The historical development of mortality in Mecklenburg-Schwerin in the 19th century

Marlen Toch, Jim Oeppen and Joshua R. Goldstein

Introduction

Record life expectancy has risen almost linearly by a quarter of a year for 170 years (Oeppen & Vaupel 2002). But still we do not know why the modern life expectancy revolution began. What we know is that North-Western Europe - especially France, England & Wales, Sweden, Norway and Denmark (see e.g., Bengtsson, Fridlizius, Ohlsson 1984; Brändström & Tedebrand 1989) - has been the forerunner of this development. Although these states went through the same population changes, they started from different positions. The Western European parts had higher density areas, whereas Sweden and Denmark were mainly rural (Perrenoud 1984; Riley 2001). The latter was also true for some northern German states, which were situated near the Baltic Sea, e.g. the Grand Duchies of Mecklenburg-Schwerin and Mecklenburg-Strelitzia, and the Prussian province of Pomerania (which today form the German federal state Mecklenburg-Western Pomerania). But how did these states perform? Does the Scandinavian scheme fit all countries situated near the Baltic Sea? Or did these parts of the German Empire perform differently? We know that mortality declined during the first demographic transition. But did the mortality decline set in later, or have there been phases of stagnation as there were in the whole of the German Empire (Imhof 1990; Spree 1992)? This project aims to analyze the development of mortality in Mecklenburg-Schwerin in the nineteenth and early twentieth century, the biggest part of today's Mecklenburg-Western Pomerania and to gather new evidence for understanding the modern rise in life expectancy.

The paper is organised as follows. In the first chapter we give an overview of population development in Northern Europe, especially Denmark and Sweden and describe the conditions of Mecklenburg-Schwerin in the nineteenth century. The data we use, the possible complications we expect with it and the data analysis techniques - Generalised Inverse Projection - will be examined in the second and third chapter. The heart of our analyses will be addressed in the fourth section, where we discuss the development of mortality in Mecklenburg-Schwerin and compare it with the Northern European scheme. Finally, we discuss our results and review secular trends of the mortality development in the states under observation.

1.1 Historical development of mortality in Northern Europe

Since the end of the eighteenth century industrialised countries experienced a revolution in life expectancy. At that time the record life expectancy was about 45 years for women in Sweden and has now moved towards 86 years for women in Japan (Oeppen & Vaupel 2002, Christensen et al. 2009).

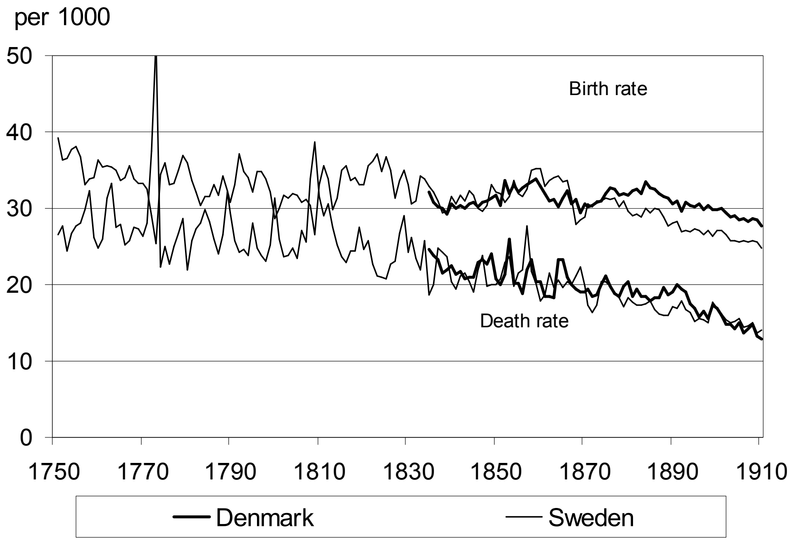
But what has caused this increase in expected years of life? Or in other words: what made mortality decline? Today we know that North-Western-European countries, especially England and Wales, France and Sweden (and somewhat later Denmark) were the forerunner of this development, while the former were urbanised and the latter were mainly rural. As we aim to analyse the mortality development in a mainly rural area with small cities, we will now focus on Sweden and Denmark. Over all, the development of Sweden and Denmark is very similar, which supports a comparison of both countries and a comparison of both with another more rural area (Johansen & Oeppen 2001).

In Sweden we can find reliable official population data from 1749 onwards, which provides a unique opportunity to investigate the very early stages of the transition towards low mortality - and later low fertility, which together are known as the demographic transition. As can be seen in Figure 1 there are three stages of this development (see also Hofsten & Lundström 1976). The first stage ended about 1810 after constant fertility and an early mortality decline, although, the latter showed rather strong fluctuations. The second stage (until the 1860s) is marked by a constant high level of fertility and an accelerating decrease in mortality. Until the middle of the twentieth century Sweden was in the third stage of the transition and mortality as well as fertility declined strongly. Between 1800 and 1900 the crude death rate decreased from 25 to 15 per 1000 and the birth rate decreased from about 35 to 25 per 1000. Owing to constant fertility and decreasing mortality up to the middle of the nineteenth century the population rose nearly fourfold, from 1.4 million in 1700 to 2.3 million in 1800 and 5.1 million in 1900 (Hofsten & Lundström 1976). Further, life expectancy at birth increased by more than 25 years from the end of the eighteenth until the beginning of the twentieth century, progressing from 33 years in 1800 to 59 years in 1910 (see Figure 2).

But why did mortality decline? First of all, we have to look at the age distribution of the decline. The early development was mainly shaped by decreasing infant and child mortality from 1800 onwards (continuing after 1900). Infant mortality decreased steadily from 200 to 100 per 1000 in one hundred years, mostly caused by a decline in post-neonatal mortality (Fridlizius 1984). Mortality in older age groups also decreased during the nineteenth century, but was marked by fluctuations. A strong decrease became established at the end of the nineteenth century and the beginning of the twentieth and still continues.

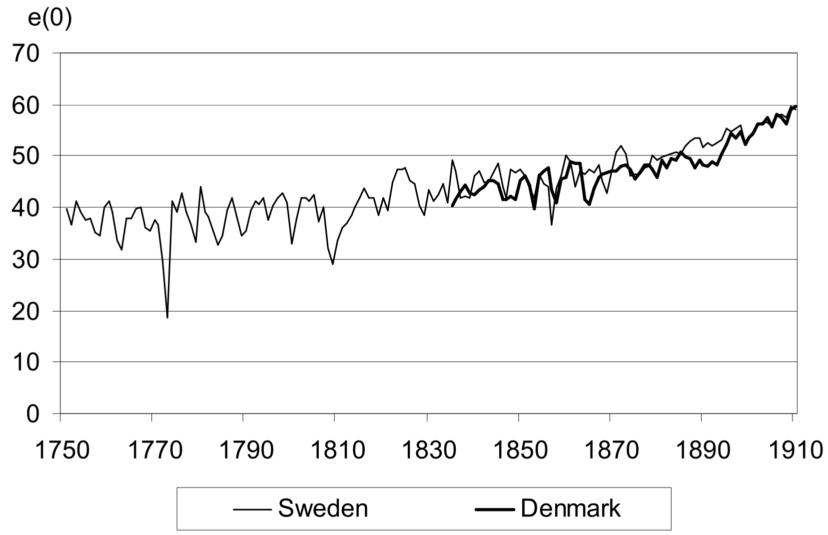
There are several explanations for the mortality transition in Sweden. Fridlizius (1984) claims that vaccination and the relationship between infection and host rather than improvements in living standards, climate or childcare were the main causes of the early mortality decline. Bengtsson & Ohlsson (1994) suggest that improvements in agriculture and industry, nutrition, hygiene and sanitation and medicine triggered and extended the mortality decline. On the other hand there is evidence that public health played its role in the development (Riley 2001) as smallpox vaccination, breast-feeding campaigns, education of midwives, disease control, investments in water supply and sewage systems, and promotion of improved personal hygiene were introduced (Bengtsson 2006). Bengtsson further discusses that living standards or equal income distribution may not have been the main causes (as real wages of workers increased after 1870 (Bengtsson & Dribe 2005)), but emphasizes public health and especially the low level of urbanization and less virulent environments.

Figure 1: Crude Birth and Death Rates - Sweden and Denmark



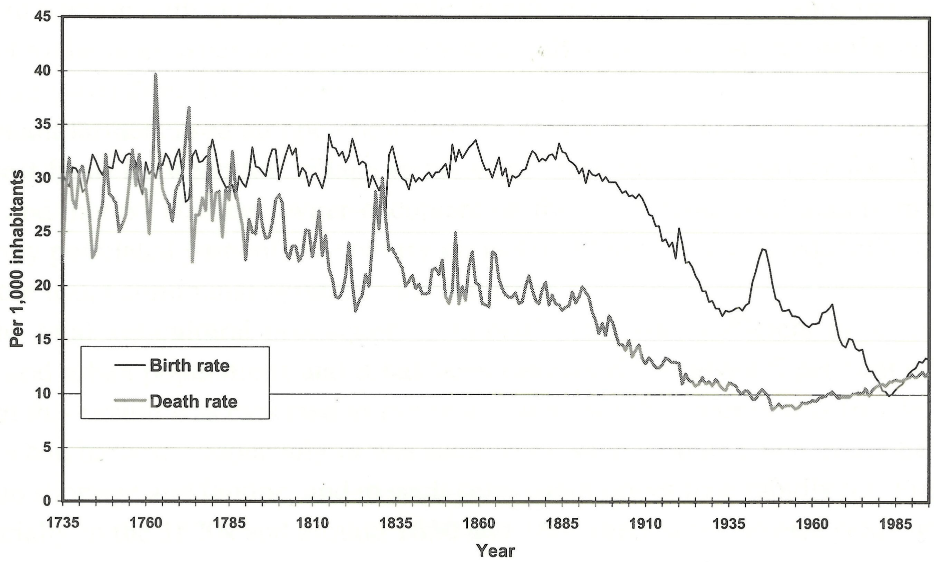
Source: Human Mortality Database: own calculations.

Figure 2: Life Expectancy at Birth- Sweden and Denmark



Source: Human Mortality Database.

Figure 3: Crude Birth and Death Rates - Denmark



Source: Johansen 2002.

Reliable official data for Denmark can be found from 1735 onwards, which again allows one to examine the very early stages of the demographic transition (see also Johansen 2002). Figure 3 shows the development of the crude birth and death rates for Denmark from 1735 to 1985. As can be seen, the first stage of the transition - starting about 1775 and lasting until 1840 - showed an early decrease of mortality but constant fertility, where the latter was lower overall than in Sweden. The middle stage (ending around 1890) showed relatively unchanged conditions, with constant fertility and steadily decreasing mortality. As Denmark entered the third stage of transition, mortality as well as fertility declined strongly and did so until 1939. In the period between 1800 and 1900 the Danish crude death rates fell - as the rates in Sweden did - from 25 to

15 per 1000. Danish fertility in contrast started at the same level as Sweden but remained slightly higher in 1900 (see Figure 1). Again, the population size increased strongly throughout the transition and thus tripled by 1910. Between 1775 and 1789 the total population was slightly more than 0.8 million (GIP estimates by Johansen 2002) and increased to 1.2 million in 1835 and to 2.4 million in 1900 (HMD). Life expectancy at birth increased by more than 20 years from the end of the eighteenth to the beginning of the twentieth century, ranging from 37 years between 1795-1800 to 59 years in 1910.

To explain the mortality decline we again need to look at the age distribution. The first stage of the transition was also triggered by decreasing infant and child mortality, whereas adult mortality played a minor role. Infant mortality declined significantly from 180-200 per 1000 between 1780 and 1801 to 130-150 per 1000 between 1835 and 1839 (Johansen 2002). In the following stages infant and child mortality as well as adult mortality played a role in the decline, whereas the latter (especially mortality up to age 60) was particular important in the last stage (ibid.).

There is consensus that the early mortality decline in Denmark was promoted by significant agricultural developments. New laws of land ownership, enclosure of rural areas, improved technology and increased production and thus, better nutritional intake, which in turn caused better resistance against infectious diseases, were the main factors (Andersen 1984). Medical innovation, public health improvements - such as improved housing, better water supply, and sewer systems - and improved living standards were more important in the later stages of the transition (Andersen 1979). Further, there have been no large-scale epidemics after the malaria epidemic in 1830 (Johansen 2002).

1.2 Mortality Decline - European Explanations

Until today there have been many debates - and just as many explanations - concerning why mortality declined. For a long time there were two main directions of argument: the influence of improved nutrition (e.g., McKeown & Record 1962, McKeown 1976) and the influence of public health and medical innovation (e.g., Omran 1971, Preston 1976, Szreter 1988). Later discussions however, have addressed a more holistic view, as mortality decline is seen as a multi-causal development (e.g., Schofield et al. 1991, Riley 2001).

McKeown's "*Modern Rise of Population*" has long been one of the main approaches towards an explanation of population development during the demographic transition. In his original approach - primarily using data from England and Wales - he claimed that population growth since the eighteenth century was caused by a decline in mortality and not increased fertility. Modernization and especially economic modernization is seen as the trigger of this population development. McKeown explains that the early mortality decline was triggered by the reduction of infectious diseases and that this was caused by a rising standard of living rather than by medical or public health improvements. Living standard is mainly seen in terms of quantitative and qualitative improvement of nutritional intake, which strengthens the body and the immune defence and thus, reduces vulnerability to infectious diseases. In McKeown's view improvements in public health measures and medical technology became important as mortality was already declining and thus, had no main influence on the early mortality decline.

McKeown's explanation was challenged by several authors. Szreter (1988) for example critiques his rejection of the role of public health and medical innovation and questions if the mortality decline was mainly due to increased nutritional intake and increased living standards. He claims the McKeown's hypothesis is based on assumptions and inference and not on existing data. He argues further that tuberculosis (TB) for example, is not the predominant factor in the mortality decline - whose reduction McKeown claimed to be the leading cause. He explains that some TB deaths could be caused by a weakened immune system - perhaps caused by lack of nutrition - but that this could as well be caused by other diseases. In addition, those other diseases might have been more lethal than TB. Szreter summarizes that not only the decline in airborne diseases, but also the decline of classic sanitation and hygiene diseases and thus, sanitary reforms and changing public health measures instead of nutrition (or rising living standards) played a major role in the mortality decline. However he does not neglect the influence of nutrition but asks if it was so universally effective. Beyond Szreter's critique there are several other authors who have found no evidence that the mortality decline was primarily caused by increased nutritional provision. For example, Preston (1976) found evidence that better medical technology and the introduction of public health measures had much more influence than the standard of living in developed countries. Livi Bacci (1991) doubts that mortality decreased because of nutrition, as it started declining in the eighteenth century while nutrition was not yet improving.

Another medically influenced approach towards an explanation of the mortality revolution is Omran's epidemiological transition theory. In his first description of the theory in 1971 he describes that, during the transition, fundamental changes in the main causes of death occurred and that there was a shift from pandemic infectious diseases towards an era of man-made degenerative diseases. He further acknowledges that mortality is an essential factor of population development.

The epidemiologic transition occurs in three stages and is determined by several interacting factors: balance of disease agents and the host; socioeconomic, political and cultural determinants (standards of living, health habits and hygiene, nutrition); medical and public health determinants (public sanitation, immunization, decisive therapies) (Omran 1971:520). He further claims that the transition is closely connected with modernization and the socioeconomic and demographic processes related to it.

All explanations described so far have a somewhat one-sided view into the underlying factors of the transition. Several authors however, have promoted a more holistic view and tried to explain the development with different (interacting) factors. Schofield (1984) states that in analyzing mortality decline immunological aspects and nutritional aspects have to be addressed and compared especially.

Schofield, Reher and Bideau (1991) also promote a broad view in their book "*The Decline of Mortality in Europe*". Here diverse authors address the multiple determinants of the mortality decline. Schofield and Reher state that besides nutrition, living standards, public health and sanitation, there are other factors such as living conditions, workplace, urbanization, education, aetiology of old and new diseases, physicians and medical science, mothers, infant-feeding practices and hygiene, politicians and reformers and also climate that have an influence on mortality development (Schofield & Reher 1991:10). Puranen divides the determinants into those affecting exposure and those affecting actual infections. Thus, exposure is determined by living conditions (hygiene and population density), occupational structure and location and infections are determined by nutrition, general health, absence or presence of other diseases, stress, age and alcoholism (Puranen 1991:117).

Brändström & Tedebrand (1991) also concentrate on a broad interdisciplinary approach to improvement when they compare the effects of medical technology and nutrition and housing, and analyze the effect of the reduction in the virulence of pathogens, acquired immunities, public sanitation and explore overall social, economic, cultural, medical, political and biological factors on mortality development.

Another more recent publication is Riley's (2001) "*Rising Life Expectancy*", where he describes the global history of the modern life expectancy revolution. He firstly compares the economic modernization and epidemiologic transition theories as explanations for mortality decline. Then he concludes that the development could not be explained by a single cause and thus, analyzes life expectancy development with respect to: public health; medicine; wealth, income and economic improvement; famine, malnutrition and diet; households and individuals as well as literacy and education.

1.3 Mecklenburg-Schwerin

Mecklenburg-Western Pomerania, the Northern German federal state situated near the Baltic Sea, as it exists today was founded in 1990, after the reunification of both Germanys. In the late eighteenth, nineteenth and early twentieth century today's territory was divided into the Grand Duchy of Mecklenburg-Schwerin, the Grand Duchy of Mecklenburg-Strelitzia and the province Pomerania which was a part of Prussia (Gruner 2002). Here we analyze the mortality development of Mecklenburg-Schwerin in the nineteenth and early twentieth century, as the grand duchy formed the biggest part of today's Mecklenburg-Western Pomerania (Figure 4). Further, this state provides the best German data to perform our analysis.

Figure 4: Map of Mecklenburg-Schwerin and its surrounding states

Source: http://www.ieg-maps.uni-mainz.de/gif/p71HMk_a4_mb.gif

Mecklenburg was special among the provinces later forming the German Empire (1871). Its constitution, the "Landesgrundgesetzliche Erbvergleich" (constitutional succession settlement) which formed Mecklenburg-Schwerin and Mecklenburg-Strelitzia and gave the power to one sovereign (the Duke, who was given the rank of Grand Duke in 1815) was written in 1755 and remained nearly unchanged until 1918 (Karge et al. 1993). Further, this constitution gave huge power to the nobility ('Ritter') and the guilds, what made reforms even more difficult (Bei der Wieden 1994). Although democratic reform movements emerged in the years 1848/49 (March

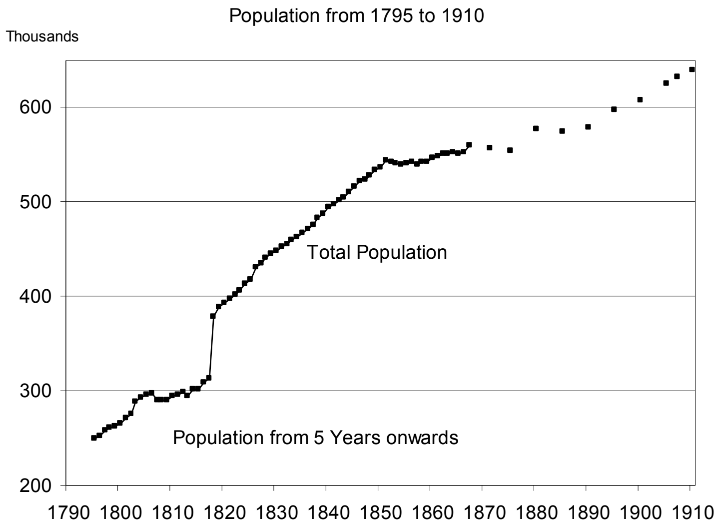
Revolution), no real constitutional changes occurred, and the Duke as well as the nobility ('Ritter') and the guilds remained as powerful as before (Boll 1856).
Another characteristic of this feudal state was its low degree of urbanisation. Mecklenburg-Schwerin was mainly rural with some small cities, where the biggest were Schwerin and Rostock with 38,642 and 28,849 inhabitants respectively in 1871, forming about 5% to 7% of the total population. In conjunction with this low urbanisation, the Duchy had a very low degree of industrialisation until the end of the nineteenth century. The first shipyards for example, emerged in 1890, but they still mostly building sailing ships (North 2008). This suppression of industrialisation was mainly due to the power of the guilds, the mandatory guild memberships and traditional lines of business (agriculture, shipping) (Karge et al. 1993). In 1900 about half of all workers were still agrarian workers. There were very few small farms and most of the land was owned by great land owners, of which 50% were noblemen, who were allowed to press farmers into serfdom and incorporate their land (Vitense 1920). After serfdom was abolished in 1820 the situation for small farmers was not better, as land was (highly) charged with taxes. An exception were the noblemen, as they only had to pay taxes for the land they had incorporated from small farmers and thus their heritage ('Rittergüter') stayed tax free (North 2008). In addition, the now free day labourers had very few rights and became even more dependent, as they could easily be laid-off and thus, would lose their income and dwelling (Bei der Wieden & Schmidt 1996). Although there was no great industrialization movement, Mecklenburg-Schwerin's agriculture developed and thus production could be improved. Farmers turned away from three-field crop rotation at the end of the eighteenth century, which doubled the crop and allowed improved cattle and sheep breeding (Karge et al. 1993). Later on, as agriculture was one of the few fields of technological progress and invention, farming output was steadily improved, which allowed Mecklenburg-Schwerin to export its products, e.g., to England.

2. Data

Our analysis is based on the aggregate data of the "Großherzoglich Mecklenburg-Schwerinscher Staatskalender", an annual calendar issued by the Grand Duke of Mecklenburg-Schwerin for the years 1786 to 1910. These calendars give annual counts of population movement, births, deaths, marriages and population totals and subpopulations classified by parishes (1786-1875) and the civil registry offices of the districts ("Bezirke") (1876-1910). No information is given for the militia. Since the first years of the calendar contain no reliable information on population totals (see also Manke 1999) we analyze the data from 1818, which was the first year with population totals for all ages. Births counts are given separately for both sexes and deaths are also counted by sex but without stillbirths. Stillbirths and deaths before baptism are given together in an extra category and marriages are given for pairs that were espoused. From 1818 to 1867 population totals are given for every year and include the censuses from 1819, 1866 and 1867. For the period from 1868 to 1875 the totals from two censuses (1871 and 1875) are available and from 1875 onwards the totals are derived from the quinquennial censuses. Net migration can be calculated via the population renewal equation as the residual change in population after natural increase has been accounted.

Additional data on the age structure of the population, on mortality, fertility and nuptiality and on migration can be derived from two other official sources: the statistical handbooks of the Grand Duchy and the "Contributions to the statistics of Mecklenburg-Schwerin" (original title "Beiträge zur Statistik Mecklenburgs."). The three statistical handbooks were published in 1898, 1910 and 1931 and provide information on the age structure of the population for males and females (in five year age groups for 1891 and 1910) as well as information on the age structure of the mortality. The "Contributions to the statistics of Mecklenburg-Schwerin" were published from 1859 to 1912. These 16 issues give exceptional information on mortality, fertility, nuptiality and migration as well as economy and meteorology. For our analyses we used information on seven censuses, divided by single year, age, sex and marital status, from 1867 to 1910 and additionally assessed data for calculating life tables (total population and deaths by single ages, sex and marital status).

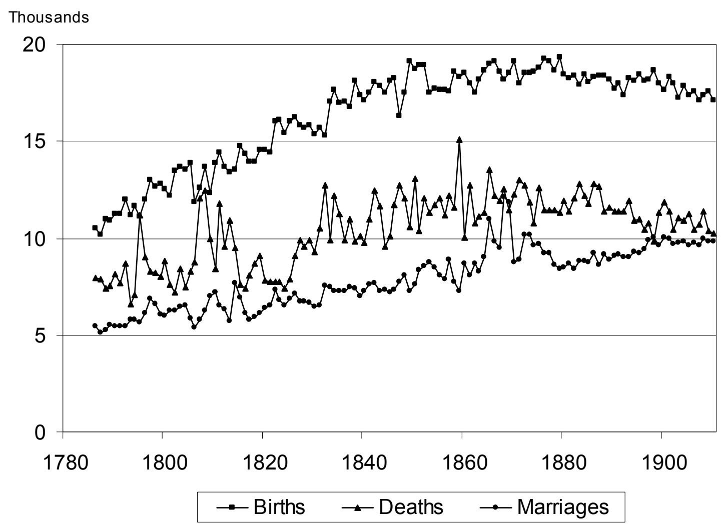
Figure 5: Population totals from 1795 to 1910



Source: Grosherzoglich Mecklenburg-Schwerinscher Staatskalender (1818-1910), own calculations.

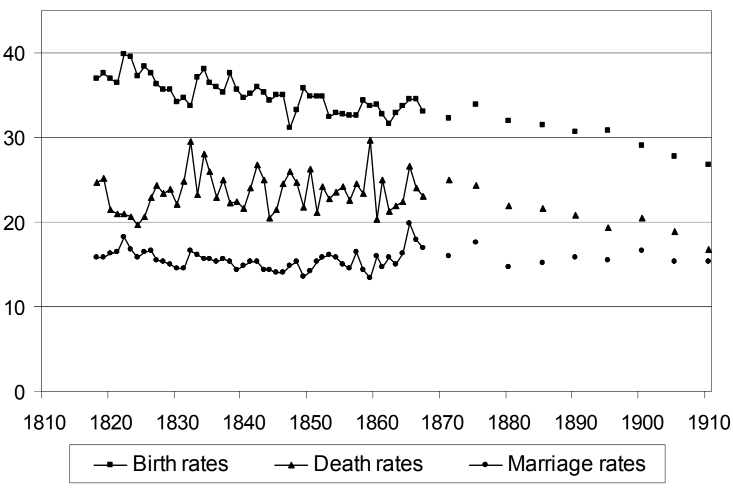
The following descriptive findings are taken from the 'Staatskalender' data. Figure 5 shows the total population of Mecklenburg-Western Pomerania from 1818 to 1910. The number of people increased from about 380,000 people in 1818 to 640,000 people in 1910, but underwent a period of stagnation from the 1850s to the 1880s. This stagnation was probably caused by mass outmigration which started in the early 1850s and continued until the early twentieth century (Bade 2000; Pade 2004). In the 1880s the effect of the mass emigration was slowed by waves of immigration e.g. from Sweden, Russia or Austria-Hungary to compensate for the great losses of agricultural workers (Bade 2000).

Figure 6: Total numbers of births, deaths and marriages from 1786 to 1910



Source: Grosherzoglich Mecklenburg-Schwerinscher Staatskalender (1818-1910), own calculations.

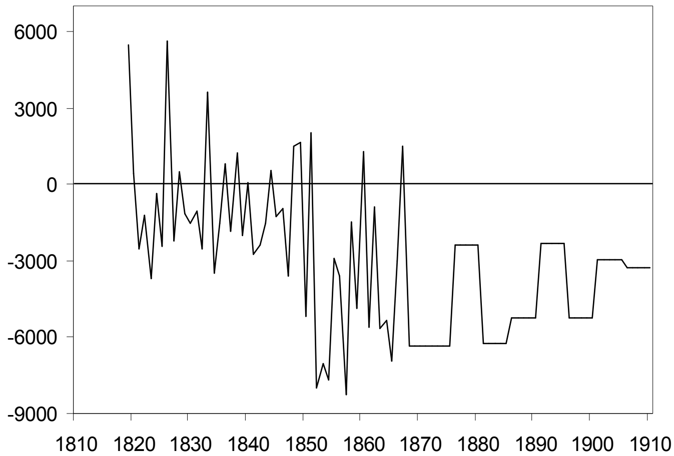
Figure 7: Crude birth, death and marriage rates from 1818 to 1910



Source: Grosherzoglich Mecklenburg-Schwerinscher Staatskalender (1818-1910), own calculations.

The totals of births, deaths and marriages from 1786 to 1910 are shown in Figure 6. Births, as well as deaths counts, show an inverse u-shaped development with an increasing trend until the 1870s and a decreasing trend afterwards, whereas fertility increased to a greater extent than mortality. The number of marriages increased over nearly the whole period.
Figure 7 depicts the crude rates for births, deaths and marriages (per 1000) during the observation period. Births rates are declining over the whole period. Up to the 1870s the death rates fluctuate between 20 and 25 per 1000 and decline afterwards. Marriage rates show a fairly constant level over the whole period.

Figure 8: Total numbers of net migrants from 1818 to 1910



Source: Grosherzoglich Mecklenburg-Schwerinscher Staatskalender (1818-1910), own calculations.

The estimated total net migration between 1818 and 1910 is shown in Figure 8. From 1886 onwards there are no annual population totals, so the average net migration between two censuses is shown. Losses due to net emigration increased over time. Net losses due to emigration over the whole period were 279,678, and over 90% of these occurred between 1850 and 1910.

2.1 Data Quality

To perform a sophisticated historical demographic analysis it is important to examine data quality, as this might become a problem, either for interpretation or for obtaining sound results at all.
Manke (1999; 2005) gives detailed descriptions of the statistics of Mecklenburg-Schwerin. First of all we have to consider that there have not been statistical offices in the Duchy until 1851; therefore it may be difficult to find adequate publications except for the 'Staatskalender'. In

analyzing the data derived from the 'Staatskalender' one should take into account that until 1875 the population counts were derived from parish registers and afterwards from civil registry offices of the districts ("Bezirke"). Thus, there might be differences in the data quality, as the registration from civil offices would have been much better. Comparative analyses of different cities or regions over a longer period might not be possible, as registration areas as well as boundaries have changed. Since we examine the total population of Mecklenburg-Schwerin, this might not be too problematic, as the ducal boundaries changed to a lesser extent.

Up to 1803, data from the parishes were collected from 1st Advent to 1st Advent (ecclesiastical year) and thereafter until 1874 at Martinmas (end of November). From 1875 onwards the population movement was registered from January to December. These discrepancies in the collection cycles have to be considered in analysing and interpreting the data.

Until 1818 children under the age of five, as well as people with other than Lutheran confession, were not included in the parish registers, the population totals in the 'Staatskalender' can not be used directly in the early years. Further, Manke points out that data collection in bigger cities was somewhat problematic until the late nineteenth century. Additionally, the 'Staatskalender' gives no information on militia, what could affect the male population estimates in the middle age groups.

In terms of accuracy, there are sometimes deviations in the totals from one year to the other, which might be due to 'human error'. On the one hand, clergymen often took their data from sextons and schoolmasters, who might not be too accurate. On the other hand, count lists were not always sent on time. We account for these inaccuracies in using the totals at time t_x that were published in t_{x+1}. Although there are some constraints in the 'Staatskalender' data, we will use them for our analysing mortality development in Mecklenburg-Schwerin in the nineteenth century.

In addition to the 'Staatskalender' we use publications on several censuses. The first census was taken in 1819, but except for population totals, we could not identify any further publications.

As there were statistical offices from 1851, we have information on several censuses from 1867 onwards. The 1867 census - the second real census in Mecklenburg-Schwerin - was initiated by the North German Confederation and recorded the residential population, taking into account those who should be there and excluding those who were there temporarily. In terms of accuracy Manke (2005) points out that there might be over registration of some age groups, due to age heaping or age vanity. Further, it is not exactly clear to what extent there were problems in the data collection process. Overall, it is said that all censuses from 1867 onwards are fairly accurate and could be used for statistical analysis of population development.

3. Generalised Inverse Projection

Inverse Projection is used to estimate demographic parameters of fertility and mortality, by using aggregate data - such as birth and death counts - which are commonly available. Therefore it is especially useful in historical demographic research, as vital or parish registration was relatively good in previous centuries, but reliable census or survey data were often lacking (McCaa 2001).
Inverse Projection was first developed by Lee in 1974, when he calculated "*series of vital rates and age structures from baptisms and burials*" and age structures of a population at the beginning of the period, using the balancing equation. In this first attempt Lee applied his method to a closed population, which was latter extended, as populations are usually not closed over time (McCaa 2001). One problem that remained is that migration in the latter application was included exogenously (Johansen & Oeppen 2001). Another rather problematic issue of Inverse Projection is the need for an initial age structure, when the observation reaches far into the past and there might not be such information. In order to deal with both issues, Wrigley and Schofield (1981) developed Back Projection, where they estimated migration from a terminal age structure backwards, again, using the renewal equation. This attempt was critiqued by Lee (1993) as it ignores the weak ergodicity of populations.
Another attempt to revise Inverse Projection was undertaken by Oeppen in 1993, when he developed Generalised Inverse Projection, an incorporation of Inverse and Back Projection methods. GIP uses annual numbers of births and deaths and a terminal age distribution of the population and tries to calculate net migration endogenously (Johansen & Oeppen 2001). In using parameters to define mortality and migration, birth cohorts can be projected. These cohorts may not be complete, as the cohorts they stem from are unknown. This problem can be solved by assuming a stable growth rate (Johansen & Oeppen 2001).
GIP calculates the levels of mortality and migration in one optimisation procedure - a standard non linear least squares algorithm - that minimises the following objective function:

$$\min F = \sum_{t=1}^{T}\left(\frac{D_{.t}-\hat{D}_{.t}}{D_{.t}}\right)^2 + \sum_{x=1}^{K}\left(\frac{N_{x,T}-\hat{N}_{x,T}}{N_{x,T}}\right)^2 + \lambda.\sum_{t=1}^{T-1}(\mu_t-\mu_{t-1})^2$$

Where D denotes the given death counts, N is a census - the ^ symbol denotes estimated values -, μ is the net-migration parameter, t is the time, x is the age groups and T denotes the terminal year and K the number of age groups. The first and second error terms in the equation measure the relative discrepancy between the estimated deaths and the terminal census age groups and the corresponding observed data, and the third term controls whether the development of net-migration is smooth - as this is a basic assumption of the model (Oeppen 1993). In changing the smoothness parameter λ the fit of the estimations and the migration assumption can be adjusted. A rule of thumb therefore is: the higher λ the more weight is given to the assumptions compared to the observed data. As we have lots of original data we apply a λ of 0.001 and thus give more weight to the data.

One special feature of this approach is its flexibility, as any item of information - the so called targets, which can be data as well as assumptions - can be included. The objective function described above shows the simplest case, where no additional data are included in the analysis. In our study we incorporate the following targets: additional census age structures for 7 censuses (1867, 1871, 1875, 1880, 1885, 1890 and 1900); single age life tables for 1867-1871, 1872-1876 and 1877-1881 […]. Another feature of this model is that it gives errors for every target, where the sum of (these) squared errors (SSE) is a consistency measure between the model and the targets (Johansen & Oeppen 2001).

GIP in its flexibility has its constraints, as the results strongly depend on the quality of the original data as well as the feasibility of the assumptions. It is desirable to include much information, especially as historical data often lacks quality, but one should be aware that incorporating additional targets can produce even more insecurity. Therefore, iterating models, applying different bits of data and checking if they produce better outputs, are needed. Further, reliability testing of input data as well as results and external checking is crucial (van Leeuwen & Oeppen 1993).

4. Development of mortality in Mecklenburg Schwerin

In this chapter we analyse the population development of Mecklenburg-Schwerin from 1786 to 1910, assessed from GIP. We used the following input data: birth and death counts from 1786 to 1910; the terminal age structure in 1910, in five year age groups until age 80; population totals from 1819 (year of first census) to 1910; a model life table (North) with life expectancy at birth of 50 years; a model migration table from […] and a fertility table with the mean age of birth of 32 years.

The population of Mecklenburg-Schwerin more than doubled in about a century, from a total of about 0.3 million to 0.64 million. Figure 9 shows the age structure of at the beginning and the end of our observation. In 1785 we find the typical pyramid shaped form of the age structure, whereas in 1910 this shape changed, as there are fewer people between the ages 20 and 40. This slump could be partly explained by massive out-migration of young people at the end of the nineteenth century.

Figure 9: Population pyramids, 1785 and 1910

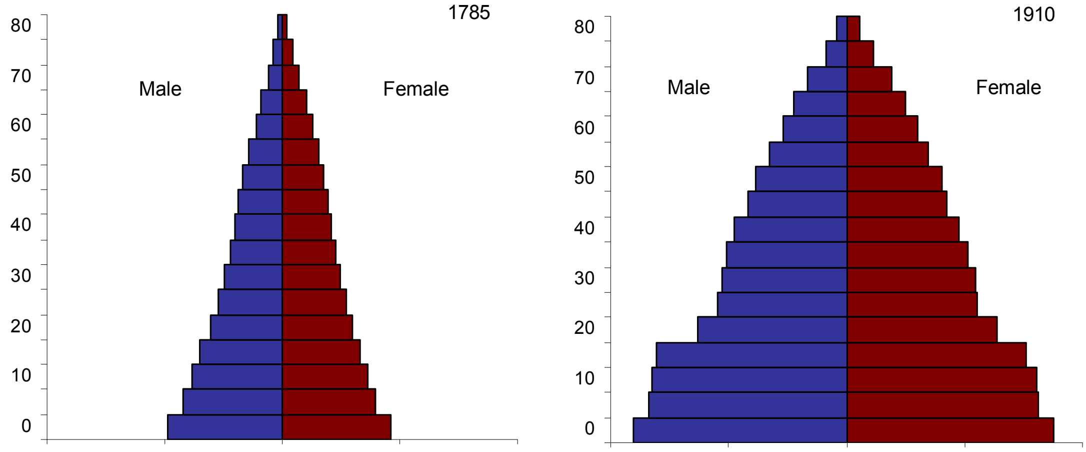


Figure 10: Development of e(0), 1785-1910

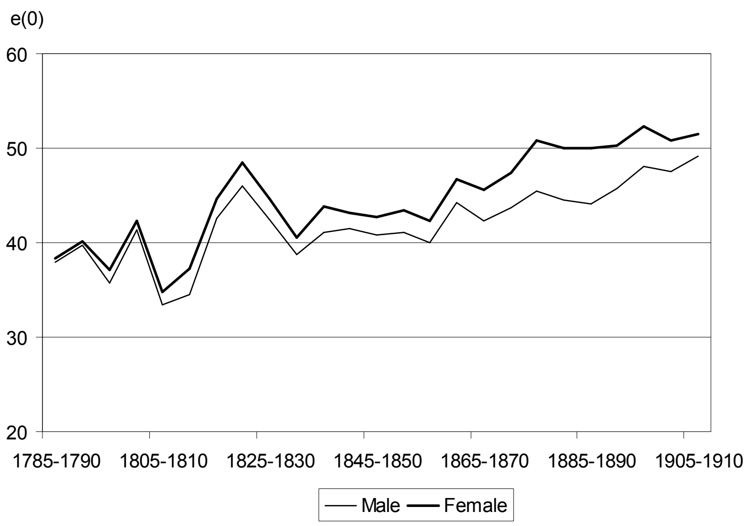


Figure 10 shows the development of e(0) in five year intervals from 1785 to 1910. Life expectancy at birth increased relatively steadily from about 38 years for both sexes to about 49 years for men and about 51 years for women, peaking once in the 1820s. The gain in life expectancy at birth is bigger for women than for men, but both seem to converge at the end of the period.

The net reproduction rate (NRR), the average number of daughters a woman would have given birth to, is depicted in Figure 11 where 1 would be the exact replacement of a female birth in the subsequent generation. In Mecklenburg-Schwerin we find over-replacement of births and thus population growth, for the entire period. Again, the peaks display period fluctuations, where the high level in the late nineteenth century is caused by a high level of fertility and declining mortality during the transition.

Figure 11: Development of the NRR, 1785-1910

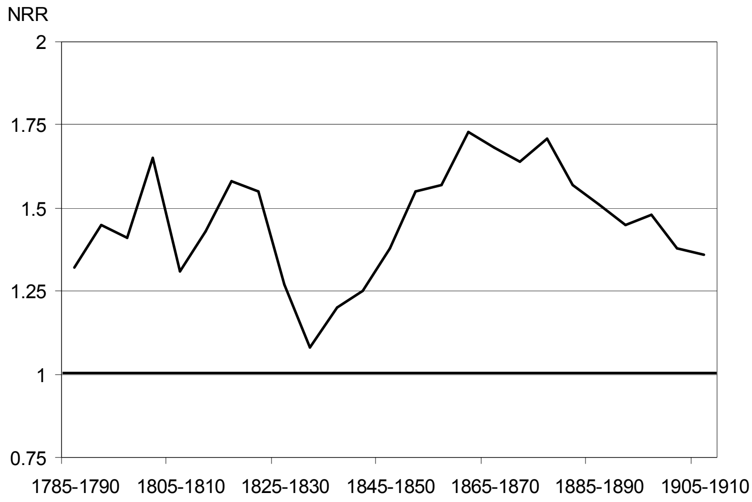
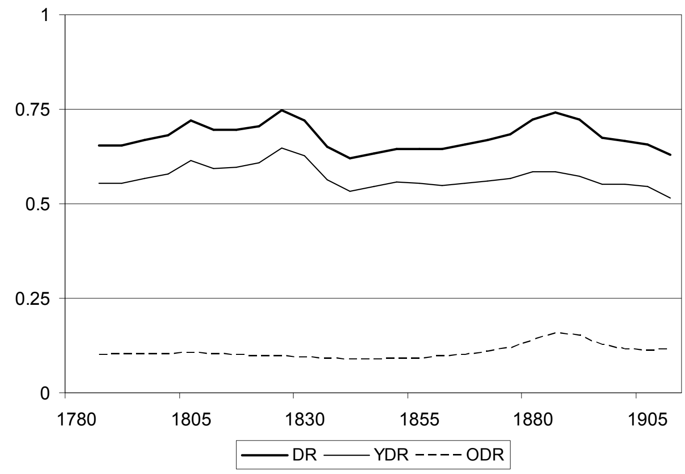


Figure 12: Dependency Ratio, total population 1785-1910



The dependency ratio indicates the proportion of people in non-working ages in contrast to people in working ages, where 1 displays a balanced share. This measure is based on a rather modern definition of working and retirement age, but we include it as a comparative component. Figure 12 shows the 'common' dependency ratio (DR) of those aged 0-15 and 64+ to people aged 15-64. In addition, comparisons of working age people with young (YDR) respectively old (ODR) people are included.

For the whole period the share of people in working ages is higher than of non-working ages. This share is mainly shaped by the proportion of young people (YDR). The sharp decrease in the 1830s is the result of the period fluctuation in fertility (see also Figure 11). The peak in the 1890s is to some extent a result of an increased share of older people (ODR), which might be caused by massive out migration of people in working ages.

For backwards estimation of the incomplete cohorts, a factor of annual population growth, which can be assessed either from the development of births or population totals, is needed. From our original data, we calculated growth factors of 1.0354 from the total of birth and 1.0339 from the population totals, and chose the former to be applied in our further analysis. In controlling for both sexes the population growth factors are estimated to be 1.0351 and 1.0341 for men and 1.0356 and 1.0365 for women. Again the value based on birth is applied in our analysis. A striking fact is, that both growth factors are very similar, which is a sign of good data consistency.

Table 1: Sum of Squared Errors, by targets

Target	Sub Total	Per cent of Total SSE
Total SSE	0.00543539	100.00%
Census Age Structure	0.00021563	3.97%
Death Totals	0.00019421	3.57%
Population Totals	0.00461927	**84.99%**
Migration Schedule	0.00040628	7.47%

Table 2: Sum of Squared Errors, by targets and sex

Target	Sub Total	Per cent of Total SSE	Sub Total	Per cent of Total SSE
	Male		Female	
Total SSE	0.00322867	100.00%	0.00213197	100.00%
Census Age Structure	0.00007999	2.48%	0.00004059	1.90%
Death Totals	0.00007833	2.43%	0.00004736	2.22%
Population Totals	0.00268147	**83.05%**	0.00161905	**75.94%**
Migration Schedule	0.00038887	12.04%	0.00042497	19.93%

As GIP gives the SE for every target included, we can assess the overall quality of the estimates as well as the contribution of every target. In this model the SSE is 0.00543539, a value that as such can not be interpreted, but if compared between different models can give a direction. Therefore, a rule of thumb is: the lower the SSE the better the model, as we aim to minimise errors. Table 1 shows a summary of the contributions of all targets to the SSE. Here, the errors in the population estimates account for 84.99% of the SSE, which means that there is some inconsistency between estimated and observed population totals. Census age groups, death totals and the smooth migration schedule instead have a better fit. When contrasting men and women, we can see that men have a higher overall SSE than women (Table 2). Again, the population estimates seem to be the main factor of discrepancy between estimates and observations, whereas the contribution is higher for men than for women. Migration seems to be a bigger factor of uncertainty for women.

In order to assess the magnitude of the mortality decline in Mecklenburg Schwerin, Figures 13 and 14 compare the development of life expectancy at birth in Mecklenburg-Schwerin with Germany and with Sweden and Denmark. Data for Germany are derived from Imhof (1994) and data for Sweden and Denmark stem from the Human Mortality Database and GIP calculations.

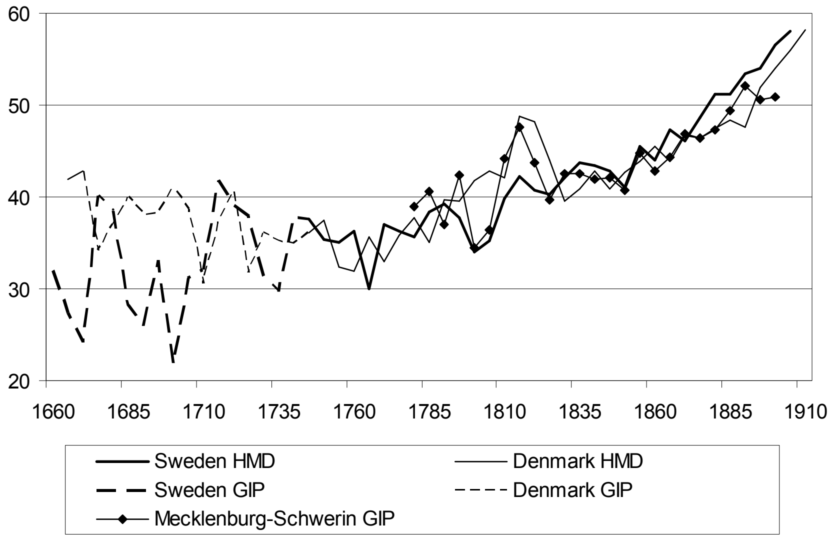
During the late eighteenth and early nineteenth century life expectancy at birth in Germany was somewhat higher than in Mecklenburg-Schwerin. After 1820 however, this relation changed and Mecklenburg-Schwerin followed a different development to Germany. In Mecklenburg-Schwerin, e(0) increased over almost the whole period - only slowing down between 1830 and 1850 - , while Germany stagnated and even declined for some time, to rise from 1870 onwards. Female life expectancy however, seems to converge at the beginning of the twentieth century.

Figure 13: e(0) in Germany and Mecklenburg-Schwerin, 1790-1915

Source: GIP for Mecklenburg-Schwerin; Imhof (1994)

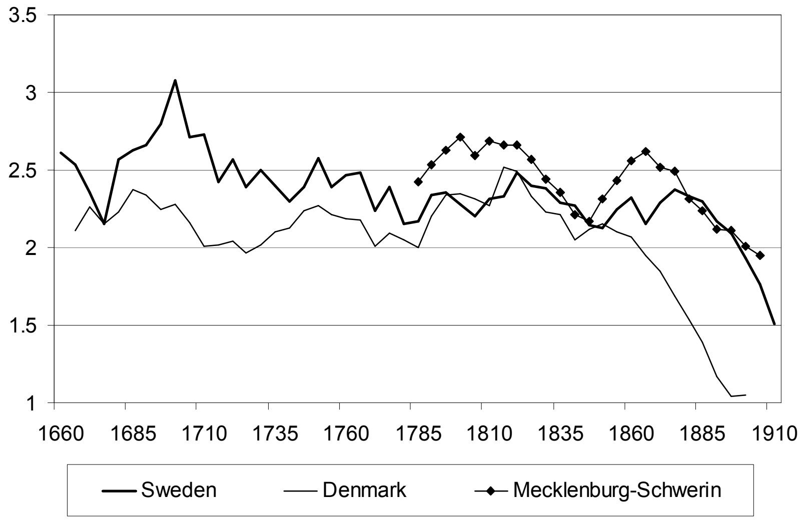
When comparing the development of Mecklenburg-Schwerin with Sweden and Denmark, a striking similarity appears. For the entire period, life expectancy at birth in Mecklenburg-Schwerin seems to follow the Northern-European pattern, rather than the German one. Unfortunately we do not have early data from Mecklenburg-Schwerin and thus can not examine early mortality development.

Figure 14: e(0) in Sweden, Denmark and Mecklenburg-Schwerin



Source: Human Mortality Database and GIP.

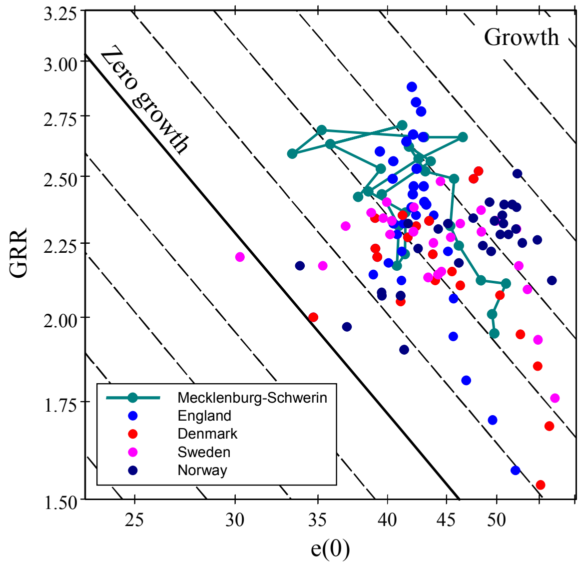
Figure 15: GRR, Sweden, Denmark, Mecklenburg-Schwerin



Source: Human Mortality Database and GIP.

The Gross Reproduction Rate (GRR) is the average number of daughters a female birth would bear, assuming her survival until age 50. Figure 15 compares the GRR estimates for Mecklenburg-Schwerin with Sweden and Denmark. Again there is some similarity in the shape, but not in the level of the development. For most years, fertility in Mecklenburg-Schwerin was higher than in Northern-Europe, especially as Danish fertility showed an early decline. Sweden and Mecklenburg-Schwerin instead seem to have a somewhat uniform fertility pattern up to 1900. Figure 16 shows the relative importance of changes in the GRR and e(0) in influencing the intrinsic growth rates for Germany, Sweden, Denmark, Norway and England between 1785 to 1905 (see also e.g., Wrigley & Schofield 1981, pp. 242). Mecklenburg-Schwerin, Sweden, Denmark, and England seem to have similar levels of survival before the modern rise. Fertility seems to have had a bigger impact on population dynamics in Mecklenburg-Schwerin - as it did in England - than in Sweden and Denmark. Sweden, Norway and Denmark show a rather horizontal spread of points, indicating smaller fluctuations in fertility than in mortality. Mecklenburg-Schwerin and England in contrast move vertically through time, Of the areas shown, Mecklenburg-Schwerin was the most stable with respect to intrinsic growth. Changes in mortality and fertility were largely offsetting so that growth was generally stabilized between 1.0 and 1.5 percent *per annum*.

Figure 16: Combined effect of GRR and e(0) on the intrinsic growth rate, 1785-1905



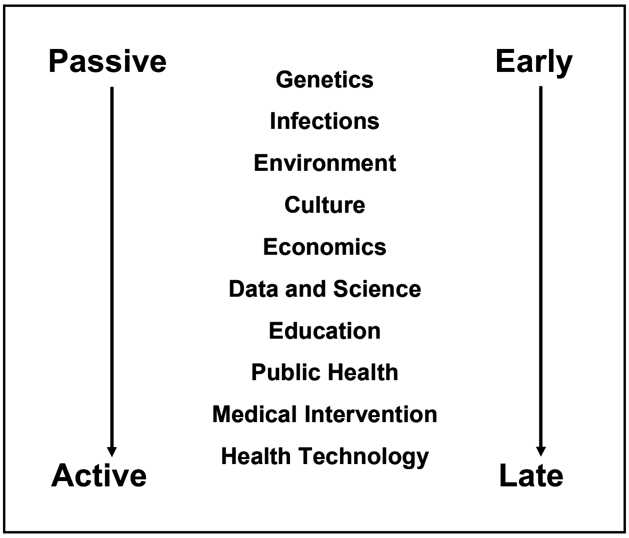
Source: Own calculation.

5. Discussion and Conclusion

In this project we aimed to analyse the mortality development of Mecklenburg-Schwerin in order to better understand the modern rise of life expectancy. In addition we wanted to find patterns that help locate Mecklenburg-Schwerin's mortality development in historical Europe.

Mecklenburg-Western Pomerania today has the lowest average live expectancy in Germany. Does this development have its roots in the past, because regional mortality differences in Germany already existed in the nineteenth century (Lee 1984)? Or does the federal German state have another mortality history? Can the present mortality patterns have been influenced by historical or more current factors? At first sight the initial question is not raised without reason, as there are regions in Germany whose position - in terms of mortality development - has not changed for centuries. In his study of regional mortality differences, for example, Luy (2004) found that Saarland and Hartum (a region near Bremen) had the lowest average life expectancy in the eighteenth and nineteenth century. Today the German federal states of Saarland and Bremen still have leading positions in high mortality (Sommer 2002). On second thought however, one might argue that Mecklenburg-Western Pomerania - respectively its historical counterpart Mecklenburg-Schwerin - in its location at the Baltic Sea might have more 'Nordic' patterns of historic mortality development, and that the present state of life expectancy was influenced by more recent developments. This similarity of population development might stem from natural and historical conditions such as the degree of urbanisation, natural resources and soil conditions, culture, climate or natural resistance and stamina.

Figure 17: Forces of Mortality Integration



There are several explanations why mortality in general, and in Mecklenburg-Schwerin in particular, declined. Our finding that Mecklenburg-Schwerin followed the same trajectory as Denmark and Sweden leads us to the question of which of these factors resulted in the spatial integration of mortality. In Figure 16 we tried to position these possible forces of mortality on a scale from passive to active integration. By passive integration we mean a process with little or no conscious intervention, such as the spread of a virus or gene. An example of an active intervention would be the provision of piped waste disposal, which implies deliberate, mass action. We observe that this scale also implies a temporal scale. Some of the components of active interventions only become available towards the end of the nineteenth century and are associated with economic growth and the diffusion of ideas.

The early mortality decline was triggered by more passive factors as genetics, infections, environment or culture. Northern European people are often said to be more robust and taller, what might give them a better starting point in the life expectancy revolution. As early as 1858 Dippe stated that people in Mecklenburg-Schwerin lived longer than most other people in Germany and claimed that they seemed to have had an extraordinary robust physique, which might have a beneficial effect on survival.

Increased natural immunity or reduced lethality of infectious diseases might also be one factor of the early mortality decline (see e.g., Omran 1971; Schofield 1984, Brändström & Tedebrand 1991). The last big outbreak of the plague in eighteenth century Europe initiated the phase of reduced epidemics, as thereafter infectious diseases (e.g., plague, smallpox, dysentery and typhus etc.) tended to become endemic or to die out. It is not clear to what extent this is due to natural immunity or reduced lethality, but it seems to be a plausible explanation, as nutrition and public health had not improved so much in the very early stage of the transition. In Mecklenburg-Schwerin, for example, the last outbreak of plague occurred after the Thirty Years' War (Boll 1856). Thereafter other infectious diseases played a major role, and these did not kill as many people as before.

Other rather passive factors of mortality decline were environmental circumstances and culture, which might explain some of the similarities between Mecklenburg-Schwerin, Denmark and Sweden. Dippe (1858) argued that Mecklenburg-Schwerin had fertile soil, which granted good harvests and sufficient food. All of the countries we examined were mainly rural and had a very low degree of urbanisation. This provided less crowded spaces, with less virulent environments, which in turn might have led to better health and survival (e.g. Bengtsson 2006). They also had a very similar climate, with temperate summers and relatively mild winters and fresh air, which provided good living conditions.

Culture seems to be rather a factor of similarity between Mecklenburg-Schwerin and Denmark and Sweden than of mortality decline per se. As we have seen, all three countries had very similar environmental conditions. In addition, they had similar religious backgrounds - as all were primarily protestant - and therefore, their culture, habits and ways of living may also have been alike. Further, these states have a common past, as for example the city of Wismar was in possession of Sweden for several years after the Nordic Wars (Vitense 1920), which might have caused cultural exchange. As early mortality decline was triggered by decline in infant mortality, another factor may have been breastfeeding patterns, as breastfed children had a lower risk of dying than children fed with surrogates. Breastfeeding was traditionally more common in Northern German states, which might to some extent explain the differences in life expectancy

we found between Mecklenburg-Schwerin and Germany as a whole (Knodel 1988). In Sweden breastfeeding was promoted through campaigns and thus was also relatively widespread (Bengtsson 2006).
Another factor of increasing life expectancy could be welfare of the elderly. With improvements in old age living conditions, mortality might decrease which in turn would cause an increase in life expectancy. Germany was to some extent the forerunner of old age security and might thus be a forerunner of increased life expectancy due to higher proportions of elderly people. As Bismarck's insurances however were not introduced before the late nineteenth century (1883 health insurance; 1884 accident insurance; and 1889 disability and old age insurance) it is not clear to what extent they would have influenced the mortality transition (Loth 1996, Gall 2002).
In the middle stage of modern life expectancy development the impact of economic factors grew. For instance, an increased intake of food, both in terms of quality and quantity, provided people with better resistance to infectious diseases and thus triggered mortality decline. There is evidence that Mecklenburg-Schwerin experienced good harvests and thus could provide more and better food. The Duchy was specialised on agrarian production - which was in fact one of the few areas of technological progress and invention - and thus modernisation of field production as well as cattle and sheep breeding started relatively early (Karge et al. 1993). Increased agrarian production was one factor that Johansen (2002) also found to be one of the main reasons for mortality decline in Denmark. Alongside improved food production, the increase of per capita income and the overall rise of living standards throughout the transition are also said to be factors of the later stages of mortality reduction. It is not clear however to what extent this was true for Mecklenburg-Schwerin, but we know that income (e.g., Gömmel 1979) and living standards increased for the whole of Germany as well as Scandinavia (e.g., Bengtsson & Dribe 2005).
Another middle stage occurrence was the interest in data and science. With Prussia, Mecklenburg-Schwerin was a pioneer in Western Europe of the systematic and centralised collection of vital statistics. It may be that its proximity to Scandinavia and the role of German as an international language of science were contributory factors. The improvements in data collection and quantitative analysis and the understanding of the causes of disease in the nineteenth century, and their dissemination through publication, provided justification for later public health measures.
At the later stages of mortality decline, more active forces of mortality intervention emerged. Education as well as health and medical factors triggered further increases in life expectancy. In terms of education, especially women's education towards hygiene and nutrition - for themselves

as well as their children - and breastfeeding was important, which improved health and thus reduced mortality. Unfortunately, we do not have direct evidence of educational progress.

Another commonly stressed explanation for rising life expectancy is the influence of public health, medical intervention and health technology (e.g., Omran 1971, Preston 1976, Szreter 1988). It is however not clear to what extent this applies to Mecklenburg-Schwerin. What we know is that smallpox vaccination was first used in 1808 and became statutory in 1816. As medical invention lagged behind and the consultation of physicians was not very common, this was relatively early (Boll 1856). The (early) decline of mortality was probably not influenced by better water supply and improved sewage systems. As Uffelmann (1889) described for Rostock (one of the biggest cities in Mecklenburg-Schwerin): it was not until the 1880's that water was generally supplied through (lead) water pipes and the sewage system was fully installed. Usually water was supplied through water pumps and public wells. The first water works were installed in 1866, taking water from the river Warnow, where the sewage was returned. We do not exactly know where the more rural areas supplied their water from, but it is most likely that they used wells and water pumps throughout the beginning of the twentieth century.

Through GIP the following phases of transition during the modern life expectancy revolution, starting in the late eighteenth century were detected. At the beginning of the transition, mortality in Mecklenburg-Schwerin was rather constant but fluctuating. After the crisis years resulting from the Napoleonic invasion (from 1806 to 1815), life expectancy at birth started to increase and kept this steady development until 1910. However, there was a plateau in the 1840s and 1850s, which might be related to the start of mass out migration. The March Revolution (1848-49) may not have had a great impact on this development, as it had only a minor effect in Mecklenburg-Schwerin (Boll 1856).

The comparison of Mecklenburg-Schwerin with Germany and Sweden and Denmark revealed striking results. There was a different pattern of mortality decline in Mecklenburg-Schwerin than in Germany as a whole, as this decline started earlier and had a stronger impact (higher e(0) over the entire period). In fact, Mecklenburg-Schwerin did experience a levelling off of life expectancy at birth, but not as long as for Germany. Additionally, the Duchy did not go through an increase in mortality. In contrast, we found evidence that Mecklenburg-Schwerin followed the Scandinavian scheme of mortality transition. The development of life expectancy at birth between 1785 and 1910 followed almost the same level and direction as Sweden and Denmark. Fertility was somewhat higher but again followed a similar trend.

Our analyses have shown that the high mortality patterns of today's Mecklenburg-Western Pomerania are not founded in the early historical population development. In fact, Mecklenburg-Schwerin - as the biggest part of today's Mecklenburg-Western Pomerania - had higher life expectancy and an earlier decline in mortality. Mecklenburg-Schwerin in the nineteenth and early twentieth century seems to have experienced the same developments that could be detected for the Scandinavian states of Sweden and Denmark, which at that time were among the forerunners of the demographic transition and, with Norway, were leaders in the modern life expectancy revolution. Thus, the contemporary development of life expectancy in Mecklenburg-Western Pomerania might to a great extent be due to unemployment and mass out migration of young and educated people - and especially young women (Kück et al. 2006; Werz & Nuthmann 2004). With a continuing high level of out migration of young people this development has not come to a halt.

In order to better understand the modern rise of life expectancy this project found evidence that in addition to those countries we have known so far, there are other areas that went through similar demographic transition phases. Further, we have found that another region situated at the in Germany as a whole, as this decline started earlier and had a stronger impact (higher e(0) over the entire period). In fact, Mecklenburg-Schwerin did experience a levelling off of life expectancy at birth, but not as long as for Germany. Additionally, the Duchy did not go through an increase in mortality. In contrast, we found evidence that Mecklenburg-Schwerin followed the Scandinavian scheme of mortality transition. The development of life expectancy at birth between 1785 and 1910 followed almost the same level and direction as Sweden and Denmark. Fertility was somewhat higher but again followed a similar trend.

Our analyses have shown that the high mortality patterns of today's Mecklenburg-Western Pomerania are not founded in the early historical population development. In fact, Mecklenburg-Schwerin - as the biggest part of today's Mecklenburg-Western Pomerania - had higher life expectancy and an earlier decline in mortality. Mecklenburg-Schwerin in the 19th and early 20th century seems to have experienced the same developments that could be detected for the Scandinavian states of Sweden and Denmark, which at that time were among the forerunners of the demographic transition and, with Norway, were leaders in the modern life expectancy revolution. Thus, the contemporary development of life expectancy in Mecklenburg-Western Pomerania might to a great extent be due to unemployment and mass out migration of young and educated people - and especially young women (Kück et al. 2006; Werz & Nuthmann 2004). With a continuing high level of out migration of young people this development has not come to a halt.

In order to better understand the modern rise of life expectancy this project found evidence that in addition to those countries we have known so far, there are other areas that went through similar demographic transition phases. Further, we have found that another region situated at the Baltic Sea has experienced mortality decline following the Scandinavian pattern. Unfortunately we could not examine the very early mortality development of Mecklenburg-Schwerin, and thus there is no proof that the increase of life expectancy started as early as in the Scandinavian countries.

Literature

Andersen, O. 1979. The development in Danish mortality, 1735-1850. *Scandinavian Population Studies* (5), pp. 9-21.

Andersen, O. 1984. The Decline in Danish Mortality before 1850 and its Economic and Social Background, in T. Bengtsson, G. Fridlizius, R. Ohlsson 1984. *Pre-Industrial population Change. The Mortality Decline and Short-Term Population Movements*. Stockholm: Almqvist and Wiksell International, pp. 115-126.

Bade, K. J. 2000. *Europa in Bewegung. Migration vom späten 18. Jahrhundert bis zur Gegenwart.* [Europe in motion. Migration from the late 18th century until present.], München: Beck.

Bengtsson, T. 2006. Linear Increase in Life Expectancy: Past and Present, in: T. Bengtsson (eds.), *Perspectives on Mortality Forecasting. III. The Linear Rise in Life expectancy: History and Prospects.* Stockholm: Swedish Social Insurance Agency, pp. 83-99.

Bengtsson, T., C. Cameron, J. Z. Lee, et al. (eds.) 2004. *Life under Pressure. Mortality and Living Standards in Europe and Asia, 1700-1900*. Massachusetts: The MIT Press.

Bengtsson, T., M. Dribe 2005. New Evidence on the Standard of Living in Sweden during the Eighteenth and Nineteenth Centuries: Long-Term Development of the Demographic Response to Short-Term Economic Stress, in: R. C. Allen, T. Bengtsson, M. Dribe (eds.*): Living Standards in the past. New Perspectives on Well-Being in Asia and Europe*. Oxford: Oxford University Press, pp. 341-372.

Bengtsson T., R. Ohlsson 1994. The Demographic Transition Revised, in T. Bengtsson (eds.). *Population, Economy, and Welfare in Sweden.* Berlin: Springer.

Boll, E. 1856. *Geschichte Mecklenburgs mit besonderer Berücksichtigung der Culturgeschichte. Zweiter Theil.* [The History of Mecklenburg with special focus on cultural history. Second part.] Neubrandenburg: self-published. Reprint: Neubrandenburg: federchen Verlag 1995.

Brändström, A., Tedebrand, L.-G. (eds.) 1989. *Society, Health and Population during the Demographic Transition.* Stockholm: Almqvist and Wiksell International.

Brändström, A., Tedebrand, L.-G. (eds.) 2000. *Population Dynamics During Industrialization.* Umeå University.

Christensen, K., G. Doblhammer, R. Rau, J. W. Vaupel 2009. Ageing populations: the challenges ahead. *Lancet* (374), pp. 1196-1208.

Dippe, Dr. 1858. Die lange Dauer des menschlichen Lebens in Mecklenburg. [The long duration of human life in Mecklenburg.] *Archiv für Landeskunde in den Grossherzogthümern Mecklenburg* (8), pp. 545-562.

Ehmer, J. 2004. *Bevölkerungsgeschichte und historische Demographie 1800-2000.* [Population history and historical demography 1800-2000.], Enzyklopädie deutscher Geschichte Band 71, München: Oldenbourg.

Fridlizius, G. 1984. The Mortality Decline in the First Phase of the Demographic Transition: Swedish Experiences, in T. Bengtsson, G. Fridlizius, R. Ohlsson (eds.). *Pre-Industrial population Change. The Mortality Decline and Short-Term Population Movements.* Stockholm: Almqvist and Wiksell International, pp. 71-114.

Gall, L. 2002. *Bismarck. Der weiße Revolutionär.* [Bismarck. The white revolutionist.], Berlin: Ullstein.

Gehrmann, R. 2000. *Bevölkerungsgeschichte Norddeutschlands zwischen Aufklärung und Vormärz.* [Population history of Northern Germany between Enlightenment and the Age of Metternich.] Berlin: Arno Spitz Verlag.

Grosherzoglich Mecklenburg-Schwerinscher Staatskalender: Jahrgänge 1784 bis 1910. Schwerin im Verlage der Hofbuchdruckerei.

Grossherzogliches Statistisches Amt (eds.): Statistisches Handbuch für das Grossherzogthum Mecklenburg-Schwerin. Jahrgänge 1898 bis 1915. [Statistical handbook of the Grand Duchy of Mecklenburg-Schwerin. Volumes 1898-1915.] Schwerin: Bärensprungsche Hofbuchdruckerei.

Gömmel, R. 1979. *Realeinkommen in Deutschland. Ein internationaler Vergleich (1810-1914).* [Real wages in Germany. An international comparison (1810-1914)] Nürnberg: Self-published.

Gruner, W. D. 2002. Überlegungen zur Geschichte der mecklenburgischen Großherzogtümer in der europäischen Geschichte zwischen Wiener Kongreß und Reichsgründung (1815-1871) [Thoughts on the history of the Grand Duchies of Mecklenburg in between the European history between Wiener Kongreß and foinding of the German Empire.], in: I. Buchsteiner (eds.). *Die mecklenburgischen Großherzogtümer im deutschen und europäischen Zusammenhang 1815 bis 1871.* [The Grand Duchies of Mecklenburg in German and European context 1815-1871.] Rostocker Beiträge zur Deutschen und Europäischen Geschichte.], Band 11, Universität Rostock, pp. 7-39.

Haines, M. R., H. J. Kintner 1993. The mortality transition in Germany, 1869-1935. *International Population Conference*, Montreal 1993, Volume 1, Liège: IUSSP, pp. 399-418.
Hofsten, E., H. Lundström 1976. *Swedish Population History. Main trends from 1750 to 1970*. Skriftsreie utgiven av statistika centralbyran (Number 8), Stockholm.
Imhof, A. E. 1990. *Lebenserwartungen in Deutschland vom 17. bis 19. Jahrhundert*. [Life expectancy in Germany from 17th to 19th century.], Weinheim: VCH, Acta Humaniora.
Imhof, A. E. (eds.) 1994. *Lebenserwartungen in Deutschland, Norwegen und Schweden im 19. und 20. Jahrhundert.* [Life expectancy in Germany, Norway and Sweden in 19th and 20th century], Berlin: Akademie Verlag.
Johansen, H. Chr. 2002. Danish Population History 1600-1939. Odense: University Press of Southern Denmark.
Johansen, H. Chr., J. Oeppen 2001. *Danish Population Estimates 1665-1840.Danish.* Center for Demographic Research, Research Report 21, Odense University.
Knodel, J. E. 1988. *Demographic behavior in the past. A study of fourteen German village populations in the eighteenth and nineteenth centuries*. Cambridge Studies in Population, Economy and Society in Past Time. Cambridge: Cambridge University Press.
Lee, R. D. 1974. Estimation Series of Vital Rates and Age Structures from Baptisms and Burials: A New Technique with Applications to Pre-industrial England. *Population Studies* 28(3), pp. 495-512.
Lee, R. D. 1984. Mortlaity levels and agrarian reform in early 19th century Prussia. Some regional evidence. in T. Bengtsson, G. Fridlizius, R. Ohlsson (eds.). *Pre-Industrial population Change. The Mortality Decline and Short-Term Population Movements*. Stockholm: Almqvist and Wiksell International, pp. 161-190.
Lee, R. D. 1993. Inverse projection and demographic fluctuations: a critical assessment of new methods, in D. S. Reher, R. S. Schofield (eds.) *Old and New Methods in Historical Demography.* Oxford, England: Clarendon Press, pp. 7-28.
van Leeuwen, M. H. D., J. E. Oeppen 1993. Reconstructing the Demographic Regime of Amsterdam 1681-1920. *Economic and Social History in the Netherlands* (5), pp. 61-102.
Livi Bacci, M. 1991. *Population and Nutrition. An Essay in European Demographic History.* Cambridge Studies in Population, Economy and Society in Past Time (No. 14).
Loth, W. 1996. *Das Kaiserreich. Obrigkeitsstaat und politische Mobilisierung.* [The Empire. Authoritarian state and political mobilization], München: Dt. Taschenbuch-Verlag.
Luy, M. 2004. *Mortalitätsanalyse in der historischen Demographie. Die Erstellung von Periodensterbetafeln unter Anwendung der Growth-Balance-Methode und statistischer Testverfahren.* [Mortality analysis in historical demography. The development of period life tables with Growth-Balance-Method and statistical testing.] Wiesbaden: S Verlag für Sozialwissenschaften.
Karge, W., E. Münch, H. Schmied, 1993. *Die Geschichte Mecklenburgs*. [The history of Mecklenburg.], Rostock: Hinstorff Verlag.
Knodel, J. E. 1988. *Demographic behavior in the past. A study of fourteen German village populations in the eighteenth and nineteenth centuries*. Cambridge: Cambridge University Press.
Kück, U., H. Fischer, J. Karpinski 2006. Bevölkerung in Mecklenburg-Vorpommern: Bilanz nach 15 Jahren und Ausblick. [Population in Mecklenburg-Wetsern Pomerania: Conclusions after 15 years of reunion and outlook.] *Statistische Hefte Mecklenburg-Vorpommern*, 1, pp. 1-11.
McKeown, T. 1976. *The Modern Rise of Population.* London: Edward Arnold.
McKeown, T., R. G. Record 1962. Reasons for the Decline of Mortality in England and Wales during the Nineteenth Century. *Population Studies* 16(2), pp. 94-122.
Manke, M. 1999. Die historische Bevölkerungsstatistik in Mecklenburg-Schwerin bis zur ersten Hälfte des 19. Jahrhunderts. [The historical population statistics in Mecklenburg-Schwerin until the firts half of the 19th century.], *Genealogie* 48(24), Heft 9-10, pp. 641-658.
Manke, M. 2005. Die Volkszählung des Großherzogtums Mecklenburg-Schwerin in den Jahren 1819 und 1867 unter Mitberücksichtigung der Volkszählung des Jahres 1866. [The censuses of the Grand Duchy Mecklenburg-Schwerin in 1819 and 1867 considering the 1866 census.], *Genealogie* 54(27), Heft 3-4, pp. 449-468.
McCaa, R. 2001. *An Essay on Inverse Projection.* http://www.hist.umn.edu/~rmccaa/populate/index.htm.
Oeppen, J. 1993. Generalized Inverse Projection. *Population Studies* 47, pp. 29-39.
Oeppen, J., J. W. Vaupel 2002. Broken Limits to Life Expectancy. *Science* 296, pp. 1029-1030.
Omran, A. R. 1971. The Epidemiologic Transition: A Theory of the Epidemiology of Population Change. *The Milbank Memorial Fund Quarterly* 49(4), Part 1, pp. 509-538.

Pade, W. 2004. Mecklenburgische Emigranten im 19. und 20. Jahrhundert [Emigrants from Mecklenburg in 19th and 20th century], in N. Werz, R. Nuthmann (eds.). *Abwanderung und Migration in Mecklenburg und Vorpommern.* [Emigration and migration in Mecklenburg and Western Pomerania.], Wiesbaden: VS Verlag, pp. 61-76.

Perrenoud, A. 1984. The Mortality Decline in a long-term Perspective, in T. Bengtsson, G. Fridlizius, R. Ohlsson (eds.). *Pre-Industrial population Change. The Mortality Decline and Short-Term Population Movements.* Stockholm: Almqvist and Wiksell International, pp. 41-70.

Preston, S. H. 1976. *Mortality Patterns in National Populations with Special Reference to Recorded Causes of Death.* New York: Academic Press.

Puranen, B. 1991. Tuberculosis and the Decline of Mortality in Sweden, in R. Schofield, D. Reher, A. Bideau (eds.) 1991. *The Decline of Mortality in Europe.* Oxford: Clarendon Press, pp. 97-117.

Riley, J. C. 2001. *Rising Life Expectancy. A Global History.* Cambridge: Cambridge University Press.

Schofield, R. 1984. Population Growth in the Century after 1750: the Role of Mortality Decline, in T. Bengtsson, G. Fridlizius, R. Ohlsson (eds.). *Pre-Industrial population Change. The Mortality Decline and Short-Term Population Movements.* Stockholm: Almqvist and Wiksell International, pp. 17-40.

Schofield, R., D. Reher 1991. The Decline of Mortality in Europe, in R. Schofield, D. Reher, A. Bideau (eds.) 1991. *The Decline of Mortality in Europe.* Oxford: Clarendon Press, pp. 1-17.

Sommer, B. 2002. Die Sterblichkeit in der Bundesrepublik Deutschland in der Regionalisierung der Länder [Mortality in the Länder of the Federal Republic of Germany.], in J. Cromm, R. D. Scholz (eds.): *Regionale Sterblichkeit in Deutschland.* [Regional Mortality in Germany.], Augsburg, Göttingen, pp. 18-32.

Spree, R. 1992. *Der Rückzug des Todes. Der Epidemiologische Übergang in Deutschland während des 19. und 20. Jahrhunderts.* [Retreat of Death. The epidemiological transition in 19th and 20th century Germany.], Konstanz: Universitätsverlag.

Szreter, S. 1988. The Importance of Social intervention in Britain's Mortality Decline c. 1850-1914: a Re-interpretation of the Role of Public Health. *The Society for the Social History of Medicine,* pp. 1-37.

Uffelmann, J. 1889. *Hygienische Topographie der Stadt Rostock.* [Hygienic topography of the city of Rostock.], Rostock: Wilhelm Werthers Verlag.

Vitense, O. 1920. *Geschichte von Mecklenburg.* [History of Mecklenburg.], Reprint 1990. Würzburg: Weidlich Flechsing.

Werz, N., R. Nuthmann (eds.) 2004. *Abwanderung und Migration in Mecklenburg und Vorpommern.* [Emigration and migration in Mecklenburg and Western Pomerania.], Wiesbaden: Vs Verlag für Sozialwissenschaften.

Wrigley, E. A., R. S. Schofield 1981. *The Population History of England 1541-1871. A Reconstruction.* London: Edward Arnold.