The Impacts of Smallpox Vaccination on British India

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HICKEY Thomas, "Portrait of Three Princesses from Mysore", 1806[*]

* Cover image: “Thomas Hickey, Portrait of Three Princesses from Mysore, oil on canvas, 124 by 100 cm. in Sotheby's,https://www.sothebys.com/en/auctions/ecatalogue/2007/important-british-paintings-l07122/lot.45.html, accessed 31 October 2024

It “(...) seems likely from [Nigel Chancellor] revised identification, [that] Hickey's portrait of the three royal women of Mysore was commissioned by the Government of Madras to coincide with the public announcement of the young queen's vaccination on 19 July 1805”[1]. Indeed, “The central figure[’s] fingers of her right hand point towards the younger woman in the white sari, as if to emphasize her priority within the composition”[2]. The latter wears a bandage applied following her vaccination, which she reveals by lifting her sleeve[3].

I. Abstract

The eradication of smallpox in 1980 remains one of the most significant events in the history of global health. Indeed, to this day, it is the only human disease to have been successfully eradicated thanks to medical advances. However, an examination of the measures implemented in British India (1858–1947) to fight the *variola virus* reveals the ambivalent nature of colonial policies and their considerable impact on societal, cultural, and economic structures.

This paper explores the dual impact of smallpox vaccination campaigns, by first providing a clear overview of the complex historical and medical background of the subject. Indeed, on one hand, it presents the significant benefits they had on the country’s public health. On the other hand, it also explores the devastating impacts of such measures on India’s cultural heritage and economic prosperity. This research reveals that colonial medical initiatives, which were often presented as acts of benevolence, were in fact frequently used as instruments of control, fostering resistance among the Indian population - resistance that ultimately became an important factor in the country's struggle for independence.

By addressing all these aspects, this paper provides a thorough assessment of the various measures implemented during the vaccination campaigns in British India. This approach offers an understanding of the ambivalent legacy of colonialism, the ethical dilemmas of public health interventions, and the enduring importance of critical reflection on history to address contemporary global challenges.

II. Introduction

The early 2020s were marked by suffering on a global scale, due to a global pandemic. The daily life of humans all over the globe was turned upside down. An estimated 7 million people have lost their lives as a result of COVID-19 infection[4]. However, this alarming figure seems derisory compared to the 300 million deaths caused by smallpox during the twentieth century, according to the most optimistic estimates[5]. However, since 1980, this once devastating disease has been eradicated[6].

Following the various measures taken to combat this new pandemic, some claimed that “the eradication of smallpox by India, through a vast vaccination campaign, is a perfect example for the deployment [...] of the COVID-19 vaccine”.[7] This comparison therefore invites us to ask ourselves whether the measures put in place during the fight against smallpox really constitute a model to follow. Indeed, although its eradication is frequently used as an example of the accomplishments that can be achieved through global cooperation, it is essential to nuance this vision.

As the British colonial empire often declared, vaccination had led to a significant reduction in smallpox mortality[8]. However, the various measures undertaken had not had exclusively positive consequences. Thus, the analysis of the history of smallpox vaccination in British India is a key topic, including several aspects that have long been neglected, while others continue to be glorified. In addition, it addresses an often-forgotten point of view of the natural sciences, highlighting the various socio-economic repercussions generated by advances in this field.

Throughout this research, we will attempt to answer the question: to what extent did smallpox vaccination campaigns benefit the population of British India? To do so,we will examine the impact of these campaigns on the Indian people, from 1858, when British India was declared under the direct control of the Crown, to the year 1947, marked by the country's independence.

To do this, we will first focus on the historical context surrounding the subject. We will then examine the various benefits brought by the vaccination campaigns, before studying the various harmful aspects they have generated. Finally, the profound complexity of the subject will be addressed, in order to take a position.

III. Historical Background

In order to be able to properly assess the nature of the various impacts of vaccination campaigns in India, several pieces of knowledge are required, as the historical and medical context dealt with is complex. We will discuss some of the key elements of the history of the colonization of India, as well as various aspects concerning smallpox and its treatments.

III.I. British India

The British Raj was the British system of rule over the entire Indian subcontinent, and the areas under its direct control constituted British India[9] which included the present-day territories of India, Pakistan, and Bangladesh[10]. This colony was divided into eight major provinces, with areas ranging from 127,000 km^2 to more than 440,000 km^2.[11] five minor provinces, with areas ranging from 4,000 km^2 to 119,000 km^2,[12] and the princely states[13], semi-autonomous territories ruled by a local ruler, under the suzerainty of the British Empire[14].

We will now address crucial elements concerning the colonization of India, as well as its independence.

III.I.I. Settlement by the British Empire

On May 20, 1498, Vasco da Gama, a Portuguese navigator, arrived in Calicut, a city in southern India, now called Kozhikode. Thus, the Europeans, who sought to extend their trade market with Asia, which was then exclusive to the Arab countries, discovered India. They prized this region in particular for its various spices, textiles, and cotton[15].

In 1600, the British Empire founded the *East India Company* to strengthen their trade[16]. In 1757 the Battle of Plassey took place. Siraj ud-Daulah, the Nawab[17] of Bengal, a state in the southeast, who supported the French colonists, had attacked English trading posts, notably in Calcutta. A battle had broken out, and the British Company had emerged victorious. After the former Nawab fled, Mir Jafar, a puppet leader obedient to the British, was placed in power[18].

In 1857, the Sepoy Revolt, Indian soldiers with a European education, broke out[19]. They had questioned the authority of the British colonists by refusing to use cartridges that had been lubricated with tallow, as their use represented a religious desecration for Hindus and Muslims. The revolt had spread, and English officers were assassinated. British forces had quickly suppressed the revolt[20], and the British East India Company was disbanded. Queen Victoria announced that India would be directly under the control of the British Crown[21], in order to ensure better management of Indian affairs[22]. Historians refer to this “period of direct British rule over the Indian subcontinent from 1858 until the independence of India and Pakistan in 1947”[23] by the term British Raj.

III.I.II. Independence

For nearly a century, the British Empire exercised great control over India[24]. The colonists "(…) centralised the military and fiscal operations, (…) [and in order to] secure its own future, the British raised a large standing army"[25]. However, despite their efforts, their control over India did not persist indefinitely. Indeed, in 1885, the Indian National Congress was founded, marking the first major movement in favour of Indian independence[26].

Later, during World War I, the British government stepped up repressive measures to combat rebel activity. These measures persisted after the end of the war because of the passage of the Rowlatt Acts. As a result of these repressions, demonstrations broke out, including the one on 10 April 1919 in Amritsar, which had taken place following the arrest of Indian leaders[27]. Soldiers made very violent arrests there, and the British forces then forbade public gatherings. On April 13, 1919, thousands of unarmed Indians defied this ban, including at Jallianwala Bagh. British troops opened fire on the demonstrators, until their ammunition ran out. This sparked widespread outrage, and discontent with the colonial empire grew[28].

In August 1942, the Indian National Congress, under the leadership of Gandhi, an Indian lawyer known for his peaceful revolts[29], launched the *Quit India* movement, demanding the immediate withdrawal of the British from India. This contributed to a general awareness that led to numerous protests, some of which were violent, often followed by arrests and murders, which intensified the revolts fighting for independence[30].

During the Second World War, the British Empire used many Indian soldiers[31]. After the end of the war, negotiations began, encouraged by the depletion of English resources and their loss of power over the colony. Thus, on August 15, 1947, India gained independence from the United Kingdom[32].

III.II. Smallpox

Information about smallpox is needed in order to understand the various elements that will be mentioned in the analysis of vaccination campaigns. Thus, we will now explore the clinical and historical aspects of the disease.

III.II.I. Pathogenesis

Smallpox is a viral disease caused by an infection of the *Variola Virus*, of which there were two strains: *Variola Major* and *Variola Minor.* They had many genetic and structural similarities[33], which gave them shared immunity[34]. However, there were differences in their genetic code[35], and thus these strains had different infective powers[36]. Infections by *Variola Major*, the most common, caused more severe symptoms, and its mortality rate (30%) was much higher than that of *Variola Minor* (nearly 1%)[37].

Belonging to the *Poxvirus family*, the *Variola Virus* has a unique mode of infection within DNA viruses[38]. Indeed, its replication does not rely on the replication of the host cell's DNA[39], like other DNA viruses that insert their genetic material into that of the cell[40], but is carried out in the cytoplasm of the host[41]. At least four viral proteins and two host receptor molecules participate in the entry of the virus. Inactivation of any of these attachment proteins does not prevent its entry, although it can significantly reduce its infectivity. Their links promote the activation of several enzymes, and these induce the formation of actin-enriched membrane protrusions[42]. This allows the host cell membrane to fuse with the viral membrane, thus releasing the contents of the virus into the now infected cell[43].

Viral enzymes, which were already present inside the virus, initiate the transcription of early genes, which encode the proteins needed to begin viral DNA replication. The mRNAs formed are translated into proteins used for DNA replication, including DNA polymerase and helicase-primase. Within structures called viral factories, the complete replication of viral DNA begins, using the newly produced enzymes[44]. The newly replicated chromosomes and the newly created viral molecules are grouped under a phospholipid bilayer. These new viruses undergo a maturation process[45]

A mature virus can follow three different pathways in order to exit the cell. One of these is to transport it to the Golgi apparatus where it is enveloped in two additional phospholipid bilayers, now called an wrapped virion. During exocytosis outside the cell, the virus loses the outermost membrane[46].

Another route begins with the transport of mature viruses to the type A inclusion body, where they accumulate[47] until they cause cell lysis[48], cell death “caused by damage to its plasma (outer) membrane(...)”[49], releasing them into the rest of the body. In some cases, the host cells realize they are infected and trigger their own apoptosis[50], stopping the production of viruses[51].

Six hours after infection, proteins encoded by viral DNA are placed on the membrane of the host cell, and prevent the entry of other *poxviruses*. This allows the virus to replicate without competition, and to optimize the number of infected cells[52]. In addition, the virus produces proteins that block type I interferons[53], which normally initiate an antiviral response and prevent nearby cells, making them less susceptible to infection[54]. Protein binding thus prevents type I interferons from interacting with cell receptors and triggering antiviral responses[55].

Smallpox could only be transmitted between humans[56], but was easily spread, including through mouth or nasal projections, or through contact with contaminated objects. It could also be transmitted through the air in closed rooms, although this was rarer[57].

Before the first symptoms, the disease had an incubation stage of about 14 days, during which it was not contagious[58]. Then, the first symptoms appeared, including high fever, headache, and vomiting. About three days later, while becoming more and more contagious, lesions appeared mainly on the hands and head. Four days later, they turned into pustules, and after five days, the latter formed scabs[59]. There was also the formation of pus, especially in the nose and mouth that dripped down the throat[60].

More than 30% of patients died as a result of the infection[61]. In most cases, death was due to interstitial lung disease[62], a build-up of scarring in the lungs, which affected the ability to breathe and obtain sufficient oxygen[63], and/or tubulointerstitial nephritis[64], inflammation of the tubules of the kidneys and the tissues around them, leading to fatal kidney failure[65].

The survivors, whose scabs had all fallen off about four weeks after the first lesions appeared, were no longer contagious[66]. In addition, all those who had been infected, even those who had not experienced strong symptoms, were given the development of powerful and long-lasting immunity[67]. However, many patients were left with after-effects, including visible scars on the face or limbs, which were often a source of great shame[68].

III.II.II. Origin and history of the disease

The majority of historians claim that smallpox has existed for more than 3,000 years, with Egyptian mummies bearing scars specific to the infection having been found[69].

However, its place of origin is still a source of uncertainty. Indeed, the majority of historians agree that it most probably originated in the East; but some say it is more likely to have started in Egypt[70], others claim that it most likely originated in India[71], and others believe that it originated in the Horn of Africa[72].

Smallpox persisted for centuries, and arrived in Europe before the seventh century. It had spread to North Africa and southern Europe in the eighth century, in particular because of the Muslim conquests. In addition, the Crusades in the eleventh century had contributed to the accentuation of the epidemic in Europe. At the end of the fifteenth century, it had reached the Americas with Christopher Columbus, who had tried to reach India, and was one of the diseases contributing to the annihilation of many natives[73].

III.III. Evolution of treatments

In order to analyze the consequences of the smallpox vaccines in British India, it is necessary to mention notions concerning its history as well as elements concerning the means of protection that existed long before its invention.

III.III.I. From the first measures to global eradication

Inoculation is a process that consists of the “voluntary introduction (...) of a micro-organism in the body (...) “.[74] Pus was taken from an infected person and applied to the wound of someone who had never been infected[75]. The latter then became infected, but its symptoms were more controlled than during an epidemic, and became immune.

This technique, which was used in particular to artificially acquire immunity to smallpox, has been around for more than 500 years. Indeed, many historians claim that Chinese writings, dating from the middle of the sixteenth century, mention the practice of inoculation[76]. Others claim that other writings, even if sometimes less detailed, prove that inoculation was already practiced in China in 200 B.C[77].

It was only with the creation of vaccines that humans were able to acquire immunity without actually encountering the pathogen, and without suffering various symptoms of the disease, in addition to not being at risk of being contagious[78].

At the end of the eighteenth century, European scientists had already noticed that dairy cows who had already been infected with vaccinia, cowpox, were very often protected from smallpox[79]. This is because these *poxviruses* were closely related, giving them cross-immunity[80]. However, *cowpox virus*, unlike *variola virus*, could be transmitted between various species, including cattle to humans. Its contraction also led to the formation of pustules, especially on the hands, but at a much less beneficial stage than during a *smallpox virus*[81] infection.

Based on these conclusions, established in particular thanks to the observations of John Fewster[82], Edward Jenner, an English surgeon born on May 17, 1749 in Berkeley[83], decided to use vaccinia as a means of protection against smallpox[84]. In May 1796 he took material from the lesions of a young milkmaid, Sarah Nelmes, whom he had just diagnosed with an infection with vaccinia[85]. On May 14, he used these samples, containing *cowpox viruses*, to inoculate an 8-year-old child, James Phipps, the son of his gardener, by rubbing them on his arm, which he had scratched beforehand[86]. The latter developed a slight fever and discomfort

in his armpits, and nine days after the operation, he complained of being cold and had lost his appetite. However, he was much better the next day. In July 1796 Jenner inoculated the boy with materials from a person suffering from smallpox. Following this, the boy did not have the slightest sign of infection. Jenner concluded that the protection provided by a previous infection with vaccinia was complete[87].

In 1797, Jenner sent a communication in which he described his observations to the *Royal Society*[88], a scientific academy founded in 1660, offering scholarships to promote scientific excellence through research and publications[89]. However, the paper was rejected, citing Jenner for performing the experiment on only one patient[90].

In 1798, after repeating his experience with more patients[91], Jenner self-published *An inquiry into the causes and effects of the variolæ vaccinae, a disease discovered in some of the western counties of England, particularly Gloucestershire, and known by the name of the cow pox*. In it, he demonstrated how his discovery worked, and described his great "(...) hope of its becoming effentially beneficial to mankind"[92]. Despite various difficulties, including the shared fear that the vaccine would turn the vaccinated into cows[93], vaccination, named after the Latin term for cow: *vaca*[94], quickly became popular. Thus, in 1800, the practice of arm-to-arm vaccination was common in most European countries[95].

In 1870, Henry Austin, an American surgeon, introduced the animal vaccine, which gradually replaced arm-to-arm vaccination. This process had various advantages, eliminating the risk of accidentally transmitting other diseases, and being able to be produced in large quantities[96]. These vaccines used calves raised in premises that were monitored for cleanliness. In addition, it was common practice to slaughter the calf and examine its organs to ensure that it did not carry any other diseases, before using its samples to create vaccines[97].

In 1980, nearly a hundred years later, the World Health Organization declared the disease to be eradicated[98]. This achievement is the result of joint efforts across the globe, promoting vaccination and information campaigns, and promoting the development of new technologies[99]. This eradication program was originally created in 1959, but had real impacts from 1967 onwards, thanks to the increase in funds and laboratories producing [100]vaccines.

III.III.II. From inoculation to vaccination under the British Raj

Before the arrival of the Western vaccine, inoculation was practiced in the majority of India[101], written documents dating from 1731 confirming this practice as early as 1580[102]. In India, this way of acquiring smallpox resistance was coupled with religious beliefs[103]. It began with the collection of pieces of crust from a person whose infectious period had passed, then mixed with rice and milk. This mixture, with reduced infective power, was applied to an open wound often made above the wrist[104]. The inoculated, who was often a child, developed an attenuated form of the disease, bearing fewer pustules than those infected during waves of smallpox[105]. In addition, the inoculated, being contagious, were kept away for about 21 days in order to avoid the emergence of epidemics[106]. During this period, the healers in charge of inoculation monitored the condition of the inoculated, and reduced their fever in particular by applying neem leaves, known for their febrifuge properties[107]. Once this period was over, the inoculated person developed a strong immunity to the disease, and his scabs were harvested in order to be able to inoculate other individuals[108].

In 1802, for the first time, a shipment of vaccines arrived in India, which had had to make a long journey[109]. Indeed, "dried vaccine matter was sealed between glass plates and successfully delivered from Vienna to Baghdad in March 1802. It was then used to vaccinate an

Armenian child and the lymph from his arm was taken to Basra, in Iraq, where an East India Company surgeon established a supply arm-to-arm that was sent to Bombay (now Mumbai)"[110]. This allowed the first smallpox vaccination in India, which had been carried out on a 3-year-old Indian girl, Anna Dusthill, on June 14, 1802[111].

Centers creating smallpox vaccines emerged in India, most notably in Madras in 1879, where calf scabs and pus were used[112]. Then, from the beginning of 1890, laboratories creating vaccines based on calf lymph emerged in the city of Shillong[113], the capital of the state of Meghalaya, in northeastern India[114].

Over the years, the number of measures carried out by the British Empire increased[115]. In 1892, in order to move in the direction of global efforts, vaccination was made compulsory for the entire Indian territory[116]. Such measures were reinforced over the years. Even after India's independence, its leaders continued to enact laws reinforcing similar measures, including in the legislatures of Jamu and Kashmir
in 1967. This act made it the responsibility of the guardians to vaccinate any child under six months of age who had never previously contracted the disease, and to administer a second dose five years later[117].

However, it was very complex to ensure compliance with all of these laws, especially because of the geographical distribution of the Indian population at the time. Indeed, many villages were located far from major cities, which greatly complicated the distribution of vaccines. The chairman of the British *State Section of Epidemiology and State Medicine* had announced on 24 November 1944 that "among the 380 million people of India, some 90o% of whom reside in about one million villages, scarcely any of which have a doctor (…)"[118]. Thus, historians estimate that six years after its implementation, the *Compulsory Vaccination Act* was not respected in nearly 20% of Indian districts[119].

IV. Beneficial impacts

In order to assess the nature of smallpox vaccination campaigns, we will now discuss the various beneficial impacts they have brought to the population of British India. We will examine improvements in the field of public health as well as the various beneficial repercussions on national education. Finally, we will study the economic benefits brought by the countryside.

IV.I. Public Health

It seems obvious that the vaccination campaigns had led to a decrease in the mortality rate of smallpox. However, this is not the only improvement they have brought to the field of public health. As we will see, they had also contributed to the implementation of measures to renew the sanitary conditions. We will also analyze the benefits of these changes on the life expectancy of the Indian population.

IVI.I.I. Mortality

In India, various means were put in place to increase the proportion of people vaccinated. However, archival analysis of the number of vaccinations carried out in Bombay shows that the administration of the vaccine did not increase significantly in number when it arrived in India in 1802[120]. Indeed, historians estimate that about 10,000 people were vaccinated on average per year, between 1805 and 1820[121]. This slow progress can be explained in part by the people's reluctance to vaccinate, and by the practice of inoculation, which was more popular. However, this method did not provide sufficient protection for the eradication of the disease, with historians estimating that 80% of the population at the beginning of the nineteenth century did not carry significant immunity to smallpox[122].

Historians have observed that a real increase in the number of new people vaccinated did not occur until 1855. Indeed, the number of annual vaccinations suddenly reached an average of 300,000 between 1855 and 1860 in Bombay[123]. This increase can be explained by the reinforcement of vaccination measures put in place by the British crown, which had just declared its authority over India. As a result of this considerable change, the number of annual vaccinations continued to increase sharply until 1890, reaching about 850,000 annual vaccinations. In the following years, the number of vaccinations decreased, but remained much higher than at the beginning of the century. Indeed, about 600,000 people per year were vaccinated in the last five years of the nineteenth century[124]. This decrease could be partly explained by the early deployment of the vaccine in this city, leading to an anticipated drop in the number of unvaccinated people compared to the national situation.

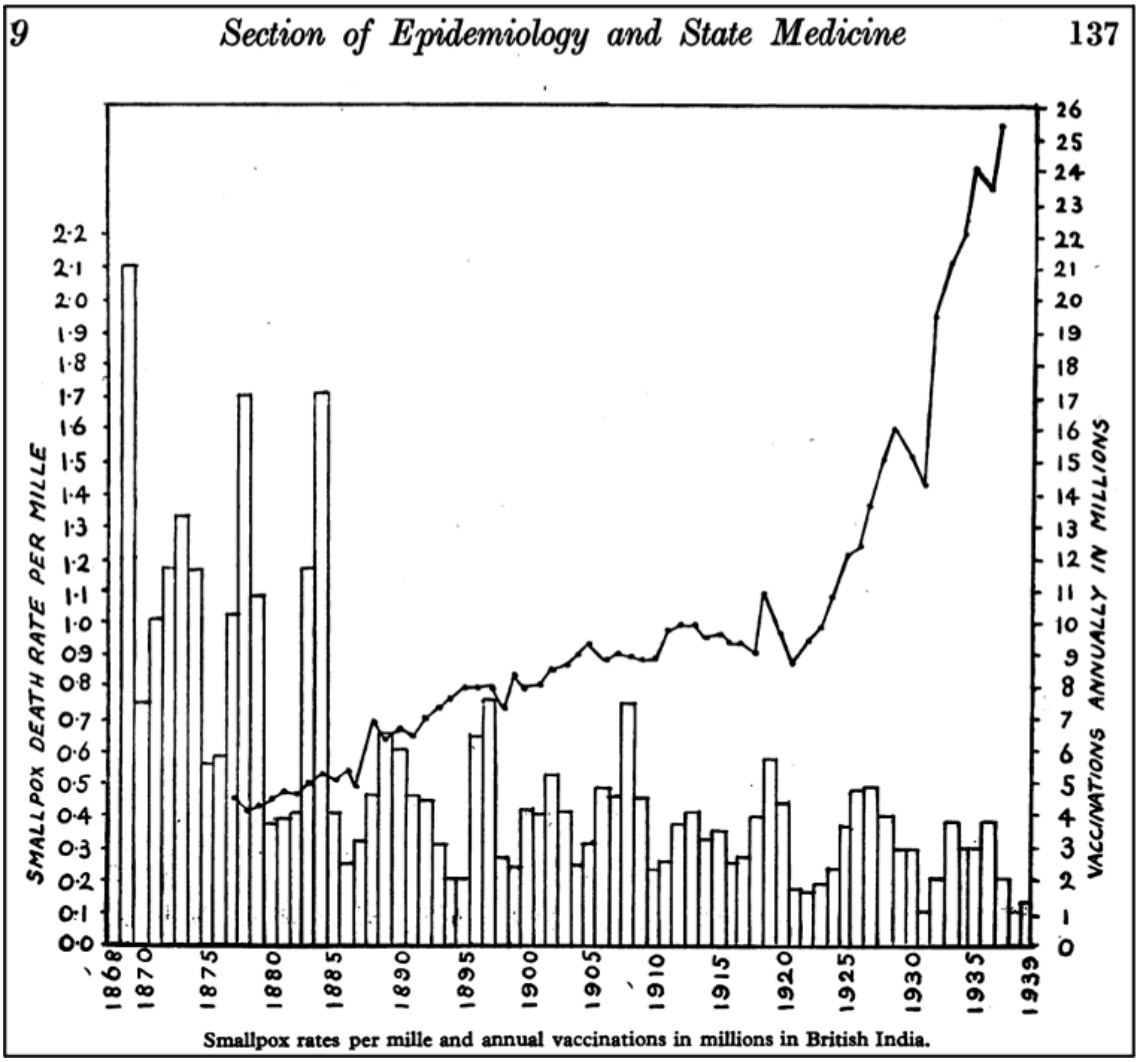
However, this decrease in the number of vaccines distributed annually was not felt nationally. The number of annual vaccinations continued to increase over the years in India, reaching an average of 19.1 million vaccinations per year from 1928 to 1937, according to British medical authorities[125].

In the year 1880, the Bengal government passed a law making it compulsory for children to be vaccinated. Similar legislation was put in place in the rest of the Indian provinces in the years that followed[126].

Thus, at the national level, the number of vaccinations at birth rose from 19.9% from 1880 to 1881, to 39.1% from 1902 to 1903[127]. This increase had a direct impact on the number of people contracting smallpox and succumbing to it. Indeed, even if we can see fluctuations in the number of infected, the effectiveness of the vaccine is undeniable. Annual variations coincide

with the seasonal nature of the disease[128]. In addition, experts believe that errors may have been made by hospitals when reporting on the number of infections, contributing to variations in these measures. Indeed, patients with diminished symptoms, or who are in the incubation period of the disease, have certainly not been counted[129].

The effectiveness of vaccination campaigns can be seen by the decrease in the number of deaths due to smallpox. An average made from the registers of the major provinces of India from 1865 to 1899 shows a very important difference between these years. Indeed, there were an average of nearly 150,000 deaths per year from smallpox from 1865 to 1869; and less than 84,000 per year from 1895 to 1899. This improvement must certainly have been even more significant; data on the oldest years are missing for some provinces. Thus, the incorporation of registries from more regions has caused false increases in the annual death toll at the national level[130].



Graph showing the number of annual vaccinations and the mortality rate of smallpox in British India, from 1868 to 1939 [131]

The graph published in November 1944 in *the Section of Epidemiology and State Medicine* clearly illustrates the benefits of vaccination campaigns supported by the British crown. Indeed, it shows its undeniable effectiveness in reducing the mortality rate of smallpox in India. In addition, it shows the effort made to continue this trend until the last years of the colony; more than 20 million vaccinations were distributed each year by the late 1930s[132].

These reductions in the mortality rate can be explained by the protection offered by the vaccines against infections, but also by their role in increasing recovery rates in fragile vaccinated people, who were still infected. This notion is particularly visible through the data recorded in Bombay between 1935 and 1939. During this period, the mortality rate from smallpox was 4.5% among those infected and vaccinated, while it was 41.4% among those who were not. This difference underscores the critical importance of vaccines in the fight against this disease[133]. In addition, the improvement in care and hygiene, which we will discuss later, certainly helped the recovery rate following an infection.

IV.I.II. Sanitary measures

Vaccination campaigns have not only led to the taking of smallpox vaccines. Indeed, smallpox being one of the aspects at the centre of governance in India, the quest for its control had motivated the adoption of various measures. Thus, several of these initiatives have improved sanitary conditions, contributing not only to the fight against smallpox, but also to the prevention of many other infections[134].

By the end of the 17th century, the colonial empire had already built the first hospital practicing Western medicine in Asia, and encouraged the construction of other hospitals. Thus, there were about 1,200 in 1880, and this feat continued: almost twice as many existed less than 25 years later, with nearly 2,500 hospitals in 1902[135].

In 1864, the *Cantonment Act* came into force. He introduced compulsory health checks for women who prostituted themselves to British soldiers[136]. Thus, a sanitary police force led by English military doctors was created, with the aim of improving the hygiene of the soldiers[137]. In the same year, other health commissions were established in each Indian province. Then, in 1870, this health service merged with the vaccination service, and the two thus formed a central health service[138].

In 1880, the Governor-General of India, Lord Ripon, an English statesman, ordered a census of various records[139]. He demanded that health workers inspect sanitation and vaccination conditions in all major provinces[140]. The policies of local self-government that he established in the two years that followed allowed for an increase in the funds available for local services[141]. Thus, following the statements of the civil surgeons, measures were put in place to improve the infrastructure guaranteeing sanitation.

These advances continued, and in 1912 the Indian government appointed and funded health commissioners for local organizations, some of which had been in existence since 1885. Funds for sanitation projects were also provided[142]. Thus, by the early 1890s, filtered water was being distributed in Bombay, Madras, and Calcutta, and urban health activities were focused on achieving such goals in other provinces[143].

IV.I.III. Life expectancy

Another public health aspect that has been improved as a result of the measures put in place by vaccination campaigns is the overall life expectancy of the Indian population. Indeed, the fall in the risk of infections and the decrease in the mortality rate as well as the improvement in sanitary conditions are factors that have contributed positively to the increase in life expectancy in India. The latter went from an average of between 20 and 25 years from the year 1800 to 1920[144], being about 21 years in the 1820s, and 24 in the 1900s[145], at about 33 years old in 1945[146].

In addition, the improvement of sanitary conditions, as well as the training of nursing staff, which we will discuss, have made it possible to provide better care in general in hospitals. These improvements can be seen in the fact that smallpox mortality decreased even among unvaccinated people. Indeed, except for a fluctuation that occurred between 1935 and 1939, the *Smallpox and Infection Disease Hospital Arthur Road* in Bombay noted that mortality for this group of patients had risen from an average of 40.9 per cent from 1905 to 1909 to an average of 32.8 per cent from 1940 to 1944 [147]. Thus, improvements in health care contributed to the improvement of the quality of life, and contributed to the increase in the average longevity of the Indian people.

IV.II. Education and Research

The British-led vaccination campaigns have also had a significant impact on the Indian education system by strengthening the training of health professionals and improving medical research.

IV.II.I. Training

The British government organized the Indian medical system and education according to its own system. This allowed a strong development of the medical services offered in India from the end of the nineteenth century to the beginning of the twentieth century[148].

Indeed, as we mentioned earlier, the British had facilitated the creation of hospitals in India, doubling their number in less than 25 years (2,500 in 1902), some of which were university hospitals[149]. Thus, they simultaneously participated in the improvement of public health and medical training. Indeed, reports tell us that health inspectors were trained in these teaching hospitals, in particular at the *King Institute of Preventive Medicine*[150].

In addition, the historian David Arnold shows the extent of the development of the training of Indian doctors practicing Western medicine, aided by the British Empire. As early as 1858, *Bombay's Grant Medical College* set up financial aid for students in the process of obtaining a doctorate in medicine. This allowed students from middle-class families to follow this path to higher education. Thus, by the 1880s, more than 300 doctors had been trained there in total[151].

Furthermore, the smallpox campaigns dictated by the British played a major role in the education of women in India. In 1880, Dr. Fanny Butler was the first female medical missionary sent to India[152]. In 1885, at the request of Queen Victoria, Vice-Queen Lady Dufferin founded a national association for the grant of medical aid to women. Thus, other women health specialists were sent there in the following years. As a result, in the 1920s, more than 150 doctors, mostly English, practiced in India[153]. In addition, more than half of the *mission hospitals*, “private hospitals sponsored by any religious body”[154], were dedicated to

women[155]. This helped advance women's rights in India, although at an even slower pace than the progress made in Europe.

Thus, in 1914, India allowed Indian women to pursue medical studies[156]. The Dufferin Fund also promoted women's medical education, including by subsidizing the establishment of a women-only university in Delhi in 1916[157].

IV.II.II. Research Development

In 1869, the government appointed a commissioner of public health and statistics. In 1896, following the abolition of the presidential system, these departments were under the direct control of the *Army Medical Department*[158], now called *the Royal Army Medical Corps*[159]. In 1919, the duties of ensuring public health and collecting various statistics concerning it were transferred to the provinces[160]. This development of national statistics has greatly benefited the Indian population, making it possible to adapt health measures, particularly those concerning smallpox vaccination campaigns.

The Bengal Births and Deaths Registration Act of 1873 made the registration of births and deaths compulsory, in order to maintain statistics on the evolution of national population growth[161]. This change brought a direct benefit to the government, in addition to serving in the study of smallpox, because, as we saw in the analysis of the effectiveness of the vaccine, much data concerning the first century after the introduction of the vaccine in India is missing for various provinces[162]. The health authorities, wishing for proper compliance with this treaty, made it the responsibility of the parents or the midwife to inform the authorities of each birth, according to section 7[163], and the duty of the man closest to the deceased to do the same, according to section 8[164]. In both cases, negligence resulted in a fine of 5 rupees to the offender[165]. In addition, Section 9 stated that each negligence of the clerks could cost them Rs 15[166].

All this data, as well as the knowledge imported by the British Empire, allowed India to develop its medical research. As soon as centers creating vaccines were established, experiments were carried out there. This was particularly the case in the centre founded in Madras in 1879; that in Calcutta in 1880; those in Punjab from 1885; where various derivatives the retro-vaccination was practiced[167]. This technique consisted of the use of “(…) smallpox virus from human vesicles [to] seed virus in producing smallpox vaccine in cattle”[168].

In Burma, solutions based on bovine crusts dissolved in a mixture of glycerin and distilled water were used, and this method proved promising, allowing a better preservation of the vaccine than other techniques[169].

In addition, various experiments on vaccines based on animal lymph were sources of success, as early as 1879, in Madras[170]. A vaccine production centre was established on 13 January 1890 in Shillong, and after analysis the production was found to be of better quality than that from English centres[171].

All these advances allowed India to be home to one of the largest scientific communities in 1939, apart from those in Europe and North America[172].

IV.III. Economy

Vaccination campaigns have also had a positive impact on various markets in India, helping to create new jobs, strengthening existing jobs, and facilitating productivity in other economic sectors.

IV.III.I Medical field

As we detailed in the previous section, vaccination campaigns have contributed to the development of training of health professionals, as well as to the creation of medical research. Thus, historians estimate that these changes resulted in the employment of more than 1,000 Indians as surgeons in the 1920s across the various provinces, as well as 4,000 Indians as assistant surgeons[173]. Positions in vaccine production centers also emerged, and their number increased from the first installation of such infrastructure in 1892[174].

The law put in place in 1873, governing the registration of births and deaths, also promoted job creation. Indeed, section 7 of the *Bengal Births and Deaths Registration Act of 1873* stated that “the commissioners should [henceforth] be authorized to provide out of the municipal fund for the employment of a sufficient number of registrars (…)for the maintenance of shuch registers (...)”[175].

In addition to creating new jobs, the vaccination campaigns had a direct impact on the evolution of the jobs of those who were fighting smallpox before the arrival of the vaccine. Historians report that as early as the mid-1860s, members of the British health services[176], including several officials under the supervision of A. M. Garden, the General Superintendent of Immunization in Punjab at the time[177], “recruit[ed] (...) experiences lower-class inoculators and hakims to work with itinerant vaccinators”[178]. These locals were of crucial help, being familiar with the place. Indeed, a large part of the population was dispersed, and some people migrated seasonally. Historians have found a report by a British doctor, saying that when the vaccinators arrived, “the tahsildar, Maindi Khan, made admirable arrangements for carrying on the work (...) in such a manner that the whole of the villages were vaccinated in about two weeks”[179]. In addition, it is reported that various Brahmins, respected religious members[180], had followed Western training, allowing them to carry out vaccinations[181].

IV.III.II Other socio-economic sectors

Although less obvious, smallpox vaccines have had positive effects on non-medical professions. Indeed, the modernization of the medical system favored the general modernization of the country, which led to the development of new markets, and thus, the creation of new wealth[182].

Moreover, even Indians belonging to the lower social classes have benefited economically from vaccination. Indeed, vaccination did not require quarantines after its administration, unlike the variolation process. Thus, it was particularly appreciated by those whose profession was nomadic, such as breeders, workers and traders[183].

In addition, some Indians, like practitioners of traditional medicine, carried out Western studies. Thus, some joined other government professions, notably in the army and police forces. It was common for the latter to return part of their remuneration to the members of their village of origin[184].

V. Adverse impacts

It is essential to mention the harmful impacts of smallpox campaigns, which are often less mentioned in the articles available to the general public. We will thus see the extent of the damage caused, particularly on Indian culture and religions, the country's economy, and other societal aspects.

V.I. Religion and culture

One of the greatest features of India has been damaged by vaccination campaigns. Indeed, India is known for its cultural and religious diversity; the number of exact languages and dialects is not known, but includes at least 112 different languages, each with at least 10,000 speakers[185]. In addition, the inhabitants followed various religions, the most practiced being: Hinduism, Christianity (whose popularity increased mainly in the Bengal region, following the intervention of missionaries)[186], Islam, Sikhism, Jainism, Zoroastrianism, Judaism, and Buddhism[187]. Jainism and Sikhism are religions that originated in India[188][189], and with Zoroastrianism, are religions whose adherents are almost restricted to this country[190].

We will therefore see how the various actions aimed at eradicating smallpox have degraded the cultural heritage of India, generating opposition, and limiting the practice of traditions.

V.I.I. Tensions

In the pre-colonial years, when the West was gaining power in Asia, as well as when India was a colony, clerics from various branches of Christianity were sent to India. From the beginning of the eighteenth century, Lutheran missionaries were dispatched, and from the nineteenth century, the British Crown sent Anglican religious. They were intended to follow the belief shared at the time among Westerners, dictating that they had a duty to “civilize” Eastern countries[191]. These actions, based on a sense of superiority on the part of the settlers, were perceived as extreme betrayal by the Indian people. Widespread panics emerged, and revolts broke out in which Indians claimed the merits of their own religions and their rights as British subjects[192].

The arrival of the vaccine reinforced these discords. Indeed, their production via the exploitation of heifers, young cows that have not yet given birth[193], came as a shock to the Indian people[194]. Hindus believe in the sanctity of cows, which represent divine and natural beneficence, and therefore deserve to be protected and venerated[195]. Thus, the latter, as well as Muslims, saw vaccines as blasphemous substances[196]. By importing vaccines into India, and establishing centers that produced them, the colonists disrupted a veneration dating back to 200 B.C[197]. The obligation to be vaccinated increased the number of resistances that could manifest itself in various forms, ranging from refusal to pay to attempted murder of vaccinators[198].

V.I.II. Damage to cultural heritage

In India, inoculation was very closely linked to religion. Indeed, at the time, Hindus represented between two out of three and five out of six people[199]; and the latter believed in the importance of the Goddess Shitala during this process[200]. She could also be found in the company of her sisters: Masani, Basanti, Maha Mati, Polamde, Lamkaria, and Agwani during the rites[201], particularly among the Punjabis, an Indo-Aryan ethnolinguistic group located in the Punjab region of northwestern India, which includes part of eastern Pakistan[202]. The believers believed that their lack of worship in favor of Shitala, as well as social conflicts between members of the village, could enrage her, causing her to scatter pustules accompanied by fevers before each spring harvest[203]. Thus, prayers were addressed to him between March and April[204] in anticipation of the waves of smallpox that were most common during dry winters[205], which peaked between March and April[206].

In addition to being recognized as the cause of the infection, this goddess also played a role in the healing of smallpox. In order to achieve his desires, his followers had to undergo a ceremony that included inoculation[207]. In addition, part of his worship included offering water and neem leaves to those suffering from smallpox in order to calm their fever[208]. This characteristic earned her the nickname *Thandi*, meaning “cold one”[209] in Hindu.

Thus, taking into account all these interconnections between smallpox care and religion, we can guess that the arrival of vaccination, which replaced inoculation as a means of obtaining active artificial immunity, disrupted various religious activities. By “outlawing [variolation, and] by making vaccination more widely available and overcoming initial resistance to it, the English were able by the close of the nineteenth century to effectively suppress a once widespread practice”[210]. In this way, the Hindu ritual was completely turned upside down. In addition, wanting to reduce the waves of smallpox, the English put in place sanitary measures that regulated gatherings. This led to the cancellation of religious festivals, disrupting respect for Indian traditions[211].

In addition, these measures contributed to the establishment of medicine imported from the West in India. As a result, the use of natural treatments, rooted in Indian culture, decreased, in favor of industrial and non-traditional alternatives[212]. Thus, as renowned historian David Arnold states, “the impact of British attitudes on indigenous medical ideas and practices can most clearly be seen in the case of smallpox”[213].

V.II. Economy

From the middle of the sixteenth to the middle of the nineteenth century, India experienced a very prosperous period. Indeed, economists estimate that during the sixteenth century, India's gross domestic product was about 25.1% of that of the world economy[214]. Once the colonial government was established, India's land revenues were used to fight wars there, as well as to finance other wars in Europe. This spending encroached on the country's economic development. In addition, India went from being an exporter of processed goods to an exporter of raw materials and a buyer of manufactured goods[215]. According to the economist Angus Maddison, these events were the cause of India's decline in GDP, which in 1950 accounted for only 4.2% of world income[216].

Thus, the exploitation of the country by the British colonial regime devastated the Indian economy. We will see how vaccination campaigns have in some cases contributed to these economic deteriorations, in particular through the elimination of jobs, but also through the scale of the funds they required.

V.II.I. Business disruption

Before the arrival of vaccines, when the Indians were in charge of regulating the control and prevention of smallpox contamination, the people benefited from the revenues obtained from this trade[217]. Indeed, several healers and doctors belonging to the lower social classes took part in the inoculation process, including the vaids and hakims, doctors practicing traditional Indian medicines[218]. The vaids practiced the Ayurvedic system of medicine[219], which relied on “panchakarma (“5 actions”), yoga, massage, acupuncture, and herbal medicine, to encourage health and wellbeing”[220]; and the hakims which followed the Yunani system, whose “healing is based on principles of harmony and balance, uniting the physical, mental, and spiritual realms”[221]. This practice was an important part of their professional activities[222]. Thus, vaccinations impacted this environment, gradually replacing it.

In addition, the new local doctors who were trained in vaccination, and who replaced these inoculators, were not properly paid. This is mentioned in one of the annual reports on vaccination in the Madras Presidency, which encompassed most of southern India[223]. In the report dedicated to the year 1913, it is mentioned that “the rates of pay allowed to vaccinators [were] absurdly low, the minimum being Rs. 5 per mensem”[224].

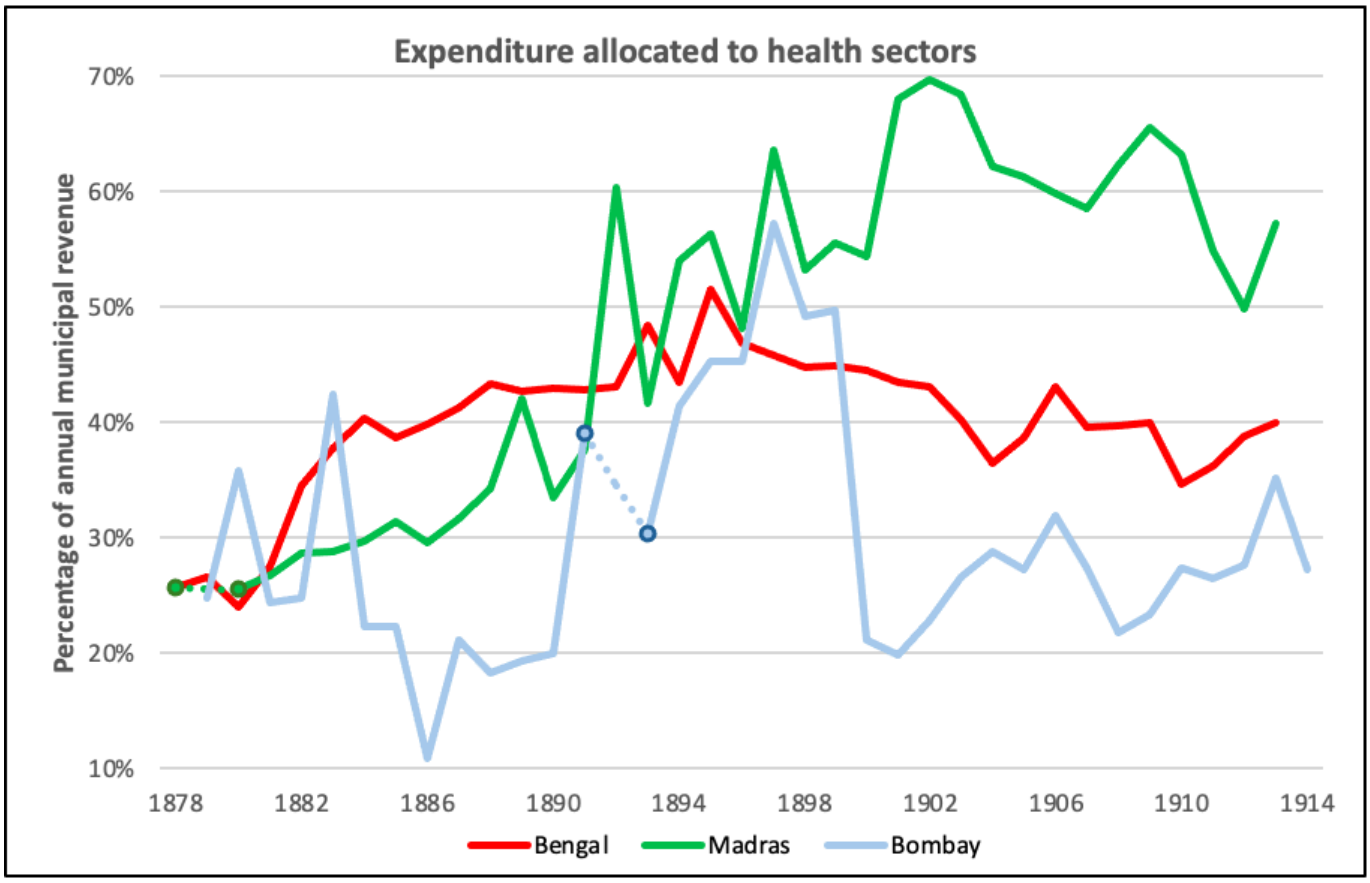
Finally, the fight against smallpox had a direct impact on the agri-food sector. This is because calves were separated from their mothers to be used for vaccine production. This separation, even if short-lived, considerably reduced the mother's milk production, as well as their fertility. The proportion of vaccines made from animals increased, reaching more than 9% by the end of the 1890s. The result was a significant decrease in the cattle population, so much so that the farmers revolted[225]. Motivated by the severe famines that resulted from these production cuts[226], the *Tahsildar* (official of the Ministry of Revenue)[227]in the city of Kharar, Punjab[228], started a petition to stop the calf loans[229].

V.II.II. Costs

Vaccination campaigns have also had a negative impact on the country's economy. As we will see, the State allocated a very large budget to it, which inevitably led to a reduction in its investments in other crucial sectors. This prioritization of vaccination spending has had a negative impact on the country's finances and economic development[230].

One of the main complications of the vaccination program was its cost. Personnel, equipment, transportation, storage, distribution, and research for vaccines have all required significant financial investments[231]. In addition, as already mentioned, the registration of every birth and death was made compulsory, especially for research into the effect of vaccination, and required the employment of new civil servants, paid by the state[232].

Thus, it is estimated that more than 0.7 million rupees were dedicated to the expenses of smallpox vaccination campaigns from 1880 to 1881, and that this budget continued to increase, exceeding 1.1 million rupees between the years 1902 and 1903[233].



Graph showing expenditure allocated to the health sectors, Bengal, Madras, and Mumbai [234]

These expenditures were a significant contributor to the total costs of public health measures, which accounted for a significant portion of the country's expenditures. Indeed, from the year 1881 to 1882, the municipalities of Bengal, Madras, and Bombay devoted about 25% of their annual income to this milieu, accumulating more than 1.8 million rupees. This proportion of public spending continued to increase over the years. Thus, in 1913, expenditure related to sanitary measures represented 35% of the expenditure of the municipality of Bombay, and 57% of that of Madras, i.e. nearly 13 million rupees in total. Madras had experienced a peak in spending in this sector 11 years earlier, dedicating 70% of its revenues to it[235]. The most extreme case occurred in 1893, when the municipality of Nasirabad spent more than 82% of its income in this area[236].

Thus, the analysis of these expenditures clearly shows the importance of the funds allocated directly to vaccination campaigns, as well as their contribution to the increase in public spending in the field of health. The latter represented a major part of municipal budgets, and thus weakened the local economy.

V.III. Society

Eventually, the measures put in place to eradicate smallpox had a devastating impact on the Indian people, deepening class inequalities, and causing physical and mental pain.

V.III.I. Inequalities

The introduction of the vaccine accentuated the disparities between citizens in many ways. As mentioned earlier, the actions taken by the health authorities disrupted the practice of Shitala's worship, while he participated in social solidarity. During the ceremonies dedicated to this goddess, one of the main activities was the redistribution of food. The religious leaders taught that “Sitala and her sisters (...) only cared for porridge and other plain offerings, and that these ought to be given to the lowest castes in the villages”[237].

Vaccine distribution was also uneven, favouring densely populated urban areas. As noted later, vaccine production centres and hospitals were established in some cities, leaving out the rural areas[238], accentuating the differences within the population of British India. In addition, until the 1900s, the vaccine was subject to a fee due to the limited number of qualified vaccinators, which was the main reason for “the low coverage among rural areas and by the poor people”[239].

Moreover, for reasons that will be discussed later, many Indians were reluctant to be vaccinated using the arm-to-arm method, not wanting to supply their lymph after being vaccinated, as this practice required[240]. Thus, vaccines based on calf lymph were often preferred, although they did not satisfy everyone, especially for religious reasons. However, access to these vaccines was highly uneven, with limited distribution. Indeed, his arrival did not immediately replace the arm-to-arm method[241]. British vaccinators were instructed to inform people who were reluctant to donate their own lymph that they had the option of going to medical colleges. They could receive an animal lymph-based vaccine, without having to give their own[242]. However, many could not travel the kilometres needed to access these centres, making this vaccine inaccessible to the most disadvantaged families.

All the measures undertaken by the vaccination campaigns have contributed to the modernization of the country, which “intensified (...) the income differentials among [farmers], favouring (...) some merchants, civil servants and peasants [but also in the decline] of agriculturalists, [and] enlarged landless class”[243].

In addition, while vaccination campaigns have helped improve access to education and provide more professional opportunities for women, they have also created new sources of gender inequality. Indeed, many reports show that strong stereotypes about Indian women were often conveyed by English professionals. The latter perceived them as ignorant, which greatly limited their opportunities. As a result, women often found themselves confined to the paediatric and/or maternal sector, without the possibility of accessing positions of administrative responsibility comparable to those of men[244].

V.III.II. Concern and misunderstandings

As already mentioned, vaccination campaigns disrupted the practice of religious rites and customs as well as the local economy. These deteriorations were in themselves sources of misfortune and indignation, but other actions put in place by the vaccination campaigns were the cause of various sufferings. Indeed, we can already recall the very large famines caused directly by the creation of smallpox vaccines[245].

In addition, when the first vaccines were distributed through human lymph, many parents were afraid of them. Indeed, they believed that “the introduction of blood of one child into another (…) was likely to produce disease of whatever nature the vaccinifer may be suffering from”[246]. This fear was reiterated with the introduction of bovine lymph-based vaccines, which, in addition to being religiously offensive, raised fears about diseases transmitted by these animals[247].

In the late 1870s, as the vaccine became popular, there were reports of vaccination failing to prevent smallpox. In rarer cases, some even succumbed to it. Thus, “with growin frequency, parents complained that they could not be sure whether vaccination had “taken” their children”[248].

In addition, many parents were very skeptical about taking their children's lymph following their vaccination, thinking that this practice could cause infection or even kill them. Thus, “parents generally hid them from the inspectors [in charge of measures] vaccination stations”[249]. As we learn from the first annual report of the *Ranchee Circle of Vaccination*, fears were often based on a shared idea, which said that the English “wanted to steal the children for some purposes of witchcraft (…). The most general idea was, (…) that the operation of vaccination was for the purpose of extracting a drop of blood, many of which would be given to a ship proceeding to England, and that in the event of shipwreck the sailors drowned would return to life, at the expense of an equal number of the native children vaccinated in India (whose blood they had brought with them) who would as suddenly die”[250].

These major fears were not unfounded, however. Indeed, real horrors were carried out in order to allow the spread of resistance against smallpox. Until the arrival of the animal vaccine, the so-called arm-to-arm vaccination method was widespread in India. Children, mostly from lower social classes[251], who had received the vaccine, were used to spread resistance. Blood was drawn from them, which always contained the attenuated forms of the virus, in order to vaccinate other people[252]. In some cases, children became weak because of these samples, some became ill, and although it was rare, some succumbed to it. These tragedies reinforced families' fears about vaccination[253].

When the vaccines were administered, lancets, “small surgical instruments used to make small incisions”[254], were initially used[255], with the vaccine applied to these cuts[256]. As early as 1883, the six-point vaccination, with three incisions on each arm, was made mandatory, in order to ensure better contact with the lymph, and thus to guarantee a higher success rate. In 1909, thanks to the improvement in the quality of the injected lymph, the number of obligatory incisions was reduced to four[257]. These incisions left distinct marks that were the source of various apprehensions and fears for the Indian people. Some feared that the mark would allow the British authorities to identify and trace each individual[258]. Many historians report that Indians saw this mark as offensive and unholy[259], being a *tilak*, “a mark, usually made on the forehead, indicating sectarian affiliation (...)[260]“, imposed by British vaccinators[261], and was “felt as [a symbol] of colonial power [and] enslavement (...)”[262].

V.II.III. Impact on other diseases

Although vaccination campaigns contributed to several areas of public health, their impact was not exclusively positive in this sector.

Historians claim that “British methods of improving urban health rapidly limited specific diseases like smallpox and cholera, [...] often encouraged more deadly diseases, such as malaria, tuberculosis, and plague”[263]. Indeed, in the 1980s, the supply of filtered water in urban areas increased. This contributed to the various health measures that reduced the number of people suffering from smallpox and/or cholera infection. However, the increase in water supply had favoured the reproduction of mosquitoes, and thus contributed to an increase in infections[264] with the *Plasmodium parasite*[265].

VI. Conclusion

The analysis of the different effects of smallpox vaccination campaigns highlights the complexity of this subject. In order to assess whether these campaigns were beneficial or harmful to the population of British India, other aspects related to this opposition will be discussed. Finally, the criticisms will be put into perspective, taking into account the fact that they have been formulated according to current criteria.

VI.I. Summary

As we have seen, vaccination campaigns have had various impacts on the population, sometimes positive, sometimes harmful. Thus, the disrespect and suffering inflicted by the settlers has raised growing questions about the legitimacy of their rule. This fuelled revolts that led to India's independence, marking the end of the period under study. The hindsight we have today therefore allows for an in-depth understanding of smallpox vaccination, and leads to a clear definition of its impacts on the Indian population.

VI.I.I. Independence

One of the indirect consequences of the expansion of the smallpox vaccine was undoubtedly the acquisition of India's independence.

Indeed, since the arrival of the British colonists, Indians had objected to the services they offered. Although this trend diminished over the years, in part because of the education offered there, according to the Anglican system, resistance persisted[266]. Western medicine also received various resistances fuelled by various fears previously discussed. Vaccination was commonly seen by the population “as a practice of oppression or torture against them (...) ”[267]. The “cultural clash in terms of religion, practices, ethos and philosophy between traditional forms of native medicine and western medicine”[268] was noticeably perceptible in this area.

The Indians' responses to the settlers' attacks on their religious festivals, declared to defy local authority, were “seized upon and exaggerated (…) as a way of protecting a stereotypical image of Indian ignorance (…)”[269]. In addition, the colonists implemented general censorship on this subject[270]. Historians claim that the introduction of vaccination has helped justify their racist acts and the exploitation of the country[271]. Indeed, “the introduction of the cowpox vaccine, (…) was unambiguously conceptualized by the colonizers as one of European benevolent medicine versus indigenous prejudice and superstition (…)”[272].

This “subsequent conduct (…) only increased the rejection of vaccination. “[273], and doubts about the real benefits of India's modernisation began to emerge[274]. The real selfish motivation of the colonists was a source of rumours among the Indians[275]. In addition, many Indian doctors resigned due to the lack of respect of European professionals[276]. All of this was one of the various factors that led Indians to join the *Quit India* movement, led by Gandhi[277], which greatly contributed to the fall of British power in the country, which played a crucial role in achieving India's independence on August 15, 1947[278].

The time for the assessment of the vaccination carried out during colonization could then begin.

VI.I.II. Review

In conclusion, the smallpox vaccine made smallpox the first, and, to date, the only human disease completely eradicated. This invention by Edward Jenner dating from 1796 was based on various observations by other scientists of people who had contracted vaccinia as well as their non-contraction of smallpox.

The first dose of the vaccine was administered in India in 1802. This country, where variolation had been practiced since 1580, had come under the direct control of the British Crown in 1858, and was now part of British India. During this colonial period, the measures put in place to fight the disease had various impacts on the population. India had regained its independence in 1947, and the various measures taken over the years contributed to the eradication of smallpox in 1980.

The vaccination campaigns under the governance of the British Raj had many positive effects. Indeed, public health was greatly improved, notably marked by a reduction in the number of infections, a significant drop in mortality, and improved sanitary conditions. All this allowed for an increase in life expectancy. In addition, these campaigns allowed the training of professionals in the medical field and encouraged various research carried out in India. Thus, they contributed to the creation of many jobs in hospitals, and workers in other sectors benefited from the speed of the vaccination process.

However, various negative consequences also arose from the smallpox vaccination. Indeed, this initiative led to a loss of cultural heritage, limiting certain religious practices, traditions, and local medicines. In addition, it contributed to the significant collapse of the economy by disrupting the practice of lucrative activities, which led to famines, as well as by employing a large part of the revenues of the municipalities, preventing their economic development. In addition, social inequalities were amplified, and the countryside caused moral and physical suffering, as well as indirectly contributing to an increase in the number of deaths from other diseases.

Therefore, the complexity of the different aspects of the impact of vaccination campaigns makes it impossible to describe its nature unequivocally. As with all subjects dealing with the humanities, nuances are mandatory in order to fully understand them, which makes it possible to reduce any bias as much as possible. Indeed, even the medical field, despite the obvious and widely acclaimed benefits attributed to it, is not exempt from exceptions. Indeed, the increase in water intake, one of the measures to combat smallpox, led to an increase in malaria cases in some regions.

The various topics covered show that claiming that the campaigns against smallpox were beneficial, as argued by the majority of articles intended for the general public, would omit a major part of the story, thus perpetuating prejudices.

Conversely, to assert that vaccination against smallpox was harmful to the Indian population would not allow us to arrive at a satisfactory definition of the impacts of the campaigns either. While this may prompt reflection on aspects that are often overlooked, the benefits, including the remarkable medical feat of eradicating a disease completely, cannot be ignored.

Thus, the smallpox campaigns could be described as having had beneficial impacts on the population of British India, particularly in the medical field, but also marked by various disastrous acts and consequences, the mention of which is essential.

VI.II. Perspectives and reflections

To complete the analysis of vaccination campaigns against *poxvirus*, other avenues of analysis could be mentioned. Indeed, it is crucial to grasp both the historical context in which these decisions were taken as well as subsequent realizations.

VI.II.I. Challenges of the Historical Context

When the vaccination campaigns were introduced in India, the world was still greatly affected by this disease. Indeed, in London, this disease was the cause of more than 15% of annual deaths during the peaks of pandemics, until the end of the eighteenth century[279]. Historians estimate that even after the rollout of vaccines, smallpox still caused between 5% and 10% of annual deaths, until the end of the 19th century. The *Bills of Mortality* only took into account Anglican burials[280]; An official system of registration of all deaths did not appear until 1836[281]. Thus, historians believe that this proportion was surely even higher[282]. The vaccine, which had been invented 46 years before the colonization of India, had not led to an instant and complete decrease in deaths. In fact, in the early 1870s, in various cities in Germany and the Netherlands, 25% to more than 40% of deaths in children between the ages of 1 and 5 were due to smallpox[283].

In order to deal effectively with the disease, the population had to be protected in a generalized way, especially as means of transport developed, thus facilitating the spread of infectious agents between countries[284]. Immunization on a global scale was so essential to the eradication of the disease that less than 20 years after India's independence, the World Health Organization set up the *Smallpox Eradication Program,* which allowed for the coordination of efforts to develop vaccination strategies, which led to the elimination of the disease worldwide[285].

In this way, the choices made by British officers, in particular the obligation of vaccination and the repression of variolation, can be better understood. Indeed, if these measures had been delayed, smallpox would have continued to cause terrible suffering, infecting many people, and causing many deaths. It can therefore be argued that it was their moral duty to stop this pandemic as quickly as possible by increasing the number of vaccinations. In addition, philosophers “argue that individuals who have access to vaccines and for whom vaccination is not medically contraindicated have a moral obligation to contribute to the realisation of herd immunity by being vaccinated”[286]. This justifies the reasoning behind the measures imposed on the population of British India.

Thus, while it is crucial to recognize the various negative consequences of vaccination campaigns, it must also be understood that the urgency of the situation required such actions to respond effectively to the crisis. Better solutions could not have been implemented so quickly, especially considering the resources and prevailing mentality of the time. Indeed, the latter as well as the absence of modern means of communication had certainly restricted the understanding of the English towards the local cultures. Moreover, it had limited the dissemination of information on the origin and benefits of vaccines, complicating global vaccination. In addition, although the creation of railways had already begun in British India, the means of transport were not as fast as they are today[287], which complicated the logistics of vaccination campaigns.

VI.II.II. Postcolonial Awareness

In many reports on vaccination campaigns, medical prowess was highlighted, while resistance, famine and other negative consequences were not mentioned. Indeed, as explained above, smallpox vaccination was a massive argument to “demonstrate the growing sense of superiority of the Western medicine over the indigenous practice”[288]. Historian describes how various documents counting resistance to vaccination have long been hidden to serve the “great epic narrative of the WHO”[289].

Historian Paul Greenough stated in 1990 that “several [former vaccinators sent to India] now express regret over their participation in patterned acts of intimidation and coercion”[290] during the *Smallpox Eradication Programm*. Indeed, some have confessed that their vaccination methods follow an almost military model, which consisted of hunting down those who resisted vaccination, and forcibly vaccinating them[291].

Therefore, the change in mentality and the guilt felt by some have allowed access to certain information. The account of these events allows us to imagine the censored horrors that took place during India's colonial period. However, the extent of these past censorships makes it extremely difficult to assess the violence in British India[292].

The confessions concerning the actions committed after 1860 make it possible to note a certain awareness of past injustices[293]. However, it also shows that atrocities, rooted in biased ideologies, continued to be committed at the end of the twentieth century. This underscores the importance of not forgetting these past topics, as they remain essential to avoid the recurrence of such events.

Thus, the analysis of this subject also raises questions about current decisions. Indeed, nowadays, the number of annual measles cases is increasing[294], in particular because of parents refusing to vaccinate their children[295]. Hence, it would be relevant to study the ethical nature of the means put in place to push for vaccination, motivated by the effectiveness of the latter in reducing epidemics, and its ability to save lives. For example, in various countries, it is common to limit access to education to vaccinated individuals. This is the case in France, where eleven vaccines are mandatory for the admission of children born after 2018 “(...) in a nursery, school, daycare, holiday camp or any other children's group”[296].

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