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The impact of smallpox and vaccination in Northern Germany in the 18th and 19th centuries

Introduction

For the enlightened contemporaries of the late 18th and early 19th century, the struggle for inoculation and vaccination was part of the battle for the progress of humanity. Authors like Voltaire had no doubt that the inoculation of Louis XVI after the death of his father, a victim of smallpox, was a big step to modernity. Certainly, the French court had learned its lesson in 1774, and the women showed their commitment to the noble cause by their hairstyle "à l´inoculation" – symbolised by a snake, a hammer, a sun and an olive tree. Inoculation had not made its breakthrough to a wider public yet, however. In this sense, the situation in Germany was similar. In contrast to Britain, the story of inoculation in Germany was a story of obstacles rather than of success. The English doctor William Baylies[1], who came to Berlin in the same year, could not make any progress towards the cause of inoculation in the Prussian capital, because his first intervention resulted in a lethal issue. Nevertheless, twenty years later an intensification of inoculation practices could already be noted, and the last obstacle to a more extensive use, i.e. the defence of inoculation in the absence of an epidemic of smallpox, was about to fall. Though we ignore the exact scope of a phenomenon that deserves further research, it can be supposed that inoculation not only prepared the way for vaccination by spreading the acceptance of such a preventive medical intervention,

[1] William Baylies, *Nachrichten über die Pocken-Inoculation zu Berlin*, Dresden 1776. To some extent inoculation, first practised in 1721 in Bernburg and 1722 in Hanover, spread after the Seven Years War (for further references see Rolf Gehrmann, *Bevölkerungsgeschichte Norddeutschlands zwischen Aufklärung und Vormärz*, Berlin 2000, p. 291–298).

but also contributed directly or indirectly to a decline in mortality, the first signs of which were perceptible in the same decade.

In principle, the story is well known. Like in other countries, the protective power of a cowpox infection was known in Germany before Jenner. A simple village teacher experimented with vaccination in 1791 and although he reported his findings to the medical faculty of the University of Kiel[2], his experiences were largely ignored until Jenner wrote about his own discovery. Within about ten years after this decisive year of 1798, vaccination then turned into a mass movement. It began with the foundation of a very active vaccination institute in Berlin in 1802, continued by an official recommendation in Hanover (1803) and became general with the laws about compulsory vaccination in Bavaria in 1807 and in Wurttemberg in 1818. Even without such laws, prescriptions for pupils or children who were to be confirmed sufficed to guarantee a large coverage in all German states[3]. This did not exclude a regression of the coverage and the reoccurrence of the epidemic smallpox after the 1820s, so that the final point to the problem was not set before the legislation of 1874.

For a long time, there was no doubt that the introduction and the spread of vaccination after 1800 had all the attributes of a success story. Nevertheless, two questions continue to intrigue researchers in historical demography and the history of medicine who look for statistical evidence: 1) Was vaccination the unique or at least the main cause for the diminishing power of this disease? 2) Did the fading of smallpox lead to a decline in mortality and did it contribute in this way to the acceleration of population growth in the first half of the 19th century? The debate is still open, and it points to the fact that the information handed down by generations of medical historians may still need completion and perhaps even a critical re-assessment.

The opposite positions may be outlined as follows. On the one hand, there are scholars like Mercer who work on sources like the London Bills of Mortality and the enquiries of the Royal Commission on Vaccination[4]. They ascertain that in England, a first mortality decline accompanied inoculation, and that vaccination caused the decisive decline from 1810 onwards. Furthermore, they state that vaccination

[2] Thorkild Kjaergaard, *Den danske revolution 1500–1800*, Gyldendal 1991. Already in 1769 an article in a Göttingen magazine (*Von der Seuche unter den Kindern; über Stellen aus dem Livio*, „Allgemeine Unterhaltungen" 39, 1769 (24 V), cited by Paul Kübler, *Geschichte der Pocken und der Impfung*, Berlin 1901, s. 144) drew attention to the possibility to get protection by cowpox.

[3] The Prussian smallpox census of 1810 revealed that 35 000 persons lived in the Electoral March and 61 527 in Silesia that were neither vaccinated nor had they ever had smallpox. For this reason the reinforcement of the propaganda for vaccination had to be completed by strict quarantine rules and compulsory vaccination in the event of outbreaks in this part of the population, roughly 5% of the total (F. L. Augustin, *Die königlich preußische Medicinalverfassung*, 2 vols, Potsdam 1818).

[4] Alex Mercer, *Smallpox and Epidemiological-Demographic Change in Europe: The Role of the Vaccination*, „Population Studies" 39, 1985, p. 287–307. Still useful: Charles Creighton, *A History of Epidemics in Britain*, London 1965.

in the 1870s contributed to a further improvement of life expectancy. On the other hand, there are historical demographers who work on sources on a micro-level like Dyrvik who throw a general doubt on the effectiveness of vaccination. They suggest for example that mutation of the virus of smallpox itself may have been the main reason for the decline in mortality through this disease[5]. Additional doubts are nourished by an idea that goes back to Malthus who, in his well-known parable, claimed that smallpox were one of the channels which nature had opened to keep down the population. In this perspective, a substitution process cannot be avoided: „Has this [door] been closed, others would have become wider"[6]. Evidence for the replacement of smallpox by other child diseases can be found indeed. There are some more general reasons that this kind of scepticism still falls on fertile grounds. In German historiography, it is especially the tendency to a general aversion against all explanations of historical processes as stories of progress or modernisation. Though not concerned by Malthusianism, actually rare or even absent in historical debates, such a critical attitude against the actions of rulers or an enlightened elite combined with the reappraisal of popular resistance against such impositions sometimes comes to a similar end. A naïve reader of recent works may thus draw the conclusion that, even if the intentions were honourable, the means were difficult to defend and, after all, the results were too uncertain to justify them.

Therefore, there are good reasons to reconsider the impact of medical struggle against smallpox. For the purpose of this reappraisal, we will focus on Northern Germany with its comparably good statistical sources. For the western part of present-day Poland, such a reappraisal has been done separately[7]. Our argumentation will be based on the age distribution of deaths and the contemporary information

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[5] 1) Stale Dyrvik, *The Effects of Smallpox Vaccination on Mortality: A Norwegian Case Study 1770–1840*, [w:] *Society, Health and Population during the Demographic Transition*, edited by Anders Brändström, Lars-Göran Tedebrand, Stockholm 1988, p. 495–522. Main argument: mortality decline was twice as big as it could have been caused by the disappearance of smallpox. That is why he supposes a „mutation of the disease itself" (p. 412) since 1798, followed by an new aggravation in the 1840s. The „virulence hypothesis" first advanced by Fridlizius seems less and less convincing (see Peter Sköld, *Les effets de la vaccination antivariolique en Suède: protection des enfants et menace nouvelle pour les adultes*, „Annales de démographie historique" 1997, p. 47–87), but it has not entirely disappeared.

2) According to Thomas McKeown (*Fertility, Mortality and Causes of Death: An Examination of Issues Related to the Modern Rise of Population.* „Population Studies" 32, 1978, p. 535–542) inoculation caused more damage than benefit and even vaccination did not bring a sufficient immunisation of the whole population.

3) An example for such a sceptical point of view: Eberhard Wolff, *Einschneidende Maßnahmen: Pockenschutzimpfung und traditionale Gesellschaft im Württemberg des frühen 19. Jahrhunderts*, Stuttgart 1998.

[6] Thomas Robert Malthus, *An Essay on the Principle of Population. Selected and introduced by Donald Winch*, Cambridge 1992, p. 240.

[7] Rolf Gehrmann, *Der demographische Umbruch vom 18. zum 19. Jahrhundert in Norddeutschland — ein auf die Gebiete östlich von Oder und Neiße übertragbares Modell?*, [in:] *Przemiany*

about causes of death. For smallpox, such statistics were not difficult to establish, but this does not mean that there were no methodological problems linked to it. They shall not be dissimulated here. For instance, it cannot be said to what degree infant mortality was influenced by hidden smallpox[8]. On the other hand, the quality of the data collected by contemporary observers deserves surely more confidence than conjectures based on present-day knowledge, which is no longer based on observation of smallpox. The aggregated data of parish statistics of the 18th and 19th century can even be considered as an independent source, since doctors were not involved in it, so that their commitment to inoculation and vaccination could not create a fallacy.

The impact of smallpox, as measured by 18th-century scholars

In the second half of the 18th century, doctors became aware of the possibility to convince an enlightened public of the blessings of inoculation by arguing with statistical probabilities, in comparing the risk of a medical intervention with the „normal" risk for children to die from smallpox. In relative terms, the risk of inoculation could be presented as nearly absent indeed. For some mathematicians the problem turned into an interesting exercise that helped to demonstrate the application of integral calculations to life tables. This is what Daniel Bernoulli did in 1766 when he introduced what may be called „the rule of the 1/8th"[9]: i.e. 1/8th of all children contracted smallpox each year and 1/8th of them died. Eradication of smallpox would then add a little bit more than three years to the life expectancy at birth, which is similar to what Duvillard stated later. Another mathematician, Alsatian and correspondent of Bernoulli, Lambert, continued to develop this approach by using mortality data from The Hague and supplementary lethality data from Winterthur. By this, he managed to produce, based on the Süßmilch table, a disease-specific life table that he also proposed for other death-causes like measles (1772)[10]. Taking into consideration the increasing number of already immunised children, he concluded that after the 4th year of life smallpox constituted a greater risk for the non-immunised than all the other death-causes put together. The basic sample for Winterthur was extremely small (72 sick persons, 15 deaths), but quan-

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demograficzne Europy Środkowej w czasach nowożytnych, ed. Hanna Kurowska, Zielona Góra 2010, p. 231–253.

[8] A. Mercer, *Smallpox* [4], p. 290, 299. Perrenoud shows by exact data, that a relation between smallpox and convulsions did not exist (cited by Patrice Bourdelais, *Epidémies et population: Bilan et perspectives de recherches*, „Annales de démographie historique" 1997, p. 20).

[9] Daniel Bernoulli, *Essai d'une nouvelle analyse de la mortalité causée par la petite vérole*, Paris 1766.

[10] Johann Heinrich Lambert, *Beyträge zum Gebrauche der Mathematik und deren Anwendung*, vol. 3, Berlin 1772.

titative sources of greater importance, as the Bills of Mortality of London, could not be used for computing risks. However, simply counting the number of deaths gave already impressive results. Süßmilch, who was convinced of the advantages of inoculation and argued in its favour, proved the threat of smallpox by relating that deaths due to this cause were in a ratio of 8% of all burials in London[11].

Table 1a. Deaths by smallpox in Berlin, 1758–1774

Age	Cases	Month	Cases
0	1790	January	807
1	1416	February	566
2	1113	March	467
3	1001	April	421
4	556	Mai	418
5–9	742	June	367
10–14	42	July	379
15–19	27	August	471
20–24	9	September	529
25–29	3	October	719
30–34	3	November	774
35–39	1	December	787
40–44	–		
45–49	1		
50–54	1		
	6705		6705

Source: Möhsen 1775

For comparison:

Total number	of deaths	81134			
	of births	65633	of this stillbirths	3390	5,20%

[11] Johann Peter Süßmilch, *Die göttliche Ordnung in den Veränderungen des menschlichen Geschlechts, aus der Geburt, dem Tode und der Fortpflanzung desselben erwiesen*, vol. 2, Berlin 1765, p. 530. Baumann added a table for Leipzig 1759–1774 to the third volume (1775), which showed that only 938 of 22 475 death cases (4%) were attributed to smallpox (table 16).

Table 1b. Detailed statistics from Juncker´s archives for 1796

Wernigerode (county in central Germany)			Three towns in Prussian Poland		
Age	Cases				
0	130				
1	106		non-immunised before	1,774	
2	91		cases	1,250	(70,4%)
3–5	301		lethal issues	199	(15,9%)
6–10	159		handicaped	17	
11–15	29				
16–20	1				
Total	817				
			Source: Junckers Archiv (etc.)		
of these lethal issue	127	(15,5%)			

Complements:

live births	deaths
333	98

Source: Gehrmann 2000

For the purpose of inoculation propaganda, such absolute figures were sufficient. They were collected for a larger part of Germany at the end of the 18th century, when the doctor Juncker founded a special journal for the medical profession and clergy fighting against smallpox — which is the meaning of its German title „Archiv der Aerzte und Seelsorger wider die Pockennoth" (1796–1799). Several governments contributed to the revue with sanitary statistics. Some articles for smaller regions even contained information of the risk of infection and permanent handicaps caused by the scourge (see table 1), but they stayed anecdotal. The work of the doctor Johann Möhsen must be considered as the only detailed enquiry based on mass data and published at that time. He had the chance to dispose of the Berlin death lists that covered a sufficiently long period (from 1758 to 1774) before inoculation and he provided information about the distribution of lethal cases by age and by season[12].

[12] Johann Carl Wilhelm Möhsen, *Sammlung merkwürdiger Erfahrungen, die den Werth und den großen Nutzen der Pocken-Inoculation* näher bestimmen können, 2. und 3. Stück, Berlin-Leipzig 1775.

It is self-evident that in a city like Berlin, where the disease was endemic, nearly all of the cases happened before the age of ten. It must be specified however that 1,790 infant deaths by smallpox did not represent more that 7% of the overall infant mortality. This information was not available for Möhsen, who could not afford to make age-specific death statistics for more than 80 000 deaths. Computer-based historical research can fill this gap.

Contemporary perception of the mortality decline after vaccination

When the Berlin doctor Johann Casper reconsidered the problem of smallpox mortality by statistical means in 1825, he found himself in a particularly favourable situation with an exceptionally low mortality at that time. He compared the detailed Möhsen data, well known after their utilisation by Duvillard[13], and the general figures of another period of a similar length (1782–1801), to the deaths by smallpox during the two decades after the foundation of the Royal Vaccination Institute in Berlin (1802). Therefore, he could establish a close relationship between the 33 780 vaccinations realised there and the reduction of mortality by smallpox to less than a half, in absolute numbers. From a methodical point of view this work, which was probably the first quantitative approach to this question after the interruption of the Napoleonic wars, must be considered as disappointing, because Casper only considered crude numbers instead of using more advanced statistical methods such as computing of probabilities. He could have done so, at least to a certain degree, by exploiting the statistics compiled and conserved in the Prussian offices. Even without this, the results seemed so evident for Casper that he firmly refuted the Malthusian assumption that no decisive mortality decline was possible because of a mechanism by which one death cause would be replaced by another[14].

In certain respects Möhsen's material must be considered as superior to Haygarth´s, when he wrote on Chester in 1793 (cited by Harald Westergaard, *Die Lehre von der Mortalität und Morbidität: Anthropologisch-statistische Untersuchungen*, Jena 1901, p. 264).

[13] Emmanuel-Etienne Duvillard, *Analyse et tableaux de l'influence de la petite vérole sur la mortalité à chaque âge et de celle qu'un préservatif tel que la vaccine peut avoir sur la population et la longévité*, Paris 1806.

[14] Johann Ludwig Casper, *Beiträge zur medicinischen Statistik und Staatsarzneikunde*, 2 vols, Berlin 1825.

Table 2. Prussian smallpox statistics from the first half of the 19th century (deaths by smallpox per 100 000 inhabitants per year)

Period	Prussia	East Prussia	Pomerania	Berlin
1810/15	103	195	11	56
1816/31	21	41	3	10
1832/46	25	45	25	18

Source: Dieterici 1851.

Later on, the detailed Prussian statistics were eventually published by Hoffmann for the period 1820–1834 by districts (Kreisgruppen) and for Berlin from 1816 to 1841, but they were not analysed[15]. Dieterici, who succeeded to Hoffmann as director of the Prussian Statistics Service (Statistisches Bureau), compiled further state-wide series of data and compared it to rather isolated 18th century data. His only ambition was to show the accomplishment of a progress, and for theses purposes the number of deaths in relation to the population total was sufficient (see table 2). His conclusions were far-reaching, however, since he claimed that vaccination was one of the causes, which contributed to the faster increase of European population in his century[16]. It was only after the epidemic of 1871 that the real impact of vaccination was measured in terms of the coverage of the age group of children. For Berlin, this was done in retrospect from 1840 onwards. The figures obtained showed a relation of 8:10 between vaccinations and births in the 1840s, and a decline to less than 5:10 in several years of the 1860s, that is before the revaccination campaign of 1871, which attained more than 100 000 people. At that moment, the historical material served mainly to maintain that the efforts had been insufficient in the past. In this context, there was a condescending attitude towards inoculation. They were even blamed to be responsible for the endemic nature of smallpox in Berlin in the 18th century[17].

[15] Johann Gottfried Hoffmann, *Darstellung der Bevölkerungs-, Geburten-, Ehe- und Sterblichkeits-Verhältnisse, welche im preußischen Staate in den 15 Jahren 1820 bis mit 1834 bestanden*, Berlin 1843; Johann Gottfried Hoffmann, *Übersicht der Geburten, neuen Ehen und Todesfälle in den Jahren 1816 bis mit 1841, nach den für die Stadt Berlin amtlich aufgenommenen Tabellen*, Berlin 1843.

[16] „[...] und es ist unleugbar der Segen der Impfung eine von den mehreren Ursachen, welche der schnelleren Zunahme der Bevölkerungen aller Länder im gegenwärtigen gegen das verflossene Jahrhundert zum Grunde liegen" (Dieterici, *Übersicht über die Zahl der im Preußischen Staate vor und nach dem Jahre 1806 bis zu Ende 1850 an den natürlichen Pocken gestorbenen Menschen*, „Mitteilungen des Statistischen Bureaus in Berlin" 4, 1851, p. 309).

[17] Albert Guttstadt, *Die Pocken-Epidemie in Preußen, insbesondere in Berlin 1870/72*, „Zeitschrift des Königlich Preussischen Statistischen Bureaus" 13, 1873, p. 116–158. In general such

Results from recent research on the population history of Northern Germany

Each assessment of the impact of the efforts to fight against smallpox must begin with an estimation of its potential effects, as revealed by the general evolution of mortality in the first decades of the 19th century. The discussion of the question what the characteristics of the mortality decline were at that period and to what degree it might have contributed to the growth of European population is not a new one. Though it is has not always been treated based on reliable data, it has been largely discussed in historical demography. Briefly, the main problem is the opposition between two theses which each fit well with one specific national type of evolution, in setting apart the particular case of France. For a long-time, the richly documented Swedish statistics provided the material for what might be called by now the classic pattern of an increase in population boosted by a decline of mortality, which began in the 18th century and marked a decisive step forward after 1815. In spite of some apparent difficulties („it was rather the end of something old than the beginning of something new"[18]) to fit it into a more general model of evolution in establishing a link to the demographic transition, the mortality decline is often considered as its first phase. Similar changes have been observed in other parts of Europe, so that a decline of 15 to 20% of the crude mortality rate between 1750/59 and 1830/ seems to be a general rule. Such a decline took place in Britain too, but Wrigley and Schofield argued in the sense of a different explanation of population growth[19]. They presented the remarkable rise of the gross reproduction rate as the principal cause, at least for England and Wales. The later complementary study on family re-constitutions relativized these results of back projection somewhat, revealing the impact of the mortality decline. For England, it is still difficult to assess the effects of the changing age-structure of mortality, because on the national level the evolution of the structure of mortality cannot be traced before the end of the 1830s.

In order to measure the possible effects of vaccination, information about age groups is a condition sine qua non, however. For several states of Northern Germany, such statistics exist, especially for Prussia. There the impact of Süßmilch´s research was particularly strong. It led to crucial improvements of the vital statistics, for which the clergy raised the basic data until 1874. In 1765, Frederick II ordered a classification of deaths by age and sex, with a special column for stillbirths. Fortunately, this classification was a quite modern one, in separating the age group 0–1 from

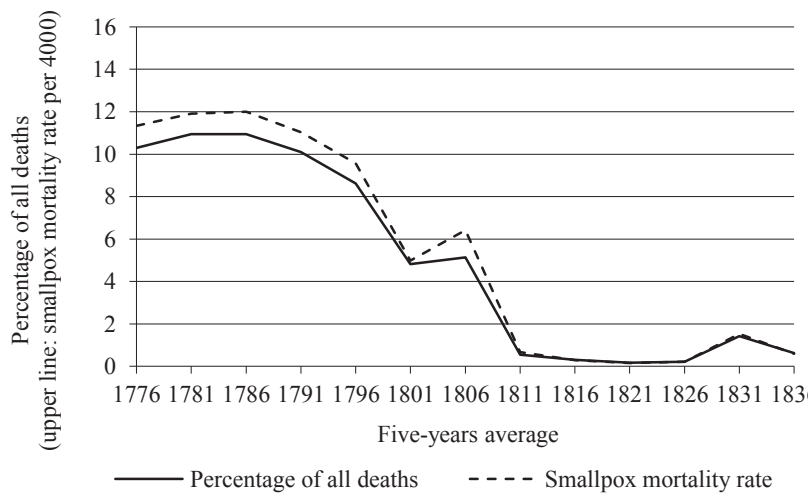
statistics did not exist before the 1870s (Karl Kisskalt, *Die Sterblichkeit in der ersten Hälfte des 19. Jahrhunderts in deutschen Städten*, „Zeitschrift für Hygiene" 98, 1922, p. 1–22).

[18] Gunnar Fridlizius, *The Mortality Decline in the First Phase of the Demographic Transition: Swedish Experiences*, [in:] *Pre-Industrial Population Change*, edited by Tommy Bengtsson, Gunnar Fridlizius i Rolf Ohlsson, Stockholm 1984, p. 109.

[19] Edward A. Wrigley i Roger S. Schofield, *The Population History of England 1541–1871: A Reconstruction*, Cambridge etc. 1981.

that of 1–4 and in using five-year intervals all over the age groups. In the Prussian archives, such statistics have been preserved for most of the provinces between 1774 and 1798 and, in a modified form, from 1816 onwards.[20] Thus, it is possible to define the level of infant and child mortality before vaccination as compared to the situation afterwards. A second improvement realised simultaneously to the introduction of the classification by age was the aggregation of statistics by death causes, sub-classified by sex too. For our purposes, this is a source of inestimable value, since it shows us the number of deaths by smallpox, a disease that after all was not difficult to detect.

Figure 1. Deaths from smallpox in Northern Germany, 1776/80–1836/40 (Kurmark, Berlin, Mecklenburg, Lippe)



Mecklenburg and Lippe since 1788, Kurmark 1774–1798 and 1810–1840.

These data enables us to represent directly the general evolution of smallpox mortality, the way it was done by Sköld for Sweden[21]. They also give us the material for an estimation of its effect on the overall mortality by a simple and robust method. For a comparison with Sweden, a graph as the one presented by Sköld is sufficient (fig. 1). For Northern Germany, it is based on statistics from central Prussia (including Berlin) and the states of Mecklenburg and Lippe. The upper

[20] R. Gehrmann, *Bevölkerungsgeschichte* [1].

[21] Peter Sköld, *From Inoculation to Vaccination: Smallpox in Sweden in the Eighteenth and Nineteenth Centuries*, „Population Studies" 50, 1996, p. 247–262.

line shows the impact on the general death rate, per 4 000 and not per 1000 as usual. There is no doubt that the changes were as evident in Northern Germany as in Scandinavia, though data for the transition period of the Napoleonic wars are not complete. It made no difference whether vaccination was compulsory or not. The initial level is the same as in Sweden (about 10%) and the general trend only shows a deviation in the second half of the first decade of the 19th century, due to an epidemic in Mecklenburg in 1807/08. From that turning point on, the part of smallpox always remained below 2% and most of the time it was even less than 1%. It is not exaggerated to call this not only a fading away but a quasi-disappearance of the „scourge". This holds for the period until the 1860s, when the threshold of 1% was passed more frequently. The epidemic of 1871, when a rate comparable of those of the 18th century (8,1%) was registered in Prussia, marked a serious setback, but this was only a temporary one[22]. A somewhat disturbing detail is the slight diminishing of the smallpox mortality rate in the 1790s that announced already a reversal of the trend before the introduction of the procedure discovered by Jenner. It points out to the question of inoculation in the last decade of the 18th century, which cannot be assessed yet.

Table 3. Life expectancy

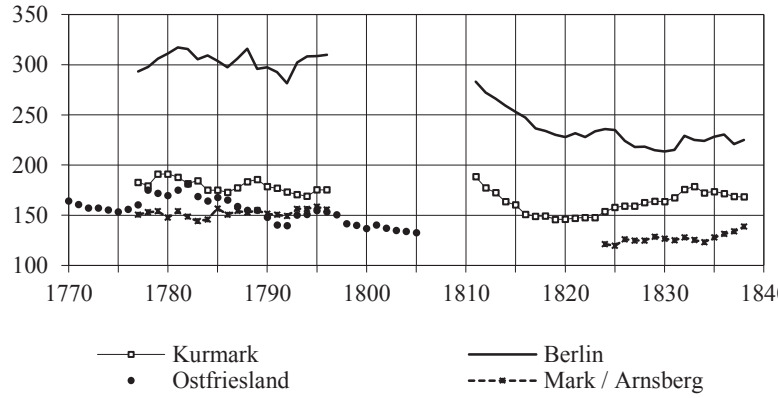
Territory	1775/98			1835/39		
	e_0	e_{20}	e_{60}	e_0	e_{20}	e_{60}
Kurmark	36,5	38,2	11,7	41,2	39,4	12,4
Ostfriesland	38,2	37,1	13,0	44,2		13,4
Mark	37,7	38,8	12,1	39,7	38,8	13,0
Lippe	36,4	37,9	11,7	39,6	38,8	11,7

As evident as the decline in general mortality is the drop in infant and child mortality. Two graphs (fig. 2, fig. 3) show the considerable improvements between the 1790s and the 1820s. Survival chances for infants improved in most of the regions of Northern Germany, but the principal effects appeared in the elder child ages. Else than the decline in infant mortality, there was a general progress that did not exclude Southern Germany[23]. Even though these improvements were followed by an inversion of the trend, this could not completely wipe off the net gain obtained since the 18th century. The Prussian data allow even deeper insights into

[22] A. Guttstadt, *Pocken-Epidemie* [17].

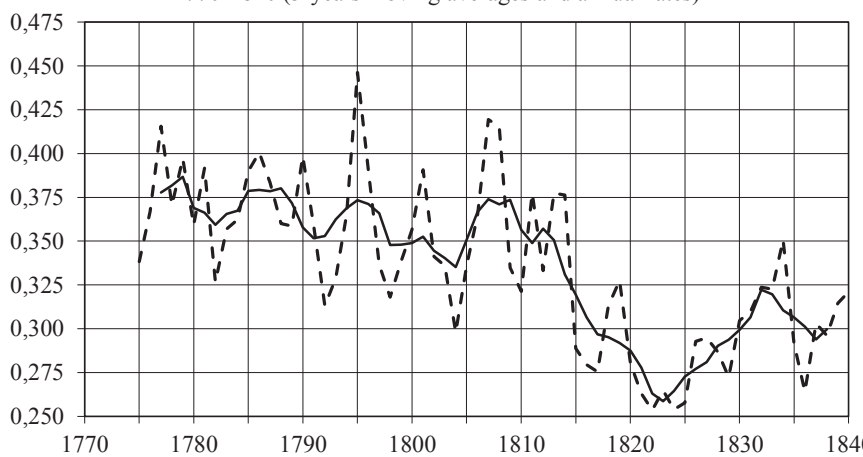
[23] Arthur E. Imhof, *Lebenserwartungen in Deutschland vom 17. bis 19. Jahrhundert. Life Expectancies in Germany from the 18th to the 19th Century*, Weinheim 1990.

Figure 2. Infant mortality in Northern Germany, 1770–1840
(5-years-moving averanges, per 1000 live births



the mechanisms of mortality decline. The age-specific rates can be transformed into life tables by a procedure based on the presumption that there existed a semi-stable population, which is quite reasonable when Berlin is excluded[24]. A condensed version is presented here (table 3). These figures reveal nothing less than a revolution in the conditions of living and surviving. It was a limited and a very particular

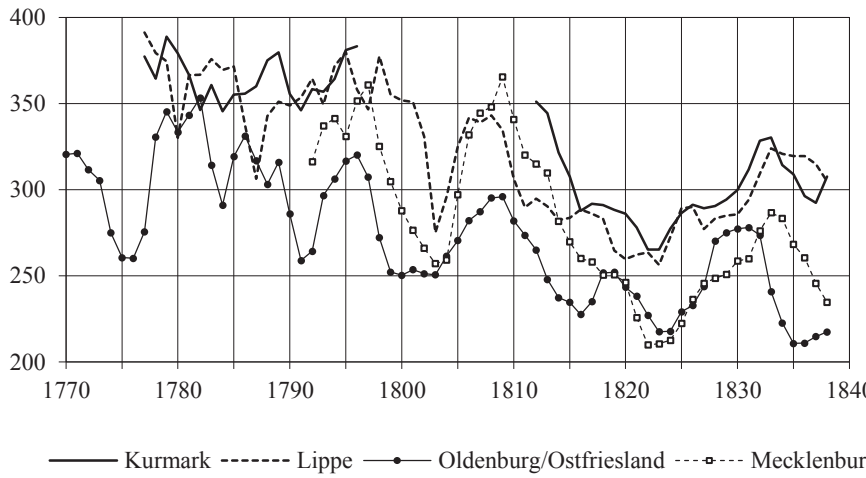
Figure 3. Infant and child mortality (10q0) in Northern Germany,
1770-1840 (5-years moving averages and annual rates)



[24] Jean Bourgeois-Pichat, *La dynamique des populations: Populations stables, semi-stables, quasi-stables*, Paris 1994.

revolution, however. In spite of some gender differences, adults did rarely benefit from the overall increase in life expectancy. Children did. Even in less favourable conditions like in the Ruhr region (Mark) the fall in infant and child mortality was noticeable and everywhere else it was simply impressive (between nearly 20% and over 30%).

Figure 3a. Infant and child mortality: regional differences



The influence of the disappearance of heavy smallpox epidemics can be estimated by the crude death rates, including or excluding them alternatively. The last quarter of the 18th century then can be compared to a period of similar length after the Napoleonic wars (table 4). In this case, the figures vary between the regions and between urban and rural districts. That is not surprising, since the simultaneous decline in infant mortality took place on the background of different regional patterns, which were not determined by vaccination. Considering the global evolution, a strong link between the fading away of the smallpox and the mortality decline of the early 19th century can be claimed. There were no balancing effects of other diseases that might have set in. In the life-tables, they are not visible either. In general, the gain in the crude mortality rate was the expected one, and often it outstripped the numeric gain acquired by the extinction of smallpox. Only in one province (the Kurmark), there was a small counterbalancing effect, but it does not re-establish the initial level.

Table 4. The impact of smallpox mortality on the crude death rate

Territory		1775–1798	1816–1840
rural Kurmark	deaths by smallpox	27 099	1 794
	in % of all deaths	10,50	0,72
	CDR	26,0	24,6
	CDR without smallpox	23,2	24,4
urban Kurmark	deaths by smallpox	12 342	846
	in % of all deaths	9,89	0,60
	CDR	29,6	26,7
	CDR without smallpox	26,6	26,5
Berlin	deaths by smallpox	6 949	909
	in % of all deaths	7,79	0,53
	CDR	31,3	26,5
	CDR without smallpox	28,7	26,3
Mecklenburg	deaths by smallpox	9 019	1 186
(1786–)	in % of all deaths	8,55	0,51
	CDR	27,1	21,4
	CDR without smallpox	24,9	21,3
Ostfriesland	deaths by smallpox	4 522	
	in % of all deaths	6,71	
	CDR	25,9	20,7
	CDR without smallpox	24,1	
Mark / Mark-	deaths by smallpox	8 056	1 157
Ruhr district	in % of all deaths	8,39	0,78
(1820–1839)	CDR	31,0	24,8
	CDR without smallpox	28,3	24,7
Lippe	deaths by smallpox	2 176	160
(1788–)	in % of all deaths	10,25	0,51
	CDR	26,9	23,8
	CDR without smallpox	24,2	23,7

Discussion

Old and new measurements of the impact of the decline in smallpox mortality on the evolution of total mortality lead to the same conclusion: the effects were considerable. This is also confirmed by a comparison with regions in present-day Poland, where it is was not so easy to obtain a good coverage of vaccination[25]. It is highly probable that the oldest and simplest explanation is also the best, as it suggested a causal link between mortality decline and the vaccination campaigns. Though only a rather small age group benefitted from this kind of intervention, already contemporaries supposed that there was a more general impact on the growth of population. Is this assessment well founded?

Since the mortality decline took place in the younger age groups, it influenced the probability of survival until the mean age of maternity (p(m)). For the reproduction of a population, this is a very important index. It is self-evident that the effects of the mortality decline in younger age groups on the growth of population were bigger than it would have been the case if it had concerned age groups beyond the age of procreation. Considering only life expectancy at birth and supposing a constant model life table would be misleading. However, a discussion of such methodological problems is not necessary in the case we are studying here, since the effects on the general growth rate are clearly visible. They can be modelled as follows: given that the victory in the battle against smallpox meant a gain of 2 points (see table 4), this would contribute to an increase of a normal growth rate of the European Ancien régime of more than a third. This assumption is based on an earlier growth rate of 0,5%, which can be observed in Northern Germany. Elsewhere it was even lower, which means that the potential impact of vaccination was even higher.

The indirect consequences of the attenuation of smallpox have to be assessed positively too, although it would be hard to prove statistically. Certainly, a new immune-parasitic equilibrium appeared, but equilibrium does not mean replacement of one cause of death by another. An interruption of the vicious circle of infection and malnutrition is rather supposed to have general positive effects[26]. For instance, it seems that the absence of smallpox influenced positively the height of adults and this must be interpreted as an expression of a better health status[27]. Considering the direct and the indirect improvements, produced by the synergy of enlightened medicine and policy (in Germany called „medicinische Policey", an expression that sums up the general tendencies in this domain at that time), very strong arguments

[25] R. Gehrmann, *Umbruch* [7].

[26] *Histoire des populations de l'Europe*, edited by Jean-Pierre Bardet i Jacques Dupâquier, vol. 2, Paris 1998, p. 82.

[27] Hans-Joachim Voth i Timothy Leunig, *Did Smallpox Reduce Height? Stature and the Standard of Living in London, 1770–1873*, „Economic History Review" 49, 1996, p. 541–560.

would be necessary in order to come to another end result than a globally positive one. Such arguments are still missing, although a sceptical argumentation exists. So why not simply acknowledge the work accomplished by public health in this special sector? The comparison between old and new measurement presented here suggests the conclusion that doctors who defended inoculation and vaccination knew what they did, and they did well.

The impact of smallpox and vaccination in Northern Germany in the 18th and 19th centuries
Summary

In Germany, like in other parts of Europe, vaccination has traditionally been considered as a success story, but recent research has led to some doubts about its true effects. Although the demographic impact of this innovation is the most important criterion for its evaluation, a larger statistical research into the matter has never been carried out. The present article provides one remedy in the form of an analysis based on contemporary statistical material from Northern Germany, especially Prussia, concerning the period between the Seven Years' War and the 1840s. Calculations from the literature of that time have also been taken into consideration. The results show impressive direct and indirect effects of vaccination on demographic growth in Germany. Its main agent was a decline of child mortality with all its consequences, in particular a larger number of adults entering a far more deregulated matrimonial market, but, to some degree, probably also an improved health status of these generations.