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Information, trust and diffusion of smallpox vaccination the case of Scania, Sweden 1802-1835

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2002

Document Version:

Publisher's PDF, also known as Version of record

[Link to publication](#)

Citation for published version (APA):

Dribe, M., & Nystedt, P. (2002). *Information, trust and diffusion of smallpox vaccination: the case of Scania, Sweden 1802-1835*. (Lund Papers in Economic History: Population Economics; No. 77). Department of Economic History, Lund University.

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Lund Papers in Economic History



No. 77, 2002

Population Economics

Information, Trust and Diffusion of Smallpox Vaccination

The Case of Scania, Sweden 1802-1835

Martin Dribe & Paul Nystedt

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Abstract

This study deals with the diffusion of a new medical technology – smallpox vaccination – in nineteenth century Scania, Sweden. Using an aggregated sample of parishes as well as a micro-level dataset for four parishes, we investigate the socioeconomic as well as the geographical patterns of diffusion of smallpox vaccination in the province. We also relate the adoption of vaccination between geographical areas, as well as between social groups, to availability of information, ability to acquire and process this information, and to levels of social capital and trust in society. Our results point to the conclusion that while smallpox vaccination spread very fast geographically after its introduction, there were considerable differences between social groups. The better situated, better educated, landholding peasants were faster to adopt the new technology of smallpox vaccination. This had little to do with better access to economic resources as vaccination in general was provided free of charge, but was instead probably related to a higher ability to acquire and utilize the information available, and/or a higher level of trust in the authorities among these peasants.

Lund Papers in Economic History

ISSN 1101-346X

ISRN LUSADG-SAEH-P--02/77--SE+25

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Printed by KFS, Lund, Sweden, 2002

Orders of printed single back issues (no. 1-65)

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Full-text electronic issues (no. 60, 61, 66--)

www.ekh.lu.se

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Martin Dribe & Paul Nystedt

Introduction

Smallpox, which is a highly infectious disease, acted as a deputy grim reaper in Europe during the eighteenth century and approximately 60 million people, mainly children, died during this period. Besides high mortality (commonly about 10-30 percent), individuals who once had been infected also suffered from different kinds of life-long complications such as blindness, disfiguring pockmarks, baldness and infertility. Another effect of the disease, which indicates its severe impact, is that it also seems to have adversely affected the future adult height of infected children. In a study of London between 1770 and 1873 Voth and Leunig found that smallpox reduced adolescent heights by up to one inch (Voth and Leunig 1996; Leunig and Voth 1998, 2001; Razzell 1998, 2001). A secondary social effect of smallpox was that the age at marriage for individuals (especially women) who had had the disease was higher than for the rest of the population, which could be a consequence of the complications described above (Sköld 1996: 207-220).

This paper has been written within the research project *Early Life Conditions Social Mobility and Health in Later Life*, financed by the U. S. National Institutes of Health/National Institute of Aging (1P01AG18314-02), the Swedish Council for Social Research and the Bank of Sweden Tercentenary Foundation. Martin Dribe gratefully acknowledges financial support from Jan Wallander and Tom Hedelius Foundation, Svenska Handelsbanken. We also wish to thank Dr. Ragnhild Kornfält at the Lund University Hospital for sharing her vaccination statistics with us, and Tommy Bengtsson and Grethe Banggaard at the Department of Economic History, Lund University for most valuable comments and suggestions. Martin Dribe, Department of Economic History, Lund University. Martin.Dribe@ekh.lu.se. Paul Nystedt, Department of Economics, Linköping University. Paul.Nystedt@eki.liu.se.

One anecdotal example of the contemporary attitude towards the potential consequences of smallpox is given by the physician Munck af Rosenschöld, who was a pioneer in introducing vaccination into Sweden. He refers to the parents of a four year old girl who died of smallpox: "... the parents viewed it to be a blessed providence, that death relieved them from the horrible sight of a child, who went to the sickbed beautiful and well-shaped, but would have been revived deformed, misshapen, and forced to lead her life in a sad darkness." (Munck af Rosenschöld 1802)

Inoculation, i.e. application of smallpox matter from poxes of an infected individual on a healthy individual via the nostrils or the skin, which was based on eastern medical tradition, reached Europe, via Constantinople, during the first half of the eighteenth century (Razzell 1977). Inoculation was not a totally safe procedure and a substantial share of the inoculated individuals died of smallpox. The acceptance of inoculation differed across Europe. It was, for example, quite wide spread in England (Razzell 1977), while in Sweden it was practiced mainly among the upper classes, but never reached any high levels among the general public (Sköld 1996: 344). In total Sköld estimates that about 35000 inoculations took place in Sweden (excluding Finland) between 1750 and 1800 (Sköld 1996: 288).

According to British countryside folklore of the late eighteenth century, milkmaids who suffered the relatively mild disease of cowpox never contracted smallpox. Based on the implications of this, attempts were made to use matter of cowpox in order to generate immunization against smallpox and Edward Jenner outlined the method of vaccination in 1796.¹ He published a number of articles in the following years. The results spread among the medics around Europe at a fast pace, Swedish medics were well aware of the method at the turn of the century and vaccination was also implemented very swiftly in Sweden. The first vaccination in Sweden was performed by Munch af Rosenschöld in October 1801 in Lund (just one day before another Swedish physician, Engelhardt, made his first vaccination, also in Lund) and in 1815, one year before vaccination became compulsory, approximately 50 percent of the children, computed as number of vaccinations divided by number of children born the previous year, were vaccinated (Sköld 1996: 473). It should be noted that this measure underestimates the actual share of vaccinated children, since infant mortality was about 20 percent during this period and a significant proportion of these children probably never were vaccinated. From 1830 and onwards more than 70 percent of the children were vaccinated by the same measure. In fact Sweden was

¹ Note that Jenner named his method vaccination after the Latin word for cow, "vacca".

considered by both contemporary physicians and later researchers to have been the most successfully vaccinated country in the world (Sköld 1996: 366).

Sköld (1996) have thoroughly investigated the main reasons for the successful introduction of smallpox vaccination in Sweden, and attributes the development mainly to organizational factors. Contrary to inoculation, vaccination was not monopolized (i.e. a limited number of physicians had no exclusive right to perform vaccination). Instead the organization of the church was used, the clergy promoted vaccination within their parishes, church assistants were the most common vaccinators, vaccination fees were very low or zero, and vaccination was free for the poor. The authorities also quickly adopted a strategy aiming at promoting vaccination. As early as 1804 every parish was instructed to appoint a vaccinator and statistics on vaccination and mortality was gathered which served as convincing proofs for the general public of the method's accuracy. It may seem contradictory, but it is possible that the limited use of inoculation in Sweden facilitated the introduction of vaccination, since displacing an old technique (inoculation) with a new one (vaccination) generally involves convincing reluctant advocates of the old procedure including not only practical issues but also matters of prestige and economic incentives etc.

Prior empirical studies on smallpox morbidity, mortality and vaccination have mainly been performed on aggregated data (e.g. on country or county level), and macro-level analyses based on such data have been common (e.g. Mercer 1985; Bantia and Dyson 1999; Pitkänen, Mielke and Jorde 1989; Sköld 1996). Whereas most researchers conclude that vaccination had an impact on mortality there is no absolute consensus regarding the magnitude of this impact neither on overall, nor on smallpox-specific mortality (Hardy 1983; Mercer 1985; Pitkänen, Mielke and Jorde 1989; Razzell 1965. In Sweden, the decline in smallpox mortality started well before the introduction of vaccination (Fridlizijs 1984: 79-81). Nevertheless, vaccination constitutes the first preventive health measure that effectively contributed to control an infectious disease Sköld 1996: 347.

The impression from prior studies are that even though there were geographical variations on county level and between towns, where mostly physicians vaccinated, and rural areas, where church assistants acted as vaccinators, the introduction of vaccination to Sweden was so swift and smooth that there were no substantial differences between the social classes, and that soon after its introduction virtually all social classes adopted the technique. For example, in his 1996 book Sköld states that "[t]here are good reasons to believe that there were no

differences by sex or social status in the practice of vaccination in Sweden” (Sköld 1996: 467). This implies that information on this preventive health measure spread among the population very quickly and that norms regarding health-related behavior, at least in this respect, changed rather uniformly among the population.

A macro-oriented approach is understandable, as analysis on a lower level of aggregation requires high quality micro-orientated data, which is rare. However, such an approach may conceal important initial characteristics of societal processes that appear to be “smooth”; even if vaccination was almost universally practiced in Sweden 20 years after its introduction, the diffusion process during the first 20 years need not to have been uniformly distributed neither geographically within counties, nor between social classes.

In this article we explicitly study the geographic and socio-economic patterns of diffusion of smallpox vaccination during the initial stage, relating it to the concept of information flows and trust concerning achievements in the field of medical science among the population. We use an aggregated sample of 72 parishes as well as a longitudinal, micro-level dataset based on four Scanian parishes. To our knowledge, there has been no prior attempt to simultaneously capture to what extent the diffusion of smallpox vaccination primarily took place within social strata of the population or geographically (i.e. from one parish to another). There are several reasons for this approach. Firstly, at least until 1816 when vaccination became compulsory, the decision to have ones children vaccinated was familial. Thus, it was based on the family’s accessible information, beliefs, trust, experiences and expectations. Secondly, this decision incurred external effects as once vaccinated individuals was not only less inclined to become inflicted with disease, they were thereby also less likely to infect others. The decisions at family level, aggregated to macro-level, thereby had important repercussions on mortality levels and demographic development.

Information, trust and investments in health

Medical advances together with economic growth constitute integral parts of the general development by which humans have gained higher living standards, increased longevity and improved health status. In many cases, the actual implementation of medical advances involves decisions made within the medical profession, since they have the strongest influence on which technology to apply in the treatment of an illness. However, equally important for improvements in health are all

the scientific health related achievements that it is up to the individual to react upon, for instance new information about smoking, drinking, diets, the impact of regular exercise or the introduction of a new vaccine. From an economic perspective, the individual response to such information can be viewed as an investment in health capital. Similar to devoting time and money to investments on financial markets (yielding future consumption) or in human capital through education (yielding knowledge and higher future earning potential) the individual may invest in his health capital yielding future health and longer life expectancy (e.g. Grossman 1972).

In order to react to a new medical achievement by making the concerned health investment some basic prerequisites need to be fulfilled. Firstly, the individual has to be aware of the new achievement, which implies that information must have reached the individual incurring some basic knowledge of the technique. Secondly, the individual must have obtained some trust in the technique and be convinced about the benefits of applying it. In short, this constitutes the basis for the individuals' demand for making investments in health. Thirdly, and meeting this demand, there is obviously also a supply side mirroring the availability and price of the procedure.

Turning to the supply side of the introduction of smallpox vaccination we know that the distribution of lymph was supervised by the medical board who already in 1803 initiated establishments of vaccine stations across the country who were responsible for keeping and providing fresh vaccine upon request, which ensured that the availability of vaccine generally was very good (Sköld 1996: 396). The costs of the vaccinations were mainly financed via church collections and was free of charge for the families after 1810. Before 1810 some parishes instructed the vaccinator not to charge the parents, while others allowed a small fee as long as the parents were not too poor (Sköld 1996: 396).² As the price of vaccination generally was zero, or at least very low, we conclude that the price was not an issue preventing parents from having their children vaccinated and therefore the focus of this study will be on the demand side.

As indicated above we view the family's decision to have their children vaccinated as an expression for their willingness to invest in the health of their children.³ As was previously argued, this demand for

² In fact it was not uncommon that the price was negative during the initial stage, i.e. that the pioneering vaccinator had to pay the parents a fee in order to be allowed to perform a vaccination. From 1853, the vaccinator was again permitted to charge the patient or the parents for a vaccination (Sköld 1996: 415)

³ Besides pure parental affectionate and altruistic motives it should also be noted that children in preindustrial society constituted valuable assets for the future, due to

health reflects information flows in society, accessibility of, and ability to process, information, but ultimately also trust in the information received.

The information flow in society concerning smallpox vaccination was rather swift. Swedish medics became aware of the technique shortly after its invention; some of them wrote pamphlets, the Swedish newspapers had articles of which a great majority was positive (Sköld 1996: 370-374), the authorities quickly promoted vaccination and the clergy were used to reach the inhabitants via, for instance, church services and sermons. Moreover, we know from the writings of Munck af Rosenschöld (1802) and others that such written information did exist in newspapers and other printed material. Hence, information was spread to the general public both via written material but also orally via the clergy and between neighbors and friends. Naturally, medics were the best informed probably followed by the upper classes and the nobles. We cannot, however, conclude that the information was spread evenly across the rest of the population. We know, for instance, that reading and writing ability generally was higher among landholding peasants than among landless (Nilsson and Svärd 1994) and that they might have invested in this knowledge with the deliberate aim to use it in their entrepreneurial activities (Nilsson, Pettersson and Svensson 1999; Svensson 2001), which shows that they at least possessed the basic skills to acquire written information to a higher degree than the landless.

The second, and ultimate, prerequisite, besides acquiring and process information, needed in order to trigger a demand for investing in a health promoting behavior, such as adopting vaccination, is that the individual or family are convinced of the benefits. Thus, they have to trust the information received.

Trust is closely related to the concept of social capital, which recently have gained increased attention among social scientists (Arrow 1972; Fukuyama 1995). The term social capital has been used to “call attention to the ways in which our lives are made more productive by social ties” (Putnam 2001: 19). Though there is no generally accepted definition of this, in some respects, intangible term there is some consensus that it is founded in social interaction and trust among citizens of a society. Putnam advocates that social capital reflects “features of social life – networks, norms and trust – that enable participants to act together more effectively to pursue shared objectives” (Putnam 1996). One such objective may, for instance, be the eradication

underdeveloped social security systems and imperfect capital and insurance markets. Cf. Cain 1981; Lee 2000).

of a devastating disease via a preventive health measure such as smallpox vaccination. Social capital is sometimes considered to be a macro phenomenon or a “community level attribute” (Glaeser et al. 1999, 2000), in empirical studies often proxied by the general trust level in a society.⁴ However, it is important to recognize the fact that this general trust level is an aggregated measure built by the varying individual trust levels of the citizens of the society. Further, one distinction in the trust literature is made between horizontal and vertical trust where the former describes trust between citizens and the latter the trust citizens have in the authorities (Braithwaite and Levi 1998; Newton 1999).

There are several pathways by which social capital and trust levels affect performance and the development of a society. The more people trust each other, and the authorities, the more likely they are to cooperate and engage in activities beneficial for society. From a purely economic perspective, people who trust each other interact more frequently and more efficiently; they may trade and/or cooperate in long-term projects without sacrificing valuable time and money to different precautionary actions such as monitoring each other’s behavior. A high level of interaction and trust in society also improves decision making processes via increased copying and pooling of information as individuals in such a society are more likely to share personal knowledge based on individual experiences and skills. The more they trust each other the more effective is the horizontal flow of information between them. Thereby the individuals’ ability to make adequate decisions is positively connected to the level of horizontal trust and social capital. Similarly, a high level of vertical trust yields a smoother flow of information between authorities and the general public, implying that it becomes easier for authorities to initiate and implement societal developments that demand civic engagement. Empirical studies have revealed positive connections between general trust levels and important factors of societal status and development such as economic growth and the general health conditions of the population (e.g. Putnam 1993; Knack and Keefer 1997; Kawachi et al. 1996, 1997).

From this respect it is inevitable that the level of trust in society influences the implementation of a preventive health measure, such as smallpox vaccination. Even though smallpox vaccination is a societal

⁴ The level of social capital in a society is often measured via surveys on trust levels (e.g. in the General Social Survey in the United States) including questions such as: “Generally speaking would you say that most people can be trusted or that you can’t be to careful in dealing with other people?”. The proportion stating that “most people can be trusted” is then viewed as a measure of the level of social capital (see e.g. Knack and Keifer 1997).

phenomenon with repercussions reaching beyond the vaccinated individual as he is not only less inclined to become inflicted with disease, but also less likely to infect others resulting in reduced disease transmission, the decision to have one's children vaccinated was initially familial (at least until 1816 when vaccination was made compulsory).

There is no direct information available regarding trust levels and social capital during the period under study. In modern studies the most robust correlate of trust levels and other social capital variables is the level of education (e.g. Helliwell and Putnam 1999). Different social capital variables have also been found to be positively connected to homeownership (DiPasquale and Glaeser 1999). To the extent that nineteenth century rural society was characterized by similar interactions between education and homeownership, on the one hand, and social capital and trust, on the other, landholding peasants, who were both better educated and had a stronger connection to the land, can be expected to have been better able to comprehend information, and also to have had higher levels of social capital and trust. Accordingly, they can be expected to have responded stronger to the information on smallpox vaccination than the landless, yielding a diffusion pattern in which landholding peasants were more prone to vaccinate their children than the landless in the same area during the initial stage.

On the contrary, a mainly geographical diffusion pattern, where vaccination is spread from parish to parish, but rather uniformly among different social groups within each parish, implies a society where the structure of information flows and trust are rather homogenous and shared vertically in the population.

Area and Data

This study deals with Scania, the southernmost province of Sweden, which until 1658 belonged to Denmark, and in many respects resembles closer this country than Sweden. For example, compared to most parts of Sweden, which were dominated by freeholders or tenants on crown land, large parts of Scania was dominated by a manorial system, which, at least up until 1800, had considerable similarities with the Danish one (Olsson 2002), and also when it comes to geographic conditions, especially the southern and western parts of the province resemble the Danish island of Zeeland more than the Swedish provinces to the north. The province is highly diverse both when it comes to geographic and socio-economic conditions. Compared to other provinces in Sweden,

Scania did not show a particularly high frequency of vaccination between 1804 and 1820 (Sköld 1996: 571).

In this article two separate analyses are carried out. First, in an aggregate analysis we use a sample of parishes from different parts of Scania, looking at differences in vaccination rates between these areas and relating it to socio-economic differences. Second, we use micro-level, individual, data for four parishes in one of the areas to make a deeper study into potential social-group specific patterns in the spread of vaccination. The first, aggregated, dataset is based on a stratified sample of parishes in Scania and comprise of a total of 72 parishes. The sample was made by Gunnar Fridlitzius and has previously been used in studying economic-demographic issues (Fridlitzius 1975, 1979a, 1979b).⁵ Some of the neighboring parishes have been grouped together because of data constraints, resulting in a sample of 54 parishes/parish pairs, spread over Scania and grouped into six different areas (see figure 1):

1. Southern plain area
2. Central plain area (the area surrounding the city of Lund)
3. Northern plain area
4. Western transition area
5. Eastern transition area
6. Northern forest area

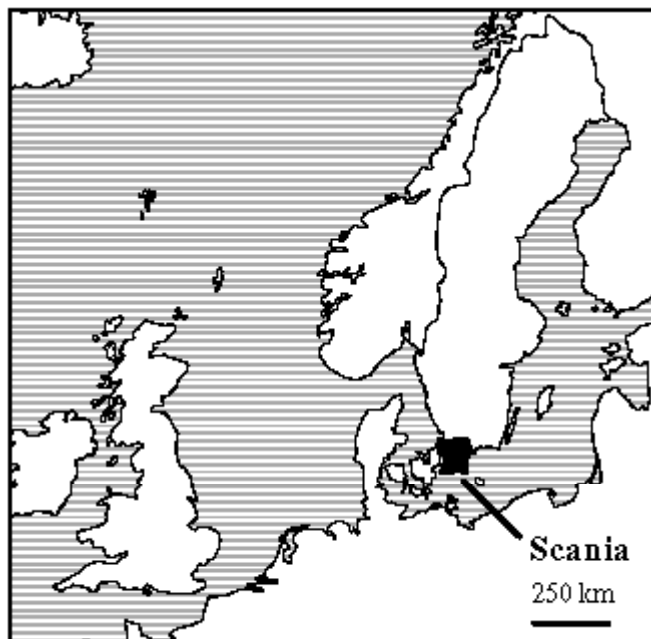
For these parishes information on vaccination was gathered from the mortality tables of the Tabular Commission (*Mortalitetstabellerna*), which give such information on a yearly basis starting at different points in time for different parishes. This source also provides information on annual number of births at parish level back to 1749. Information on age structure and socio-economic structure is available in the population tables (censuses) every five years (during the period under study) and was linked to the yearly data from the mortality tables. Thus, any observation in a given year will have census information from the preceding census, e.g. in 1806 from the census of 1805, etc. In some cases we have data on vaccination already from 1805 onwards (even 1804 in some cases, which we have excluded here), while in other cases registration does not start until later. Moreover, even after the first recording of vaccination in the mortality tables gaps could occur. It is

⁵ The sample was stratified on area and tenure (peasant vs. noble) and designed to study economic demographic interactions from 1750 to 1860 (see Fridlitzius 1975).

Figure 1. Geographical location of the parishes in the sample.



I – Southern plain II – Central plain III – Northern plain
IV – Western transition V – Eastern transition VI – Northern forest



Map by Henrik Svensson, Department of Social and Economic Geography, Lund University.

very difficult to ascertain whether missing information should be interpreted as an indication that no vaccinations took place, or if it should be seen as a missing record. Table 1 shows the availability of vaccination information by area and period. Clearly we lack information on a substantial number of observations during the first three periods, while records are more complete in the last four periods. The analysis is limited to the observations for which we have information on vaccination (number of vaccinated or that no vaccination took place).

Table 1. Availability of data on vaccination in the dataset. Percentage of total number of observations with information on number of vaccinated by area and period

Period	Area						N
	1	2	3	4	5	6	
1805-09	60	51	48	60	54	85	265
1810-14	58	64	50	72	43	35	270
1815-19	62	80	60	62	80	20	265
1820-24	92	98	92	90	90	80	265
1825-29	100	98	97	94	94	80	260
1830-34	98	100	100	92	100	90	270
1835-39	100	100	98	96	100	100	270
N	410	315	420	350	235	135	1865

Source: Tabular Commission material (mortality tables and population tables), the Regional Archives, Lund. See also text.

The second dataset is longitudinal at the individual level and covers four parishes located in the western part of the province.⁶ Two of the parishes (Halmstad and Sireköpinge) are included in the aggregate sample (area 3, northern plains), while the other two (Hög and Kävlinge) are located adjacent to the parishes in the central plain area (area 2). The social structure of the parishes differed. Hög and Kävlinge were dominated by freeholders and tenants on crown land, a group rather similar to the freeholders regarding its social characteristics, while Halmstad and Sireköpinge were totally dominated by tenants on noble land. In addition to the peasant group the parishes also hosted various landless and semi-landless groups, dependent on working for others to cover the subsistence needs of the family. In 1805 the four parishes had 1,778 inhabitants, which increased to 2,333 by 1830.

⁶ The data used comes from the Scanian Demographic Database, a collaborative project between the Research Group in Population Economics at Lund University and The Regional Archives in Lund. For a description see e.g. Reuterswärd and Olsson 1993; Bengtsson and Lundh 1991, 1993; Dribe 2000).

The dataset is based on a family reconstituted population of these four parishes. To these reconstituted families information from poll-tax registers (*mantalslängder*) has been added on, for instance, size and type of the landholding. Information on whether or not an individual had been vaccinated was linked from catechetical examination registers, together with information on individual level migration and household composition (Dribe 2000: ch. 2). Since vaccination seems to have taken place on a quite irregular basis, especially in the beginning, there are many notations on vaccinated people in some years, while very few in other years. This may, of course, also have to do with the accuracy of registration of vaccination information in the registers. For this reason, we decided to use a cohort measure of vaccination, which gives an indication whether or not an individual was vaccinated at his tenth birthday, rather than trying to pinpoint the exact date of vaccination (the measure will be described in more detail below).

Empirical results

The dataset contains information from the mortality tables on the number of vaccinations in a year, as was described above. In order to compare different parishes we need to relate these numbers to some group under risk of being vaccinated. Most vaccinations were made on children under the age of three (e.g. Sköld 1996: 462-464), but since we do not have yearly information on the age structure on parish level, we chose to use the number of births in the preceding year as a proxy for the group at risk. Clearly this is a far from perfect measure because high infant mortality (ca 20 percent) implies that a fairly large proportion of children born died before they were vaccinated, which implies that vaccination rates calculated in this way will underestimate the proportion vaccinated. On the other hand, there were also children who were not vaccinated until after age one especially during the introductory phase, which instead tends to overestimate the vaccination rates based on the number of births the year before.

Table 2 displays average vaccination rates by area and period in Scania between 1805 and 1839, and clearly shows the increasing rate of vaccination over time. In all periods after vaccination became compulsory in 1816, vaccination rates were above 80 percent on average. Within the sample, however, there were also pronounced differences between parishes as well as between different areas, even though it is quite difficult to find a clear pattern in these differences. It seems that area 2 generally shows a somewhat higher frequency of vaccination than the other areas, especially between 1810 and 1819.

Interestingly, this is also the area surrounding the city of Lund, where, as was mentioned previously, two of the pioneers in Swedish smallpox vaccination lived and worked.

Table 2. Average vaccination rates by area and period.

Period	Area						Total	N
	1	2	3	4	5	6		
1805-09	0.29	0.56	0.45	0.51	0.73	0.66	0.50	150
1810-14	0.49	0.93	0.78	0.85	0.68	0.84	0.75	152
1815-19	0.78	0.96	0.88	0.87	0.69	1.73	0.87	168
1820-24	0.83	0.81	0.83	0.75	0.75	0.75	0.80	241
1825-29	0.86	0.92	0.81	0.78	0.83	0.76	0.84	249
1830-34	0.92	0.86	0.83	0.78	0.75	0.76	0.83	263
1835-39	0.88	0.86	0.83	0.89	0.87	0.86	0.87	267
Total	0.76	0.86	0.79	0.79	0.77	0.81	0.80	
N	333	266	327	282	188	94		1490

Source: See table 1.

Note: Vaccination rates were calculated for individual parishes as the number of vaccinations divided by number of births the previous year. The average rates are the average of these parish rates for each area/period. N gives the total number of parish observations in each area/period.

In order to simultaneously control for other potentially important determinants we have also conducted a multivariate regression analysis (OLS) of the vaccination rates. Besides controlling for area and time period, we also include a variable indicating the proportion of landed persons, calculated as the number of landed peasant head of households divided by the number of landless and semi-landless heads of households, and a variable indicating the whether the parish was dominated by noble land or freehold land/ crown land. Results from this analysis are presented in table 3, and show that the higher vaccination rates in area 2 that was indicated previously are visible also when controlling for time period, proportion landed and tenure.

Time period shows the expected pattern with an increasing frequency of vaccination over time, with the exception of comparatively high vaccination rates during the period 1815-1819, when vaccination was made compulsory (1816). Modern studies of diffusion of technologies in general, and medical technologies in particular, have revealed that the common shape of a technology diffusion process is somewhat S-shaped or in more specific terms sigmodial (e.g. TECH Research Network 2001; Escarce 1996; Klausen, Olsen and Risa 1992).

Table 3. OLS estimates of vaccination rate in the Scanian sample 1805-1839.

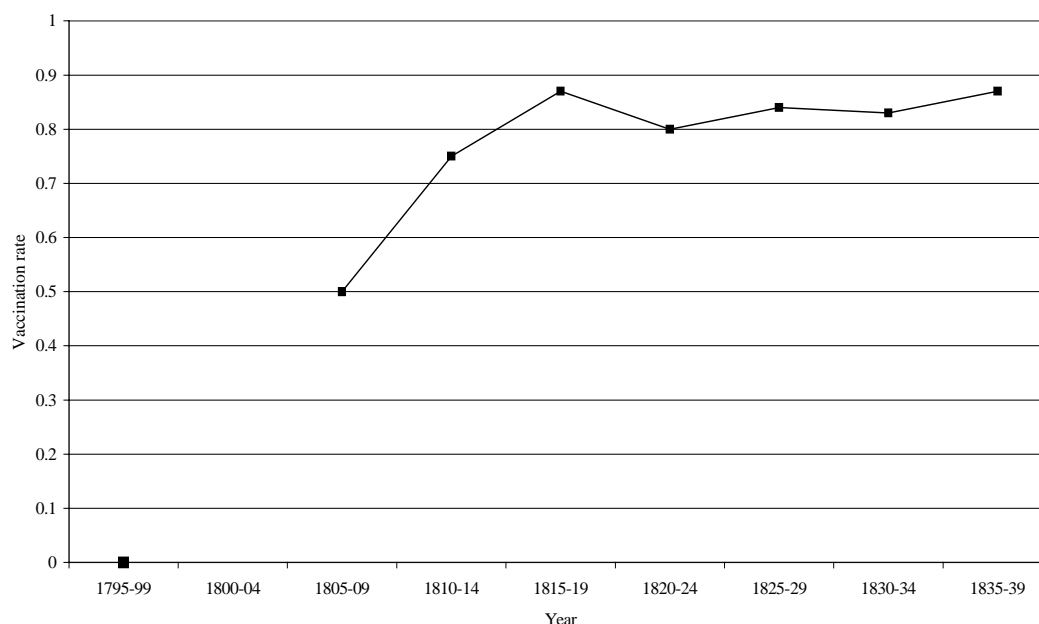
Variable	Coefficient	Std.error	P-value
Constant	0.833	0.065	0.000
Time period (ref.cat:1835-39)			
1805-09	-0.367	0.049	0.000
1810-14	-0.115	0.049	0.019
1815-19	0.001	0.047	0.988
1820-24	-0.069	0.043	0.103
1825-29	-0.030	0.042	0.485
1830-34	-0.034	0.042	0.413
Area (ref.cat: 1)			
2	0.089	0.044	0.046
3	0.024	0.038	0.523
4	0.025	0.039	0.528
5	0.003	0.045	0.951
6	0.075	0.062	0.222
Proportion landed	-0.002	0.043	0.970
Tenure (ref.cat: Freehold)			
Noble land	0.005	0.036	0.893
Rsquared	0.050		
F-test	0.000		
N	1490		

In the beginning there are a few early adopters who act as forerunners (pioneers), followed by the majority and finally there are the late adopters, which gives the S-shape: low initial levels and rather slow diffusion (only pioneers uses the technology) followed by an expansion phase where the increase in utilization is steep (the majority follows), and finally a stage where the expansion slows down and a steady state is reached (the late adopters). In figure 2 the total average smallpox vaccination rates from table 2 are pictured over time. Unfortunately information on vaccination rates 1800-1804 is not available (we know that no vaccinations were performed prior to 1801) leaving a somewhat incomplete picture for the initial stage. Nevertheless, the vaccination diffusion seems to have been very fast overall – it boomed right away and the initial low levels (the beginning of the “S”) were of very short duration. 5-10 years after the introduction more than 50 percent of the children were vaccinated.⁷ One deviation from the traditional S-shape of

⁷ A contributing factor to this rapid diffusion might have been that the province was struck by smallpox epidemics in 1798, 1800, 1801 and 1802, according to the annual reports of district physicians (*Provinsiälläkarrapporterna*), (see Banggaard 2002). These epidemics may have increased the willingness of people to adopt the new technology.

diffusion is the relatively high levels in 1815-1820 compared with the subsequent periods. Besides being enforcing, the legislation on compulsory vaccination in 1816 was probably an integral part of the agenda of the contemporary public debate and served as a transmitter of information to the general public. Hence, the major expansion phase occurs until 1820 and the final steady state phase starts around 1830, implying almost full coverage.

Figure 2. Average vaccination rates in the 72 parishes 1805/09-1835/39.



Note: Based on figures in table 2.

There are no effects of either proportion landed or tenure. This may of course be seen as corroborating previous opinions that there were no large socio-economic differences in diffusion of vaccination. It could, however, also be a result of a measurement error; in other words that proportion landed is not a good indicator of socio-economic differences, making it necessary to use individual level data to capture potential differences between social groups within an area, rather than measuring social differences between areas. For tenure, table 4 shows an interesting difference between parishes dominated by freehold land and those dominated by noble land. Apparently the proportion of missing values, i.e. years for which no records of vaccinations could be found, were considerably lower in the parishes dominated by noble land up until 1815-19. This could perhaps be interpreted as indicating that estate owners were more careful in reporting vaccinations than were clergymen in peasant parishes. However, depending on how we interpret

a missing observation, it is also possible that this indicates an earlier introduction of vaccination in areas dominated by noble land, but this is highly uncertain given the nature of the data.

Table 4. Availability of data on vaccination in the dataset. Percentage of total number of observations with information on number of vaccinated by tenure and period

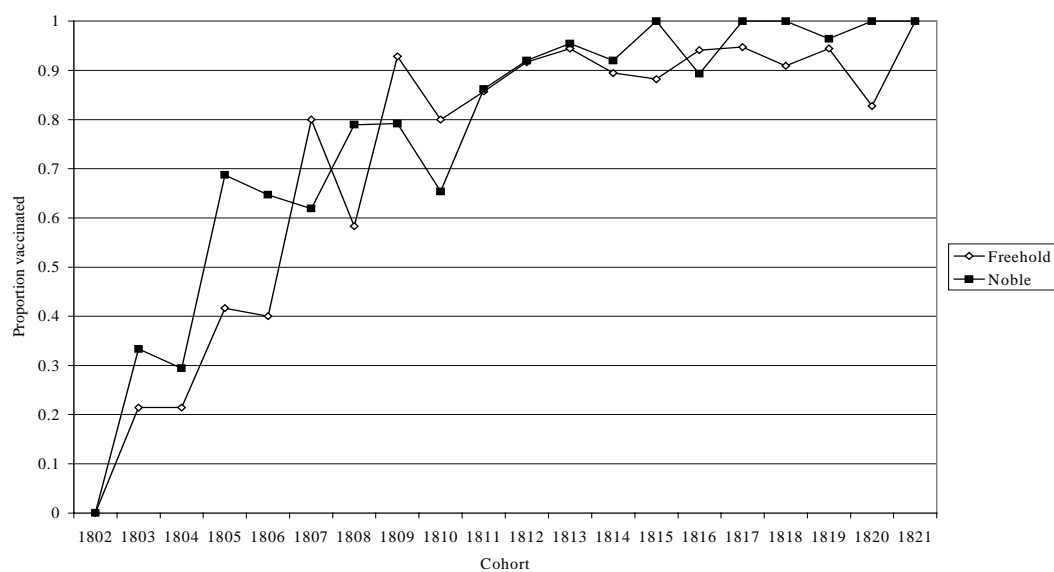
Period	Tenure		N
	Freehold	Noble	
1805-09	54	59	265
1810-14	50	61	270
1815-19	53	71	265
1820-24	91	92	265
1825-29	94	97	260
1830-34	97	98	270
1835-39	100	98	270
N	760	1105	1865

Source: See table 1.

We now turn to an analysis of vaccination at individual level, using the sample of four parishes described above. We have constructed a measure of the proportion of a birth cohort who had been vaccinated at age 10. Figure 3 shows the results by tenure, and figure 4 shows the same measure by social status. Tenure is based on parish since two of the parishes were completely dominated by freehold land and crown land, while in the other two there were almost only noble land (one freehold farm is the exception). Social status is based on father's occupation and landholding and is divided into two groups: landed peasants on the one hand, and landless and semi-landless on the other. Only peasants having land at or above subsistence level have been considered as landed, the rest as semi-landless (see Dribe 2000: 27).

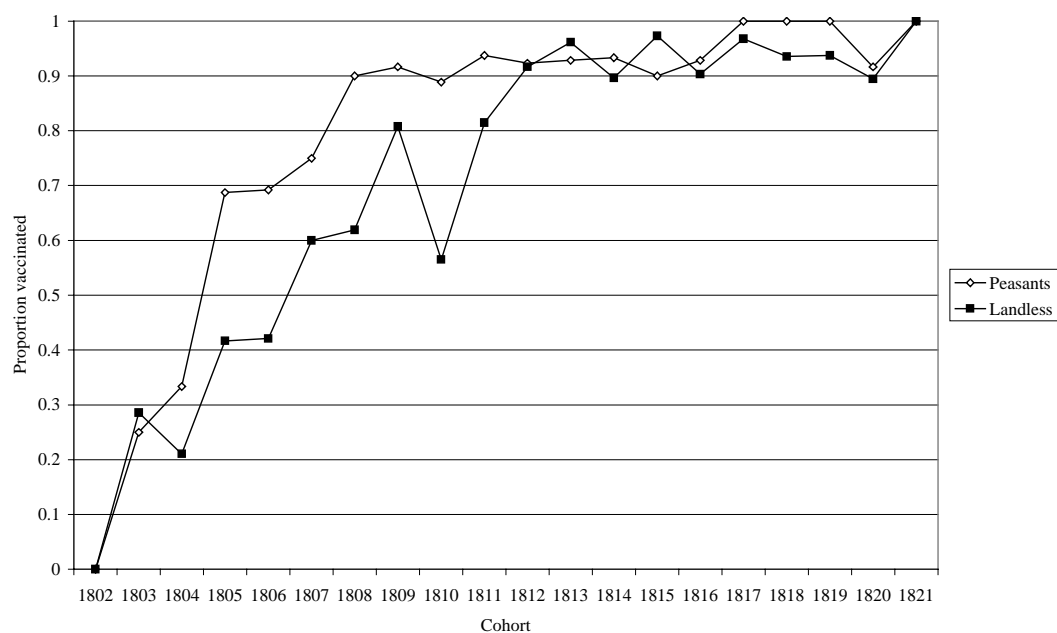
From figure 3 it is evident that the introduction of vaccination in noble parishes came earlier than in freehold parishes, which lends some support to interpreting the findings in table 4 as indicating an earlier introduction of vaccination in areas dominated by larger estates. Turning to differences between the two social groups, figure 4 pictures considerable differences between landless and landed for cohorts born up until at least 1811. Thus, there appears to be clear socio-economic differences in the spread of vaccination in the area studied here, at least in the initial stage before vaccination was made compulsory in 1816. In

Figure 3. Proportion vaccinated at age 10 in different cohorts by tenure (based on parish). Four parishes cohorts 1802-1821.



Source: Scanian Demographic Database.

Figure 4. Proportion vaccinated at age 10 in different cohorts by social status. Four parishes cohorts 1802-1821.



Source: Scanian Demographic Database.

order to test the difference between the two social groups we have aggregated the children in two groups: those born 1802-1811 and 1812-1821 respectively (see table 5). A Fisher exact test reveals that the difference between the two social groups is statistically significant at the 0.15 percent level during the first period but that there is no significant difference the second period (p-level 36 percent).⁸

Table 5. Test of socio-economic differences in proportion vaccinated at age 10 by period.

	Birth cohorts 1802-1811		Birth cohorts 1812-1821	
	Vaccinated	Unvaccinated	Vaccinated	Unvaccinated
Peasants	90 (67%)	44 (33%)	125 (95%)	6 (5%)
Landless	99 (50%)	98 (50%)	296 (94%)	19 (6%)
Fisher p-value	0.001572		0.361132	

Thus, while the aggregated analysis did not reveal any socioeconomic differences in the diffusion of vaccination on parish level, the micro-level analysis clearly showed that such differences did exist. Similarly, while we could not find any effect of type of land tenure (noble or freehold) in the sample of 72 parishes, the analysis of the four parishes indicated that such differences existed in the early phase of the diffusion process, although the differences were not as large as between social groups.

Discussion

The introduction of smallpox vaccination in Scania, Sweden was very successful. In fact, the pace at which it occurred rather closely mirrors the introduction of measles vaccination (and later MPR) during the last 30 years in Sweden. Despite the revolutionary development of legal and political institutions, economic conditions and information transmission channels such as TV, radio, newspapers etc, the introduction of a preventive health measure (vaccination) that required participation from

⁸ The Fisher exact test is a non-parametric statistical test for the difference between two independent random samples (of e.g. different socioeconomic status) when all of the study objects fall into one or the other of two mutually exclusive classes (e.g. vaccinated or unvaccinated). In short, the test computes the probability that one by chance would get the actual, or a more extreme, distribution of the two samples given that there is no difference between the two populations from which the samples were drawn. For further details see e.g. Siegel and Castellan 1988).

a large share of the population to be successful was essentially as fast in the early nineteenth century as in the late twentieth century.⁹

Although the introduction of smallpox vaccination in Sweden and Scania was very successful, there were some interesting irregularities in the diffusion process during the initial phase. We suggest that these irregularities reflect information flows and/or diverging trust levels within the Swedish society. As was shown previously, the area surrounding Lund appears to have had higher vaccination rates than the other areas during the initial phase of the diffusion process. One potential explanation behind this finding could be the closeness to Lund, which at the time, and still today, is a major medical center of Sweden. The city of Lund constituted a center of enthusiasm and knowledge regarding smallpox vaccination. The influence of Munck af Rosenschöld, who was one of the pioneers in introducing vaccination into Sweden, was substantial. He performed more than 2000 vaccinations during 1802, and already in 1801, he published a document where he advocated vaccination and he viewed his recommendation that all citizens should be vaccinated so important that he wrote that “every citizen in Scania, that desire this document will have it for free from the author” (Munck af Rosenschöld 1801).

Recent medical research has attributed geographical variations in procedure rates to differences in attitudes among surgeons, the “enthusiasm hypothesis” (Chassin 1993). Clearly, Munck af Rosenschöld was an enthusiast whose efforts directly implied a large number of vaccinations in the closest area during the initial stage. However, his influence on vaccination rates was not limited to the vaccinations he actually performed by himself and it seems plausible that his pioneering work constituted a good ground for a fast diffusion process in the surrounding parishes. Even if people in the surroundings of Lund never came in direct contact with Munch af Rosenschöld, or any of his papers, they were more likely to come in contact with, or observe, other people who had been influenced, or perhaps vaccinated, by him than people living further away. Our results suggest a geographical diffusion pattern where vaccination was spread from the

⁹ The smallpox vaccination rates measured as number of vaccinations divided by number of births the previous year were about 50% 1805-1809, 75% 1810-14 and 80-90% hereafter (see fig. 2). Measles vaccination was introduced in Sweden 1971, 170 years after the first smallpox vaccination (1801). It was replaced by the combined MPR-vaccine (Measles, Parotitis and Rubella) 1982. The proportion of children born 1974-1978 being vaccinated against measles in Sweden 1981 varied between 46% and 63% (this is the first officially recorded figure on measles vaccination frequency). 1982 and onwards greater efforts were made in order to promote vaccinations and within two years the proportion of children vaccinated (before the age of two years) increased to above 90% (Bergström, Mäkinen and Romanus 2001).

medical center of Lund and then, rather uniformly, across the rest of the province.

There were no substantial differences between parishes according to structure of landowning (tenure) in the aggregate analysis, though the analysis of the four parishes showed a somewhat higher frequency of vaccination in the noble areas, at least in the beginning of the period, indicating that there might have been differences. However, there was also a marked difference in the sense that missing vaccination reports were considerably less prevalent in the noble parishes. One possible reason for the higher report frequency in the noble parishes could be the presence of an influential, rather well informed landlord, who also served as a natural supervisor of the local vaccination administration. As early as 1804 all Swedish parishes were instructed to appoint a vaccinator who was responsible for the annual reports and from 1812 all parishes should have a supervisor responsible for the vaccinations – and it was often a landlord who served as a natural supervisor of the local vaccination administration (Sköld 1996: 395), facilitating the production of the annual reports. The presence of an influential landlord might also, at least partly, explain the faster initial diffusion process in the noble parishes in our micro-analysis. Besides exercising some control over tenants directly dependant upon him, a landlord might also have served as a role model for other people in the area who trusted him. In parishes dominated by freeholders and tenants on crown land peasants were more independent and lacked the strong influence of a landlord, which may have contributed to a slower introduction of vaccination there. In this way a landlord could facilitate the information flow between authorities and the general public of the parishes in both directions, from parishes to the authorities in the form of vaccination reports and regarding health related advice and measures in the opposite direction. The prominent, open-minded, and in some respects controversial landlord Rutger Macklean at the Svaneholm estate in Scania constitutes an example of this. Besides initiating a comprehensive enclosure of his estate in 1783 (i.e. 20 years before the *Enskifte* act for Scania), and building schools on the estate already in 1793, enabling children in the parishes of the estate to attend school almost 50 years before this was made compulsory in 1842, he also conducted mass vaccinations of the school children against smallpox as early as 1804 (Mårtensson 1997:23).

The results of our investigation of socio-economic differences, using micro-level data, indicate that peasants (noble tenants, crown tenants and freeholders) adopted the technique at a faster rate than the landless *in the same area*. Information spread rather fast within the medical profession and the upper classes. It also spread relatively fast to the rest

of the population, but structurally the information on vaccination altered the behavior among the peasants earlier than among the landless. Since vaccination after 1810 came free of charge, and was provided for free or at a very low cost also before this date, we can safely conclude that this difference between social groups did not result from access to economic resources. Instead, a possible interpretation is that it reflects an “informational hierarchy”, reaching from the highest class to the peasants and finally to the landless; such a hierarchy could mirror divergent general abilities to gather and process information on a general level. We know that reading and writing ability generally was higher among landholding peasants than among landless (Nilsson and Svärd 1994). Moreover, we know from the writings of Munck af Rosenschöld and others that such written information did exist in newspapers and other printed material (Munck af Rosenschöld 1802). However, social differences in vaccination adaptation may also reflect differences in trust levels among the population concerning information on new scientific developments and the authorities and their proposals.

Previous studies on diffusion of smallpox vaccination in Sweden have concluded, or at least implied, that the process was so swift and smooth that virtually no socio-economic differences emerged. Quite the contrary, our results point to the conclusion that the better situated, better educated, landholding peasants were faster to adopt the new technology of smallpox vaccination being introduced in Scania in the first decades of the nineteenth century. Most likely, this had little to do with better access to economic resources, but was instead probably related to a higher ability to acquire and utilize the information available, and/or a higher level of trust in the authorities among these peasants. This, in turn, also reflects a rather unequal society, where the economically more powerful groups in society also were more prone to respond to new information concerning health and well-being.

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