Timing of mortality improvements among the European scientific elite in the sixteenth to the early twentieth century

Robert Stelter[*], David de la Croix[†] & Mikko Myrskylä[‡]

October 30, 2019

Abstract

When did mortality start to decline, and among whom? We build a large new dataset with 33,462 scholars covering the fifteenth to the early twentieth century to analyze the timing of the mortality decline and the heterogeneity in life expectancy gains among scholars in the Holy Roman Empire. Among the key advantages of the new database are that it provides a well-defined entry into the risk group, and the opportunity to deal with right censoring. After recovering from a severe mortality crisis in the seventeenth century, life expectancy among scholars started to increase as early as in the eighteenth century, or well before the Industrial Revolution. This fluctuation in mortality directly influenced life expectancy and the number of scholars who survived and thus had important implications for the society's capacity for knowledge accumulation and diffusion. Our finding that members of scientific academies – an elite group among scholars – were the first to experience mortality improvements suggests that 300 years ago, individuals with higher social status already enjoyed a lower mortality. We also show, however, that the onset of mortality improvements among scholars in the medical profession was delayed, possibly because members of this profession were exposed to pathogens, and did not have the knowledge of the germ theory that might have protected them. Both the advantage among the members of the academies and the disadvantage among those working in the medical profession disappeared during the nineteenth century, when mortality progress was experienced across the whole population.

Keywords: Mortality dynamics, differential mortality, Holy Roman Empire, Knowledge accumulation

JEL Classification numbers: J11, I12, N30, I20, J24

[*]Max Planck Institute for Demographic Research, Konrad-Zuse-Str. 1, 18057 Rostock, Germany, E-Mail: stelter@demogr.mpg.de, Phone: + 49 381 2081 204, Fax: +49 381 2081 280, corresponding author.

[†]IRES, UCLouvain, Belgium and CEPR, London, UK. Email: david.delacroix@uclouvain.be.

[‡]Max Planck Institute for Demographic Research, London School of Economics and Political Science, UK and University of Helsinki, Finland.

1 Introduction

When the first mortality improvements occurred, and who benefited first from these gains, are among the key questions that arise in discussions of the first demographic transition. Understanding where and among whom mortality progress started is important for understanding the timing of industrialization and the long-run dynamics of human well-being. In this paper, we focus on the scientific European Elite – scholars active at a university or academy of sciences. Scholars' first appointments to a scientific institution helps to overcome common methodological issues in historical populations. The appointment precisely defines the entry in the population at risk. More importantly, scholars' field of sciences and a potential membership in an academy of sciences, provide new insights on the role of medicine and social status in the process of mortality improvements. Finally, in a world where face-to-face communication was essential for both knowledge transmission and enhancement, the length of productive life among the elite was an important determinant of the extent to which members of the elite were able to influence their cultural and economic environments (de la Croix 2017; Lucas 2009). The forerunner role of the elite in the trend towards declining mortality was essential for triggering knowledge accumulation and the Industrial Revolution.

On the basis of local evidence and data on specific social groups, historians and demographers have already shown that mortality gains were made in the seventeenth and eighteenth centuries. Hollingsworth (1977), for instance, has constructed mortality tables for British peers sampled from genealogical data. Vandenbroucke (1985) has provided vital statistics for the Knights of the Golden Fleece, an order that was started in 1430 by the Dukes of Burgundy, and that was maintained under the Habsburg rulers, the kings of Spain and the Austrian emperors. Carrieri and Serraino (2005) and Hanley, Carrieri, and Serraino (2006) compared the life expectancies of popes and artists; while van Poppel, van de Kaa, and Bijwaard (2013) examined the longevity of artists using information from the RKDartists database. In comparing the life expectancies of members in the British and the Russian academies of science, Andreev et al. (2011) relied on data on a population of scholars. Winkler-Dworak (2008) and van de Kaa and de Roo (2007) also studied the longevity of members of academies of sciences, but with a more recent focus and much smaller sample sizes.

Two recent studies have helped to paint a more general picture. Cummins (2017) greatly extended existing demographic research on Europe's aristocracy by analyzing the longevity of the European nobility over a long period of time that covered several critical events, such as the Black Death and the Industrial Revolution. Longevity started rising as early as 1400, and continued to increase over the fifteenth century. This phase of longevity improvements was followed by a second one after 1650. However, the first phase has been observed in Ireland and the UK only, and is probably subject to a broad confidence region as the number of observations was low. The second tipping point in the middle of the seventeenth century has been observed throughout Europe and is thus a considerably more robust finding. De la Croix and Licandro (2015) built a database drawn from the *Index Bio-bibliographicus Notorum Hominum* (IBN), which contains entries on famous people from about 3000 dictionaries and encyclopedias. They found no trend in adult longevity among individuals born before the second half of the seventeenth century. The findings of de la Croix and Licandro (2015) also suggest that permanent improvements in longevity preceded the Industrial Revolution by at least a century. The longevity of famous people increased steadily starting with the generations born during the 1640–1649 decade, and grew by a total of around nine years in the following two centuries.

While the studies of de la Croix and Licandro (2015) and Cummins (2017) are important, they are not without weaknesses. In the populations they studied, who belonged to the sample and when people entered the population at risk were not clearly defined. Some of the individuals in these populations, like famous martyrs, might have entered at death; while, others, such as artists, may have entered post mortem; and still others, like members of royal families, entered at birth. In this paper, we present data that overcome such weaknesses, and use these data to reanalyze the timing of mortality improvements among the European elite. Furthermore, using information about relative status within the elite, we investigate whether differentials in socioeconomic position were already influencing mortality when secular changes in mortality first started, or whether the pattern is more recent. Finally, we exploit information about the field of sciences in which the scholars of our database operated to examine whether there were leaders or laggards by discipline. A particular focus of our analysis is on medicine, which may have had both positive and negative effects, depending on whether the benefits of medical knowledge offset the added hazards resulting from exposure to pathogens.

Our sample covers 33,462 individuals born between the fifteenth and the nineteenth century. Our dataset, which is mainly based on university professor catalogues and lists of memberships in scientific academies, is constructed to clearly indicate who belonged to the population and when each individual entered the risk population. An individual entered our population at risk as soon as he or she was appointed for the first time to any of the formal scientific institution that are covered in our database. These institutions include all universities and technical universities established before 1800, as well as scientific academies located in the Netherlands and the territories of the Holy Roman Empire (HRE) as of 1648.

The advantage of restricting the sample to this area is that it enables us to base our study on a relatively continuous institutional set-up. Although its borders changed over time, the Holy Roman Empire occupied a large area of Central Europe from its founding in the Middle Ages until its dissolution in 1806. Furthermore, for most academic institutions in these territories, there are data sources that provide information on scholars' date of nomination, exit, birth and death. Our sample of more than 33,000 scholars has several advantages. First, the sample covers a clearly defined population, and allows us to take into account left truncation and right censoring. Moreover, because the sample is large and focused on a well-defined population, we can use it to make precise estimates at the total population level, while also performing subpopulation- and age group-specific analyzes.

Relying on the new data we collected, we aim to make two contributions to the literature: First, our analysis of scholars' life expectancy provides important new information about the dynamics and the timing of mortality changes before and during the Industrial Revolution. Our new estimations confirm that life expectancy started to improve in the middle of the eighteenth century – and, hence, well before industrialization. Most of the deviations of our findings from existing estimates on mortality dynamics can be explained by differences either in the methods used or in how the role of social status is taken into account. In addition, our long time-series on mortality provide a novel finding on a notable mortality crisis around 1620–1650, which was likely driven by the Thirty Years' War. Studies that do not have a long observation window such as ours, which opens before the Thirty Years' War, could mistakenly conclude that the recovery from the crisis marked the start of secular mortality improvements.

Secondly, we shed light on mortality differences between groups by comparing members and non-members of scientific academies, as well as scholars in the medical profession, with members of all other professions. Members of scientific academies represent an elite within the elite. While it may be assumed that higher social status translates into mortality advantages, the evidence on the impact of social status on mortality is mixed. Hollingsworth (1977) and Vandenbroucke (1985) found that mortality reductions occurred as early as in the seventeenth century among the nobility, and thus showed that improvements in the longevity of the upper social classes anticipated the overall rise in life expectancy by at least one century. By contrast, de la Croix and Licandro (2015) found that in the seventeenth and eighteenth centuries, mortality reductions took place not just in the leading countries, but almost everywhere in Europe. Their findings also indicate that these mortality improvements were not dominated by any particular occupation.[1] In a literature review, Bengtsson and van

[1]Furthermore, Bengtsson and Dribe (2011) found evidence of the late emergence of a mortality advantage

Poppel (2011) concluded that the impact of social status varied across areas, time periods and contexts. Meanwhile, we observe that among members of academies of science, mortality gains were made more rapidly around the time when life expectancy started to increase sustainably. This finding suggests that as early as 300 years ago, scholars with a higher social status enjoyed a lower mortality.

The role of the medical profession in these trends is less clear. As the germ theory of disease was not well-developed before the second half of the nineteenth century, it may be assumed that individuals working in the medical profession prior to that time received little protection from their medical knowledge, while also being exposed to elevated infection risks. It is, therefore, likely that medical professionals had a net disadvantage. For example, to protect against the bubonic plague, people used beak-like mask that did little more than protect against the smells – which were, at that time, believed to be the main disease vector. Thus, for medical professionals, the combination of increased exposure to sick people and the lack of medical knowledge may have been life-threatening. Our results partially support this reasoning: while we do not find any systematic disadvantage among medical professionals before sustained improvements in longevity began, we show that once mortality improvements started, medical professionals experienced life expectancy gains later than the rest of the scientific elite.

2 Scholar's in the Holy Roman Empire

2.1 Universities and Scientific Academies

Our dataset collects information on scholars who were active in the Holy Roman Empire. The Empire was founded around 962 as Otto I sought to revive the Roman Empire by laying claim to the imperial cult of Rome.[2] Thus, the HRE existed long before the first universities appeared in this area. While the borders of the Empire changed over its almost 850 years of existence, its elective monarchy unified the Germanic population and other peoples over the long period through a unique set of cultural and political arrangements. In the nineteenth and twentieth centuries, following the dissolution of the Empire in 1806, the territory of the

in Sweden. Using data from Geneva, Schumacher and Oris (2011) document an advantage among the higher classes that ended in the seventeenth and eighteenth century. Relying on Finnish data in the twentieth century, Elo, Martikainen, and Myrskylä (2014) showed that the link between socioeconomic status and mortality remained robust after controlling for observed and unobserved characteristics in childhood.

[2] Otto I (912–973) is often considered the first ruler of the HRE, even though that term was not used until the twelfth century (Arbage 2004).

German state declined substantially, and the populations of Central Europe shifted. To take advantage of the relatively stable institutional set-up provided by the Holy Roman Empire, we focus on populations living within the Empire's 1648 borders and in the Netherlands. As shown in gray in Fig. 1 the territories of the Empire correspond to the current territories of Austria, Belgium, Germany, Lichtenstein, Luxembourg, Slovenia and the Czech Republic; as well as parts of Croatia, France, Italy, Poland and Switzerland. The territories that made up the Netherlands are depicted in light gray. Scholars might have been active in universities, academies of sciences, or courts in this area. Since the first two types of institutions are quantitatively the most important, we define scholars as individuals who were active in one of these two types of scientific institutions, and we restrict our sample to scholars who were born before 1900.

[Figure 1 about here.]

We include in our database scholars who were nominated to universities that were founded before 1800. Based on Rüegg (1996) and Steiger (1981), we identify 63 such universities. Universities that were founded later than 1800 are excluded, both because of the end of the Holy Roman Empire in 1806, and because the European university underwent radical changes. A large number of universities disappeared at the beginning of the nineteenth century. In Germany, for instance, 18 out of 34 universities were closed (Rüegg 2004). More importantly, universities founded in the nineteenth century followed a new university model shaped by the Humboldt reform and by the principle of "*advancement of knowledge through research*" (Schimank and Winnes 2000).[3]

Thus, because our focus is on older universities, our results are not affected by the significant changes that occurred around 1800. Still, these older universities were rather heterogeneous along several dimensions. Figure 1 illustrates the spatial distribution of these institutions. The three oldest universities were located in the central and southern parts of the HRE. Established in 1348, the University of Prague (1) was the oldest university in the Holy Roman Empire; followed by the University of Vienna (2) founded in 1365 and the University of Heidelberg (3) founded in 1386. The University of Bonn (62) and Karl's High School (63) were the two youngest universities. However, like the University of Herborn (28), the latter was more an elite school of higher education than a university in the narrow sense. In addition, four more applied universities, like the Freiberg University of Mining and Technology (57), were among the institutions established in the eighteenth century.

[3]The first university that was founded to follow the German University Model is the Humboldt University in Berlin established in 1810 (Schimank and Winnes 2000).

In the Dutch territories, university education started in 1575 with the establishment of Leiden University (27). While a total of seven universities were founded in the Netherlands before 1800, the University of Nijmegen (46) educated students only for a very limited number of years and the universities in Franeker (31) and Harderwijk (45) closed near the end of the Napoleonic era. Several universities in the HRE met the same fate. These universities were closed either in response to geopolitical movements as was the case in Cologne (4) and Erfurt (5); or as a result of secularization, as was the case in Bamberg (44) and Dillingen (21).

Over the course of history large numbers of scientific academies have appeared and then later sometimes also disappeared. Because providing an exhaustive overview of all of the scientific academies that have ever existed would be difficult, we decided to plot only the 12 academies of sciences for which we have data.[4] By far the most important among them is the *Collegium Naturae Curiosorum*, which was established in 1652 and is better known as *Leopoldina* (64). The Bavarian Academy of Sciences and Humanities (68) and the Royal Netherlands Academy of Arts and Sciences (72) are also well-known. The latter academy was founded in 1808, which shows that we did not set a minimum age for the academies in our database.

2.2 Sources of the Dataset

Our sample of scholars was compiled using a range of sources. We assign the institutions to four classes based on data availability and the data sources used. In the first class are the institutions for which we have *(almost) complete data*. In this optimal case, we rely on two types of high-quality sources: i.e. existing online professor catalogues, such as the catalogus professorum lipsiensium; or books that provide biographical information on professors, like Drüll-Zimmermann (1991, 2002, 2009, 2012) on the University of Heidelberg. Overall, the first class includes 23 universities and 10 academies of sciences. Our sources of data for these academies include official lists of members that are provided either directly by the academy or by their publications.

For the other universities, the existing catalogues do not capture either the whole time span or all faculties. Since these sources still provide highly reliable information, they are included in the second class, which is made up of institutions with *partially complete data*. For instance, Günther (1858) only provides information on University of Jena professors up to the university's 300th anniversary in 1858; while Flessa (1969) only provides information

[4]For an overview on academies see for instance the Scholarly Societies Project (http://www.references.net/societies/).

on medical faculty professors in Altdorf. Our data on the University of Vienna are also only partially complete, as we rely on information from Lackner (1976) on all active Jesuits in the faculty of humanities for a certain period of time. In addition to 14 universities, the Royal Academy of Sciences, Letters and Fine Arts of Belgium is included in this second category.

The sources we used for the institutions in the third category enabled us to further complete our list of scholars. The available data for the institutions in this third class are less complete. For 12 universities, we reconstructed as many observations as possible from a variety of sources. These sources include lists on Wikipedia which are backed-up with additional sources like the *Deutsche Biographie* whenever possible. For example, we collected data on scholars from the University of Erfurt (5) and Brandenburg University in Frankfurt (18) using this strategy. The remaining scientific academy, the Palatinate Academy of Sciences in Mannheim (68), is also assigned to the category *non-complete data*.

In the last class *scattered data* are the remaining 15 universities. Their members are captured either via other universities of a higher class or using data collections, like Fischer (1978). The oldest university in this category is the University of Trier (14).[5]

2.3 The Population of Scholars

By combining the data from the sources in all four classes and identifying duplicates, we gathered 33,462 scholars. This population forms our sample of scholars who were born before 1900 and were active in the defined universe of universities and scientific academies. Only 86 scholars in this historical sample were women.[6] Individuals entered the population of scholars at the time when they were first nominated. During the observation window, they may have changed institutions after receiving a nomination elsewhere. If the institutions they moved to was a university, we account for the last affiliation only. If, however, individuals were nominated by an academy of sciences, they receives an additional affiliation.[7] Individuals exit the population at death, if this is observed. If death is not observed, they are censored at the last exit from one of our institutions. Thus, we take into account both left truncation and right censoring.

[Figure 2 about here.]

[5] Table 2 in Appendix A.1 provides complete overviews of the classes and sources of all 75 institutions.

[6] The first women enter our population at risk in the cohorts born in the 1830s. Women never exceeded 5% of a birth cohort.

[7] Details are documented in the online material.

Figure 2 illustrates the dynamics of the total number of scholars; limited to the sample of 31,103 scholars for whom we know the year of nomination and of death, or of exit if the latter is missing (see Column 1 in Tab. 1). Figure 2a plots the 25-year moving averages of the first nominations (solid black line) as the inflow and the outflow (solid gray line). The latter includes both death and final exits for right-censored observations. The dotted gray line additionally marks the number of deaths only. The clear difference between deaths and exits indicates that the number of right-censored cases in the fifteenth century is relatively high. In addition to the general trend of increasing nominations and exits/deaths, we distinguish four periods that are marked by the breaks in the light gray trend of Fig. 2b. Before 1620 nominations exceeded outflows except for two short periods in the middle of the fifteenth century and in the first half of the sixteenth century that were characterized by stagnation. Overall, the number of scholars grew by an average of 0.5% per year, and hence at the same pace as the total population.[8] Around 1618, nominations started to decline. This period terminated in the second decade of the seventeenth century, when exits and deaths reached a local peak that was above the local minimum of nominations. In the 1615–1639 period, outflows continued to exceed nominations, but also declined with some delay. For a quarter of a century, the population of scholars decreased by around 0.6% annually. The transition between the second and the third period is marked by a sharp increase in the inflow of scholars. For the next 250 years, between 1650 and 1900, nominations undoubtedly exceeded outflows. While both had an increasing trend over time, we document some periods of stagnation in nominations, such as around 1760 and 1800. The latter period also marks the end of the third period, which is characterized by a 0.9% increase in population size each year. Since we only considers universities established before 1800, nominations grew less rapidly in the following period, with the average growth rate declining to 0.6%. Still, at the end of the century, nominations again increased.

The population of scholars was heterogeneous along several dimensions, two of which we focus on here. To explore the potential impact of medical knowledge, we first distinguish between scholars with and without a medical background. To identify these individuals, we checked whether the scholars in our sample studied medicine, held a PhD in medicine, were active in a medical faculty, held a chair in medicine, were active in a field of research linked to medicine or belonged to a class of medicine in an academy of science. Figure 2c shows that the share of scholars engaged in medicine increased from around 5% before the sixteenth century to 23% in the most recent period.

Second, we distinguish scholars by the scientific institutions to which they belonged. Mem-

[8] Pfister and Fertig (2010) documented an average growth rate of around 0.5% p.a. for the German population.

bers of academies of sciences represent a sort of elite within the knowledge elite. Because these scholars had more scientific achievements and better access to networks than non-members, they likely enjoyed a higher social status. Thus, we use memberships in academies as indicator for the social status that we can link to mortality dynamics. Figure 2d, illustrates three groups: scholars who were active only in universities, only in academies or in both kinds of institutions. After the first academies were founded (the first academy among our institutions, the Leopoldina, was established in 1652), the sample quickly balances. However, to avoid sample noise, and given that before the eighteenth century, the Leopoldina was the only academy scholars could be nominated to, we limit our investigation to the impact of social status on mortality to the periods after 1700, when the second academy was established. Since 1800, half of the sample were active in at least one academy of sciences.

The trends we observe in the numbers of nominations and exits/deaths – and, hence, in our total population – capture different developments. First, nominations are sensitive to the size of each institution. Second, the appearance and disappearance of universities and academies, such as the closing of a number of institutions after the Napoleonic Wars, alter the number of nominations and exits. As we do not have exhaustive sources for all of the institutions in our sample, a certain number of scholars within each institution might be missing. Thus, sample selection is a third factor that could affect our results. Missing or uncertain information within the sample of scholars on the year of events are a fourth factor, we discuss in the next section. The gray dots in Fig. 2b provide some insights into the role of missing events. As soon as we limit our population to scholars whose year of birth is known, the initial population is smaller and grows faster in the early period. As ages are required to estimate mortality, further investigations rely on this smaller sample.

2.4 Data Quality

Historical data that covers more than four centuries suggests an element of data uncertainty in particular at the very beginning of our time span. In this section we discuss two potential caveats: missing values and heaping in the year of birth and death.

[Table 1 about here.]

Table 1 summarizes important descriptive statistics. The gray area marks the observations considered in estimations of period life expectancy. The total sample of scholars declines to 27,769 if we only take into account individuals for whom the year of birth, as well as the dates of nominations and death/exit, are known. Most cases for which a date is unknown suffer from multiple missings. In 96.4% of cases in which we observe the date of birth and nomination, we also have the age of death (Column 4). The share of right-censored cases is higher in the twentieth century only, due to our reliance on sources such as Conrad (1960) for the University of Tübingen or Auerbach and Gundlach (1979) for the University of Marburg. We know the age of death for scholars who died after the date of publication only if we find them in other sources. Still, at 6.7% the share of right-censored cases is low.

Even if the share of missing values is relatively small, except for the very beginning, our data might suffer from heaping. Uncertain years of birth and death are approximated with years ending on zero or five. To check the scale of heaping, we follow the idea of the Whipple-Index and compare the observed number of birth years ending on zero or five with the overall number of births in the same period (Hobbs 2004). Figure 3a and 3b display the shares of births per fifty year period ending on 0 and 5, respectively. We observe a very high proportion of birth years ending on 0 at the very beginning. However, data quality improves rather quickly. The share already converges to 0.1 in the seventeenth century. Compared to the sample from the baseline mortality estimation (solid line) data quality is almost unaltered if we exclude observations not observed in category 1 and 2. However, as soon as we restrict the sample to scholars without uncertain year of birth the data quality improves significantly and is already acceptable in the fifteenth century. We find less heaping in birth years ending on 5. As early as in the period 1500–1549 we do not document any noteworthy heaping behavior.

[Figure 3 about here.]

Data on mortality is more accurate than on fertility. While the data of births in early times was recorded for some families, like those of scholars, clergyman or nobles, the data of birth of children in ordinary families was less well documented or approximated in the data sources. However, with their appointment in one of our institutions, individuals likely became sufficiently important to record the death year. Hence, the share of death years ending on 0 or 5 is generally much closer to 0,1 in Fig. 3c and 3d. Furthermore, the observed heaping is not always due to a lack in data quality. The peak in 1900–1945 in Fig. 3d is driven by the exceptional mortality at the end of the Second World War in 1945.[9]

Albeit we document some birth year heaping at the beginning of our time period, it does not bias estimations as long as the approximated years are not systematically adjusted upward

[9]See Fig. A1–A4 for further details in the supplementary material.

or downward. In fact, it is more likely that selection in the group of scholars for whom the years of birth and death are known alters estimations in early times. As documented in Table 1, the mean age at death and (at nomination) initially decreased. We only have full information for scholars with a privileged social background. We come back to the potential impact of the data quality in the robustness checks.

3 Methods

Scholars entered the population at risk at different ages. Even if we observe first nominations below age 20, a sufficiently large population at risk is required to obtain convincing estimations of life expectancy $E_{x,t}$ conditional to the corresponding ages x at time t. Hence, it is important to define the minimum age of the life table calculation in a first step. Using 25-year rolling intervals, Fig. 4a illustrates the increasing first nomination age over time. The year always marks the middle of the 25-year rolling interval; e.g. 1550 covers 1538–1562. Indeed, in the early sixteenth century, more than 25% of all first nominations were received below age 25. For around 350 years thereafter, the 25%-quantile remained rather stable, at between ages 27 and 30; and then increased at the end of the period under investigation. The increasing trend in the first nomination age is more evident when we look at the median and the 75%-quantile. Between 1500 and 1900, the median age increased from 30 to 36. Compared to similar exercises in the literature – for instance Fornasin, Breschi, and Manfredini (2010) and Andreev et al. (2011) – we find that the nomination age of scholars was rather low and stable, which allows us to end our analysis at younger ages.

[Figure 4 about here.]

As in all periods except the early twentieth century at least 25% of all first nominations occurred before age 30, we have decided to fix the initial age for life table calculations at age 30.[10] Furthermore, adding the median, the 25%- and the 75%-quantile age at death in Fig. 4b illustrates that, on average, we are able to observe scholars for rather long age spans. The gap between the median age at death and the median age at nomination is between 24 and 35 years. In the sub-sample of scholars in scientific academies, the median age at death and first nomination are even higher, although the difference is higher for the age of nomination.

[10]Minimizing the size of the 95% confidence intervals relative to the life expectancy $E_{x,t}$ is an alternative method for determining the optimal conditional age x. We discuss this approach which leads to the same outcome in the online Appendix.

To estimate mortality dynamics, we compute conditional life expectancy from life tables for rolling 25-year intervals. Due to the limited sample size in the early years, we smooth the death rates in two dimensions: time and age (Camarda et al. 2012). We then compute the conditional life expectancy and apply Monte Carlo simulations to estimate the corresponding confidence intervals (Chiang 1984; Andreev and Shkolnikov 2010). The contributions of each age to changes in life expectancy are decomposed by the stepwise replacement algorithm from Andreev and Shkolnikov (2012) that is described in Andreev, Shkolnikov, and Begun (2002).

4 Findings

4.1 Scholars' Life Expectancy Dynamics

Figure 5 shows life expectancy at age 30 for the population of scholars from the period perspective. Three clear patterns emerge. First, we observe no systematic improvements in life expectancy among scholars before the middle of the eighteenth century. Second, we see that thereafter, a phase of steady improvements in mortality sets in. Third, we find evidence of a sharp decline in life expectancy in the first half of the seventeenth century.

[Figure 5 about here.]

The solid black line in Fig. 5 displays our estimated conditional period life expectancy for scholars at age 30 in 25-year rolling intervals. For instance, the year 1550 covers the 1538–1562 period. The gray area marks the corresponding 95% confidence intervals. It shows that no improvements in life expectancy occurred before the middle of the eighteenth century. For the following periods, permanent improvements in longevity are observed. Between 1725–1749 and 1900–1924, conditional life expectancy increased by around 7.5 years. As Fig. 6a shows, ages below 60 are the main contributors to the increase in life expectancy. Each age adds around 0.2 years. At higher ages, the positive contribution shrinks rapidly, and becomes negligible around age 90.

[Figure 6 about here.]

In line with the low mean age at death (see Fig. 4b), scholars had low life expectancy levels in the pre-eighteenth century phase of stagnation. Mortality increased rapidly at the beginning of the seventeenth century. Scholars' conditional life expectancy at age 30 declined from more than 30 to less than 27 years. To shed light on why this occurred, we added to Fig. 5 two types of historical events that might have caused the mortality crises: wars and pandemics. In the figure, wars are densely hatched in descending order and pandemics are hatched in ascending order. The thinly hatched surrounding years indicate estimated life expectancies that include years altered by the events due to the rolling intervals.

We identify four military conflicts that might have been important for mortality dynamics: the German Peasants' War (1), the Thirty Years' War (2), the Seven Years' War (3), and the Revolutionary Wars (4). The timing of the sharp decline in life expectancy perfectly coincidences with the Thirty Years' War from 1618–1648. However, not all ages were affected the same way. The mortality crisis hit scholars under age 50 especially hard. As Fig. 6b shows, there was a yearly increase in death rates of up to 2% for scholars aged 30–39 at the beginning of the crisis. After the crisis, death rates started to decrease, albeit with some fluctuations in the first part of the eighteenth century. Still, it took almost a century for life expectancy to catch up to the pre-war levels. It should be noted that this period of declining mortality can be easily misinterpreted as signaling the onset of systematic mortality improvements if the time span does not include the pre-crisis period. The decomposition of gains in life expectancy by age in Fig. 6a also shows that ages below 50 were the main contributors to the decrease in life expectancy. While the losses were moderate among scholars in their early thirties, they were much greater among scholars around age 40. The curve is mirrored if we compare it with the curve for the post-crisis contributions (between period 1618–1642 and 1725–1749). Age-specific mortality recovered to the long-run level. For the remaining wars, no clear impact is observable.[11]

Our finding that the strong impact of the Thirty Years' War had a much greater impact than the other wars suggests that mediating effects might have been more important than the direct effects of military conflicts. In Greifswald, for instance, more than thousand troopers, their horses and armament were billeted. University life was limited and professors did not receive salaries. (Langer 2011). The passing soldiers spread infectious diseases while hygienic standards deteriorated. The seemingly endless number of Black Death waves that occurred in the years 1625–1640 during the Thirty Years' War (surface B in Fig. 5) illustrate the conditions of the time and is perfectly in line with the very high death rates. During the war, people suffered not only from the plague, but from famine. Hence, it is likely that the three famous Malthusian mechanisms – famine, epidemics, and war – combined to lower life expectancy (Flinn 1981). While the Great Black Death in 1547–1550 (area A) is an example of a pandemic that probably reduced life expectancy, we do not find a clear impact of this

[11] Appendix B.2.2 in the online material briefly discusses the role of the remaining wars.

event on scholars.

4.2 Life expectancy, Social Status and Medical Knowledge

Figure 7 illustrates the sample separated by the field of sciences and being a member of an academy of sciences. In early periods of mortality stagnation, the scholars in the medical field had a small mortality disadvantage. After sustained reductions in the mortality of scholars began in the middle of the eighteenth century, mortality improvements among scholars linked to the medical field were delayed. In line with findings from van Poppel et al. (2016), we find that their life-expectancy was lower for the next one hundred years. The mortality disadvantage vanished until the middle of the nineteenth century, when the mortality of scholars in the field of medicine was close to that of scholars in all other fields of sciences. However, we find again the lower life expectancy in the early twentieth century.

[Figure 7 about here.]

Our estimations suggest the opposite finding for social status measured by a membership in a scientific academy. From 1750 to 1870, we document a mortality advantage for members. Around 1870 the mortality advantage associated with the higher social status had vanished. However, it appears again to the end of our time series.

5 Robustness of Findings

The three patterns we find in the dynamics of scholars' life expectancy are rather robust. Sustainable improvements in mortality dynamics followed the long period of stagnation in the eighteenth century. Within the period of stagnation, we find evidence of an acute crisis in the seventeenth century. Neither limiting the sample on scholars in category one and two nor the further restriction on the population of scholars with certain year of birth alters the results noteworthy, see Fig. A6–A8. The same pattern emerges if we estimate life expectancy to ages other than age 30.

Finally, to compare our findings with those of previous studies, we present the cohort life expectancy in Fig. 8. The solid black line displays our estimated dynamics of conditional cohort life expectancy for scholars at age 30 in 25-year rolling intervals. The gray area marks the corresponding 95% confidence intervals. In addition to our own estimates, we add five time-series to the picture: predicted ages at death for nobles between 1400–1800 in north and north-eastern Europe as well as central and eastern Europe (Cummins 2017); longevity of famous people between 1400–1875 (de la Croix and Licandro 2015); life expectancy for cardinals in 1400–1900 (Fornasin, Breschi, and Manfredini 2010); and, finally, Sweden's official life expectancy between 1751–1899 from the Human Mortality database.

The results clearly show that no improvements in cohort life expectancy occurred between 1450 and 1700; and, thus, over 250 years. For later periods, we observe improvements in longevity. Among the cohorts born in the eighteenth century, conditional life expectancy increased by 4.5 years from 31 years in 1700 to 35.5 years in 1800. Taking into account the specific characteristics of each time-series, our estimation fits quite well within the existing literature. Cummins (2017) predicted the age at death at age twenty; and, hence, also young adult mortality. A significant share of them died in battles. By contrast, we assume a certain survival up to age 30 without a significant role of violent deaths, which obviously results in higher estimations. The argument of initial ages also applies to cardinals, but in the opposite direction. Following Fornasin, Breschi, and Manfredini (2010), we estimate the life expectancy of cardinals with a certain survival up to age 60: the reason for the discrepancy in the levels. Nevertheless, the cardinals underwent the same systematic improvements in mortality in the nineteenth century as those we found in our estimations and in Sweden's time-series. Furthermore, we observe that life expectancy decreased in the fifteenth century. Hence, it is unclear, whether this initial drop is driven by the observed mortality dynamics, a potential selection bias, or the right-censoring; as mentioned in Section 2.3. However, unlike among the scholars, no improvements are observable among the cardinals in the eighteenth century.

[Figure 8 about here.]

The closest estimation, which comes from de la Croix and Licandro (2015), almost perfectly coincidences with our estimation in the 1450–1550 time span and at the end of the period under investigation. In contrast to Fornasin, Breschi, and Manfredini (2010), and in line with Cummins (2017) and our time-series, they found that mortality started improving in the eighteenth century. The main difference between our results and those of de la Croix and Licandro (2015) is that the findings for cohorts born after 1550 differ. Scholars experienced a period of relatively low life expectancy in the pre-eighteenth century phase of stagnation. Mortality increased rapidly for cohorts born in the second half of the sixteenth century. Scholars' conditional life expectancy at age 30 declined from above 30 to less than 27 at the end of the century. We do not find a similar sharp decline in life expectancy in any of the other time-series from the literature shown in Fig. 8.

6 Discussion

Our findings are in line with the literature that suggest a positive correlation between social status and life expectancy. Over more than a century, we observed that most successful scholars in our knowledge elite had a mortality advantage. However, we also found that in the middle of the nineteenth century, the higher social status of members in scientific academies was no longer sufficient to confer into a mortality advantage. Groups with lower social status were gradually making mortality gains, and professors without a membership in a scientific academy had already attained a very high social status. Furthermore, following the Humboldt reform, universities changed from being *vocational schools* to being *research institutions* (Schimank and Winnes 2000). The elevated social status associated with being a member in a scientific academy, rather than an "ordinary" professor, might have declined – and, hence, the mortality advantage of members of academies of sciences vanished.

Our observations regarding the interplay of social status and mortality suggest that ordinary people were likely hit especially hard by poor socioeconomic conditions and pandemics. For example, our finding that the elite lost several years of life expectancy during the Thirty Years' War might be interpreted as a very conservative estimation of the marked impact of the crisis on general mortality. It is also likely that systematic gains in mortality started later in the general population; and, hence, not before the middle or the end of the eighteenth century.

Our estimation of scholars' longevity also provides us with insights into the capacity for knowledge accumulation and diffusion. Our finding that the rise in longevity among the educated segment of society preceded industrialization lends credence to the hypothesis that human capital played a significant role in the process of industrialization and the take-off to modern growth. In a world where face-to-face communication was essential for both knowledge transmission and enhancement, the length of productive life among the elite was an important determinant of the extent to which they were able to influence their cultural and economic environments. People picked up ideas from other people they met. The more people they met, the better informed and the more influential they became. Relying on Lucas' (2009) model on the exchange of ideas, de la Croix (2017) has shown that, if they lived long, people had many more chances to achieve professional excellence, and they were able to give other people many more opportunities to learn from them. Hence, longer lives led to increased economic growth.[12] Thus, after estimating the population size and the mortality dynamics of scholars – and, hence, a population closely related to upper-tail

[12]The outstanding role of upper-tail human capital in Europe's historical developments – and, more precisely, in its knowledge accumulation, economic growth and industrialization – has been emphasized in the

human capital – we come to the following conclusions: Before the onset of the gains in mortality at the beginning of the eighteenth century, the growth in the number of scholars increased the capacity for knowledge accumulation and diffusion. Thereafter, the increase in both the life expectancy and the population of scholars facilitated the Industrial Revolution. Furthermore, a mortality crisis like the Thirty Years' War had a twofold impact on knowledge accumulation as it shrank the population of scholars and shortened the average lifespan.

The lack of understanding of the germ theory before the nineteenth century suggests that scholars in the medical field of science faced a mortality disadvantage. However, we found no systematic disadvantage among medical professionals until the beginning of the sustained improvements in longevity. A possible explanation for this pattern is that formal medicine had a limited role in healing. While having an academic career was certainly useful for obtaining official positions, like court or personal physician, and, was therefore linked to social status; it was not necessarily an advantage in competing with practitioners on the medical marketplace, like surgeons, midwives, barbers, apothecaries, and even folk healers and illegal care providers (Broman 1995). Hence, the high social status of academic medical professionals might have even been linked to mortality advantages. However, when systematic mortality improvements began and the role of formal medicine increased, the gains for medical professionals were delayed. In line with van Poppel et al. (2016), we found that medical professionals had a mortality disadvantage for half a century. Rapidly increasing medical knowledge and the diffusion of the germ theory quickly compensated for the higher infection risks. As early as in the nineteenth century the excess mortality had vanished.

7 Limitations

The population of scholars has the clear advantage of a distinct universe: individuals active at one of the defined institutions. Still, this should not paper over several limitations. First of all, the characteristics of the institutions and their members are subject to a permanent development. At the very beginning, in the late medieval age, the structure of universities was quite different from the recent institutions. A full university had a lower faculty of Arts and three higher faculties: Medicine, Theology and Law. The latter also had higher incomes and while universities were rather independent at that time, it was common that teachers

recent research literature. For example, the number of people in eighteenth-century France who subscribed to the Diderot's and d'Alembert's Grande Encyclopédie predicts subsequent economic development at both the city and the county level (Squicciarini and Voigtländer 2015). Moreover, German cities, that developed better institutions following the Reformation grew more quickly, and had more residents who were registered as famous in the German biography database (Dittmar and Meisenzahl 2016).

at the theological faculty also belonged to a religious order. Academic titles mainly signaled that a person was a mastery in his field and linked to prestige and a high social status, albeit income was generally rather low (Verger 2003).

Until the end of the eighteenth century, a variety of positions, such as ordinary and extraordinary professors, doctors, lectores with different obligations and responsibilities but also privileges and salaries existed. Albeit all enjoyed a variety of privileges, such as a special jurisdiction, tax and dress privileges or the right to carry weapons, they lost a lot of their medieval freedom. Salaries were still generally low and often not paid regularly. Thus, it was quite common that scholars from higher faculties worked in the profession they taught. Scholars from the lower faculty hold positions at schools. Beside income or privileges that varied across universities, also a doctoral degree was not always required for academic positions and the obligation to publish varied a lot. Appointments driven by kinship were rather common, for instance at the University of Gießen or Tübingen (Vandermeersch 2003).

With the crisis of universities in the second half of the eighteenth century – the population of students declined drastically – and the arisen of the German university model, institutions changed rapidly. In the first half of the nineteenth century, payments in kind ended, salaries increased and were paid periodically such that activities at universities became a full-time job. The introduction of scientific standards in the process of appointments step-wise suppressed the role of kinship. Albeit, the latter was still important in several places, for instance the University of Kiel, it was a period of *social change* towards an academic elite. Scholars were envisioning themselves as scientists. Privileges and the role of professor-dynasties declined, while the social status of the Ordinarien increased (Klinge 2004; McClelland 1988).

In addition to the change in the population of scholars and the universities there are several characteristics that are time invariant but limit comparability with the overall population. Universities and academies of sciences are urban institutions and, hence, also our population. Scholars were exposed to the urban mortality penalty (Vögele 2000; Woods 2003). Furthermore, except for a rare number of women in the nineteenth century, scholars are exclusively male. Finally, scholars educational level and social status is clearly above the average population.

8 Conclusion

We gathered data from around 33,462 scholars in the 1648 territories of the Holy Roman Empire and the Netherlands. By combining vital information with nomination and exit information, we were able to compute mortality dynamics, while taking into account left truncation and right censoring. The population of scholars increased over time, except for a period of stagnation in the first half of the seventeenth century. In this phase, a combination of lower nomination rates and higher death rates reduced the number of scholars.

To investigate whether these death rate dynamics were attributable to selection or composition effects, we first controlled for the age structure by computing life expectancies with life tables and estimating their confidence intervals via Monte-Carlo simulations. The results indicate that there was a significant decrease of around 3.5 years in period life expectancy in the first part of the seventeenth century, and that permanent improvements in mortality started as early as in the middle of the eighteenth century. These findings persisted after several robustness checks, and are perfectly in line with the existing literature on long-run mortality dynamics. Given the high social status of our population, the estimated drop in life expectancy during the Thirty Years' War might be interpreted as a conservative estimation of the general magnitude of this crisis. Furthermore, the onset of permanent mortality improvements likely occurred earlier in our study sample than in the general population.

The heterogeneity in our population of scholars enabled us to study differentials in the timing of mortality improvements. We showed that the higher social status of members of scientific academies accelerated the improvements in life expectancy in the second part of the eighteenth century, when sustained reductions in mortality started. Our finding that mortality gains were faster among the more successful elite within our elite is in line with the literature; see for instance Johansson (1999). At the same time, we found some evidence that the medical profession suffered a delay. However, we also showed that the elevated social status and the excess mortality of medical professionals vanished during the nineteenth century.

Finally, our estimations on the population and longevity of scholars enabled us to draw some conclusions on the capacities for knowledge accumulation and diffusion. Up to the beginning of the eighteenth century, the growing population might have been the driving force for knowledge transmission and diffusion, as there were no systematic improvements in life expectancy. Thereafter, the interplay of an increasing stock of scholars and greater longevity might have accelerated knowledge accumulation – and, hence, helped to create the conditions that led to the Industrial Revolution. By contrast, the Thirty Years' War was an acute crisis that had a twofold impact on knowledge accumulation, as it shrank the size of the population and shortened the average lifespan.

A Appendix

A.1 Universities and Academies of Sciences

[Table 2 about here.]

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Walter, Ludwig K. 2010. *Dozenten und Graduierte der Theologischen Fakultät Würzburg 1402 bis 2002.* Würzburg: Schöningh.

Wedel-Schaper, Eva, and Renate Wittern. 1993. *Die Professoren und Dozenten der*

Friedrich-Alexander-Universität Erlangen-Nürnberg 1743-1860: Teil 1: Theologische Fakultät, Juristische Fakultät. Erlangen: Univ.-Bibliothek.

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Woods, Robert. 2003. "Urban-rural mortality differentials: an unresolved debate." *Population and Development Review* 29 (1): 29–46.

B Online Appendix

B.1 Additional material on the data quality

[Figure A1 about here.]

[Figure A2 about here.]

[Figure A3 about here.]

[Figure A4 about here.]

B.2 Life expectancy

B.2.1 Life expectancy and the conditional age

A sufficiently large population at risk is required to obtain convincing estimations of life expectancy $E_{x,t}$. A potential approach for determining the optimal x relates the difference between upper and lower 95% confidence intervals, $CI_{x,t}^{\text{low}}$ and $CI_{x,t}^{\text{high}}$, to the corresponding life expectancy $E_{x,t}$ and, then computes the age that minimizes this value:

$$argmin_x\{\frac{1}{T}\sum_{t}^{T}\frac{CI_{x,t}^{\text{high}}-CI_{x,t}^{\text{low}}}{E_{x,t}}\}, \tag{1}$$

with T as the number of 25-year rolling time intervals. The initial period of 1400 covers all cohorts born in 1388–1412, and the last period covers all cohorts born in 1875–99. The rare and scattered observations for the period before 1388 are not included. Hence, we have chosen the age x that minimizes the relative average 95% confidence interval. Proceeding in five-year age steps, this procedure leads to age 30. In addition to the baseline age 30, presented from the period perspective in Section 4.1 and from the cohort perspective in Appendix **??**, Fig. A5 illustrates the mortality dynamics for cohort life expectancy conditional to ages 25, 35, 45 and 55.

[Figure A5 about here.]

B.2.2 Period life-expectancy and wars

The German Peasants' War 1524–1525 (1) coincides with the reduced life expectancy at the very beginning of the period in Fig. 5. Still, we would not like to overvalue the sharp decline in life expectancy before 1550. A limited number of observations goes hand-in-hand with rather large confidence intervals. Furthermore, missings on the year of birth and/or death among lesser known scholars who might have died young could have resulted in an upwards bias in life expectancy estimates. The role of the Seven Years' War of 1756–1763 (3) is less clear. The non-smoothed data shows some decline at the beginning of the war that might be related to this military conflict. Finally, while the Revolutionary and Napoleonic Wars of 1803–1815 (4) were not accompanied by an increase in mortality, the initial period of permanent growth in life expectancy was interrupted.

B.3 Additional figures on the robustness of life expectancy dynamics

[Figure A6 about here.]

[Figure A7 about here.]

[Figure A8 about here.]

B.4 Online Professor Catalogues

[Table A2 about here.]

Tables

Table 1: Observations

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Period	Scholars nominated with exit/ death date	Scholars with date of birth, nomination, exit or death								
				Right censored cases	Mean age at		Share in % in			
		Nominations	Deaths		Nomination	Death	Medicine	Academy	Uni	Uni & Academy
<1500	1442	296	182	5	33.5	61.9	5.3	0	100	0
1500–49	770	348	243	5	32.3	58.6	6.9	0	100	0
1550–99	1002	720	495	17	33.3	58.8	11.3	0	100	0
1600–49	1088	895	860	25	34.1	58.8	10.6	0	100	0
1650–99	1666	1462	1077	46	33.9	57.7	15.5	6.3	92.4	1.3
1700–49	2408	2201	1683	40	34.8	60.1	20.4	22.4	73.0	4.6
1750–99	3482	3242	2579	100	35.7	62.0	19.6	33.2	59.3	7.5
1800–49	4515	4316	3587	52	37.7	64.9	18.8	50.9	38.4	10.7
1850–99	5893	5779	4503	78	38.4	67.6	20.0	51.8	34.6	13.6
1900–29	5777	5663	3586	257	40.4	68.2	21.4	39.7	42.2	18.1
≥1930	3060	2847	7962	387	54.1	76.0	23.3	33.2	47.7	19.1
All	31103	27769	26757	1012	39.1	67.8	20.2	35.5	51.5	13.0

Column 1: Number of nominations of scholars with information on year of nomination and death or exit. Columns 2-10 relate to the population with known year of birth, nomination and death or exit used for mortality estimations.

Table 2: Sources for Universities and Academies of Sciences

No.	University	Year	Cat.	Obs.	Wiki	RAG	*Catalogs* & Books
Universities in the Holy Roman Empire 1348–1599							
1.	University of Prague	1348	2	1317	x	x	Čornejová and Fechtnerová 1986; Svatos1995 1995
2.	University of Vienna	1365	2	1507	x	x	Lackner 1976
3.	University of Heidelberg	1386	1	1994			Drüll 1991, 2002, 2009, 2012
4.	University of Cologne	1388	2	712	x	x	Bianco 1974
5.	University of Erfurt	1389	3	310	x	x	
6.	University of Würzburg	1402	2	756			Walter 2010
7.	Leipzig University	1409	1	1183			*Catal. Prof. Lipsiensium*
8.	University of Rostock	1419	1	807			*Catal. Prof. Rostochiensium*
9.	University of Dole	1422	3	63			Fourquet 1929
10.	University of Louvain	1425	2	680			Brants 1906; Nève 1856; Ram 1861; Lamberts and Roegiers 1990; Tricot-Royer 1927
11.	University of Greifswald	1456	3	716	x		
12.	University of Freiburg	1457	2	692	x		Bauer 1957; Ruth 2001; Kurrus 1977
13.	University of Ingolstadt	1472	3	236			
14.	University of Trier	1473	4	68			
15.	University of Tübingen	1477	1	989			Conrad 1960
16.	University of Mainz	1477	1	971			Benzing 1986
17.	University of Wittenberg	1502	2	169			Kohnle and Kusche 2016
18.	Brand. Uni. of Frankfurt	1506	3	135	x		
19.	University of Marburg	1527	1	1640			*Marburger Prof.-katalog* Auerbach and Gundlach 1979; Gundlach and Auerbach 1927
20.	University of Strasbourg	1538	2	524			Berger-Levrault 1890
21.	University of Dillingen	1553	3	137	x		
22.	University of Jena	1558	2	617			Günther 1858
23.	University of Douai	1559	3	63			
24.	University of Eichstätt	1564	4	13			
25.	University of Olomouc	1573	3	304	x		
26.	University of Linz	1574	4	14			
28.	University of Helmstedt	1576	1	294			*Prof.-katalog Helmstedt*
29.	University of Herborn	1584	4	12			
30.	University of Graz	1585	2	530	x		Krones 1886

* Because of a joint source, the University of Strasbourg includes most of the observations.

No.	University	Year	Cat.	Obs.	Wiki	RAG	*Catalogs* & Books
Universities in the Holy Roman Empire 1600–1799							
32.	University of Gießen	1607	1	1057			Rehmann 2006; Haupt and Lehnert 2006
33.	University of Stadthagen	1610	1	2**			Brosius 1972
35.	University of Paderborn	1614	4	42			
36.	University of Molsheim	1618	2	45*			Berger-Levrault 1890
37.	University of Rinteln	1621	1	172			Brosius 1972
38.	University of Salzburg	1622	4	24			
39.	University of Altdorf	1622	2	98	x		Flessa 1969
40.	University of Osnabrück	1629	4	29			
42.	University of Kassel	1633	4	4			
44.	University of Bamberg	1647	1	425			
47.	University of Duisburg	1655	4	15			
48.	University of Kiel	1665	1	1377			*Kieler Gelehrtenverzeichnis* Volbehr and Weyl 1956
49.	University of Innsbruck	1669	4	174			
50.	University of Franche-Comté	1691	3	11			Fourquet 1929
51.	University of Halle	1694	2	1041			
52.	University of Breslau	1702	4	156			
53.	University of Göttingen	1734	1	1742			Ebel 1962
54.	Theol. fac. Fulda	1734	4	58			
55.	University Erlangen-N.	1743	1	734			Wedel-Schaper and Wittern 1993; Wachter 2009; Ley 1999
56.	TU Braunschweig	1745	1	520			Gundler 1991; Albrecht 1986
57.	University of Bützow	1760	3	31	x		
58.	TU Freiberg	1765	1	110			Schleiff, Volkmer, and Kaden 2015
59.	TU Berlin	1770	4	5			
60.	University of Münster	1771	4	83			
61.	TU Clausthal	1775	1	146	x		Müller 1999; Valentiner 1925
62.	University of Bonn	1777	4	154			
63.	Karl's High School Stuttgart	1781	3	37	x		
Universities in the Netherlands							
27.	Leiden University	1575	1	681			*Leidse Hoogleraren vanaf 1575*
31.	University of Franeker	1585	2	151	x		Napjus and Lindeboom 1985; Feenstra, Ahsmann, and Veen 2003
34.	University of Groningen	1614	1	443			*C. P. Academiae Groninganae*
41.	University of Amsterdam	1632	1	551			*Album Academicum*
43.	Utrecht University	1636	1	491			*C. P. AcademiæRheno-Traiectinæ*
45.	University of Harderwijk	1648	1	130	x		van Epen 1904
46.	University of Nijmegen	1655	3	19	x		

** Because of a joint source, the University of Rinteln includes most of the observations.

No.	Academy		Year	Cat.	Obs.	Wiki	Reg.	Books
Academies of sciences								
64.	Leopoldina		1652	1	4886		x	
65.	Berlin-Brandenburg	(BBAW)	1700	1	2481		x	
66.	Göttingen	(AdW)	1751	1	1849			Krahnke 2001
67.	Erfurt		1752	1	1968			Kiefer 2004
68.	München	(BADW)	1759	1	2569		x	
69.	Mannheim		1763	3	47	x		Eid 1926
70.	Brussels		1769	2	56			Hasquin 2009
71.	Görlitz	(OLGdW)	1779	1	1985			Fröde 2017
72.	Amsterdam	(KNAW)	1808	1	1602			van de Kaa and Roo 2008
73.	Leipzig		1846	1	448		x	
74.	Heidelberg		1909	1	310		x	
75.	Mainz		1949	1	175		x	

Column *Wiki* indicates whether at least some of the observations were found by means of Wikipedia. *Reg* refers to sources from official registers provided by the academy. Appendix B.4 provides an overview of the links to online professor catalogues that were included.

Tables for Online Appendix

Table A2: Overview on online available and used Professor catalogues

University	Catalogue	Link
University of Rostock	Catalogus Professorum Rostochiensium	http://cpr.uni-rostock.de/
Leipzig University	Catalogus Professorum Lipsiensium	https://research.uni-leipzig.de/catalogus-professorum-lipsiensium/
University of Marburg	Marburger Professorenkatalog	https://www.uni-marburg.de/uniarchiv/pkat
University of Helmstedt	Professorenkatalog Helmstedt	http://uni-helmstedt.hab.de/
University of Kiel	Kieler Professorenkatalog	https://cau.gelehrtenverzeichnis.de/
Leiden University	Leidse Hoogleraren anaf 1575	https://hoogleraren.leidenuniv.nl/
University of Groningen	Catalogus Prof. Academiae Groninganae	https://hoogleraren.ub.rug.nl/
University of Amsterdam	Album Academicum	http://www.albumacademicum.uva.nl/
Utrecht University	Catalogus Prof. Academiæ Rheno-Traiectinæ	https://profs.library.uu.nl/
University of Mainz	Gutenberg Biographics	http://gutenberg-biographics.ub.uni-mainz.de/home.html/
University of Halle	Catalogus Professorum Halensis	https://www.catalogus-professorum-halensis.de/

Figures

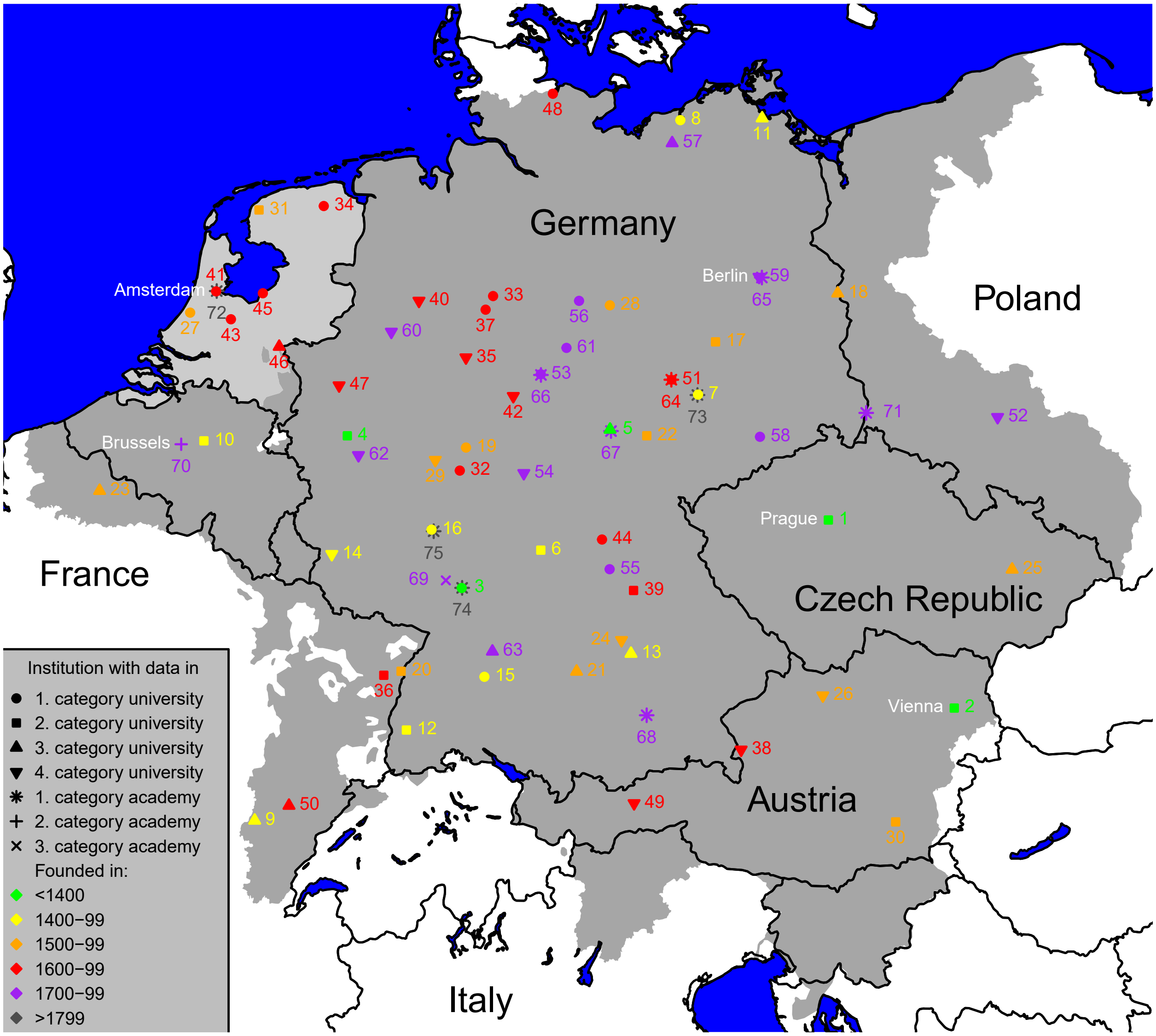
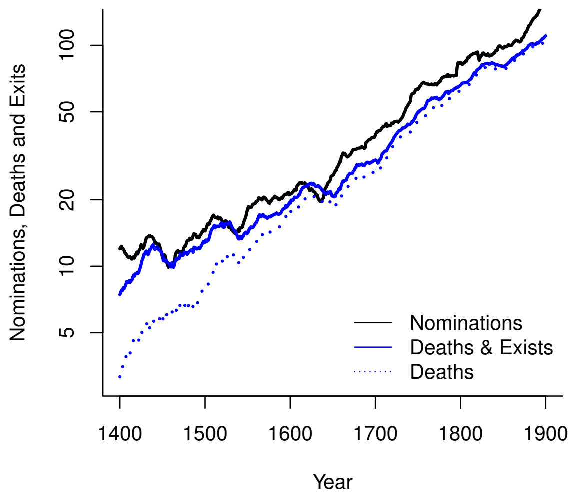
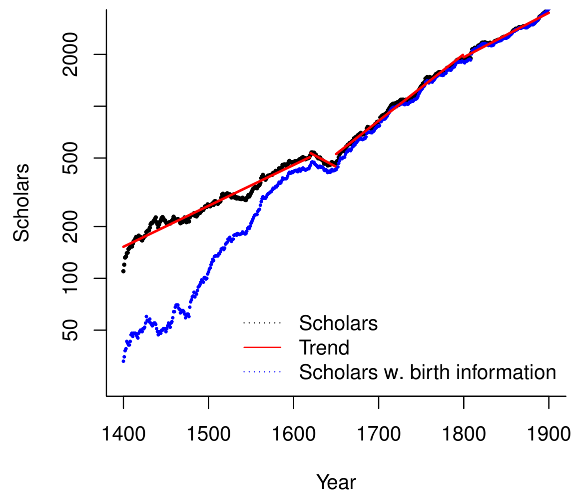


Fig. 1. Universities and academies in the territories of the HRE and the Netherlands

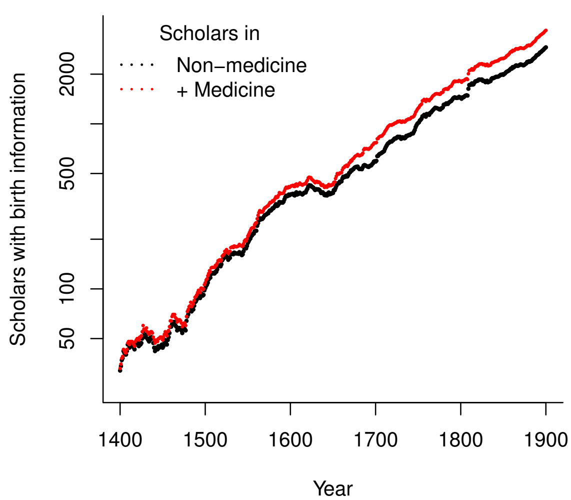
Universities and scientific academies located in the 1648 territories of the Netherlands (light gray) and the Holy Roman Empire (gray) by the category of quality of the data sources and century of foundation. Numbers 1–63 mark universities sorted by year of foundation and numbers 64–75 mark academies of sciences. For an entire list of the corresponding institutions, see Appendix A.1 in Table 2.



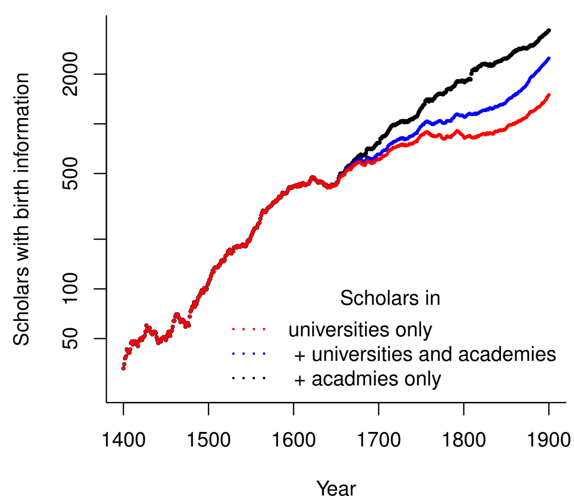
(a) 25-year moving averages in in- and outflow



(b) The number of scholars

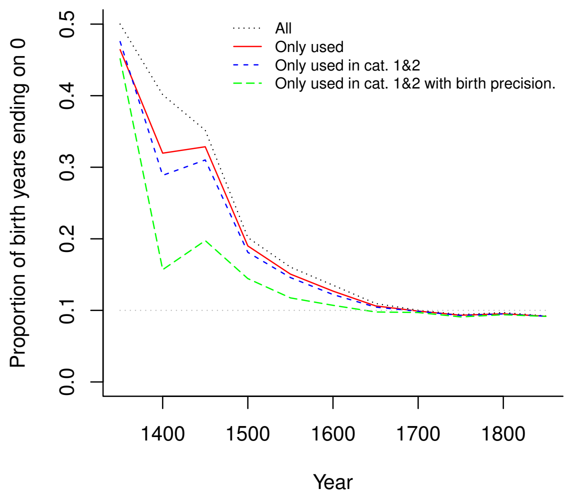


(c) The number of scholars in medicine and other FOS

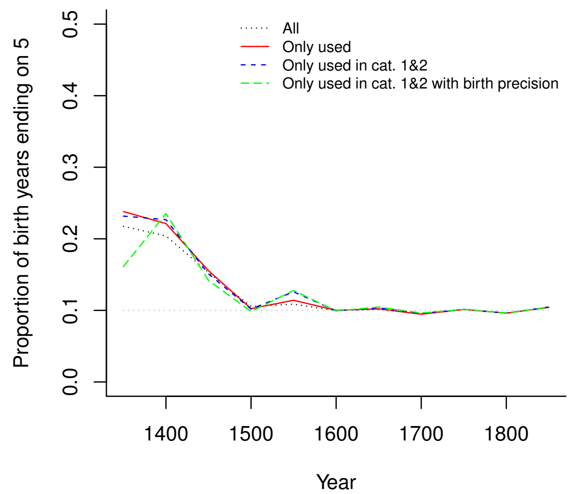


(d) The number of scholars by institution

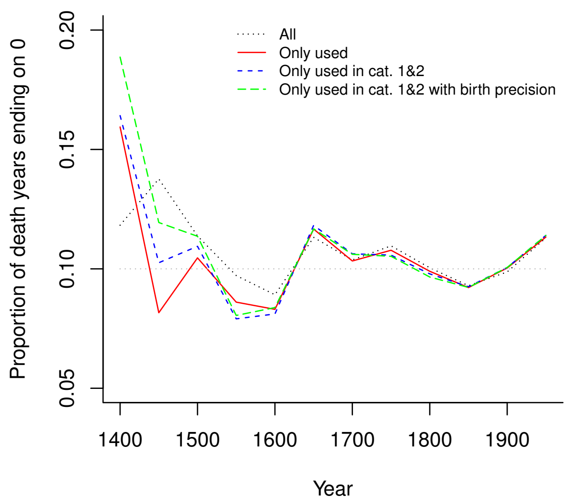
Fig. 2. The dynamics in the population of scholars



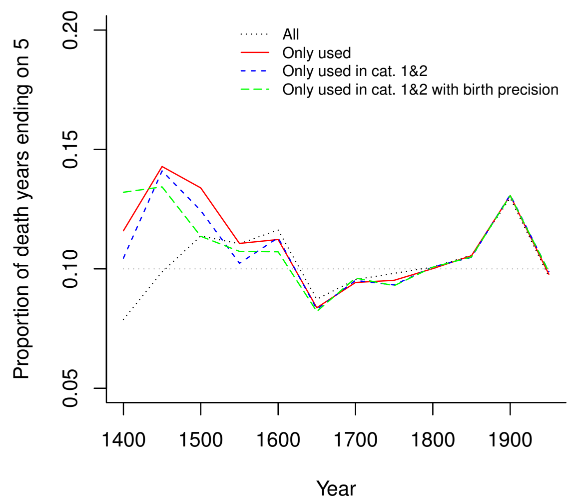
(a) Proportion of birth years ending on 0



(b) Proportion of birth years ending on 5

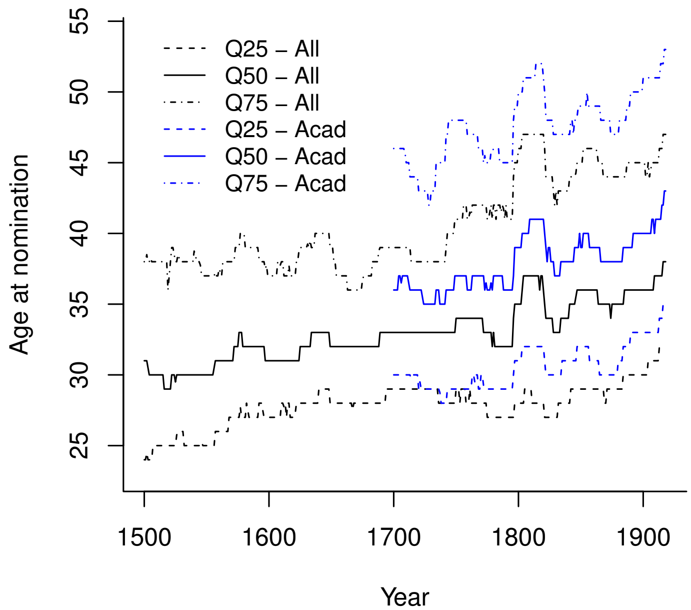


(c) Proportion of death years ending on 0

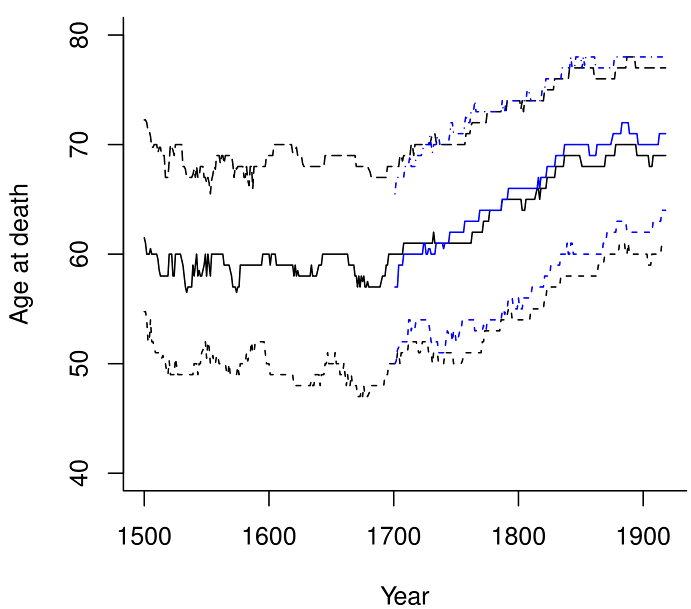


(d) Proportion of death years ending on 5

Fig. 3. Birth and death year heaping in the population of scholars.



(a) Age at first nomination



(b) Age at death

Fig. 4. The dynamics of age at nomination and age at death in 25-year rolling intervals

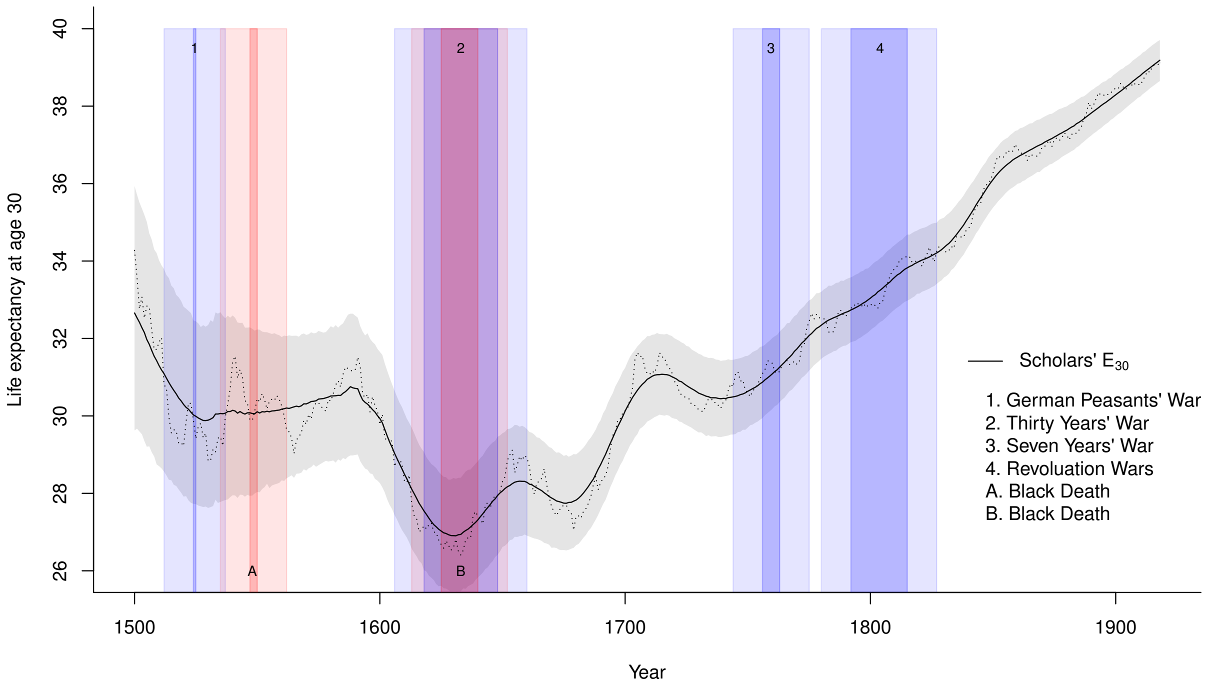
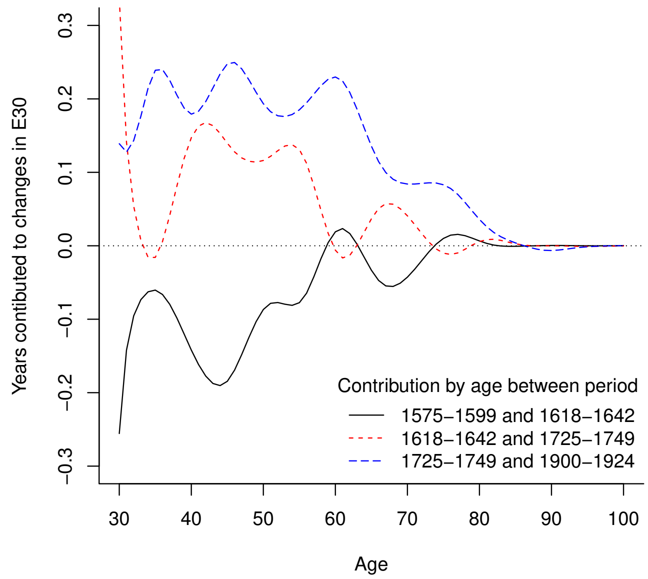
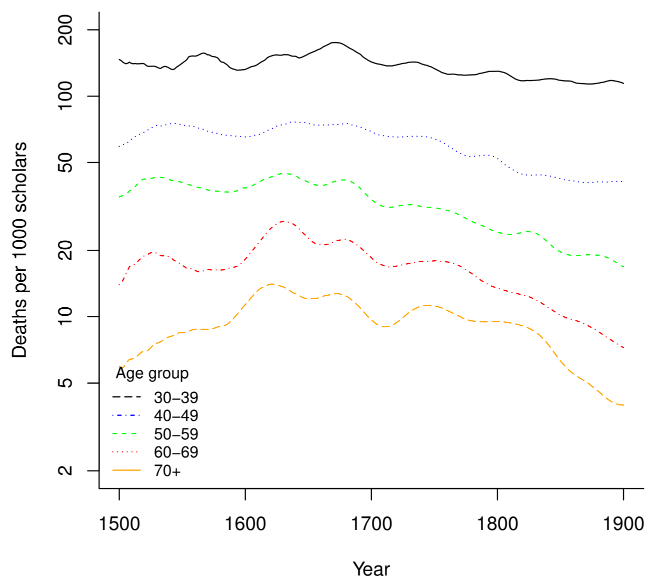


Fig. 5. The dynamics of scholars' period life expectancy and historical events



(a) Years contributed to changes in life expectancy



(b) Age-specific death rates

Fig. 6. Decomposition of gains in life expectancy.

Figure 6 applies 25-year rolling intervals and two-dimensional smoothed data.

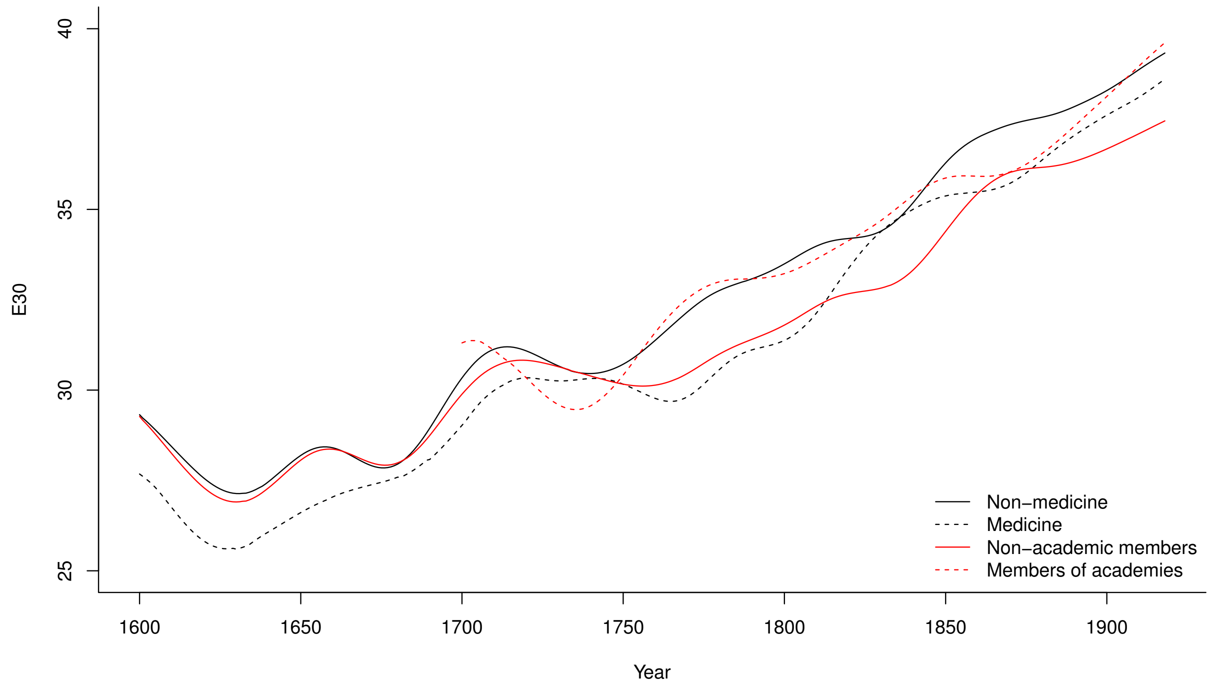


Fig. 7. Social status, Medicine and Life expectancy

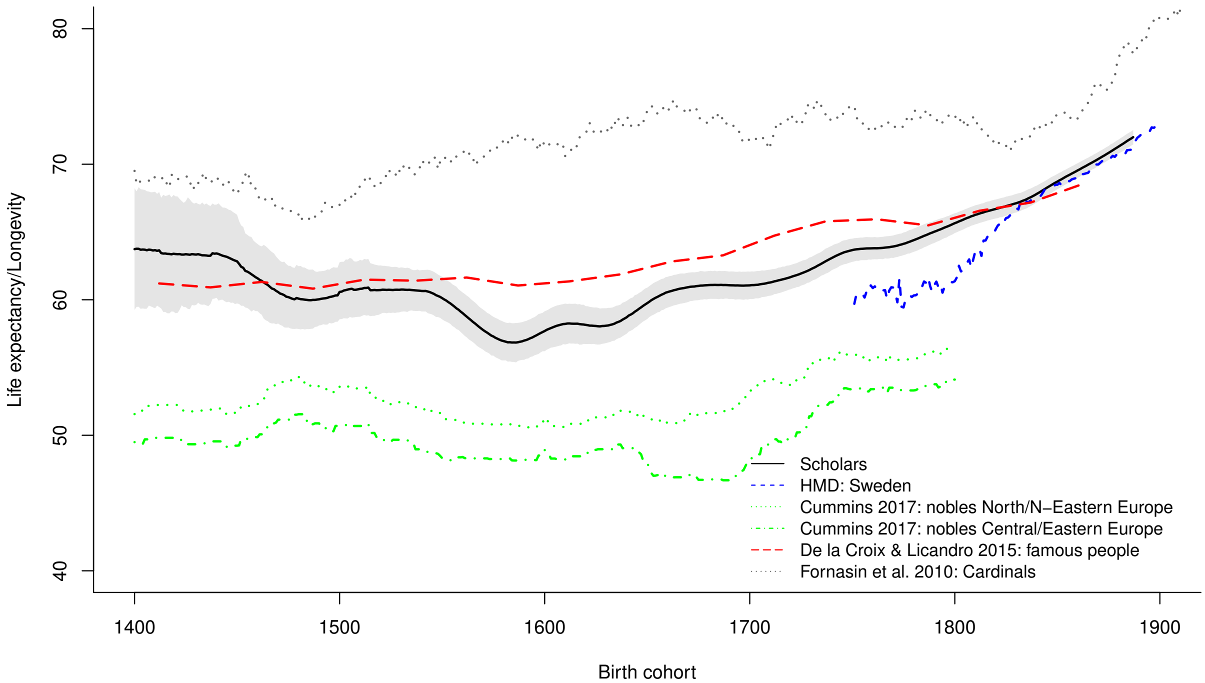
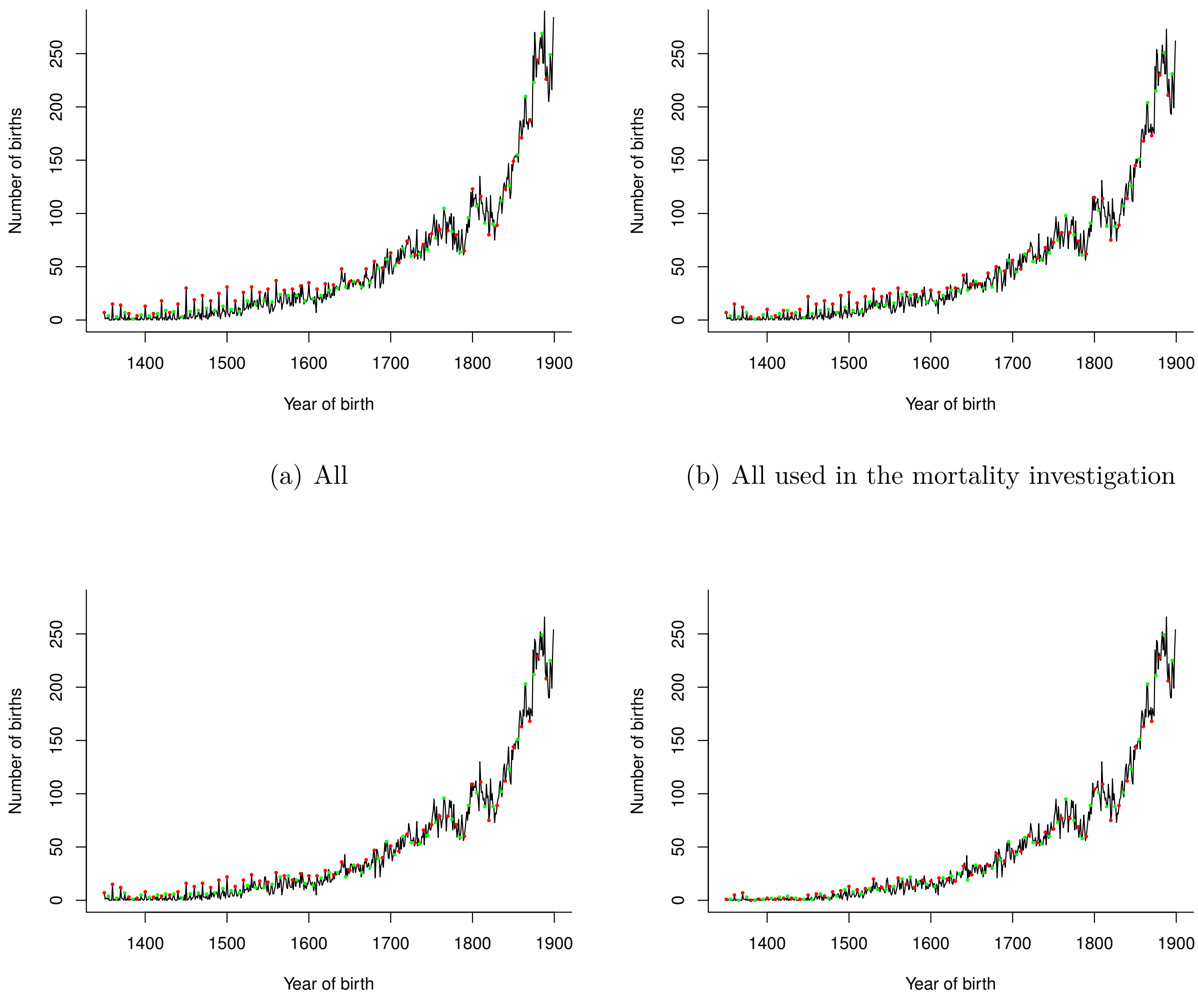


Fig. 8. The dynamics of scholars' cohort life expectancy in the light of the literature

Figures for Online Appendix



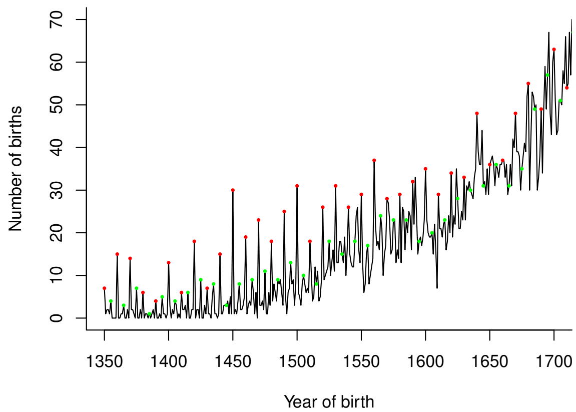
(a) All

(b) All used in the mortality investigation

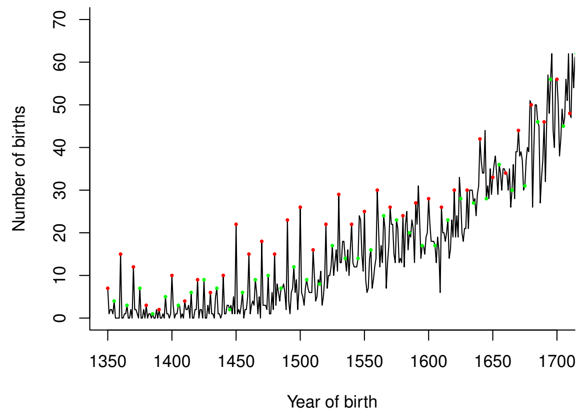
(c) All used observations in cat. 1 & 2

(d) All used observations in cat. 1 & 2 with certain year of birth

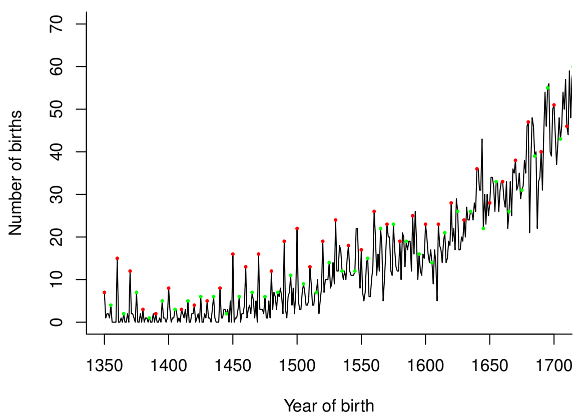
Fig. A1. Number of observations by birth year



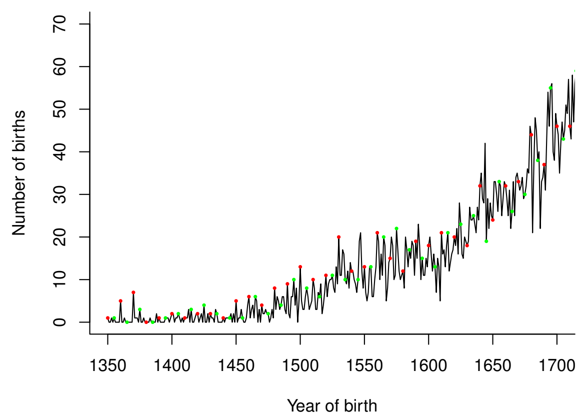
(a) All



(b) All used in the mortality investigation

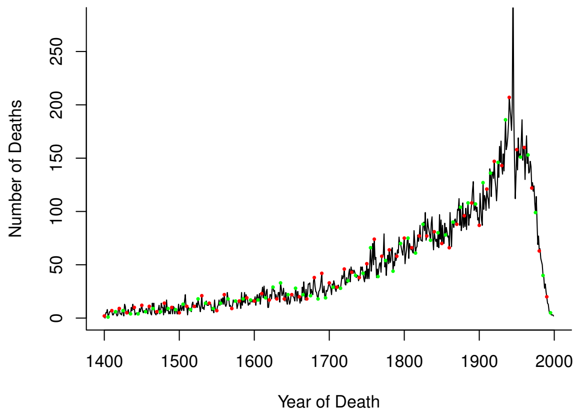


(c) All used observations in cat. 1 & 2

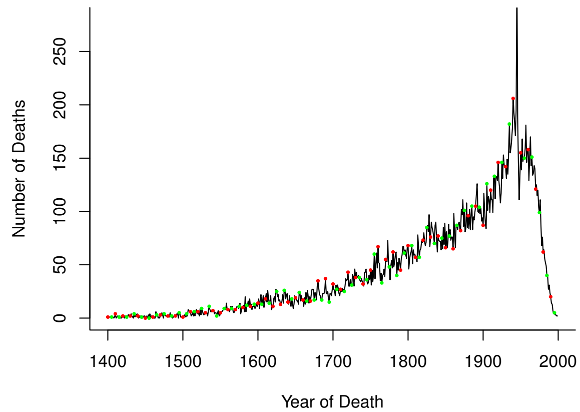


(d) All used observations in cat. 1 & 2 with certain year of birth

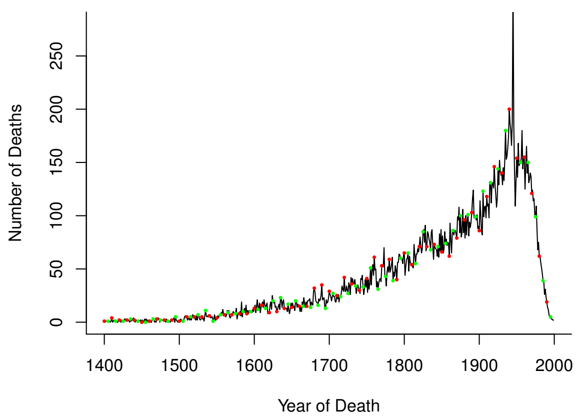
Fig. A2. Number of observations by birth year until 1700



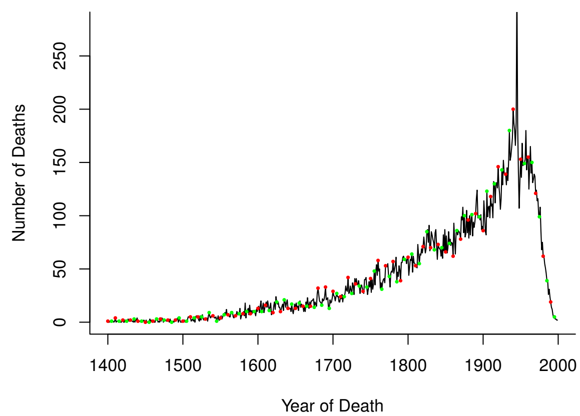
(a) All



(b) All used in the mortality investigation

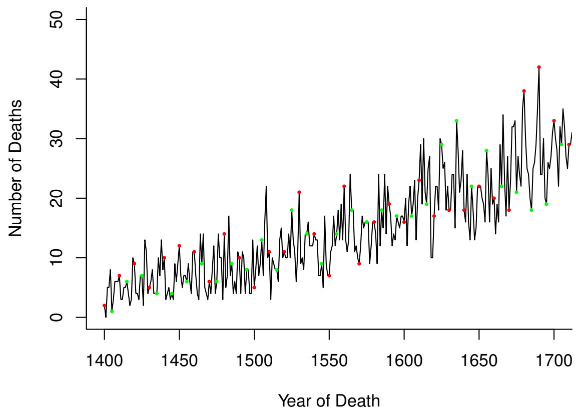


(c) All used observations in cat. 1 & 2

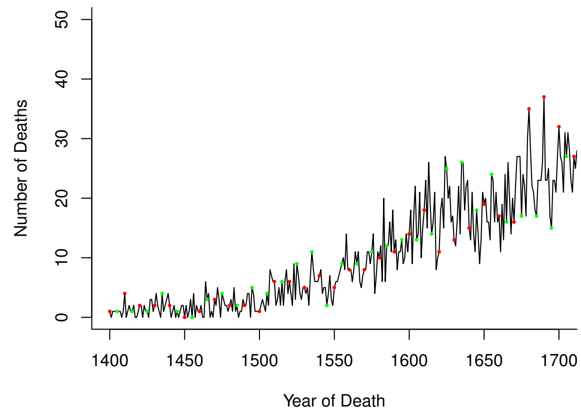


(d) All used observations in cat. 1 & 2 with certain year of birth

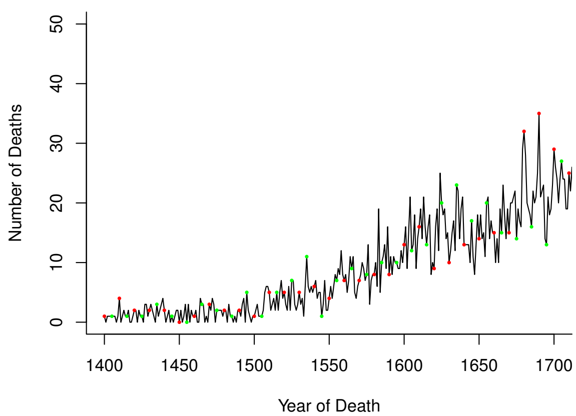
Fig. A3. Number of observations by death year



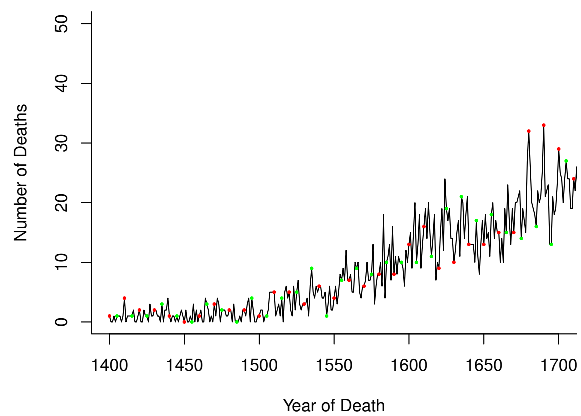
(a) All



(b) All used in the mortality investigation



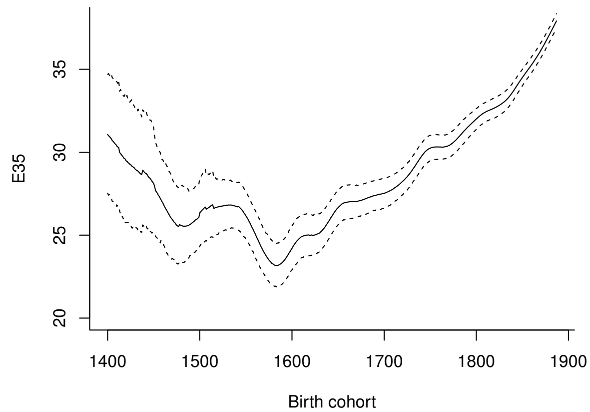
(c) All used observations in cat. 1 & 2



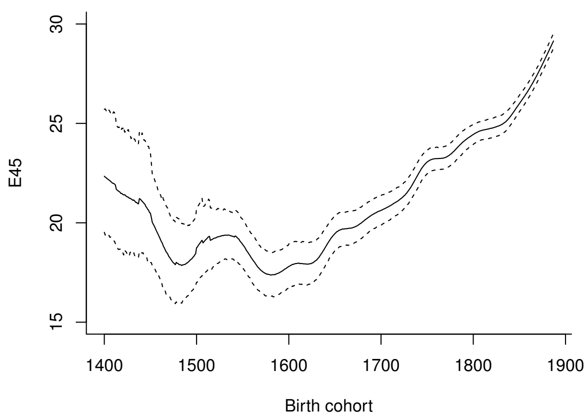
(d) All used observations in cat. 1 & 2 with certain year of birth

Fig. A4. Number of observations by death year until 1700

(a) Cohort life expectancy at age 25



(b) Cohort life expectancy at age 35

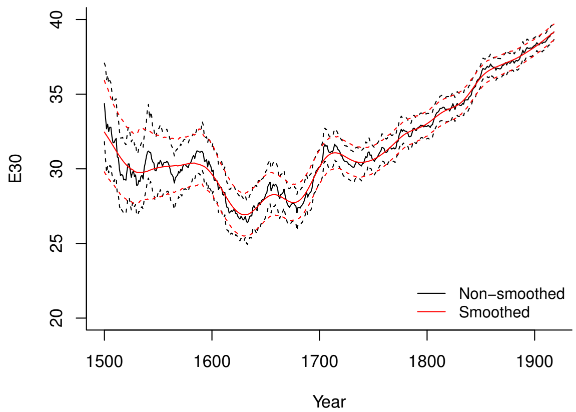


(c) Cohort life expectancy at age 45

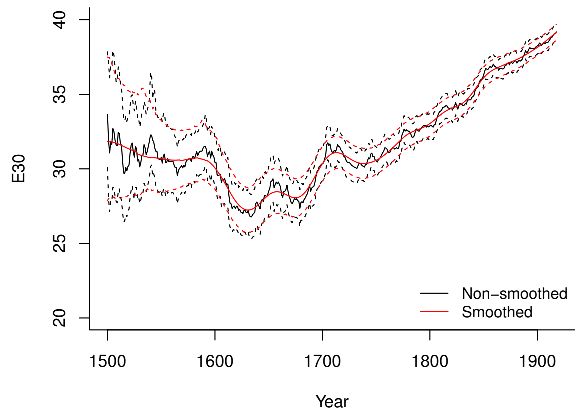
(d) Cohort life expectancy at age 55

Fig. A5. Dynamics of life expectancy at various ages

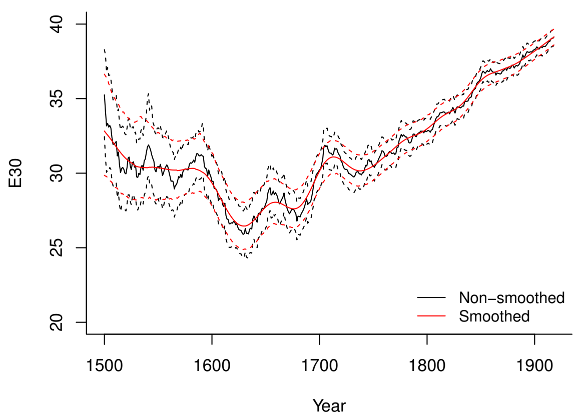
Fig. A5 applies two-dimensional smoothed 25-year rolling intervals for birth cohorts. Dashed lines mark 95% confidence intervals.



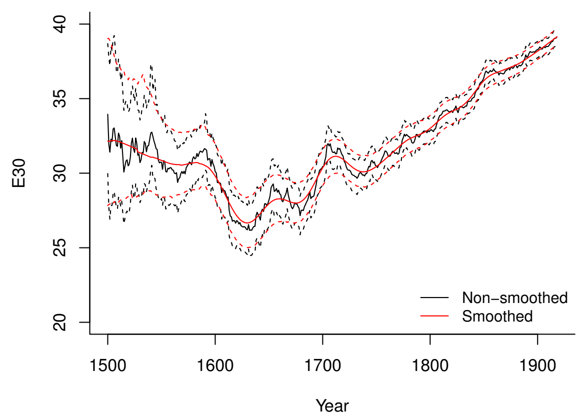
(a) Baseline estimation



(b) Estimation including only observations with certain birth year



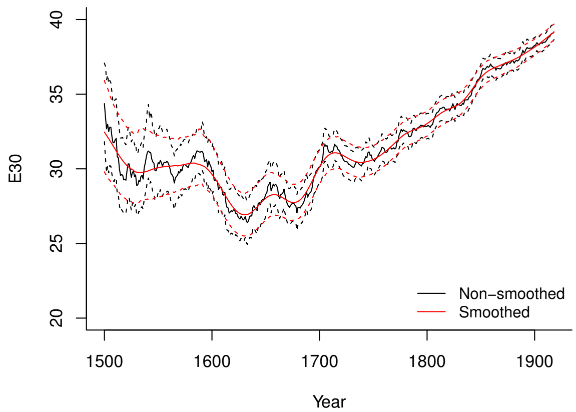
(c) Estimation including only observations in category 1 & 2



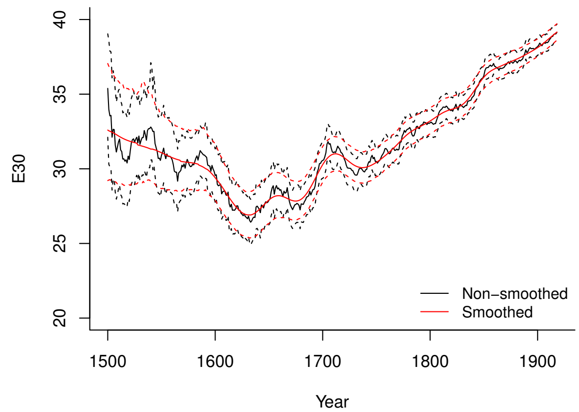
(d) Estimaiton including only observations in category 1 & 2 with certain birth year

Fig. A6. Dynamics of life expectancy according to data quality

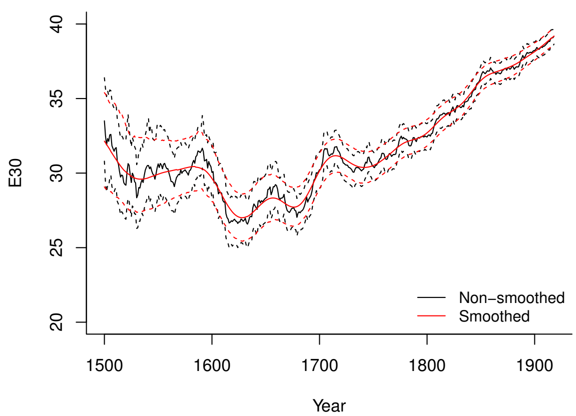
Fig. A6 applies two-dimensional smoothed 25-year rolling intervals for birth cohorts. Dashed lines mark 95% confidence intervals.



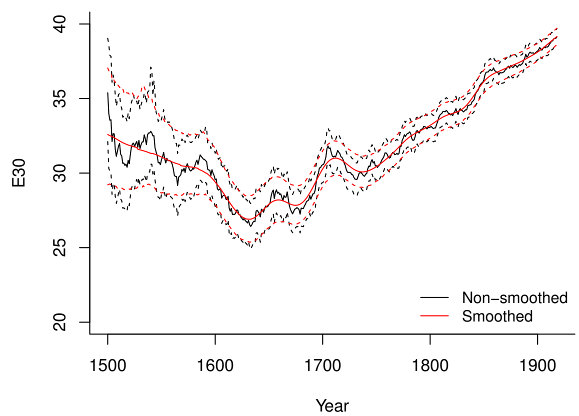
(a) Baseline estimation



(b) Estimation without birth years ending on 0



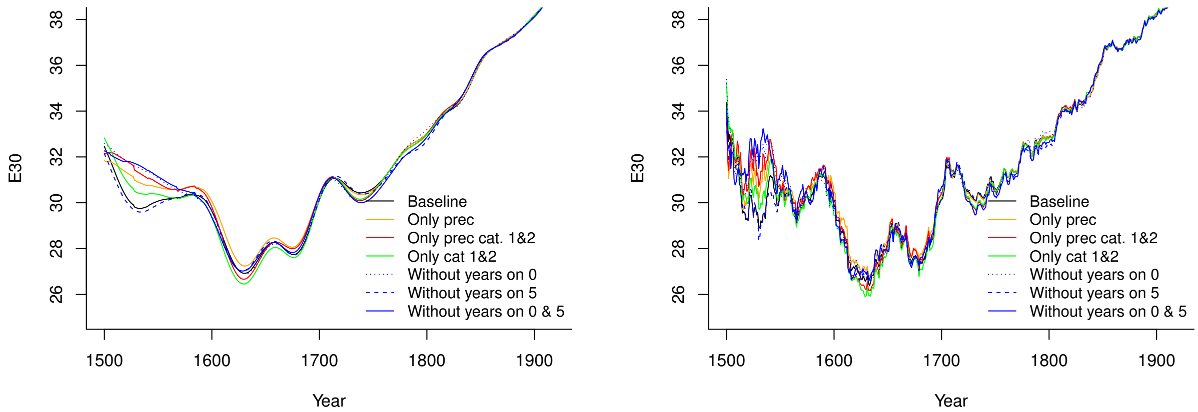
(c) Estimation without birth years ending on 5



(d) Estimation without birth years ending on 0 & 5

Fig. A7. Dynamics of life expectancy excluding potential birth year heaping

Fig. A7 applies two-dimensional smoothed 25-year rolling intervals for birth cohorts. Dashed lines mark 95% confidence intervals.



(a) Smoothed life expectancy

(b) Non-smoothed life expectancy

Fig. A8. Summary of life expectancy at age 30 according to data quality

Fig. A8 applies two-dimensional smoothed 25-year rolling intervals for birth cohorts.