to those whom they wished to spare from it, by taking pus from a someone infected by it, and mingling it with their own blood by means of incisions made in their flesh. (De la Motraye, 1727, p. 98)

He recounted in great detail an operation in which he had taken part, also noting that he had visited Timonius, a known practitioner of smallpox inoculation. Indeed, Timonius[5] (1714) published a letter dated December 1713 giving a full description of the inoculation, with useful details. While the practice was recent in Constantinople, it seemed to have more distant origins, although the author does not spell them out. He said :

3. Jean-Claude-A. Helvetius was born in 1685 in Paris. He obtained his Doctorate in Medicine in 1708 in the Faculty of Medicine of Paris. In 1721 he was nominated as medical consultant of the young King Louis XV and was informally physician of the Queen Marie Leczinska. He died in Paris in 1755.

4. In a previous paper (Courgeau, 2015) we showed, through the prism of scientific / non scientific knowledge in demography, the example of different points of view on inoculation against smallpox during the XVIII[th] century.

5. Emanuel Timonius or Timone was born at the island of Chios in the Aegean in 1665. He had medical degrees from Padua and Oxford. He was elected fellow of the Royal Society on 1703. He was living in Constantinople when he wrote his paper on inoculation. He died in 1718.

> That altho' at first the more prudent were very cautious in the use of this Practice; yet the happy Success it has been found to have in thousands of Subjects for these eight Years past, has now put it out of all suspicion and doubt. (Timonius, 1714, p. 72)

A few pages later, however, he reports the case of two children aged three who had been inoculated and later died – so he argues – of other diseases.

In 1715, Pylarinum[6] published an article in which he stated that he inoculated a friend's three children in 1701 for the purpose of inducing a benign attack that would spare them from a serious outbreak of the disease. He used practically the same terms as Timonius to describe the method's general applicability, noting that smallpox transmitted in this manner is always benign.

Yet the risk factor involved became the focus of discussions on the usefulness of inoculation in various parts of the world for nearly eighty years.

Reactions in England

In England, the two texts quoted above, despite their acceptance by the Royal Society of London, had little influence on the practices of English doctors even as smallpox epidemics raged across the country. In the event, the first European to use the method was Lady Montagu (1763), whose husband had been appointed Ambassador to the Sublime Porte. It is interesting to see a woman with scant medical knowledge become such an impassioned advocate of the new procedure, at a time when most actual physicians remained skeptical. As early as 1716, she argued that inoculation was harmless:

> There is no example of any one that has died in it; and you may believe I am well satisfied of the safety of this experiment, since I intend to try it on my dear little son. (Montagu, 1763, p. 110)

On her return to England, she also inoculated her four-year-old daughter in 1721 and campaigned for inoculation with Maitland[7]. She convinced the Prince of Wales, the future George II, to inoculate his daughters in 1722. The practice then began to spread, mostly among the British aristocracy.

However, neither Lady Montagu's enthusiasm nor the test performed on six prisoners sufficed to convince a significant number of people that the method was harmless[8]. How did different groups respond to inoculation? What arguments did they use against it? Let us examine the reaction of the populace, doctors,

6. Giacomo Pylarinum or Pylarino was born in 1659 at the island of Cephalonia in the Ionian Sea. He graduated in both law and medicine at the University of Padua. He was a wanderer appointed successively in many countries: Crete, Moldova Wallachia, Germany, Russia, Serbia, Constantinople, Smyrna, and Venezia. In 1701 he began to study inoculation at Constantinople. He died in Padua in 1718.
7. Charles Maitland was born in 1668 in Scotland. He became a surgeon and went to Constantinople in the British Embassy, where Lady Montagu asked him to inoculate her son and it proved successful. Coming back to England he received a Royal License that allowed him to test inoculation on six prisoners. All prisoners survived. He died in Aberdeen in 1748.
8. The test on these prisoners sentenced to hanging, in exchange for their freedom, leads to their survival.

and the clergy, in that order. Often, of course, these responses were not separate but intermingled.

The populace saw inoculation as a costly and complicated procedure whose outcome was uncertain. As Peter Razzell (1977) noted, the cost remained high until 1760 :

> Inoculation was so expensive at this time because of the lengthy period of preparation and after-treatment in special isolation houses, along with the complicated procedures of blood-letting and purging, as well as the special medicines prescribed by attendant physicians. (Razzell, 1977, p. 41)

The general population also greatly feared contagion from inoculated persons. Soon after the London Smallpox Hospital opened in 1746, departing patients were often insulted and beaten in nearby streets. Woodville (1793) said :

> so that they were not suffered to depart until the darkness of the night enabled them to do so without being observed. (Woodville, 1793, p. 238)

Many inoculators were forced to move after being attacked and even injured by their neighbors, who feared the spread of the disease through inoculation.

The second source of resistance was the medical profession. Many doctors were fiercely opposed to inoculation. In 1722, Wagstaffe[9], Fellow of the Royal Society, published *Letter* describing the method's dangers. He questioned the results announced by Timonius and Pylarinum. He began by pointing out that their results, obtained in other climates and in populations with other diets, could not be applied in England. Wagstaffe went even further, arguing that the diversity of smallpox forms had misled Timonius into claiming that the two exceptions he had encountered when verifying his method's effectiveness were due to causes other than smallpox. For Wagstaffe, Timonius' ignorance of such diversity led him to blame on other factors a mortality attributable to inoculation. In any event, it was essential to verify whether the harmlessness thus acquired is complete, and whether – despite the claims by "inoculators" – there might not be a significant number of deaths. Our minds, Wagstaffe argued, reject the notion that mixing purulent matter with our blood might be beneficial for us. Furthermore, by injecting the same quantity of pus in adults and children, the "inoculators" did not dose their injections at all. While inoculation could protect an individual, it could also propagate the disease to other people and in places that had been spared by the epidemic. Wagstaffe charged that inoculation was mostly administered to children whose mortality from smallpox was low (he estimated the rate at only one per cent).

Such an attack was vehement but his conclusions were somewhat contradictory. For example, while claiming that the reactions to inoculation bore no resemblance to the symptoms and course of the actual disease, he asserted that inoculation was dangerous because it tended to propagate smallpox. Other critics, however, called for fuller verification to assess the true effects of inoculation. Many authors hostile to inoculation accordingly tried to show that the disease

9. William Wagstaffe was born in 1685 in England. He had medical degrees at Oxford in 1714 and became fellow of the Royal College of Physicians in 1718. He died in Bath in 1725.

continued to spread via secondary contagion. Likewise, the claim – uncorroborated by genuine statistical evidence – that inoculation caused no smallpox-related death had to be tested by more reliable methods.

Maitland responded to this attack by publishing a brochure in September 1722.[10] He stated that Wagstaffe

> seems not quite so well qualify'd to write upon this Subject; because of the Narrowness of his Experience (as far as appears by his Letter) and his partial Credulity, or Incredulity in Matters of Fact, which he takes from others; and lastly, because of strong Prejudices, which impose upon his most excellent Understanding; and draw him into Reasonings, which either are inconsequential, or conclude strongly for the Practice of *Inoculation*, which they are brought to overturn. (Maitland, 1722, p. 1-2)

A few pages later, he added:

> I must put the Doctor in Mind, that there are very few of the most useful Discoveries in Physick, that have not been strenuously oppos'd by many of the Faculty upon their first Appearance. (Maitland, 1722, p. 3-4)

Like Graunt (1662), Maitland uses the London Bills of Mortality, this time for the period 1707-1718. Of 274,605 recorded deaths, 21,788 – *i.e.*, 7.9% (roughly 1/12 as he reports) – were due to smallpox. Assuming a stationary population, he concluded:

> During this Term of Years, London wanted an Addition of near 22,000 People yearly to keep it equally full. If all Mankind had the *Small Pox*, then 22,000 People, one Year with another had it; of which 1/12 dy'd; If one half of Mankind had the *Small Pox*, then 1 out of 6, who had the Distemper, dy'd of it. (Maitland, 1722, p. 18)

However, he does refine Graunt's analysis by incorporating the age-specific mortality figures obtained by Halley (1693) for Breslau. In that city, migration flows were smaller than in London, allowing the stationarity condition to be more fully satisfied. Maitland's final estimate of mortality from smallpox is one in ten people aged over one year. He compares this rate with the deaths of inoculated persons. The statistics, which unfortunately covered only 500 people at the time, showed a proportion of one per hundred. Maitland concluded:

> A Practice which brings the mortality of the *Small Pox* from one in ten to one in a hundred, if it obtain'd universally would save to the City of London at least 1,500 People yearly. (Maitland, 1722, p. 47)

These approximative results show the need to use more robust demographic and statistical methods to produce a satisfactory estimate of the gains achieved through inoculation. We shall see later what was done to meet this requirement.

The third source of opposition in England was the clergy, whose hostility produced many sermons that had a powerful influence on parishioners. In his *sermon against the dangerous and sinful practice of inoculation* (1722a), Massey declared:

10. This text was actually written by Arbuthnot, as noted by De la Coste in 1723.

> With this view *[Satan [...] smote Job with boils, from the sole of his foot, unto his crown],* I will not scruple to call it a diabolical operation, usurping an authority founded neither in nature and in religion; this practice also tends to support vice and immorality, inasmuch as it diminishes the salutary terror which prevails respecting the uncertain approach of this disease. (Massey, 1722a, p.15)

He thus condemned inoculation as a diabolical practice that thwarted diseases sent by Providence to punish our sins. In a letter published later that year, Massey (1722b) offered other arguments against inoculation. For instance, he denounced the fact of exposing a person in perfect health to a potentially fatal disease. He compared such an act to that of a man

> who jump'd out of the Window when his house was not on fire, only to try what he might perhaps be forced to do hereafter? (Massey, 1722b, p.15)

Without elaborating on his commonsensical arguments here, we shall show that his use of statistics – which, today, would be the most decisive argument – still depended too heavily on rough assumptions.

In the same brochure (1722) Maitland regarded the attacks by the clergy – particularly Massey's sermon – as a greater obstacle than doctors' objections to the acceptance of inoculation by the public. He reported that he was unable to find any command in the Gospels clearly forbidding Christians from undergoing inoculation. Hence, he wrote,

> if the Diminishing the Fear of Dying of Diseases catch'd by Irregularity, is an Evil, then an able Physician is a common Nuisance. (Maitland, 1722, p. 47)

Also in 1722, Nettleton[11] reported the initial results of a comparison of smallpox mortality on a sample of 3,405 non-inoculated patients, of whom 636 (18.7 %) died of the disease, whereas no deaths occurred among 60 other inoculated patients. However, Nettleton (1722) noted:

> I am very sensible you will require a great number of Observations, before you can draw any certain Conclusions. (Nettleton, 1722, p. 212)

The concerns of English researchers of that period are very clear from this text. In 1727, Jurin showed that in a larger sample of 22,151 smallpox patients, 2,848 (12.9 %) died, versus only 13 (2.1 %) of the 624 inoculated patients. Jurin decided to classify all post-inoculation deaths as due to smallpox without taking into account observers' opinions on causes of death. But the degree of proof supplied by these data falls short of today's standard.

Unfortunately, throughout the eighteenth century, there were no general statistics in England that would have made it possible to evaluate progress in the fight against smallpox. Peter Razzell's exhaustive study (1977) shows that many towns and cities resisted inoculation, but eventually adopted it when the epidemic

11. Thomas Nettleton was born in 1683 in Dewsbury. He studied medicine and was awarded in Leiden of his Doctorate in Medicine. In 1721 he began to use inoculation. He collects statistics on the mortality associated to this disease and communicated his results in a series of letters. He died in Dewsbury in 1742.

became too deadly. While Razzell demonstrates that the technique was highly effective in certain rural areas and provincial towns, it was far less so in London because of the endemic nature of the disease there – and despite the establishment of the London Smallpox Hospital in 1746.

Reactions in New England

In 1721, the same year as Lady Montagu had her daughter inoculated, a new smallpox epidemic swept New England starting in Boston, after those of 1677, 1690, and 1702.

Also in 1721, Increase Mather[12] published a document stating that God recommended inoculation to save human lives. He outlined his reasons for taking this position, including the publications of the Royal Society of London and the opinions of several European doctors. Quoting the Bible's Sixth Commandment, "Thou shalt not kill," he thought that inoculation was a gift from God, and saw no need for statistical verification. His son Cotton Mather[13] (1721) fully espoused his father's views, adding:

> I had from a Servant of my own, an Account of its being practised in *Africa*. Enquiring of my Negro-man *Onesimus*, who is a pretty Intelligent Fellow, Whether he ever had y^e^ *Small-Pox*; he answered, both, *Yes*, and, *No*; and then told me, that he had undergone an Operation, which had given him something of y^e^ Small-Pox, & would forever preserve it from it; adding That it was often used among y^e^ *Guaramantese*, & whoever had y^e^ Courage to use it, was forever free from ye fear of the Contagion. (Kittredge, 1912, p. 422)

Cotton Mather thus offered evidence that inoculation was practiced in Africa as well, before it was introduced in Europe.

Faced with the new epidemic, Cotton Mather sent a summary of the articles by Timonius and Pylarinum to Boston doctors, hoping they would respond. Unfortunately, they did not. Mather reiterated his appeal by sending more personal letters to selected physicians. He eventually obtained a single positive reply. It came from Boylston[14], who agreed to inoculate his only son and two slaves, in view of the high risk to which the epidemic exposed them. On the strength of these initial successes, Boylston managed to inoculate 248 patients in Boston, while two of his colleagues inoculated another 39. Among these 287 patients, he observed only six deaths, *i.e.*, a mortality rate of 2.1 %. By comparison, the epidemic generated

12. Increase Mather was born in 1639 at Massachusetts Bay Colony. He was awarded with a Master of Arts degree in Dublin on 1659 and then ordained as minister of the North Church on 1664 where he remained until he died. He was involved in the Salem's witch trials and he refused to denounce them. He died at Boston in 1723.

13. Cotton Mather, son of Increase Mather, was born in 1663 at Boston. He was awarded Master of Arts on 1681 at the University of Glasgow. His deep interest in science made him the first native born American to become the fellow of the Royal Society in 1713. He died at Boston in 1728.

14. Zabdiel Boylston was born in 1679 at Brookline. He studied under different physicians, as there was no medical school at this time in North America. He performed several 'firsts' operations in his country. He became a fellow of the Royal Society in 1726 for his results on Smallpox. He died in 1766 at Boston.

5,759 cases of smallpox of which 844 were fatal, a rate of 14.7 %. On the six deaths of inoculated persons, Boylston (1726) wrote :

> though they had not all the Small-Pox only by Inoculation, as we have Reason to believe, but were some of them infected in the natural Way, before Inoculated. (Boylston, 1726, p. 34)

Despite its lack of clarity, the wording does describe the notion of immunization, now fully recognized. The introduction into the organism of an infectious agent that has lost its pathogenic power triggers an immune defense response that becomes permanent. The inoculation of a patient already suffering from the disease is therefore too late to be effective.

One might have thought that the method would not encounter opposition from the medical faculty and the clergy – unlike what had occurred in England. After all, inoculation was defended by a minister of the main denomination in Boston at the time and practiced by a physician with an excellent reputation, who had performed the first surgical operation in New England in 1710. In the event, however, the opposite scenario played out. To better understand this resistance, we need to examine in greater detail the personalities of the two ministers and the doctor in the context of colonial New England.

The Mather family provided a line of Puritan ministers in Boston, and Cotton is regarded as one of the most influential clergymen of North America in his time, because of his scholarly as well as religious writings. He was an active Fellow of the Royal Society of London since 1713, reading its publications and criticizing them when he felt the need to do so. In 1716, he performed one of the first experiments in plant hybridation. However, he was criticized for his part in the Salem witch trial. As we shall see, his role and that of his father Increase Mather in the spread of inoculation came under attack as well.

Boylston received his medical training from his father, as there was no School of Medicine in North America at the time (the first was founded in 1765). He was the first American surgeon to perform a gallstone extraction in 1710 and the first removal of a mammary tumor in 1718.

Thus, in spite of their high reputation in their respective fields, the two men were violently attacked for their involvement in the brand new practice of inoculation. In other words, the method's novelty was the factor that triggered public hostility.

To begin with, as noted earlier, none of the doctors first contacted by Mather answered his call despite the Royal Society publications that he had sent them. Moreover, Boylston managed to inoculate fewer than 300 patients – a mere 3 % of the population of a town with some 10,000 inhabitants in 1720. His impact, therefore, was minimal.

In fact in 1722, Douglass[15] – the only Boston physician who had studied in Europe and therefore regarded himself as superior to his colleagues – wrote a

15. William Douglass was born in 1691 at Gifford in Scotland. He received his Master Degree at Utrecht. He arrived in Boston in 1716 where he was the only physician with a medical degree. He engaged in

pamphlet accusing "*Six men (commonly call'd the six Inoculation Ministers)*"[16] of claiming that inoculation should become universal. Curiously, Douglass directed his fiercest attacks not against inoculation itself but against the inoculators. This did not change the ultimate impact of his campaign but only affected its scope.

Douglass begins by attacking the Puritans, whose "*Infatuation*" led to "*the hanging of those suspected of Witchcraft, about the Year 1691*." Although Cotton Mather later admitted his error, his writings did indeed contribute to the trial and execution of the Salem witches. Douglass goes on to suggest that, thirty years later, Boston could relapse into the same errors by introducing inoculation.

Douglass recalls the initial refusal by all doctors to perform a procedure whose effectiveness is barely guaranteed, and then describes the outcome of Cotton Mather's second attempt to convince them :

> At length one of them (more bold than wise or knowing in his Business) finding by his bad Success in the cure of his first natural Small Pox Patients, that he should make but a poor hand of it, embraces the Project, [...] (Douglass, 1722, p. 2)

This slanted description of the way in which Boylston – whom Douglass characterizes as a poorly trained physician – tested inoculation is designed to cast doubt on the effectiveness of the method and must surely have achieved its goal. Douglass also discredits Mather's use of a black slave's knowledge :

> Their second Voucher is an Army of half a Dozen or half a score of *Africans*, by others called Negro Slaves, who tell us now (tho' never before) that it is practised in their own Country. (Douglass, 1722, p. 4)

His awareness that for many Bostonians a black slave is not a trustworthy source gives added strength to his argument.

As for the successes of the technique, which inoculators describe as harmless, Douglass writes :

> We soon found it *infecting*; many have dy'd of the Infection received from the Inoculated, whose *Deaths* in a great measure lie at the *Inoculators doors*. (Douglass, 1722, p. 11)

He thus claims that inoculation aggravated the smallpox epidemic.

Among the clergy, opposition was milder because of the support from Increase and Cotton Mather. However, of the sixteen ministers preaching in Boston, only six outspokenly endorsed inoculation. Among these others Williams (1721) wrote :

> There is no Rule in the Word of God to found Inoculation upon. *Therefore*, Inoculation cannot be according to the Will of God, nor according to Knowledge. (Williams, 1721, p. 2)

He went even further (1722) by stating that inoculation was the Devil's work, since it allowed evil people to avoid God's wrath :

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economic, political and medical controversies. He died at Boston in 1752.

16. This volume was published anonymously, but Douglass made no effort to conceal its authorship.

> I do seriously believe it*[']*s a Delusion of the Devil; and that there was never the like Delusion in New-England, since the Time of the Witchcraft in Salem, *[...]* (Williams, 1722, p. 4)

a clear reference to the trial in which Cotton Mather, unfortunately, had been heavily involved.

The press, too, played a role in this rejection. Despite declarations of neutrality, the weekly *New-England Courant* – edited by James Franklin elder brother of Benjamin who worked with him at that time – served chiefly as a medium for a host of anti-inoculation diatribes. On December 9, 1721, Cotton Mather wrote in his diary (1911):

> Warnings are to be given unto the wicked Printer, and his Accomplices, who every week publish a Vile paper to lessen and Blacken the ministers of the Town & render their Ministry ineffectual. A Wickedness never parallel'd any where upon the Face of the Earth! (Mather, 1911, p. 663)

This press campaign, combined with various publications by doctors and clergymen against inoculation, led Bostonians to take extreme action:

> So bitter was this opposition that Dr. Boylston's life was in danger; it was considered unsafe for him to be out of his house in the evening; a lighted grenade was even thrown into the house of Cotton Mather [...] (White, 1896, p. 254)

Boylston was also severely reprimanded by the *Select Men* ("an Order of Men, who are the *Overseers* and *Managers* of the *Town-Affairs*"), who advised him to refrain from practicing inoculation in the future.

The controversy did not cease until the end of the epidemic in late February 1722.

A calmer attitude eventually prevailed. Boylston visited London in 1724 and was elected Fellow of the Royal Society in 1726. In a book (1726) Boylston sought to respond to all his critics. When smallpox struck Boston again in 1730, Douglass personally administered inoculations. We can measure the impact of inoculation on smallpox mortality in Boston in the eighteenth century by using data from registers and similar documents. Table 1 shows the results.

Year	1721	1730	1752	1764	1776	1788	1792
Natural smallpox cases	5,759	3,600	5,545	699	304	122	232
Deaths	842	500	539	124	29	40	69
Rate per 1,000	146	139	97	177	95	328	298
Inoculated smallpox cases	287	400	2,142	4,977	4,988	2,121	9,152
Deaths	6	12	30	46	28	19	179
Rate per 1,000	21	30	14	9	6	9	20
Total smallpox deaths	848	512	569	170	57	59	284
Rate per 1,000	79	37	36	11	10	6	10

Table 1. Mortality from smallpox epidemics in Boston during the eighteenth century (Razzell, 1977, p. 142).

Two patterns are visible: first, the progress of inoculation in the city, from a slow start in the first half of the century but with major gains starting in 1752; second, the low mortality due to inoculated smallpox by comparison with the high rate from natural smallpox, which persisted throughout the century. Inoculation thus preserved Boston from the devastating epidemics: when smallpox broke out again in 1792, practically the whole town was inoculated within a few days and only 284 deaths occurred, leading to a death rate of 1 % for a total population of 19,300.

Inoculation was then practiced in different parts of New England, as in Philadelphia after 1730. Benjamin Franklin (1759) wrote:

> Some years since [1730], an enquiry was made in Philadelphia of the several surgeons and physicians who had practis'd Inoculation, what numbers had been by each inoculated, and what was their success. The result of this enquiry was, that upward of 800, (I forget the exact number) had been inoculated at different times, and that only four of them had died. (Franklin, 1759, p. 5)

This leads to a death rate of 0.5 % for the inoculated population. Unfortunately for him, his eldest son contracted the smallpox virus during the Philadelphia epidemics of 1736 and died shortly after. He was not inoculated. This changed the attitude of Benjamin Franklin who was critical of inoculation with the *New England Courant* in 1721, as we previously said, and became later a strong advocate of this practice.

By mid-century, the Royal College of Physicians was recommending inoculation as a safe and effective method.

Reactions in France

The situation in France was very different from the one prevailing in England and the American colonies. As noted earlier, De la Motraye did discuss inoculation as early as 1712, but it was barely applied in France.

At the end of the Regency in 1723, and after the results obtained in England and New England, the Sorbonne reviewed the advantages of inoculation and concluded that testing could begin without interfering with Divine Providence. But the Regent's death put a rapid end to the trials, and several publications fiercely attacked the new method.

For example, Hecquet[17], Dean of the Faculty of Medicine and a staunch foe of innovation, wrote a violent pamphlet against inoculation (1724) in which he leveled a barrage of charges against it. Some of these criticisms resembled those voiced in England and New England. But Hecquet produces other arguments as well, including the accusation of magic, which was hardly ever used in other countries.

17. Philippe Hecquet was born at Abbeville in 1661. He received his medical degree from the Faculty of Reims on 1684. He then came to Paris where he became Regent Doctor at the University of Paris in 1697. He was in particular doctor of medicine in the abbey of Port-Royal. He died in Faubourg Saint-Jacques in 1737.

The approval of the Royal Censor, Doctor Burette, states that Hecquet's work and the observations it contains "all conform to the ancient practice of medicine."

In December 1723, De la Vigne de Frécheville[18] discussed the following question at a meeting of the Faculty of Medicine: *Is it permissible to offer smallpox inoculation?* The answer was very clear[19]:

> Reasoning, Theory rejects Inoculation; observations are no longer favorable to it; they show us that this practice makes smallpox outbreaks more contagious & accompanied by a greater number of accidents: why should we conduct experiments? (De la Vigne de Frécheville, 1755, p. 38)

Hence he concluded that it is not permissible to offer Smallpox Inoculation.

In his thirty-year reign, Louis XV imposed the School of Medicine's vision. Ironically, he fell victim to smallpox and died of it in 1774, after having blocked all attempts to eradicate it during his years in power!

While the School of Medicine was discussing the usefulness of inoculation, Voltaire – who nearly died of smallpox – wrote a letter in 1734 on the insertion of smallpox in which he observed:

> Reportedly, there is preaching in Paris against this salutary invention just as there were writings against Newton's experiments twenty years ago. Everything proves that the English are more philosophical and bolder than us. It does indeed take time for a modicum of reason and mental courage to cross the Channel. (Voltaire, 1734, p. 103)

But this text was banned in France and had to be published abroad. For whatever reason, there were few attempts at inoculation in France, more specifically in Paris, during those thirty years. The doctors who performed the procedure were foreigners: Gatti, an Italian, and Trochin, a Swiss.

In 1754, however, De la Condamine submitted a paper on inoculation to the Academy of Science. He listed all the objections, to which he responded very clearly. Unlike the arguments of the Anglophones – who reasoned as statisticians – De la Condamine's were essentially rational. Although he did use Jurin's figures (1727), he did not present any statistical tables. He was very outspoken about this:

> As I am speaking here for everyone, & least of all to mathematicians, so that no one should be in doubt about what I want to prove, I shall avoid not only algebraic formulas but any expression that is not in common use. (De la Condamine, 1754, p. 649)

He concluded by explicitly calling on the Faculties of Theology and Medicine, and on senior magistrates, to dispel the misgivings fomented by ignorance. Admittedly, this was a way of challenging those who had banned inoculation thirty

18. Claude de la Vigne de Frécheville was born in Paris in 1695. He received medical degree from the Faculty of Paris on 1719. He was nominated physician of the King Louis XV on 1726 and of the Queen Marie Leszczynska on 1729. He died in 1758.

19. We use here the French version of this question published in 1755: *Est-il permis de proposer l'Inoculation de la petite Vérole?* Paris: Chez Delaguette, Libraire & Imprimeur, rue S. Jacques, à l'Olivier,

years earlier to reconsider their position. De La Condamine's paper proved a huge success. It was printed immediately and all the Paris periodicals talked about it.

However, in his second paper (1758), he was forced to admit that his crusade had largely failed:

> At least two hundred people have been inoculated in France in the past four years. Half of them are adults, who are more at risk of smallpox than children. (De la Condamine, 1758, p. 459)

In his third paper (1765), he reported slightly over one thousand people inoculated in France over the past decade. In fact all the institutions, from the Faculty of Theology to the provincial *parlements* (courts) rejected it, although in 1766 the Faculty of Medicine voted to tolerate it with certain restrictions. But many doctors persisted in their vehement opposition.

The first attempt to model the action of smallpox epidemics was made by Daniel Bernoulli in 1760. His exposition is regarded as the first true model in social science. Under a set of hypotheses, Bernoulli presents:

> in a single Table the two states of humanity, one as it actually is, & the other as it would be if one could deliver all of mankind from smallpox. (Bernoulli, 1760, p. 1)

From this table, he can calculate the gain in life expectancy that would be obtained by inoculating the entire population:

> that of the non-smallpox condition is twenty-nine years [and] nine months, whereas for the natural condition it is only twenty-six years [and] seven months; the gain is roughly 2/17ths of the natural average life span. (Bernoulli, 1760, p. 29)

He is reasoning here in terms of objective probabilities.

His controversy with D'Alembert offers an example of the opposition between two men of science, one of whom adopts a non-scientifically recognized point of view at that time, in order to show the inadequacy of his adversary's argument. Relations between the two were chilly. However, D'Alembert's arguments deserve more attention here, for they partly concern the relevance of objective probability in dealing with a human matter: the acceptance or refusal of inoculation by an individual member of the population. For the many other points of disagreement, we refer the reader to the study of Brian (1996) that had examined them in detail.

To begin with, D'Alembert does not reject inoculation outright – far from it. In his paper of 1760, he writes:

> that we should therefore carefully refrain from stopping or delaying its spread; & that it is the only means of acquiring on this important subject all the insights that one might wish, so as to henceforth protect inoculation from any attack. (D'Alembert, 1760, p. 45)

But he rightly notes that life expectancy – which is an average value – does not constitute a sufficient measure of the benefits of inoculation:

> a man who submits to inoculation is more or less in the same situation as a Gambler who stands one chance in two hundred of losing all his property in a day, in exchange for the hope of adding to that property an unknown

> & even fairly small sum, after a number of years in the very distant future, & when the enjoyment of this increase in fortune will mean less to him. Now how can we compare this present risk with this unknown and distant advantage ? That is a point about which the Analysis of probability cannot teach us anything. (D'Alembert, 1760, p. 33-34)

In other words, D'Alembert attacks probability analysis, which cannot assess this reasoning because it involves the long term, and the value assigned by an individual to a present event is very different from the value (s)he assigns to a future event.

The objectivist arguments that make inoculation advantageous for the *State* become worthless against the subjectivist arguments that *Individuals* put up against it. Hence the need for a subjective probability that could apply to these personal cases, which cannot be dealt with by means of objective probability.

Unfortunately, however, D'Alembert did not succeed in establishing the subjective probability that he wished to use. In his 27th paper (1768), he wrote :

> But I also hope that my doubts will prompt skilled, unbiased persons to delve deeper into this thorny subject, & to give it the degree of self-evidence that it can potentially embody. (D'Alembert, 1768, p. 308)

To this invitation, Bayes had already provided at least a partial answer (1763). He framed the problem to be resolved as follows :

> *Given* the number of times in which an unknown event has happened and failed : *Required* the chance that the probability of its happening in a single trial lies somewhere between any two degrees of probability that can be named. (Bayes, 1763, p. 376)

He offered a solution for a simple case, generalizing it to more complex ones. But his paper was received with strong hostility in France. An unsigned article in the *Journal Encyclopédique* of 1766 stated :

> We are quite surprised to find in this gathering an article filled with absurdities. The greatest Algebraists candidly admit that they fail to understand anything about it. (Anonymous, 1766, p. 84)

Regrettably, the author does not identify these algebraists, but it is hard to imagine that D'Alembert was one of them. Indeed, excluding the article above, D'Alembert was among the first in France to cite Bayes's paper in parallel with the studies by Laplace in 1774 and in connection with the probability of causes by events, in 1780. (D'Alembert, 1780, p. 60)

Arguably, however, it is Condorcet who fulfilled D'Alembert's wish when he proposed a method for addressing this problem (Condorcet, 1770, p. 256-260), which Laplace solved in 1774 by using the normal approximation. However, after trying in vain to analyze the case of inoculation with this method, Condorcet concluded :

> I do not discuss inoculation here, a difficult and important topic on which I shall be able to prepare a specific paper. (Condorcet, 1770, p. 261)

He realized that this problem is more complex than the others, as it involves other characteristics of the person concerned, but he never wrote this specific paper.

In our view, the introduction of greater freedom in prior distributions did not become a possibility until a century and a half later. This was achieved by De Finetti (1937), who axiomatized subjective probability:

> given a complete class of incompatible events , all the probability estimates that assign random non-negative values summing to unity are admissible estimates: each of these estimates reflects a consistent opinion, an intrinsically legitimate opinion, and each individual is free to adopt whichever of these opinions he prefers, or, to put it better, the opinion that he *feels*. (De Finetti, 1937, p. 8)

For De Finetti, an event is always a unique fact, and we cannot speak of the probability of a more general phenomenon. This reasoning is thus perfectly suited to a mother's assessment of inoculation for her child. As long as the risk of dying after inoculation is non-null, the mother will refuse the procedure because of her very strong "feeling" – as De Finetti puts it – that inoculation threatens to deprive her of a child who has not even been infected by smallpox. Accordingly, smallpox vaccination becomes acceptable because the population is convinced that it is harmless.

Our purpose here is not to make a value judgment on subjective probability, but merely to note that it allows a mathematical theory to take into account the non-objective reasoning of mothers.

The almost immediate success of vaccination

As with inoculation, it is hard to identify an inventor for vaccination. Without going back to its alleged origin in ancient India, discussed below, its discovery by Jenner has been contested.

First, many English farmers had long known that people in regular contact with cows infected with cowpox never caught smallpox. In a letter of 1798,[20] Fewster[21], a surgeon in Thornbury, reported that he had inoculated a large number of peasants in 1768 – to no effect. When one of the inoculated assured him that his lack of symptoms was due to his having contracted smallpox previously, Fewster ascertained that all the other inoculated were also in the same situation. He then reported the fact to a medical society of which he was a member, but no one thought to investigate further. Yet, in the same letter, Fewster declared:

> I do not see any great advantage from inoculation for the Cowpox. Inoculation for the Smallpox seems to be well understood, that there is very little need of a substitute. (Pearson, 1798, p. 103)

20. Letter quoted in G. Pearson, 1798, p. 102.

21. John Fewster was born in 1738 in Stonehouse. He began his medical career with a seven year apprenticeship at the Bristol Infirmary. He opened an 'inoculation house' and co-founded the Convivio-Medical Society discussing medical cases, in 1763. He died in Thornbury in 1824.

As we shall see, Pearson[22] (1798) did not fully subscribe to the latter conclusion, but mentioned it out of honesty.

During the 1774 smallpox epidemic in Dorsetshire, a farmer named Jesty vaccinated his wife and two children with pus extracted from a lesion in the udder of a cow infected with cowpox. When the news became known, Jesty's neighbors jeered him and threw mud and stones at him. The scientific community did not learn of Jesty's experiment until 1803, when Andrew Bell described it in a note to the Jennerian Society.[23] The Society recognized the precedence of Jesty's vaccination but did not grant him a financial reward.

Jenner[24] had been inoculated as a child and had nearly died as a result. This partly explains why, despite having become a doctor, he was so reluctant to administer inoculations. However, he observed and enumerated the patients who, after being infected by the cowpox virus, became resistant to inoculation or the disease itself. This led Jenner, in 1796, to immunize an eight-year-old child by inoculating cowpox and to observe his reaction a month and a half later. The boy's immunity was obvious, prompting Jenner to write an article that he submitted to the Royal Society in 1797.

In contrast to the acceptance of the papers on inoculation by Timonius and Pylarino in 1714 and 1715, the article was rejected on grounds of insufficient data. Home Everard, who considered informally the paper submitted to the Royal Society, wrote in 1797 :

> the instances are much to few to admit of conclusions being drawn from them – if 20 or 30 children were inoculated *[sic]* for the Cow pox and afterwards for the Small pox without taking it, I might be led to change my mind to change my opinion, at present however I want faith. (Baxby, 1999, p. 2)

We may think that the number of 20 or 30 children may always be considered as too few, compared to the numbers given for inoculation.

But Jenner was determined to publish his results. After adding nine other cases of vaccination, he issued his monograph in 1798, at his own expense. The pamphlet is the first text to contain the Latin phrase *variolae vaccinae*. After publication, Jenner went to London with his vaccine, hoping—in vain—to convince his colleagues of its usefulness. They rejected it as unnatural and even dangerous. Some time later, however, he received an encouraging letter from a physician informing him that the vaccine was effective. This news, which the physician also circulated among his colleagues, paved the way for an initial acceptance of vaccination.

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22. George Pearson was born in 1751 at Rotherham. He obtained the degree of Doctor of Medicine in 1773. He was also a chemist who discovered the calcium phosphide. He died in London in 1828.
23. Note quoted in Robert Southey, *The life of the Rev. Andrew Bell*, vol. II, London : John Murray, 1864.
24. Edward Jenner was born at Berkeley in 1749. He was instructed in the elements of surgery and pharmacy near Bristol by a surgeon and then went to London to prosecute his professional studies. He was elected fellow of the Royal society in 1788, following his zoological study of the nested cuckoo. He then undertook his work on vaccination which leads to a complete success. He died in 1823 at Berkeley.

We have seen that the debates over inoculation focused largely on demographic, statistical, and probabilistic issues. For vaccination, the main debates centered on other aspects.

Jenner's statistical arguments were indeed very weak, and the Royal Society rejected his first article for precisely that reason. His demonstration relied on so few cases that it hardly allowed practitioners to choose between the advantages of vaccination and those of inoculation. In 1798, Pearson wrote:

> For though in several hundred examples of the Cowpox, which have been under observation, not one person has fallen a victim; this might, and indeed has been, the fortunate issue of the inoculated Smallpox [...] (Pearson, 1798, p. 66)

However, Pearson noted that inoculation was especially dangerous because of the outbreak of pimples, and concluded:

> there is great probability of the Cowpox either not proving fatal at all, or at most being much less frequently so than the inoculated Smallpox. (Pearson, 1798, p. 68)

Taking the investigations further, Woodville[25] noted in 1800 that vaccination created resistance to the effects of a subsequent inoculation:

> I can now say, that more than: 1000: of those who had undergone the new inoculation had been put to the same test, and that the like result has been experienced. (Woodville, 1800, p 25)

In 1801, Jenner triumphantly asserted:

> The distrust and scepticism which naturally arose in the minds of medical men, on my first announcing so unexpected a discovery, has now nearly disappeared. Many hundreds of them, from actual experience, have given their attestation that the inoculated Cow Pox proves a perfect security against the Small Pox; and I shall probably be within compass if I say, thousands are ready to follow their example; for the scope that inoculation has now taken is immense. (Jenner, 1801, p. 7)

Despite this emphatic rhetoric, however, some voices began to speak up against vaccination.

First, unlike the human-to-human procedure of inoculation, the introduction of animal matter in a person worried many observers. In 1802, the caricaturist Gillray published a cartoon about vaccination showing the eruption of farm animals on human noses, cheeks, arms, mouths, and other body parts. Many doctors also attacked vaccination from the same angle. In a volume published in 1805, the ophthalmologist Rowley[26], author of many books for the general public on a wide variety of subjects, asserted that he had treated a boy who, after vaccination,

25. William Woodville was born at Cockermouth in 1752. He graduated Doctor of Medicine on 1775 at Edinburgh University. He was then elected physician to the London smallpox hospital and published the first volume of a history of inoculation on 1796. He died at London in 1805.

26. William Rowley was born at London in 1743. He obtained a degree of Doctor of Medicine on 1774 from the University of St. Andrew. He was a determined opponent of vaccination and wrote many books most of them popular in style. He died at London in 1806.

underwent a transformation and acquired the face of a cow. He also asserted that vaccination had led to many deaths from smallpox, the disease that it was supposed to prevent. But these anti-vaccination campaigns never reached the scale of those waged by doctors against inoculation in the eighteenth century.

Other doctors, less aggressive than these predecessors, showed that the results of vaccination were not as positive as Jenner claimed. A report submitted by a committee of doctors in 1804 examined cases of children who not only contracted smallpox after vaccination but died of the disease. While the authors recognized that the deaths were indeed caused by smallpox, they concluded:

> The Committee however, feels it a duty to remark, that the above facts are not to be considered as militating against the general practice of vaccination. (Anonymous, 1804, p. 31)

The small number of deaths was viewed as a positive factor. Throughout the nineteenth century, however, it was almost impossible to assess the protection provided by earlier vaccination on mortality from smallpox in England. During the decade 1891-1900, of a total 4,058 deaths from smallpox recorded in England and Wales, only 34 % of medical certificates mentioned whether the deceased was vaccinated or not.

By comparison with their attacks on inoculation, the Christian churches also became less hostile, and the clergy now supported the authorities in their efforts to disseminate vaccination. But in India, the sacred status of cows created strong resistance to the new method. What means did the British employ to reverse Indian public opinion in favor of vaccination? This time, the use of a non-scientific practice was invoked as a reason to accept a scientific one.

In order to provide viable vaccine to India, Jenner tried to ship in 1799 his vaccine to Bombay, but unfortunately the boat burned in 1800 and never reached its destination. Eventually, the vaccine – carried by a vaccinated child – made its way by land to Baghdad, then Bombay, in 1802. The initial Indian opposition to vaccination was all the stronger as the Brahmin had long been practicing inoculation.

To promote the new technique, the British published pamphlets in the various languages spoken in India, including Sanskrit, as early as 1802. Unfortunately, most of these publications, regarded as ephemera, have not survived. But they did ensure the success of vaccination campaigns.

In 1819, the *Madras Courier* published an article signed by a "Calvi Virumbon"[27] claiming that cowpox inoculation was known to ancient Indian doctors. Virumbon quotes a text attributed to Dhanwantari, a divine physician regarded as a human manifestation of Vishnu. The source is given as the *Sactéya Grantham*. The text, originally in Sanskrit, reads:

> Take the fluid of the pock of the udder of a Cow, or on the arm between the shoulder and elbow of a human subject, on the point of a lancet, and lance with it the arms between the shoulders and elbow until the blood appears;

27. Text unearthed by D. Wujastyk, 1987, p. 125-126.

> then mixing the fluid with the blood, the fever of the Small-Pox will be produced. (Wujastyk, 1987, p. 124)

The author goes on to describe the effect of vaccination, which is qualified as harmless.

This information was reproduced in many medical dictionaries throughout the nineteenth century. In fact, however, many signs pointed to the text as being a forgery. Wujastyk (1987) has shown that cowpox was unknown in India before 1802. In all probability, therefore, the document was concocted between 1802 and 1819. In 2006, Trautmann published a tract written by Ellis, a specialist of Dravidian languages who lived in India from 1796 to 1819. Ellis (2006) clearly demonstrated the origin of the bogus Sanskrit quotation, doubtless fabricated to promote the adoption of vaccination by Indians.

This example is thus substantially different from the ones discussed earlier. Here, the alleged discovery of a text several thousands of years old allowed a population to accept a medical treatment anathema to its religious beliefs.

Vaccination became compulsory in many countries during the nineteenth and early twentieth centuries : in Bavaria, Denmark, Hanover, Norway, and Sweden in 1821 ; in England, Scotland, and Wales in 1853 ; and in France in 1902.

However, a certain number of doctors, bacteriologists, and biologists rejected Jennerian vaccination, such as Tebb (1884)[28], Crookshank (1889)[29], Creighton (1889)[30], and Wallace (1898)[31]. A number of local and even national leagues were created in Great Britain and in America, like the Leicester (later National) Anti-Vaccination League founded in 1869. We have already presented some of their arguments on the relevance of the statistics produced by official authorities. Most often, however, they opposed the compulsory nature of vaccination, which they saw as an attack on personal freedom, and they developed a public-health-centered theory of the fight against epidemics. The title of the book by John Thomas Biggs (1912), a sanitary engineer, was very clear : *Leicester : Sanitation against vaccination*. More recently, some scholars such as Razzell (1980) deny the role of vaccination, arguing that it is in fact an inoculation, as the main stock of vaccines used by Jenner

28. William Tebb was born in 1830 in Manchester. He was a business man and wide-ranging social reformer. He was an anti-vaccinationist and author of many books against it. He died in 1919 in Burstow.
29. Edgard Crookshank was born in 1858 in London. He was qualified for medicine in 1881. His investigations led him to conclude that Jenner's vaccine was ineffective in preventing smallpox because the two diseases (cowpox and smallpox) were totally distinct. He died in 1928 in London.
30. Charles Creighton was born in Peterhead in 1847. He graduated M. B. in 1871 in Aberdeen. He was a voluminous writer on medical and literary subjects and particularly on vaccination. On this subject he came to the conclusion that Jenner's doctrine was an error. He died in 1927 in Upper Boddington village.
31. Alfred Russel Wallace was born in 1823 in Llanbadoc. He did not follow any University courses being born into an impoverished middle-class family. However he spent 14 years of life in the Amazon Basin and the Malay Archipelago collecting entomologist specimens. He developed in 1858, before the publication of Darwin *On the Origin of species*, a concept similar to his mechanism of natural selection. He won election to the Royal Society in 1893. He raised also a number of arguments against vaccination. He died in 1913 in Broadstone.

in 1799 and after was obtained not from cowpox but was prepared – by Woodville – from human smallpox.

How and when the eradication became possible

In 1966 the World Health Assembly voted a special budget to eliminate smallpox from the world. At that time, smallpox was endemic in more than 30 countries. Eventually, on May 8, 1980, the World Health Organization (WHO) declared that the disease had been wiped off the face of the Earth.

It is interesting to read the final report published in 1980 (WHO, 1980), which offers a better understanding of how this result was achieved. Mass vaccination, it turns out, had its limits :

> Eradication campaigns based entirely or primarily on mass vaccination succeeded in some countries but failed in most. (WHO, 1980, p. 31)

In some countries such as India, where vaccination coverage reached 80% or even 90%, smallpox transmission persisted, making it necessary to implement other strategies.

First, it soon became clear that an active monitoring of epidemic outbreaks would be more effective than blanket vaccination for rapid containment of contagion. This approach enabled India to eradicate the disease in a relatively short time. Second, a more detailed observation of smallpox transmission allowed more effective action :

> Careful studies showed that an infected person usually infected between one and five other persons. Thus it was apparent that intensive vaccination of household members and contacts would quickly stop transmission. (WHO, 1980, p. 32)

This finding made it possible to abandon the initial practice of vaccinating all persons living in a radius of five kilometers or more, and so to avoid wasting scarce resources. By isolating patients during the contagion period, one could thus break the contagion chain.

In sum, the new method consisted in promptly detecting new cases, then seeking out all possible contacts and quarantining them in order to halt the spread of the disease. And that is how smallpox was eradicated in many countries, more by public hygiene procedures breaking the contagion chain than by vaccination.

Sources imprimées

Anonymous, 1766, Suite de l'Extrait des Transactions Philosophiques, *Journal Encyclopédique*, 21, 2, p. 84.

Anonymous, 1804, *Report of a Medical Committee on the Cases of Supposed Small-pox after Vaccination, which Occurred in Fullwood's Rents*, London, Printed for S. Highley.

Bayes Thomas, 1763, An essay towards solving a problem in the doctrine of chances, *Philosophical Transactions of the Royal Society*, 53, p. 370-418.

Bernoulli Daniel, 1760 (1768), Essai d'une nouvelle analyse de la mortalité causée par la petite vérole, et des avantages de l'inoculation pour la prévenir, *Histoire et Mémoires de l'académie Royale des Sciences de Paris,* p. 1-45.

Biggs John T., 1912, *Leicester : sanitation against vaccination*. London, The National Anti-vaccination League.

Boylston Zabdiel, 1726, *An Historical Account of the Small-pox Inoculated in New England, upon all Sorts of Persons, White and Blacks, and of All Ages and Constitution*, London, Printed for S. Chandler, at the Cross-Keys in the Poultry.

Condorcet Nicolas de Caritat, 1770, Première ébauche d'essai sur les probabilités, *in* Bernard Bru, Pierre Crépel (eds.), *Condorcet, Arithmétique politique. Textes rares ou inédits (1767-1789)*, Paris, Institut National d'Études Démographiques, 1994, p. 247-263.

Creighton Charles, 1889, *Jenner and Vaccination : a Strange Chapter of Medical History*, London, Swan Sonnenschein & Co.

Crookshank Edgard, 1889, *History and Pathology of Vaccination ?* (2 vols), London, H.K. Lewis.

D'Alembert Jean le Rond, 1760, Onzième mémoire. Sur l'application du calcul des Probabilités à l'inoculation de la petite Vérole, NOTE sur le Mémoire précédent, THEORIE MATHEMATIQUE de l'inoculation, in *Opuscules Mathématiques, ou MEMOIRES sur différens sujets de Géométrie, de Méchanique, d'Optique, d'Astronomie &c.*, Tome second, Paris, Chez David, rue et vis-à-vis la grille des Mathurins, p. 26-95.

D'Alembert Jean le Rond, 1768, 27° mémoire. Extraits de lettres sur le calcul des probabilités, & sur les calculs relatifs à l'inoculation, in *Opuscules Mathématiques, ou MEMOIRES sur différens sujets de Géométrie, de Méchanique, d'Optique, d'Astronomie &c.*, Tome quatrième, Paris, Chez Briasson, Libraire, rue Saint Jacques, à la Science, p. 283-341.

D'Alembert Jean le Rond, 1780, Cinquante-deuxième mémoire. Sur le calcul des probabilités, in *Opuscules Mathématiques, ou MEMOIRES sur différens sujets de Géométrie, de Méchanique, d'Optique, d'Astronomie &c.* Tome septième, Paris, Chez Claude Antoine Jombert, fils ainé, Librairie du Roi, près le Pont-Neuf, p. 39-60.

De Finetti Bruno, 1937, La prévision : ses lois logiques, ses sources subjectives, *Annales de l'Institut Henri Poincaré*, 7, 1, p. 1-68.

De la Condamine Charles-Marie, 1758 (1763), Second mémoire sur l'inoculation de la petite vérole, contenant la suite de l'histoire de cette méthode & de ses progrès, de 1754 à 1758, *Histoire et Mémoires de l'académie Royale des Sciences de Paris*, p. 439-482.

De la Condamine Charles-Marie, 1759 (read at the public session of April 24, 1754), Mémoire sur l'inoculation de la petite vérole, *Histoire et Mémoires de l'Académie Royale des Sciences*, p. 615-670.

De la Condamine Charles-Marie, 1765 (1768), Suite de l'histoire de l'inoculation de la petite vérole depuis 1758 jusqu'en 1765, troisième mémoire, *Histoire et Mémoires de l'académie Royale des Sciences de Paris*, p. 505-532.

De la Coste D. M., 1723, *Lettre sur l'inoculation de la petite vérole*. Paris, Chez Claude Labottiere.

De la Motraye Aubry, 1727, *Voyages du Sr. A. de la Mortraye en Europe, Asie et Afrique, Tome second.* The Hague, T. Johnson & J. van Duren.

De la Vigne de Frécheville Claude, 1723, *Quaestio medica : An variola inoculare nefas ?* Paris, J. Quillau.

Douglass William, 1722, *Inoculation of the Small Pox as Practised in Boston, Considered in a Letter to A-S-M.D. & F.R.S. in London*, Boston, Printed and Sold by J. Franklin.

Franklin Benjamin, 1759, Some account of the success of inoculation for the small-pox in England and America, *in* Benjamin Franklin, William Heberden (eds.), 1759, *Some Account of the Success of Inoculation for the Small-pox in England and America Together with Plain Instructions for the Inoculation for the Small-pox*, London, W. Strahan.

Graunt John, 1662, *Natural and Political Observations.* London, Martin, Allestry and Dicas.

Greenhill William A., 1848, *A Treatise on the Smallpox and Measles*, London, Sydenham Society.

HALLEY, Edmond, 1693, An estimate of the degrees of the mortality of mankind, drawn from curious tables of the births and funerals at the city of Breslaw ; with an attempt to ascertain the price of annuities upon lives. *Philosophical Transactions of the Royal Society of London*, 17, p. 596–610.

Hecquet Philippe, 1724, *Observations sur la saignée du pied, et sur la purgation au commencement de la petite vérole, des fièvres malignes et des grandes maladies. Preuves de la décadence dans la pratique de la médecine, confirmées par de justes raisons de doute contre l'inoculation,* Paris, Guillaume Cavelier.

Helvétius Jean-Claude Adrien, 1722, *Idée générale de l'oeconomie animale et observations sur la petite vérole*, Paris, Imprimerie Royale.

Jenner Eduard, 1798, *An Inquiry into the Causes and Effects of Variolae Vaccinae, a Disease Discovered in Some of the Western Counties of England Particularly Gloucestershire, and Known by the Name of "Cowpox"*, London, Printed by Sampson Low.

Jenner Edward, 1801, *On the Origin of the Vaccine Inoculation*, London, Printed by D.N. Shury, Berwick Street, Soho.

Jurin James, 1727, *An Account of the Success of Inoculating the Small-pox in Great Britain with a Comparison Between the Miscarriages of that Practice, and the Mortality of the Natural Small-pox for the Year 1726*, London, J. Peele at Locke's Head in Pater-Noster Row.

Kittredge George L., 1912, *Some lost works of Cotton Mather, Proceedings of the Massachusetts Historical Society, XLV,* Cambridge, John Wilson and son.

Laplace P.S., 1774, Mémoire sur la probabilité des causes par les événements, *Mémoires de l'Académie Royale des Sciences de Paris*, VI, p. 621-656.

Maitland Charles, 1722, *Mr. Maitland's Account of Inoculating the Smallpox Vindicated, from Dr. Wagsttaffe's Misrepresentations of this Practice; with Some Remarks on Mr. Massey's Sermon*, London, J. Peele.

Massey Edmund, 1722a, *A Sermon Against the Dangerous and Sinful Practice of Inoculation, Preached at St. Andrew's Holborn on Sunday, July the 8th*, London, William Meadows.

Massey Edmund, 1722b, *A Letter to Mr. Maitland in Vindication of the Sermon Against Inoculation*, Norwich, Reprinted by order of S. Mascott, M.B.

Mather Cotton, 1721, *Sentiments on the Small Pox Inoculated*, Boston, Printed by S. Kneeland for J. Edwards at his Shop in King-Street.

Mather Cotton, 1722, *An Account of the Method and Success of Inoculating the Small-pox in Boston in New-England, In a Letter from a Gentleman there, to his Friend in London*, London, Printed for J. Peele at Lock's Head in Paternoster Row.

Mather Cotton, 1911, *Diary of Cotton Mather, Vol. II 1709-1724*, Norwood, Massachusetts, The Plimpton Press.

Mather Increase, 1721, *Several Reasons Proving that Inoculation or Transplanting the Small Pox, is a Lawful Practice, and that it Has Been Blessed by GOD for the Saving of Many a Life*, Boston, Printed by S. Kneeland for J. Edwards at his Shop in King-Street.

Montagu Mary W., 1763, *Letters of the Right Honourable Lady M—y W---y M----e : Written, During his Travels in Europe, Asia and Africa to Persons of Distinction, Men of Letters, etc. in Different Parts of Europe*, vol. III, London, T. Becket and P.A. de Hondt.

Nettleton Thomas, 1722, Part of a letter from Dr. Nettleton, physician at Halifax. To Dr. Jurin R.S. Secr. Concerning the inoculation of the small pox, and the mortality that distemper in the natural way, *Philosophical Transactions*, 32, p. 209-212.

Pearson George, 1798, *An Inquiry Concerning the History of the Cowpox, Principally with a View to Supersede and Extinguish the Smallpox*, London, J. Johnson.

Pylarinum Giacomo, 1715, Nova et tuta variolas exitandi per transplantationem methodus : Nuper iventa & un usum tractate*, Philosophical Transactions*, 29, 347, p. 393-393.

Rhazes Muhammad, circa 910, Kitab *al-Jadari wa 'l-Hasba* (Book on Smallpox and measles).

Rowley William, 1805, *Cow Pox Inoculation no Security Against Small Pox Infection*, London, J. Harris.

Southey Robert, 1864, *The life of the Rev. Andrew Bell*, vol. II, London, John Murray.

Tebb William, 1884, *Compulsory Vaccination in England : with Incidental References to Foreign States*, London, E.W. Allen.

Timonius Emmanuel, 1714, An account, or history, of the procuring the small pox by incision, or inoculation ; as it has for some time been practiced at Constantinople, *Philosophical Transactions*, 29, 339, p.72-82.

Voltaire François-Marie Arouet dit, 1734, *Lettres philosophiques*, Amsterdam, Chez E. Lucas, au Livre d'or.

Wagstaffe William, 1722, *A Letter to Dr. Friend'; Shewing the Danger and Uncertainty of Inoculating the Smallpox*, London, Samuel Butler.

Wallace Alfred R., 1898, *Vaccination a Delusion : its Penal Enforcement a Crime*, London, Swan Sonnenschein & Co.

White Andrew D. 1896. *A History of the Warfare of Science with Theology in Christendom*, vol. 2, New York, D. Appleton and Company.

Williams John, 1721, *Several Arguments Proving that Inoculating the Small Pox is not Contained in the Law of Physics, either Natural or Divine, and therefore Unlawful*, Boston, Printed and sold by J. Franklin, at his Printing-House in Queen-Street, over against Mr. Sheaf's School.

Williams John, 1722, *An Answer to a Late Pamphlet Intitled, a Letter to a Friend in the Country, Attempting a Solution of the Scruples and Objections of a Consciencious or Religious Nature, Commonly Made against the New Way of Receiving the Small Pox*, Boston, Printed and sold by J. Franklin, at his Printing-House in Queen-Street, over against Mr. Sheaf's School.

Woodville William, 1796, *The History of the Inoculation of the Small-pox*, London, Printed and Sold by James Phillips.

Woodville William, 1800, *Observations on the Cow-pox*, London, Printed and Sold by Williams Phillips, George Yard, Lombard Street.

Bibliographie

Baxby Derrick, 1999, Edward Jenner's unpublished cowpox inquiry and the Royal Society : Everard Home's report to Sir Joseph Banks, *Medical History*, 43, p. 108-110.

Brian Éric, 1996, L'objet du doute. Les articles de d'Alembert sur l'analyse des hasards dans les quatre premiers tomes de l'*Encyclopédie*, *Recherches sur Diderot et sur l'Encyclopédie*, 21, p. 163-178.

Courgeau Daniel, 2015, Démographie et probabilité. Rejets et avancées lors de leur développement, *in* Bernard Walliser (éd), *La distinction des savoirs*, Paris, EHESS.

Ellis Francis W., 2006, The legend of the cow-pox, *in* Thomas Trautmann (ed.), *Languages and* Nations : the Dravidian Proof in Colonial Madras, Berkeley and Los Angeles, University of California Press, Appendix A, p. 231-241.

Razzell Peter E., 1977, The Conquest of Smallpox : The Impact of Inoculation on Smallpox Mortality in Eighteenth-century Britain, Sussex, Caliban Books.

Razzell Peter E., 1980, *Edward's Jenner Cowpox Vaccine*, London, Caliban Books.

Trautmann Thomas, 2006, *Languages and Nations : The Dravidian Proof in Colonial Madras*, Berkeley, Los Angeles, London, University of California Press.

World Health Organization (WHO), 1980, *The Global Eradication of Smallpox. Final Report of the Global Commission for the Certification of Smallpox Eradication*, Geneva, World Health Organization

Wujastyk Dominik, 1987, 'A pious fraud' : The Indian claims for pre-Jennerian smallpox vaccination, *in* G. J. Meulenbeld, D. Wujastyk (ed), *Studies on Indian medical history*, Groningen, Forsten, p. 121-155.