

# LEADERS AND LAGGARDS IN LIFE EXPECTANCY AMONG EUROPEAN SCHOLARS FROM THE SIXTEENTH TO THE EARLY TWENTIETH CENTURY

Robert Stelter, David de la Croix  
and Mikko Myrskylä

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# Leaders and Laggards in Life Expectancy among European Scholars from the Sixteenth to the Early Twentieth Century\*

Robert Stelter<sup>†</sup>, David de la Croix<sup>‡</sup> & Mikko Myrskylä<sup>§</sup>

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## Abstract

When did mortality first start to decline, and among whom? We build a large, new dataset with more than 30,000 scholars covering the fifteenth to the early twentieth century in order to analyze the timing of the mortality decline and the heterogeneity in life expectancy gains among scholars in the Holy Roman Empire. The large sample size, well-defined entry into the risk group, and heterogeneity in social status are among the key advantages of the new database. 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. 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 lower mortality. We also show, however, that the onset of mortality improvements among scholars in medicine was delayed, possibly because these scholars were exposed to pathogens, and did not have germ theory knowledge that might have protected them. The disadvantage among medical professionals decreased toward the end of the nineteenth century. Our results provide a new perspective on the historical timing of mortality improvements, and the database accompanying our paper facilitates replication and extensions.

Keywords: Mortality dynamics, differential mortality, Holy Roman Empire, Thirty Years' War

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

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<sup>†</sup>Max Planck Institute for Demographic Research, Konrad-Zuse-Str. 1, 18057 Rostock, Germany and Leuphana University of Lüneburg, Institute of Economics, E-Mail: stelter@demogr.mpg.de, corresponding author.

<sup>‡</sup>IRES/LIDAM, UCLouvain, Belgium and CEPR, London, UK. Email: david.delacroix@uclouvain.be.

<sup>§</sup>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 long-run dynamics of human well-being.

In this paper, we focus on the European scientific elite – i.e., scholars active at universities or academies of sciences. Observing each scholar’s first appointment or nomination to a scientific institution helps to overcome common methodological issues in historical populations, as the appointment can be used to define the entry into the population at risk. More importantly, taking into account each scholar’s scientific field and potential membership in an academy of sciences provides new insights into 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).

Drawing on 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 the British nobility 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. Andreev *et al.* (2011) compared life expectancies of members of the British and the Russian academies of science.<sup>1</sup> 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. However, this first phase has been observed in Ireland and the UK only and these findings are subject to considerable uncertainty. Even though the total sample size is large, when stretched over several centuries the uncertainty regarding any specific time point becomes large. This phase of longevity improvements was

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<sup>1</sup>Edwards (2008), 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. Carrieri and Serraino (2005) and Hanley *et al.* (2006) compared the life expectancies of popes and artists; while van Poppel *et al.* (2013) examined the longevity of artists using information from the RKDartists database.

followed by another after 1650 that has been observed throughout Europe in other studies as well (Hollingsworth, 1977; van Poppel *et al.*, 2013, 2016). De la Croix and Licandro 2015 built a database drawn from the *Index Bio-bibliographicus Notorum Hominum*, 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 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 in the 1640–1649 period, 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 could not be precisely 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 this pattern is more recent. Finally, we exploit information about the scientific fields in which the scholars in our database were working 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 on longevity, depending on whether the benefits of medical knowledge offset the added hazards resulting from exposure to pathogens.

Our dataset, which is mainly based on university professor catalogs 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 institutions 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. Although its borders changed over time, the HRE 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 each scholar’s dates of appointment, exit, birth, and death.

Our sample, which covers more than 30,000 scholars born between the fourteenth and the nineteenth century, has several advantages. The sample allows us to consider 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 analyses.

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, before industrialization. Most of the deviations of our findings from existing estimates of 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.

Second, we shed light on mortality differences between groups by comparing members and non-members of scientific academies, as well as scholars in the medical field with scholars in other scientific fields. 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 association between social status and 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 longevity improvements among the upper social classes anticipated the overall rise in life expectancy by at least a 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 indicated that these mortality improvements were not dominated by any particular occupation.<sup>2</sup> In a literature review, Bengtsson and van 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 sciences, mortality gains accelerated around the time when life expectancy started to increase sustainably. This finding suggests that as early as 300 years ago, scholars with higher social

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<sup>2</sup>Furthermore, Bengtsson and Dribe (2011) found evidence of the late emergence of a mortality advantage in Sweden. Using data from Geneva, Schumacher and Oris (2011) documented an advantage among the higher classes that ended in the seventeenth and eighteenth century.

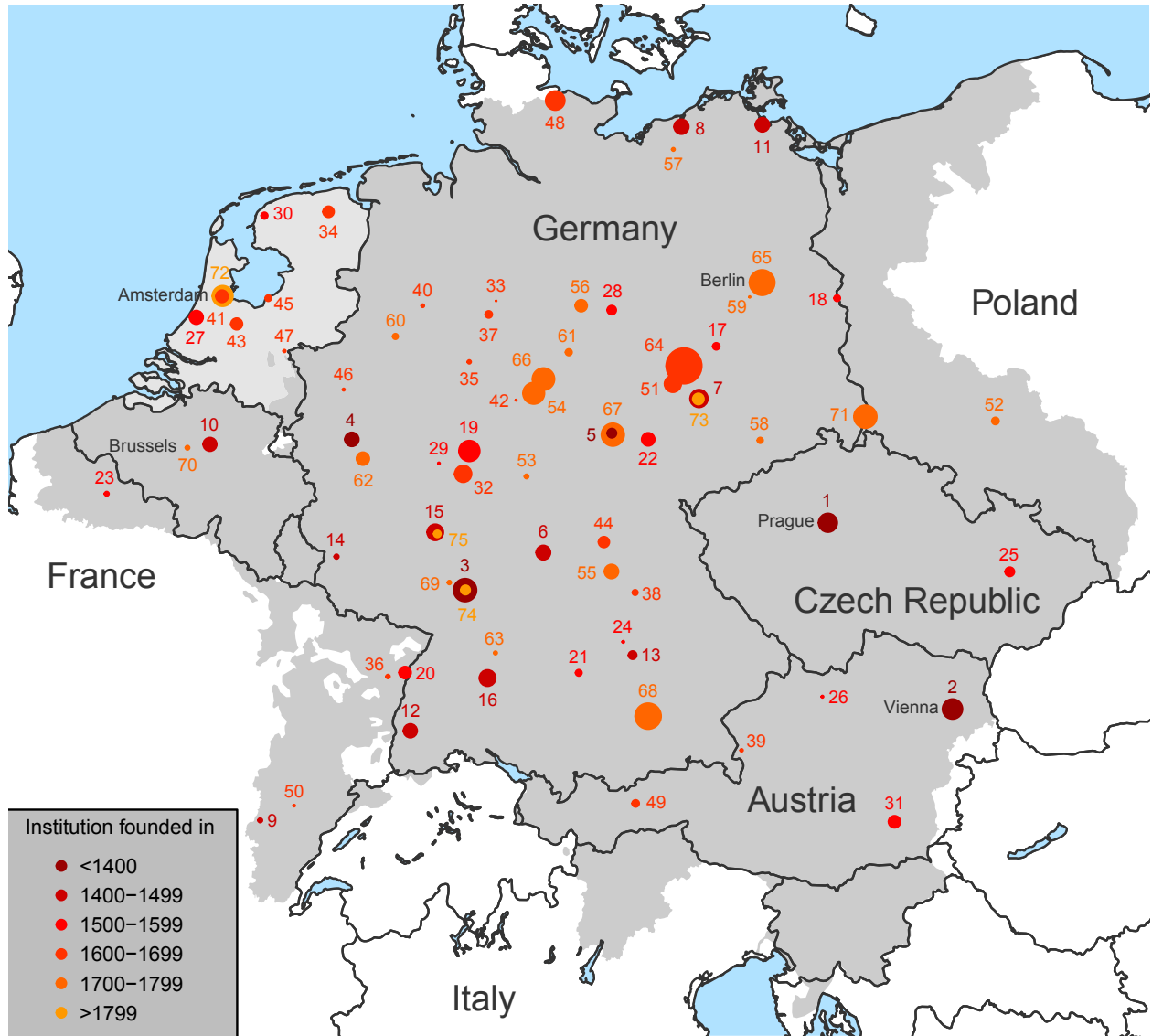
status enjoyed lower mortality.

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 (de la Croix and Sommacal, 2009). It is, therefore, possible that medical professionals had a net disadvantage. For example, to protect against the bubonic plague, people used beak-like masks 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 find only weak evidence of a 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 Scholars 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 (HRE). The Empire was founded around 962 as Otto I sought to revive the Roman Empire by laying claim to the imperial cult of Rome. 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 this 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 German state declined substantially, and the populations of Central Europe shifted. To take advantage of the relatively stable institutional set-up provided by the HRE, 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 small parts of Croatia, France, Italy, Poland, and Switzerland. The territories that made up the Netherlands are depicted in light gray.



**Fig. 1. Universities and academies in the territories of the Holy Roman Empire and the Netherlands**

Universities and scientific academies located in the 1648 territories of the Holy Roman Empire (gray) and of the Netherlands (light gray). The area of the circle is proportional to the number of observations of the institution, and the color indicates the 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 Tab. A1 in Appendix A.1.

Scholars might have been active in universities, academies of sciences, or courts. 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. This precise demarcation of our population should not cover up the fact that many things have changed since the creation of

Prague university in 1348. Rules for granting degrees, such as a doctoral degree, or the social status of university professors changed, for instance, after the Humboldt reform (Schimank and Winnes, 2000). Salaries prior to the modern period were often low, paid in kind, or not paid at all, e.g. during the Thirty Years' War (Vandermeersch, 2003; Klinge, 2004; Langer, 2011). Still, considering a changing environment, we are as close as possible to a well-defined population. Any other professions would face similar changes; even the nobility.

We include in our database scholars who were appointed to universities that were founded before 1800. Based on Frijhoff (1996) and Steiger (1981), we identified 63 such universities. Universities that were founded later than 1800 are excluded, both because the HRE ended in 1806, and because the European university underwent radical changes around this time. A large number of universities disappeared at the beginning of the nineteenth century. In Germany, for instance, 18 out of 34 universities were closed (Charle, 2004). More importantly, universities founded in the nineteenth century followed a new university model shaped by the Humboldt reform (Schimank and Winnes, 2000). Thus, because our focus is on older universities, our results are not affected by the significant changes that occurred around 1800.

Still, the 63 older universities were rather heterogeneous along several dimensions. Figure 1 illustrates the spatial distribution of these institutions, and the number of scholars related to each institution by the area of the circle. Established in 1348, the University of Prague (1) was the oldest university in the HRE; 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. In addition, four more applied universities, such as the Freiberg University of Mining and Technology (58), were among the institutions established in the eighteenth century. 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).

Figure 1 includes the 12 academies of sciences (sometimes combined with arts) for which we have data. While other academies existed during the time period we cover, these institutions were, on average, of lesser importance.<sup>3</sup> Over the course of history, large numbers of scientific

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<sup>3</sup>For an overview on academies, see the Scholarly Societies Project



academies have appeared, and, in some cases, have later disappeared. By far the most important of the scientific academies we cover 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) were also well-known. The latter academy was founded in 1808. We include this institution because academies did not undergo the same structural changes as universities. Thus, there was no reason to exclude these more recently established institutions.

## 2.2 Data and Sources of the Dataset

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

For other universities, the existing catalogs 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 category, 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 on medical faculty professors in Altdorf. In addition to 15 universities, *the Royal Academy of Sciences, Letters and Fine Arts of Belgium* is included in this second category.

The sources we use 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 category 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, whenever possible, backed-up with additional sources, like the *Deutsche Biographie*.<sup>4</sup> For example, we collected

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(<http://www.references.net/societies/>).

<sup>4</sup>The reliability of Wikipedia information is not always easy to validate. Less than 2% of our observations are solely based on Wikipedia. We have checked that all our results are robust to the exclusion of all institutions without traditional sources; for details, see section 3.4 and the online material.

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*.

The remaining 14 universities are in the last category, scattered data. 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).<sup>5</sup>

By combining the data from the sources in all four categories and removing duplicates, we gathered information on 33,498 scholars. This population forms our total sample of scholars who were born before 1900, and who were active in the defined universe of universities and scientific academies. Individuals entered the population of scholars at the time when they were first appointed. Individuals exited the population at death, if this event is observed. If death is not observed, they are censored at the last exit from one of our institutions.

## 2.3 Data Quality

Given that our historical data cover more than four centuries, some uncertainty about these data is understandable, particularly at the very beginning of our time span. In this section, we discuss two potential caveats: missing values and heaping in the years of birth and death.

Table 1 summarizes important descriptive statistics. The total sample of scholars declines from 33,498 to 31,176 if we only consider individuals for whom the year of appointment and of death or exit are known. The sample further shrinks to 27,842 if we only include individuals for whom their ages at the events are known; we use this as the baseline sample for our mortality estimations. Most cases for which the ages are unknown suffer from multiple missings. In 96.2% of cases in which we observe age, we also observe death. The share of right-censored cases for which death is unknown increases slightly for the most recent time periods because our data sources, such as Conrad (1960) for the University of Tübingen, are from a time when many of the scholars were still alive. We know the age at death for scholars who died after the date of publication only if we find them in other sources.

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<sup>5</sup>Table A1 in Appendix A.1 provides complete overviews of the categories and sources of all 75 institutions.

Tab. 1: Observations by year of appointment

Year	All appointments*	Appointments with known age**							
	N	N	Mean age at appointment	death	Death observed, %	University appointments Total	Medicine,%	Academy appointments Total	Medicine,%
< 1400	217	46	37.5	63.3	97.8	46	2.2	0	-
1400–1449	616	87	32.5	64.2	98.9	87	8.0	0	-
1450–1499	607	162	33.0	62.5	97.5	162	6.2	0	-
1500–1549	770	349	32.3	60.5	98.6	349	8.0	0	-
1550–1599	998	719	33.3	60.6	97.4	719	11.7	0	-
1600–1649	1085	893	34.0	58.8	96.9	891	10.7	2	100.0
1650–1699	1662	1458	33.9	60.2	96.9	1213	7.9	245	84.5
1700–1749	2401	2194	34.8	62.0	97.9	1497	7.5	697	42.0
1750–1799	3468	3228	35.7	64.1	97.1	1556	11.6	1672	28.9
1800–1849	4506	4306	37.6	67.0	98.6	1516	17.2	2790	20.0
1850–1899	5920	5802	38.2	69.2	98.2	2187	22.2	3615	19.6
1900–1929	5845	5730	40.3	72.0	92.5	2962	26.9	2768	18.6
≥ 1930	3081	2868	53.9	76.9	92.6	1258	24.6	1610	25.7
All	31176	27842	39.0	67.8	96.2	14443	17.1	13399	23.7

\* Used in analyses presented in Fig. 3. \*\* Used in analyses presented in Fig. 4-7.

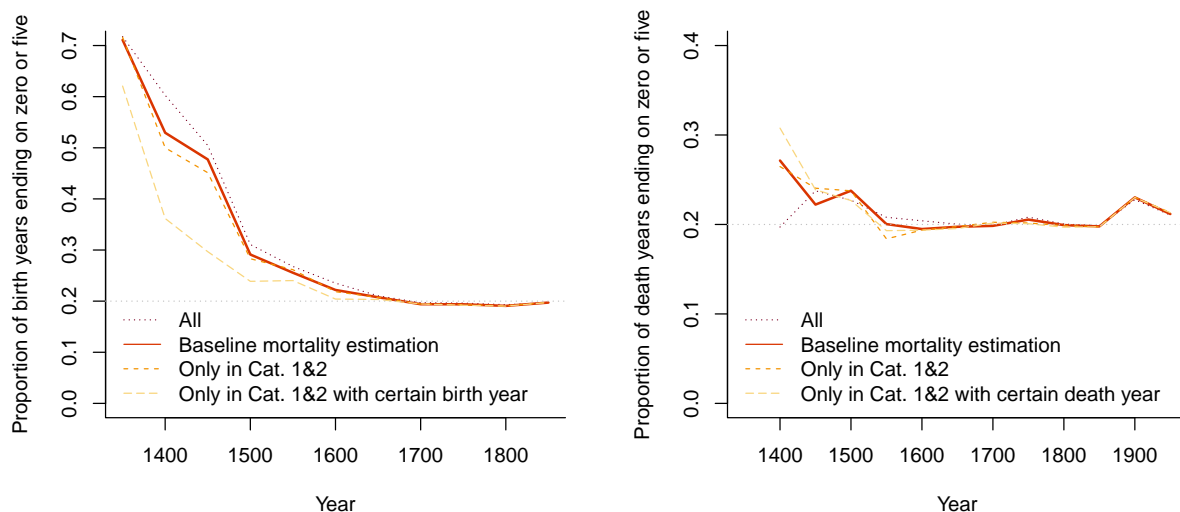
In the 1400–1700 time span, the mean age at first appointment was rather stable, at between ages 32 and 35. In the more recent period, the mean age at first appointment increased, reaching as high as age 40 in the early twentieth century. By contrast, the mean age at death followed a u-shaped pattern. Starting at around age 64 for scholars appointed in the early fifteenth century, it declined to age 59 among those who entered the dataset in the first part of the seventeenth century. The mean age at death increased to more than 70 years for scholars appointed at the onset of the twentieth century.

The population of scholars was heterogeneous along several dimensions, two of which we focus on here. First, to explore the role of medical knowledge, we 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 sciences. Second, we distinguish scholars by the scientific institutions to which they belonged. Members 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 had higher social status. Thus, we use memberships in academies as social status indicators that we can link to mortality dynamics.

Numbers for the four groups of scholars are shown in Tab. 1: scholars active only in universities, and among them those linked to the medical profession; and scholars affiliated with an academy, and among them those linked to medicine. In total, our data cover 14,443 scholars affiliated with a university only, and 13,399 scholars with an academy affiliation. While only a small percentage of scholars appointed before the seventeenth century were active in the field of medicine, this share had increased to one-quarter by the end of the follow-up.

Uncertain or unknown years of birth and death may be approximated by years ending on zero or five. While the use of this approach might reduce the share of missing values, it could cause birth and death year heaping in our data. To check the scale of the heaping, we follow the concept of the Whipple-Index (Hobbs, 2004) and compare the observed number of birth years ending on zero or five with the overall number of births in the same period. Figure 2a displays the shares of births per fifty-year period ending on zero or five. If there was no heaping, we would expect 20% of the birth years to end with zero or five. We observe that more than half of birth years ended on zero or five in the fifteenth century. However, data quality improves rather quickly thereafter: by the beginning of the seventeenth century, the share was already close to 0.2. If we restrict the sample to scholars without an uncertain year of birth, the data quality improves significantly, and becomes acceptable starting in the

fifteenth century.<sup>6</sup>



(a) Proportion of birth years ending on zero or five (b) Proportion of death years ending on zero or five

### Fig. 2. Birth and death year heaping

*All* includes all scholars with either a known year of birth or a known year of death. *Baseline mortality estimation* restricts the sample to the 27,769 scholars with known ages at appointment and at death or exit used in the estimations of life expectancy (Column 2 in Tab. 1). *Only in Cat. 1 & 2* further limits the sample to scholars with data from categories 1 (almost complete data) and 2 (partially complete data). Finally, *Only in Cat. 1 & 2 with certain death or birth year* excludes all observations with the year of birth or death marked as approximated in the sources.

We observe less year heaping for mortality data than for birth data. In previous centuries, birth data was reliably recorded for some families, like those of scholars, clergyman, or nobles; whereas the birth dates of children in ordinary families were less well-documented, or were approximated in the data sources. However, when an individual was appointed to one of our institutions, he or she likely became sufficiently important to have his or her death date recorded. Hence, the share of death years ending on zero or five is generally much closer to 0.2 (Fig. 2b). Furthermore, the observed heaping is not always due to poor data quality; e.g., the peak in 1900–1949 (Fig. 2b) is driven by the exceptionally high mortality at the end of World War II.

Significant birth year heaping and some death year heaping is found at the beginning of our observation window. Whether this heaping biases any of our results depends on whether the years are systematically adjusted upward or downward. This is difficult to evaluate

<sup>6</sup>For more detailed information, see Fig. A1–A5 in the supplementary material.

directly. As an indirect robustness check, we have replicated our analyses while excluding all individuals with a year of birth or death ending in zero or five. The results are robust to this check, see Section 3.4.

## 2.4 The Population of Scholars

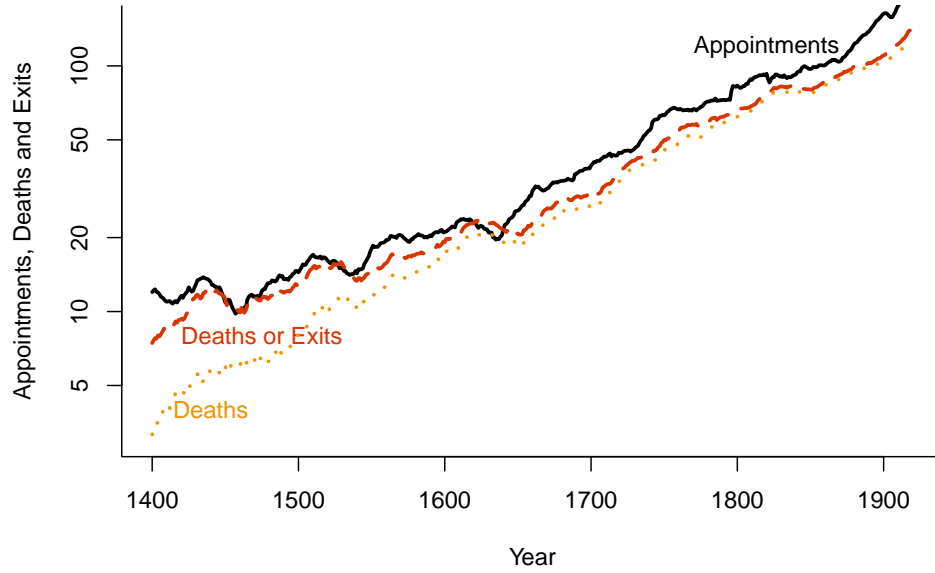
The scholars' years of first appointment and of death – or of last exit if the year of death is missing – enables us to calculate the dynamics of the total number of scholars. Figure 3a plots the 25-year moving averages of the first appointments, deaths, and deaths or exits due to censoring. The figure shows a general increasing tendency in appointments that was followed by a comparable increase in deaths.

The flows displayed in Fig. 3a are turned into stocks of scholars in Fig. 3b. This figure shows three periods marked by the trend line imposed on the total stock of scholars. First, before 1618, appointments exceeded outflows; except for very short periods in the middle of the fifteenth century. The number of scholars grew by an average of 0.5% per year, and, hence, at the same pace as the total population.<sup>7</sup> Second, around 1618, appointments started to decline and continued to decline until approximately 1648. In the 1618–1648 period, outflows exceeded appointments, and for a quarter of a century, the population of scholars decreased by around 0.6% annually. Third, the appointments bounced back starting around 1648. From that year until around 1900, appointments strongly exceeded deaths, and the population of scholars grew at an annual rate of 0.8%.

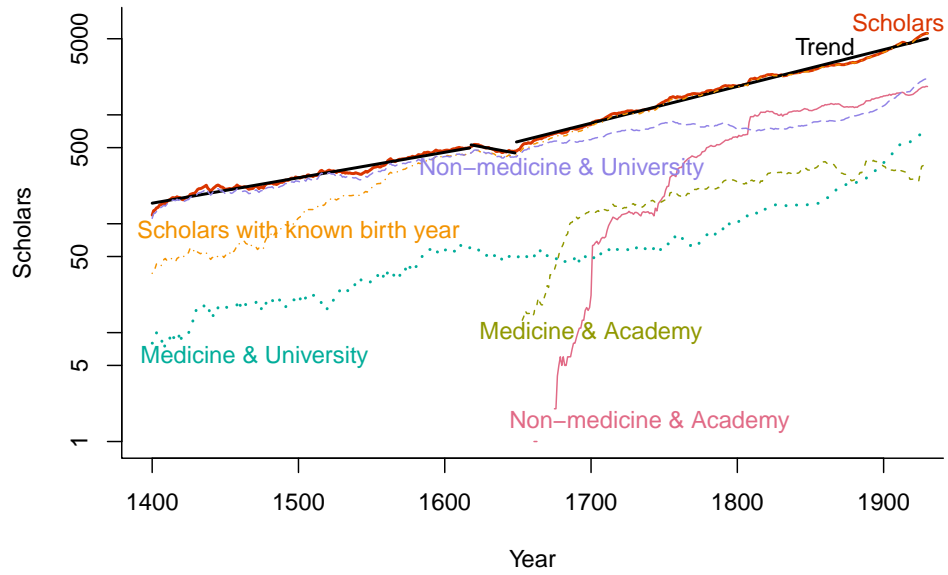
After the first academy was founded, the shares of the sample belonging to universities and academies were soon balanced. After 1800, half of the sample were active in at least one academy of sciences. However, to avoid small sample noise – and given that before the eighteenth century, the *Leopoldina* was the only academy to which scholars could be appointed – we limit our investigation of the link between social status and mortality to the periods after 1700, when the second academy was established. Before 1700, we can only compare the *Medicine & Universities* and *Non-medicine & Universities* groups. However, since Fig. 3b shows that only a few scholars were engaged in medicine before the seventeenth century, we limit our investigation of mortality dynamics to the period after 1600.

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<sup>7</sup>Pfister and Fertig (2010) documented an average growth rate of around 0.5% p.a. for the German population.



(a) 25-year moving averages in Appointments, Deaths, and Deaths or Exits



(b) The number of scholars

**Fig. 3. The dynamics in the population of scholars**

The trends we observe in the numbers of appointments and exits/deaths – and, hence, in our total population – capture different developments. First, the appointment numbers were 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 – altered the number of appointments and exits. As we lack 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 years of events is a fourth factor. Figure 3b provides some insights into the role of missing events. If 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.

## 2.5 Methods

We estimate age-specific mortality rates and life expectancy at age 30 for the population of scholars, and for the subpopulations. We use age 30 as the starting age for life expectancy because for younger ages, the sample of scholars becomes very small.<sup>8</sup> Due to the limited sample size in the early years, we first smooth the death rates over age and time (Camarda *et al.*, 2012). We then compute period life expectancy at age 30 over rolling 25-year intervals, and apply Monte Carlo simulations to estimate the corresponding confidence intervals (Chiang, 1984; Andreev and Shkolnikov, 2010). In the following, years mark the middle of the 25-year intervals. The contributions of each age to changes in life expectancy are decomposed by the stepwise replacement algorithm from Andreev and Shkolnikov (2012), which is described in Andreev *et al.* (2002).

## 3 Findings

### 3.1 Life Expectancy

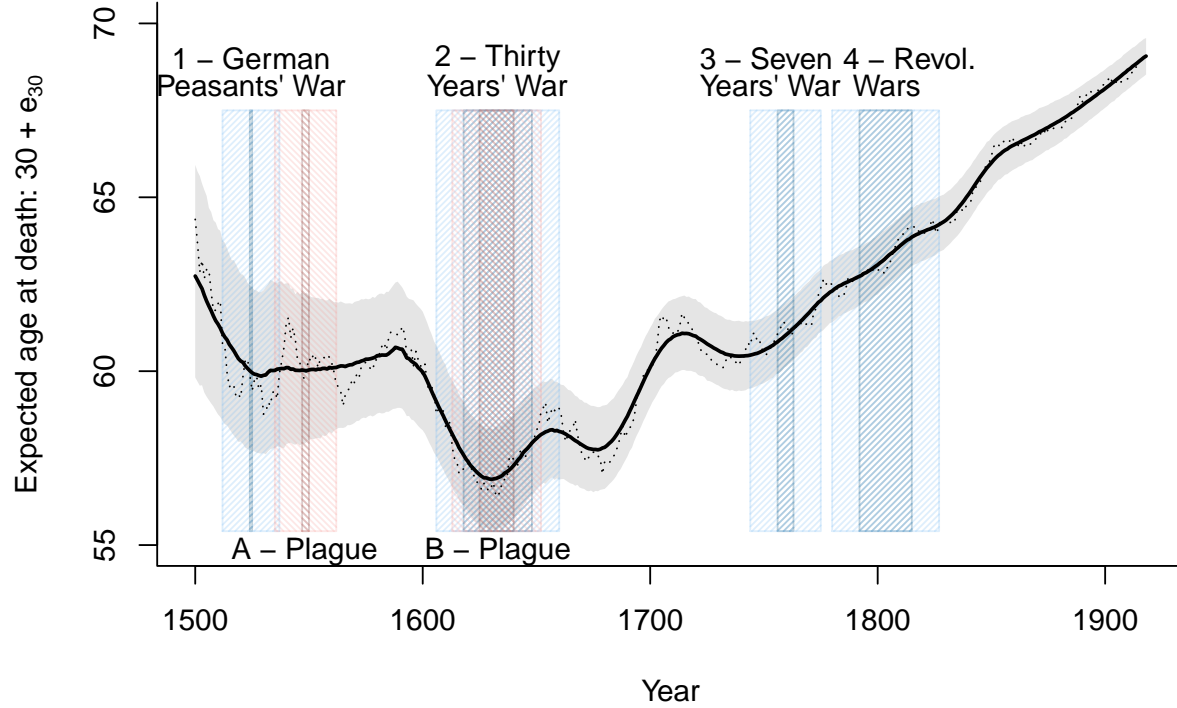
Three clear patterns emerge in life expectancy at age 30 for the population of scholars (Fig. 4). First, there was no systematic improvement in life expectancy among scholars before the middle of the eighteenth century. Second, we find evidence of a sharp decline in life

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<sup>8</sup>For a more detailed discussion, see Appendix A.3.1 in the supplementary material.



expectancy in the first half of the seventeenth century. Scholars' life expectancy at age 30 declined from more than 30 to less than 27 years. Third, we see that thereafter, a phase of steady improvements in mortality began. Between 1750 and 1900, conditional life expectancy increased by around 7.5 years.



**Fig. 4. The dynamics of scholars' period life expectancy and historical events**

Figure 4 applies 25-year rolling intervals and two-dimensional smoothed data. The solid black line displays our estimated 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. The brighter surrounding years on the left and the right of each event indicate estimated life expectancies that include years altered by the events due to the rolling intervals.

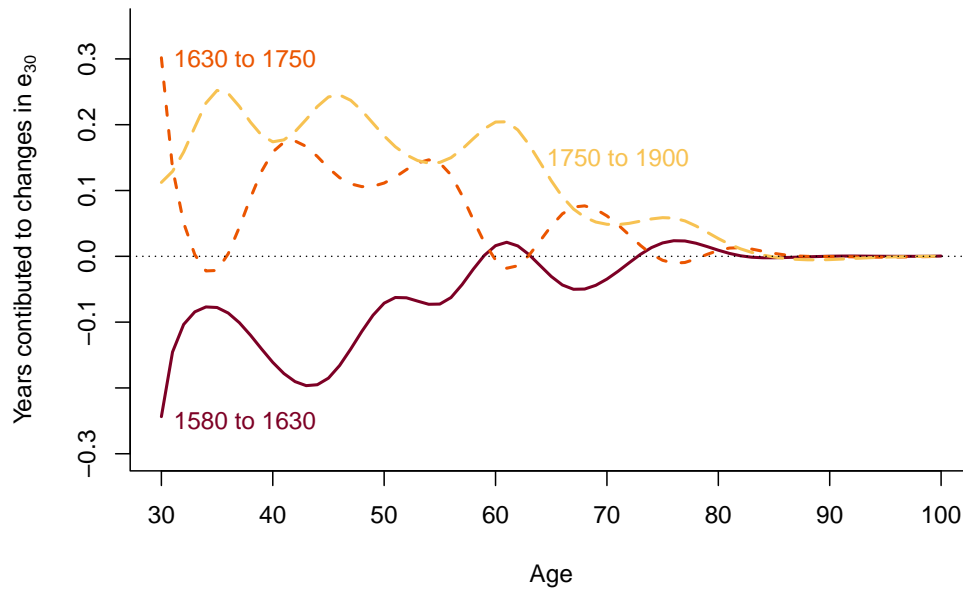
To shed light on life expectancy dynamics, we added to Fig. 4 two types of historical events that might have influenced life expectancy: wars and pandemics. We identified four military conflicts that may have affected mortality dynamics: the German Peasants' War (1), the Thirty Years' War (2), the Seven Years' War (3), and the Revolutionary Wars (4). In addition, we identified two waves of the plague (years 1547–1550 and 1625–1640) that may have influenced mortality dynamics.

In the 1500–1600 period, our point estimates for life expectancy at age 30 fluctuate strongly around the smoothed average of approximately 30 years. This period includes two important historical events that may have reduced life expectancy: the German Peasants’ War and the plague pandemic. While it is possible that these events influenced the scholars’ life expectancy, the small-sample variation and the width of the confidence intervals until around 1600 are so large that we cannot draw clear conclusions.

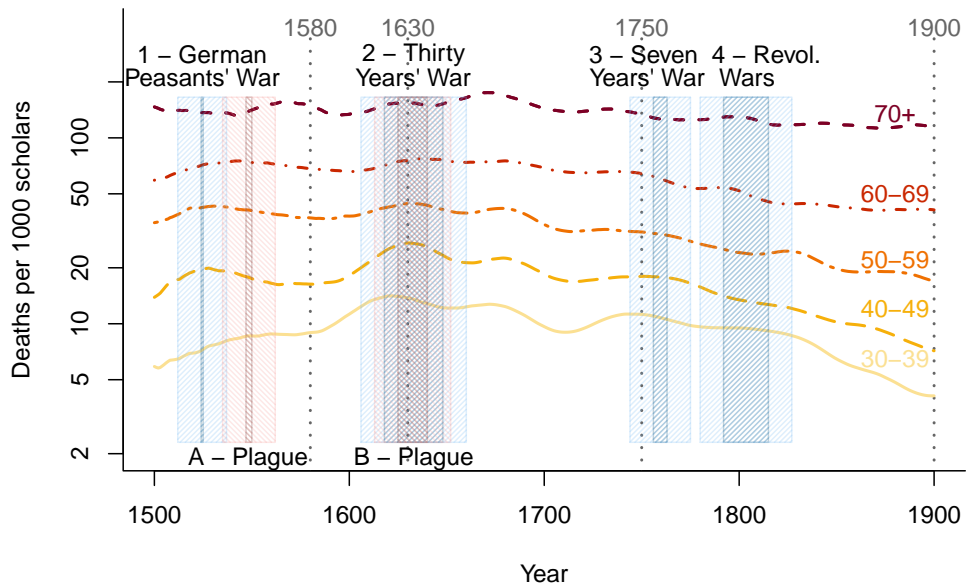
The strongest association between life expectancy and the historical events was in the early part of the seventeenth century, where we observe a sharp decline in life expectancy coinciding with both the Thirty Years’ War (1618–1648) and the second plague pandemic. It is plausible that the mortality crisis was caused by one or both of these historical events. For the Thirty Years’ War in particular, mediating effects may have been more important than the direct effects of military conflicts. Greifswald, for instance, was forced to billet more than a thousand Imperial soldiers – along with their horses and armaments – after the Duke of Pomerania surrendered in 1627. During this period, 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 string of plague epidemics that occurred between 1625 and 1640 (surface B in Fig. 4) illustrate the harsh conditions surrounding the Thirty Years’ War, and may explain the very high death rates. During the war, people suffered not only from the plague, but from famine (Alfani and Gráda, 2018). Hence, it is likely that the three famous Malthusian mechanisms – famine, epidemics, and war – combined to lower life expectancy (Flinn, 1981).

At the end of the Thirty Years’ War, life expectancy started to recover and death rates decreased, albeit with some fluctuations in the first part of the eighteenth century. Still, it took almost a century for life expectancy to return to pre-war and pre-plague levels. It should be noted that this period of declining mortality could be misinterpreted as signaling the onset of systematic mortality improvements if the time span does not include the pre-crisis period.

Figure 4 shows that systematic mortality improvements that cannot be interpreted as recovery from a crisis started around 1750. From that point onward, life expectancy increased without interruptions. Thus, no clear association between subsequent wars and life expectancy is observable.



(a) Contribution to decline (1580 to 1630), recovery (1630 to 1750), and increase (1750 to 1900) in life expectancy by age



(b) Age-specific death rates

**Fig. 5. Decomposition of gains in life expectancy.**

Figure 5 applies 25-year rolling intervals and two-dimensional smoothed data.

Figure 5a shows which ages contributed to the life expectancy changes across the three stages we identified: decline from 1580 to 1630; recovery from 1630 to 1750; and increase from 1750 to 1900. Figure 5b shows age-specific mortality trends over the whole time period. In the first stage, not all ages were equally affected by declining life expectancy. Almost all of the life expectancy losses were among people under age 60 (Fig. 5a). Older people (ages 60–69 and 70+) also experienced mortality increases during this period (Fig. 5b), but their contributions to life expectancy losses were small because so few individuals survived to these advanced ages. The decomposition also shows that people under age 60 were the main contributors to life expectancy gains in the late seventeenth and early eighteenth centuries: i.e., the increase in life expectancy was effectively driven by the same ages that drove the seventeenth-century mortality crisis. When the secular increase in longevity started in the mid-eighteenth century, people aged 60–80 joined people under age 60 in contributing to life expectancy increases (Fig. 5a). Figure 5b shows that after 1750, mortality declined fastest in the older age groups.

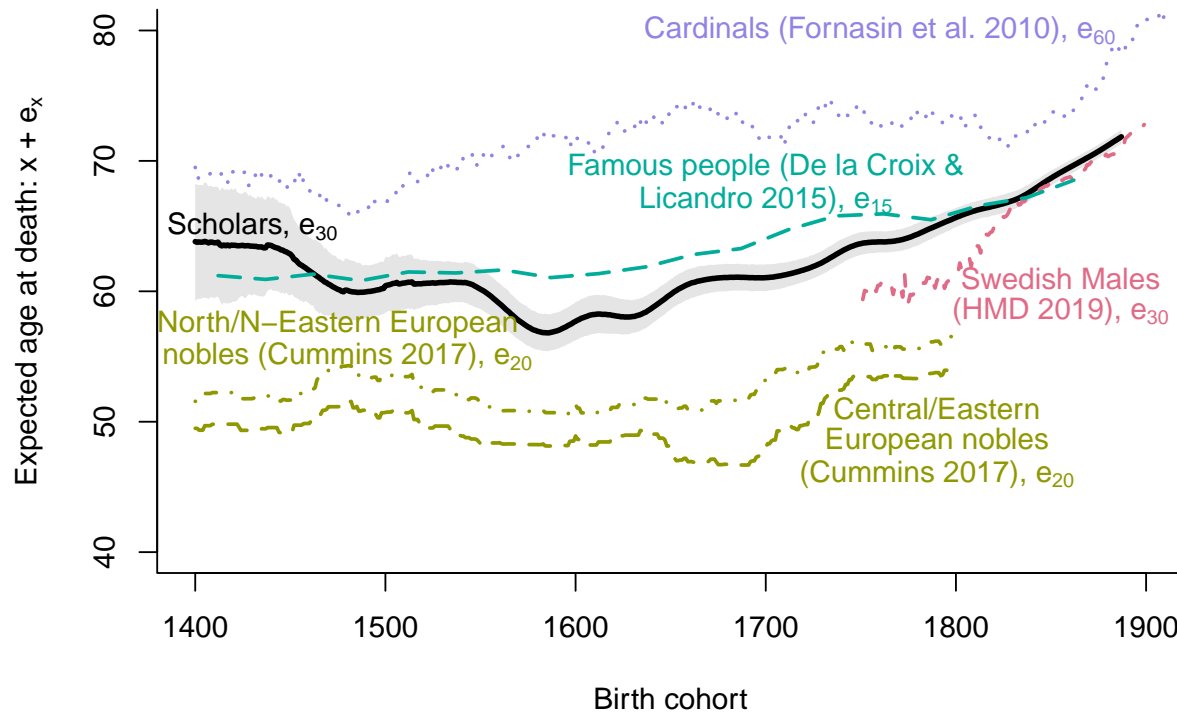
### 3.2 Comparison to Other Studies

We have presented our results by period to facilitate the analysis of *when* mortality improvements started. Many other studies have used the cohort perspective. For comparative purposes, we convert our data to the cohort perspective. The message of our cohort results is similar to that of our findings from the period perspective: i.e., cohort life expectancy did not improve between the 1400 and 1700 birth cohorts; life expectancy declined for the cohorts born in the late sixteenth century who were adults during the Thirty Years’ War and the second plague pandemic; and secular improvements in life expectancy began with the cohorts born in the eighteenth century. Figure 6 compares our cohort life expectancy estimates at age 30 to others found in the literature.

We compare our results to five other sets of findings pertaining to nobles between 1400–1800 in North and Northeastern Europe as well as Central and Eastern Europe (Cummins, 2017); famous people between 1400–1875 (de la Croix and Licandro, 2015); cardinals in 1400–1900 (Fornasin *et al.*, 2010); and Swedish life expectancy in 1751–1899 (from the Human mortality database (HMD), 2019).

We highlight two different dimensions of this comparison: trends and levels. The trends show qualitative similarities: nobles (Cummins, 2017), famous people (de la Croix and Licandro, 2015), and scholars of the HRE (this manuscript) all experienced periods of stagnation in mortality followed by sustained increases in life expectancy. However, the mortality im-

provements started earlier among famous people (1680s) and later among Sweden’s male birth cohorts (1800) and cardinals (1850s) than among scholars and nobles. More importantly, none of the other populations underwent the mortality crises observed among cohorts born at the end of the sixteenth century. Due to the differences in territorial coverage, the impact of the Thirty Years’ War is likely less important in this comparison.



**Fig. 6. The dynamics of scholars’ cohort life expectancy in light of the literature**

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

However, the studies report very different levels of life expectancy, primarily because they use different starting ages: Cummins (2017) uses age 20 and Fornasin *et al.* (2010) use age 60; while de la Croix and Licandro (2015) exclude famous individuals who died before age 15. Only the Swedish life expectancy from the HMD is based on a starting age of 30. These different starting ages lead to predictable differences in levels. It is, for example, worth considering what difference it makes that Cummins uses age 20, and therefore includes a larger share of young adult mortality. In the HMD life tables for Sweden, mean age at death conditional to surviving to age 20 for the 1800 male cohort is 56.1, and 59.2 conditional

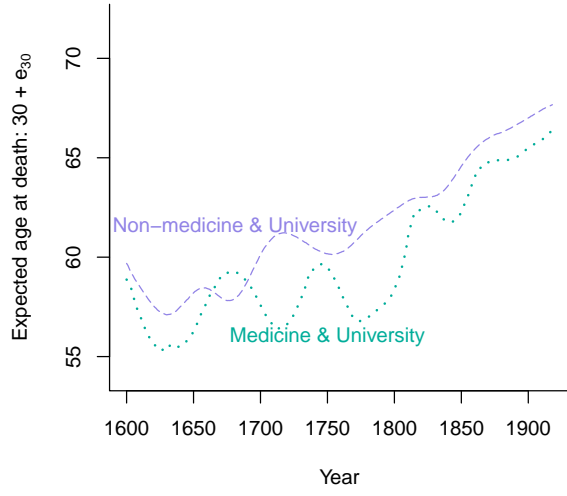
on surviving to age 30. The differences between our 1800 cohort and Cummins' nobles are 9.2 years in North and Northeastern Europe and 11.5 years in Central and Eastern Europe. Hence, these differences are larger than the 3.1 years in the HMD for Swedish cohorts. The remaining life expectancy discrepancies between scholars and nobles can be explained by the high shares of violent deaths among nobles (Cummins, 2017). The life expectancy gap between scholars and cardinals is 7.9 years in 1800, and is thus smaller than the difference based on the calculation from HMD's life tables for Swedish males (12 years). Finally, we do not observe any noteworthy systematic deviation from the unconditional mean age at death estimated by de la Croix and Licandro (2015) for famous people who survived until age 15.

### 3.3 Life Expectancy, Social Status, and Medical Knowledge

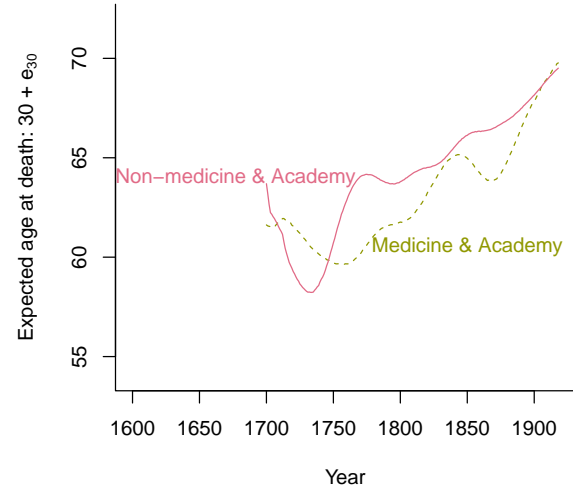
Figure 7 illustrates the mortality dynamics of scholars separated into four groups according to their field of science and membership in an academy of sciences. The figure starts in 1600 for university scholars and in 1700 for academy members, because these stratified samples would be too small for the earlier years. Panel A compares university professors who were and were not in the field of medicine. We observe no systematic mortality difference between these groups of scholars until the early to mid-eighteenth century, when life expectancy started to increase among scholars not in medicine. Mortality improvements among scholars linked to the medical field were delayed. In line with van Poppel *et al.* (2016), we find that life expectancy was lower for scholars in medicine than for other scholars for around one hundred years. However, this mortality gap decreased toward the end of the nineteenth century.

Panel B compares mortality improvements among scholars who were and were not in medicine, and who were active in academies of sciences. The pattern is similar to that observed among university scholars: starting from around 1750, scholars who were not in medicine experienced mortality declines; while those who were in medicine experienced these declines with a delay; with the gap narrowing toward the end of the nineteenth century.

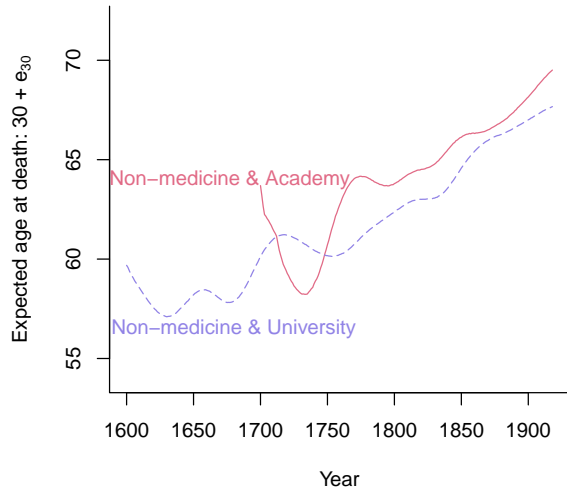
Panels C and D compare university scholars to those nominated to a scientific academy. Panel C refers to scholars outside medicine, while Panel D refers to scholars in medicine. Both panels show that around 1750, members of the academies had a higher life expectancy. This mortality advantage lasted for approximately 100 years, until 1850. Thereafter the differences fluctuated so strongly that we refrain from drawing conclusions other than that the advantage existed approximately from 1750 to 1850; and then perhaps diminished.



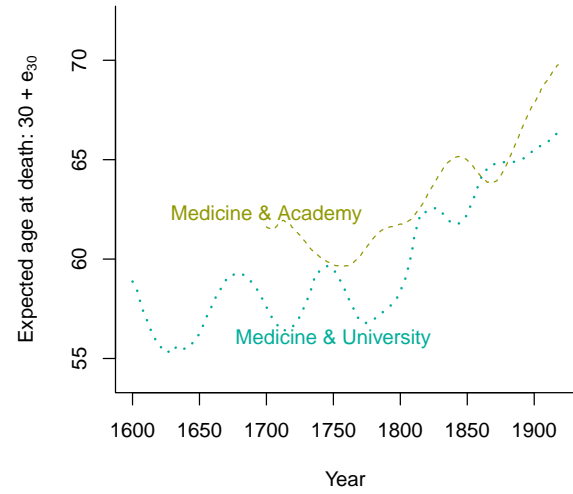
(a) Medicine and Non-medicine in Universities



(b) Medicine and Non-Medicine in Academies



(c) Non-medicine in Universities and Academies



(d) Medicine in Universities and Academies

**Fig. 7. Social status, medicine, and life expectancy**  
Figure 7 applies 25-year rolling intervals and two-dimensional smoothed data.

### 3.4 Robustness

We analyzed whether the following findings remained after data limitations: life expectancy stagnated from 1500 to 1600; the early seventeenth century was marked by a mortality crisis; secular increases started around 1750; and scholars who were outside medicine and belonged to academies of science had a mortality advantage compared to scholars who were in medicine and were not appointed to academies.

We first limited the sample to data from institutions for which we had (almost) complete data or partially complete data; these correspond to categories 1 and 2 in the classification presented in the data section. It also excludes institutions without traditional sources such as books. Second, to test the robustness with respect to birth and death year heaping, we excluded all observations with a year of birth ending on zero or five. Third, we estimated life expectancy with varying starting ages: 25, 35, 45, and 55. Our key results were robust to these tests (see Fig. A7–A10 in the supplementary material).

## 4 Discussion

We gathered data from thousands of scholars in the 1648 territories of the Holy Roman Empire and the Netherlands. By combining vital information with appointment and exit information, we were able to compute mortality dynamics, while taking into account left truncation and right censoring. Based on this novel dataset, we provide new insights into when mortality first started to decline, and which groups were the first to experience rising longevity. Our results show that adult life expectancy was stagnant from 1500 to 1750; the early seventeenth century was marked by a mortality crisis; secular increases started around 1750; and scholars outside medicine and within academies of science had a mortality advantage compared to those within medicine and not appointed to academies. These results partially corroborate and partially challenge prior findings. Furthermore, they persisted after several robustness checks were performed.

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 relative to that of ordinary scholars at universities was associated with earlier improvements in mortality. These findings are in line with the vast literature showing that social status and life expectancy are positively correlated (Johansson, 1999; Elo *et al.*, 2014; Andreev *et al.*, 2011). Importantly, we show that this difference already existed in the eighteenth century. However, our results suggest that this difference may have



been temporarily and diminished towards the end of the nineteenth century. It is possible that during this period, the comparatively elevated social status associated with being a member in a scientific academy, rather than an “ordinary” professor, might have weakened. Universities changed from being *vocational schools* to being *research institutions* following the Humboldt reform (Schimank and Winnes, 2000).

We also found that mortality improvements were delayed among medical professionals. The lack of understanding of germ theory before the nineteenth century suggests that scholars in the medical field would have faced a mortality disadvantage. However, we found no systematic disadvantage among medical professionals until the beginning of the secular longevity improvements. The limited role of formal medicine in healing is a possible explanation for this finding. 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). It is even possible that the high social status of academic medical professionals gave them a mortality advantage. 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 almost a century. Rapidly increasing medical knowledge and the diffusion of germ theory might have quickly compensated for the higher infection risks. As early as in the nineteenth century, excess mortality declined among scholars in the medical profession, regardless of whether they belonged to academies of science.

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 is consistent with the hypothesis that human capital played a significant role in the process of industrialization and the take-off to modern growth (Galor, 2011). The number of scholars and the length of their productive lives may have affected how much they were able to influence their cultural and economic environments – and, in turn, socioeconomic development and economic growth.<sup>9</sup>

The population of scholars we analyzed has the clear advantage of representing a distinct

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<sup>9</sup>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 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).

universe: i.e., individuals active at one of the defined institutions. However, our data selection also comes with limitations. First, our data referred almost exclusively to elite men (only 89 women were in the sample).

Second, as universities and academies of sciences are urban institutions, our population was also urban. Thus, these scholars were exposed to the urban mortality penalty (Vögele, 2000; Woods, 2003). As we were not able to analyze mortality among ordinary people or women, we can only speculate about the life expectancy dynamics in the general population during the era we analyzed. Our finding that the elite lost several years of life expectancy during the Thirty Years' War might suggest that the general population experienced a similar or greater mortality crisis, as it is a reasonable assumption that social status had a protective effect during wars and pandemics. The differences in the timing of secular mortality gains among the upper tail of the elite (members of the academies) and the normal elite (professors) may also suggest that in the general population, secular mortality improvements did not start before the middle or the end of the eighteenth century. However, this speculation may be wrong, as most scholars were living in urban areas. Thus, the levels and the timing of mortality improvements among scholars may have differed from those of ordinary people living in rural areas (Woods, 2003).

Third, the characteristics of the institutions and their members evolved over time. The structure of universities was quite different in the late medieval era than it was in more recent periods.<sup>10</sup> Prior to the modern era, scholars' salaries were often paid in kind (or not all). Thus, while working at a university was linked to higher social status, it often did not generate significant income advantages. Furthermore, the process of appointment – and, hence, of selection into our population – changed. The role of kinship in the appointment process was gradually replaced by scientific criteria (Vandermeersch, 2003; Klinge, 2004).

Fourth, how we defined scholars and which institutions we included are potential drivers of the estimated population size. For instance, we may have underestimated the growth in the scholar population in the nineteenth century, as we did not include universities founded later than the eighteenth century. It is also possible that scholars were active in a scientific institution before the first observed appointment. If so, we lose years at risk at earlier ages, and our life expectancy estimates are biased downwards. The academic position that defines the entry in the dataset also varies across sources.

Fifth, since the scholars were not appointed until they reached young adulthood, our investigation is limited to adult mortality. The effects of shifts in infant and child mortality on

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<sup>10</sup>We summarize some major evolutions in the characteristics of the universities and their scholars in the supplementary material.

the evolution of life expectancy are neglected.

Finally, our new dataset does not allow us to draw conclusions about the impact of social status or the medical profession on mortality. We can only identify associations.

In summary, our analysis of a new dataset covering more than 30,000 scholars provides new information on when mortality first started to decline, and on the social differentials in the first mortality gains. We find that adult mortality was stagnant or declining from the sixteenth to the seventeenth century, as wars and epidemics led to a mortality crisis that resulted in the loss of several years of adult life expectancy. However, secular life expectancy improvements started as early as in the eighteenth century, and the life expectancy of scholars associated with elite academies (rather than only being affiliated with a university) increased first, while mortality improvements were delayed for scholars in medicine. Our results provide a new perspective on the historical timing of mortality improvements, and on the socioeconomic and occupational differentials in this timing. A database accompanying our paper facilitates replication and extensions.

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Data and codes are available on OSF.

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## **A   Supplementary Material**

### **Leaders and Laggards in Life Expectancy among European Scholars from the Sixteenth to the Early Twentieth Century**

Robert Stelter, David de la Croix and Mikko Myrskylä

## A.1 Universities and Academies of Sciences

Tab. A1: Sources for Universities and Academies of Sciences

No.	University	Year	Cat.	Obs.	Wiki	RAG	Sources
<b>Universities in the Holy Roman Empire 1348–1599</b>							
1.	University of Prague	1348	2	1315	x	x	Čornejová and Fechtnerová (1986); Svatoš (1995)
2.	University of Vienna	1365	2	1508	x	x	Lackner (1976)
3.	University of Heidelberg	1386	1	1995			Drüll (1991; 2002; 2009; 2012)
4.	University of Cologne	1388	2	722	x	x	Bianco (1974)
5.	University of Erfurt	1389	3	309	x	x	
6.	University of Würzburg	1402	2	761			Walter (2010); Reindl (1966)
7.	Leipzig University	1409	1	1184			<i>Catal. Prof. Lipsiensium</i>
8.	University of Rostock	1419	1	809			<i>Catal. Prof. Rostochiensium</i>
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	725	x		
12.	University of Freiburg	1457	2	696	x		Bauer (1957); Ruth (2001); Kurrus (1977)
13.	University of Ingolstadt	1472	3	236			
14.	University of Trier	1473	4	69			
15.	University of Tübingen	1477	1	993			Conrad (1960)
16.	University of Mainz	1477	1	974			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	1634			<i>Marburger Prof.-katalog</i> Auerbach and Gundlach (1979); Gundlach and Auerbach (1927)
20.	University of Strasbourg	1538	2	531			Berger-Levrault (1890)
21.	University of Dillingen	1553	3	137	x		
22.	University of Jena	1558	2	625			Günther (1858)
23.	University of Douai	1559	3	63			
24.	University of Eichstätt	1564	4	13			
25.	University of Olomouc	1573	3	303	x		
26.	University of Linz	1574	4	14			
28.	University of Helmstedt	1576	1	294			<i>Prof.-katalog Helmstedt</i>
29.	University of Herborn	1584	4	12			
30.	University of Graz	1585	2	531	x		Krones (1886)

Column *Cat.* contains the quality of data source: 1 almost complete data, 2 partially complete data, 3 non-complete data, and 4 scattered data. Column *Obs.* indicates the number of observations, and *Wiki* indicates whether at least some of the observations were found by means of Wikipedia. *RAG* refers to data from the *Repertorium Academicum Germanicum*. Appendix A.5 provides an overview of the links to online professor catalogs that were included.

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

No.	University	Year	Cat.	Obs.	Wiki	RAG	Sources
<b>Universities in the Holy Roman Empire 1600–1799</b>							
32.	University of Gießen	1607	1	1057			Rehmann (2006); Haupt and Lehnert (2006)
33.	University of Stadthagen	1610	1	2**			Hänsel (1971)
35.	University of Paderborn	1614	4	43			
36.	University of Molsheim	1618	2	48*			Berger-Levrault (1890)
37.	University of Rinteln	1621	1	172			Hänsel (1971)
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	426			<i>Bamberger Professorinnen- und Professorenkatalog</i>
47.	University of Duisburg	1655	4	15			
48.	University of Kiel	1665	1	1373			<i>Kieler Gelehrtenverzeichnis</i> 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	1040			<i>Catal. Prof. Halensis</i>
52.	University of Breslau	1702	4	177			
53.	University of Göttingen	1734	1	1744			Ebel (1962)
54.	Theol. fac. Fulda	1734	4	58			
55.	University Erlangen-N.	1743	1	733			Wedel-Schaper and Wittern (1993); Ley (1999); Wachter (2009)
56.	TU Braunschweig	1745	1	520			Gundler (1991); Albrecht (1986)
57.	University of Bützow	1760	3	32	x		
58.	TU Freiberg	1765	1	110			Schleiff <i>et al.</i> (2015)
59.	TU Berlin	1770	4	7			
60.	University of Münster	1771	4	103			
61.	TU Clausthal	1775	1	147	x		Müller (1999); Valentiner (1925)
62.	University of Bonn	1777	2	607			Wenig (1968)
63.	Karl's High School Stuttgart	1781	3	37	x		
<b>Universities in the Netherlands</b>							
27.	Leiden University	1575	1	682			<i>Leidse Hoogleraren vanaf 1575</i>
31.	University of Franeker	1585	2	151	x		Napjus and Lindeboom (1985); Feenstra <i>et al.</i> (2003)
34.	University of Groningen	1614	1	443			<i>C. P. Academiae Groninganae</i>
41.	University of Amsterdam	1632	1	553			<i>Album Academicum</i>
43.	Utrecht University	1636	1	491			<i>C. P. Academiae Rheno-Traiectinae</i>
45.	University of Harderwijk	1648	1	130	x		van Epen (1904)
46.	University of Nijmegen	1655	3	21	x		

Column *Cat.* contains the quality of data source: 1 almost complete data, 2 partially complete data, 3 non-complete data, and 4 scattered data. Column *Obs.* indicates the number of observations, and *Wiki* indicates whether at least some of the observations were found by means of Wikipedia. *RAG* refers to data from the *Repertorium Academicum Germanicum*. Appendix A.5 provides an overview of the links to online professor catalogs that were included.

No.	Academy	Year	Cat.	Obs.	Wiki	Reg.	Sources
<b>Academies of sciences</b>							
64.	Leopoldina	1652	1	4886		x	
65.	Berlin-Brandenburg (BBAW)	1700	1	2449		x	
66.	Göttingen (AdW)	1751	1	1849			Krahnke (2001)
67.	Erfurt	1752	1	1968			Kiefer (2004)
68.	München (BADW)	1759	1	2568		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	

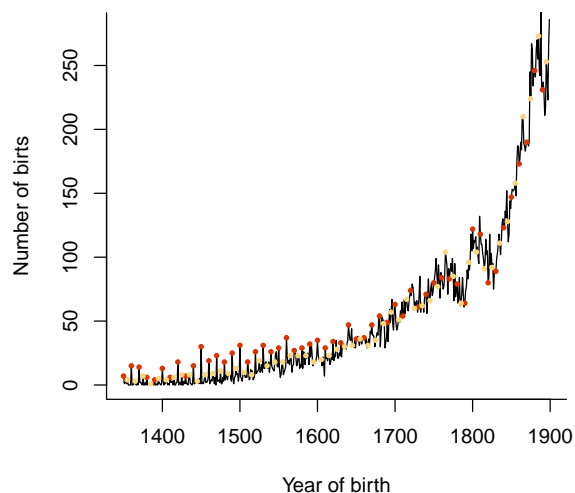
Column *Cat.* contains the quality of data source: 1 almost complete data, 2 partially complete data, 3 non-complete data, and 4 scattered data. Column *Obs.* indicates the number of observations, and *Wiki* indicates whether at least some of the observations were found by means of Wikipedia. *Reg.* refers to sources from official registers provided by the academy.

## A.2 Additional Material on the Data Quality

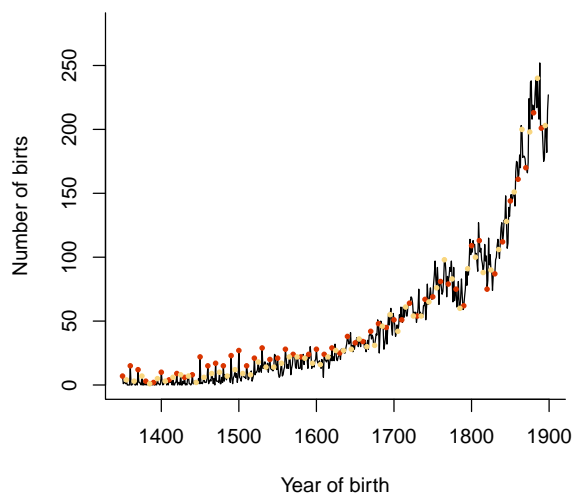
The presentation of histograms (see Fig. A1–A4) and the shares of birth and death years ending on zero or five (see Fig. A5) are only two options for evaluating the quality of the data. The calculation of an adjusted Whipple-Index (Hobbs, 2004) is another option, and it also relates the birth or death years ending on zero or five to the overall number of births or deaths in the period. The index takes values between zero and 500. The index is 500 if all observations end with zero or five, and is 100 if the observations are uniformly distributed. Provided the index is lower than 105, heaping in the year of birth or death is considered low, and the data quality is considered high. Index values of 105–110 indicate that the data are relatively accurate, while index values of 110–125 suggest the data are fairly okay. The data quality can be considered poor at index values of 125–175, and very poor at index values exceeding 175.

Findings in Tab. A2 support the observations from Fig. 2. Already at the beginning of the sixteenth century, the quality of the birth year data is fairly okay. As soon as we only include observations with a year of birth that is not marked as “around”, “approximated” and so on in the sources of our database, the data quality of early observations improves, and is already fairly okay in the second half of the sixteenth century. The adjusted Whipple-Index values on death year heaping show that the data quality is at least fairly okay already from the

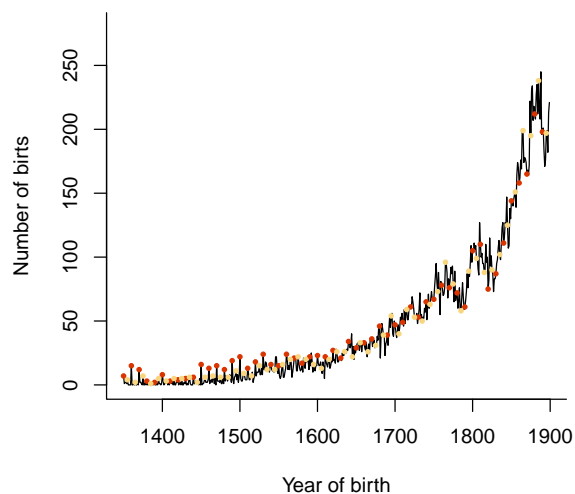
beginning of the fourteenth century in the overall sample. However, as soon as we limit the data to the observations from the baseline mortality estimation, the index does not exceed 125 fifty years later.



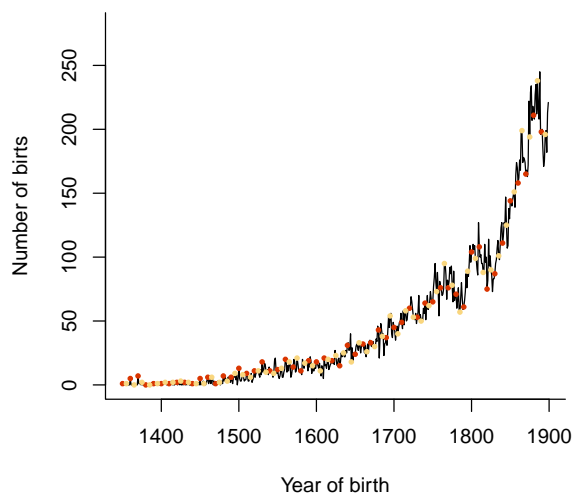
(a) All scholars with known birth year



(b) Scholars in the baseline mortality estimation

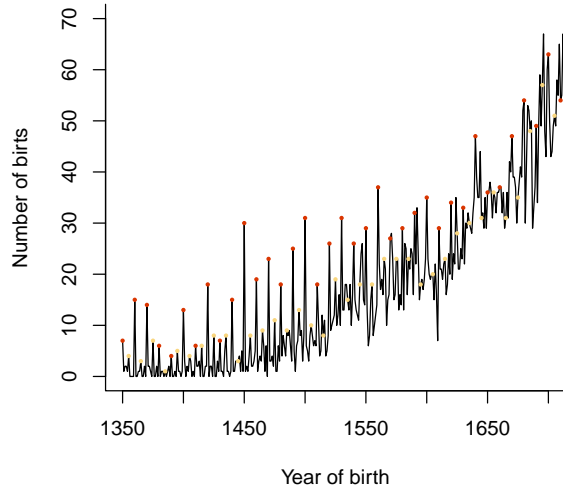


(c) Scholars from sources in Cat. 1 & 2

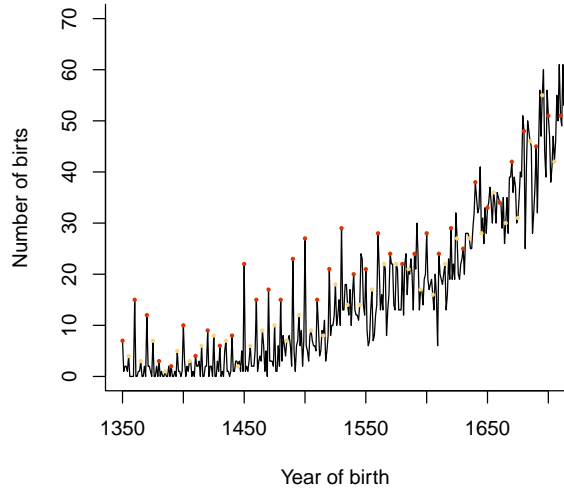


(d) Scholars from sources in Cat. 1 & 2 with certain year of birth

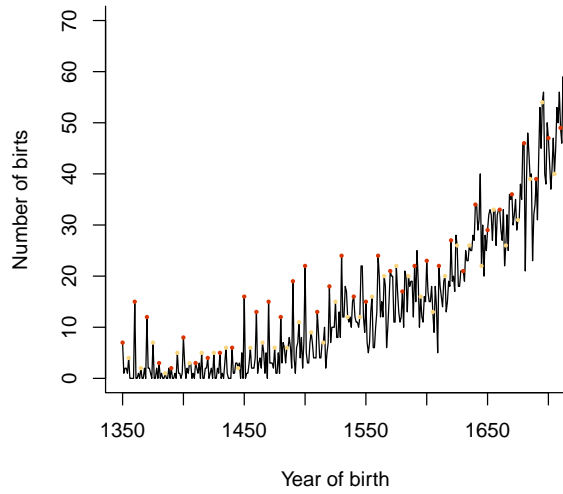
**Fig. A1. Number of observations by birth year**



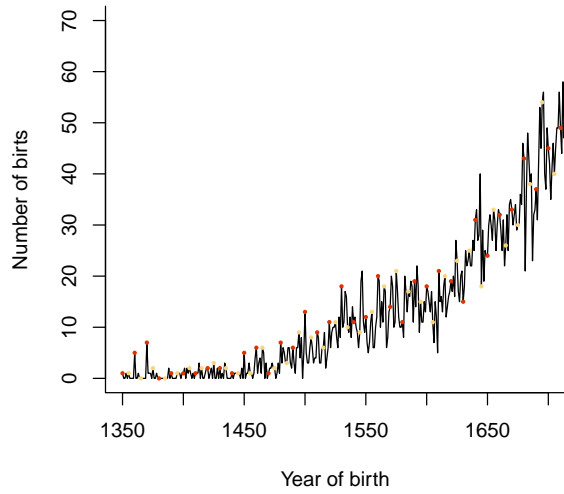
(a) All scholars with known birth year



(b) Scholars in the baseline mortality estimation

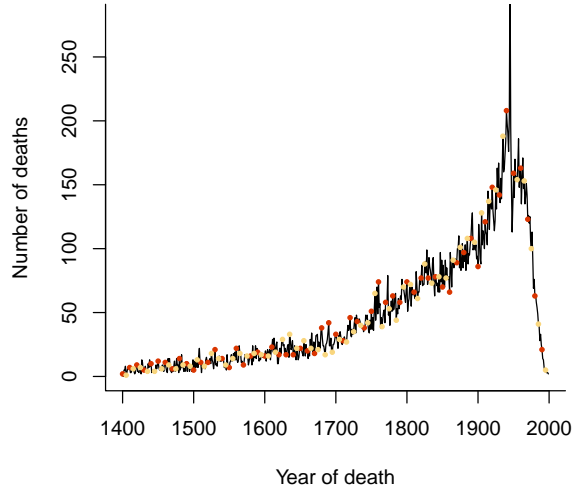


(c) Scholars from sources in Cat. 1 & 2

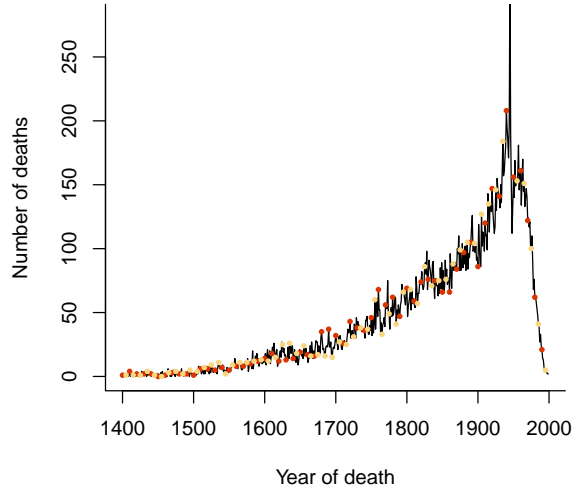


(d) Scholars from sources in Cat. 1 & 2 with certain year of birth

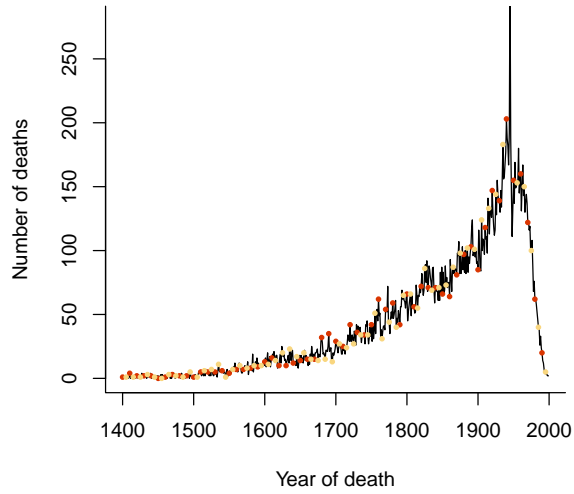
**Fig. A2. Number of observations by birth year until 1700**



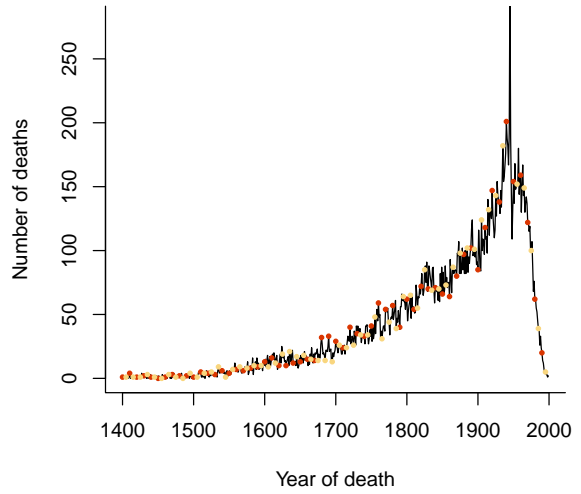
(a) All scholars with known death year



(b) Scholars in the baseline mortality estimation



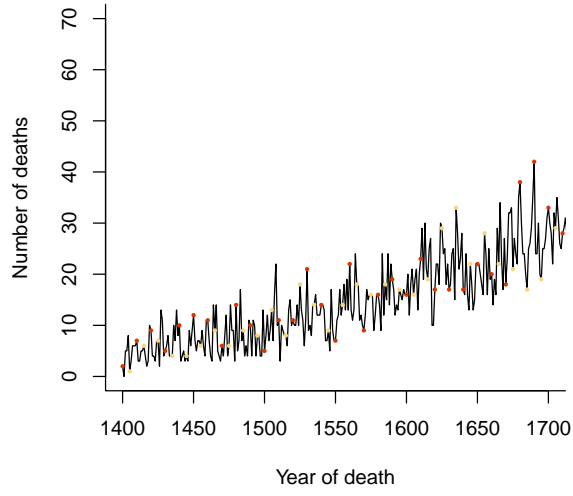
(c) Scholars from sources in Cat. 1 & 2



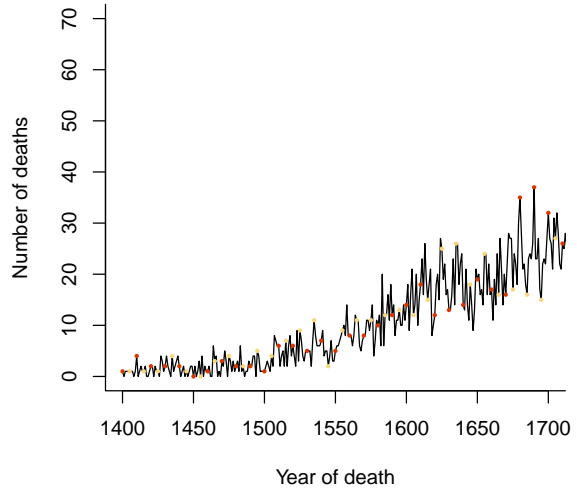
(d) Scholars from sources in Cat. 1 & 2 with certain year of death

**Fig. A3. Number of observations by death year**

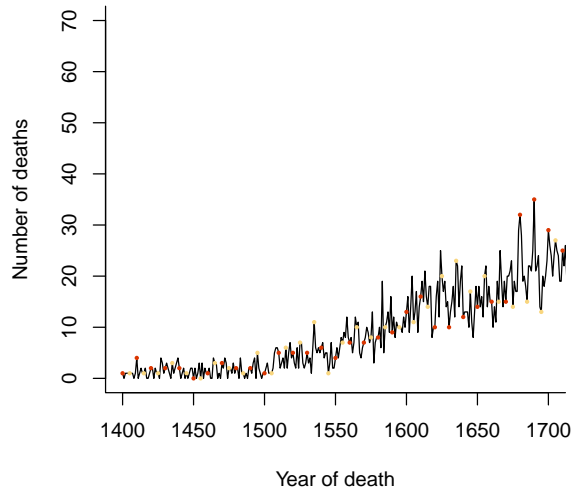




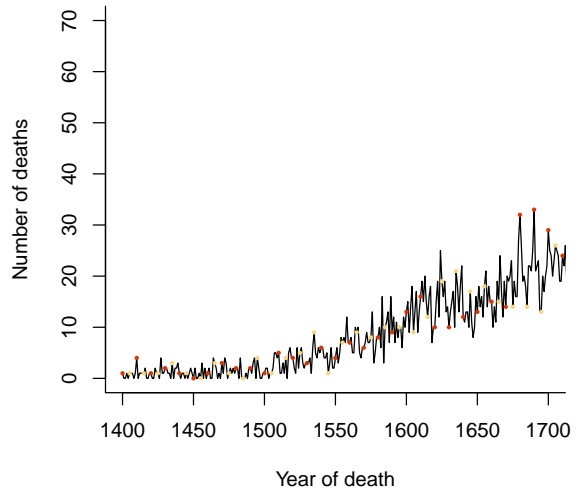
(a) All scholars with known death year



(b) Scholars in the baseline mortality estimation

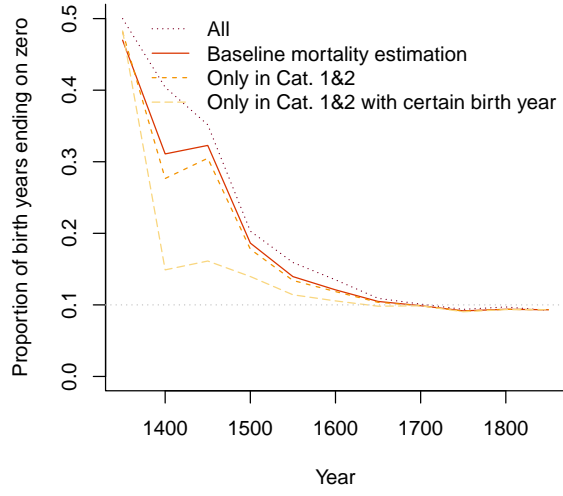


(c) Scholars from sources in Cat. 1 & 2

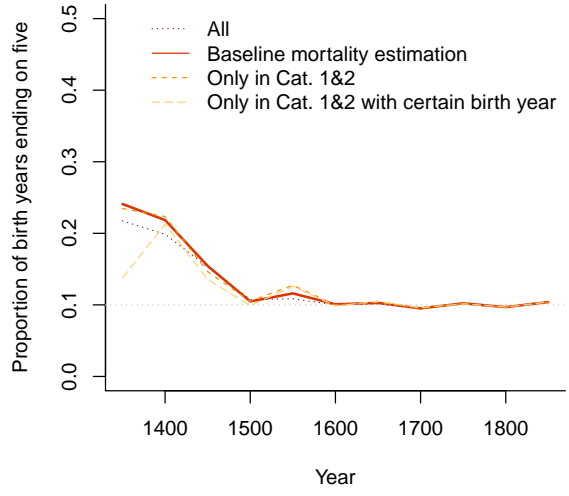


(d) Scholars from sources in Cat. 1 & 2 with certain year of death

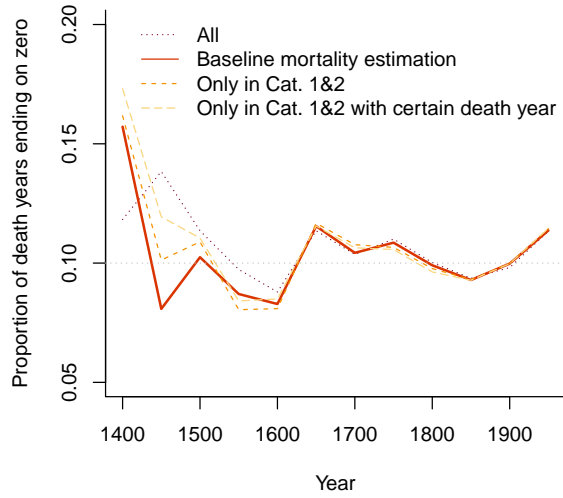
**Fig. A4. Number of observations by death year until 1700**



(a) Proportion of birth years ending on zero



(b) Proportion of birth years ending on five



(c) Proportion of death years ending on zero



(d) Proportion of death years ending on five

**Fig. A5. Birth and death years ending on zero or five in the population of scholars**

Tab. A2: Adjusted Whipple-Index to measure birth and death year heaping

Period	Birth year heaping						Death year heaping					
	All		With year of birth, nom. & death or exit		With certain year of birth		All		With year of birth, nom. & death or exit		With certain year of birth	
	All cat.	Cat. 1&2	All cat.	Cat. 1&2	All cat.	Cat. 1&2	All cat.	Cat. 1&2	All cat.	Cat. 1&2	All cat.	Cat. 1&2
1348–1397	324.2	325.8	313.3	314.8	293.1	293.1	204.5	204.5	272.7	272.7	250.0	250.0
1398–1447	312.1	295.5	280.2	266.3	196.4	184.8	100.4	95.3	146.2	142.9	170.0	166.7
1448–1497	256.2	235.0	244.6	234.4	157.0	153.3	119.4	122.4	111.1	118.8	107.6	119.4
1498–1547	159.8	150.7	152.7	146.6	127.0	123.8	113.3	109.9	120.3	118.7	115.4	115.4
1548–1597	135.7	139.3	133.8	137.1	117.8	123.3	106.4	103.5	102.6	94.7	107.1	99.5
1598–1647	119.6	116.1	116.0	113.7	105.8	104.4	102.5	102.7	98.5	98.0	95.4	97.3
1648–1697	107.3	106.6	106.1	106.1	102.3	103.6	101.9	102.5	101.3	101.3	100.2	100.6
1698–1747	99.7	99.9	98.8	99.2	97.8	98.7	100.8	102.9	100.2	102.5	100.3	102.0
1748–1797	100.0	99.5	99.5	99.1	98.3	98.1	105.8	104.2	103.8	101.7	103.3	101.3
1798–1847	97.6	97.6	96.8	97.0	96.3	96.5	101.3	100.7	100.5	100.2	99.9	99.5
1848–1897	101.0	101.1	100.4	100.5	100.2	100.4	99.7	99.6	99.4	99.3	99.1	99.2
1898–1947							114.8	115.0	116.2	116.3	116.0	116.1
1948–1997							100.0	100.7	100.5	101.2	100.5	101.2

A Whipple-Index smaller than 105 indicates very high data quality (dark green). The data are relatively accurate in a range of 105–110 (light green); fairly okay in a range of 110–125 (yellow), poor in a range of 125–175 (orange), and very poor if the values exceed 175 (red).

## A.3 Life Expectancy

### A.3.1 Life Expectancy and the Conditional Age

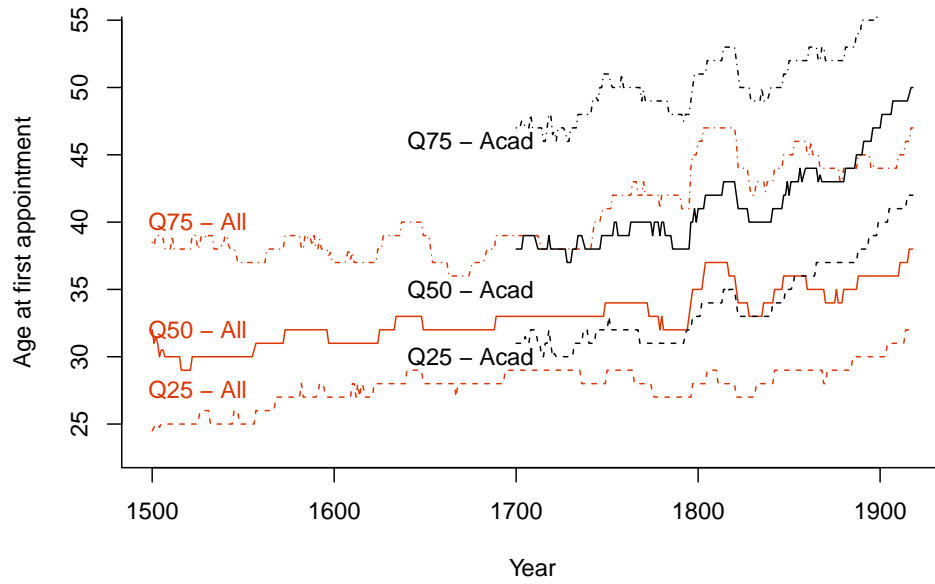
Even if we observe first appointments below age 20, a sufficiently large population at risk is required to obtain convincing estimations of life expectancy  $E_{x,t}$  conditional to the corresponding ages  $x$  at time  $t$ . Using 25-year rolling intervals, Fig. A6a illustrates the increasing first appointment 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 appointments were made 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 appointment 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 *et al.* (2010) and Andreev *et al.* (2011) – we find that the average appointment age of scholars was rather low and stable, which allows us to end our analysis at younger ages.

As in all periods except the early twentieth century at least 25% of all first appointments occurred before age 30, we have decided to fix the initial age for life table calculations at age 30. Furthermore, adding the median, the 25%-quantile, and the 75%-quantile age at death in Fig. A6b 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 appointment is between 24 and 35 years. In the subsample of scholars in scientific academies, the median ages at death and at first appointment are even higher, although the difference is greater for the age of appointment.

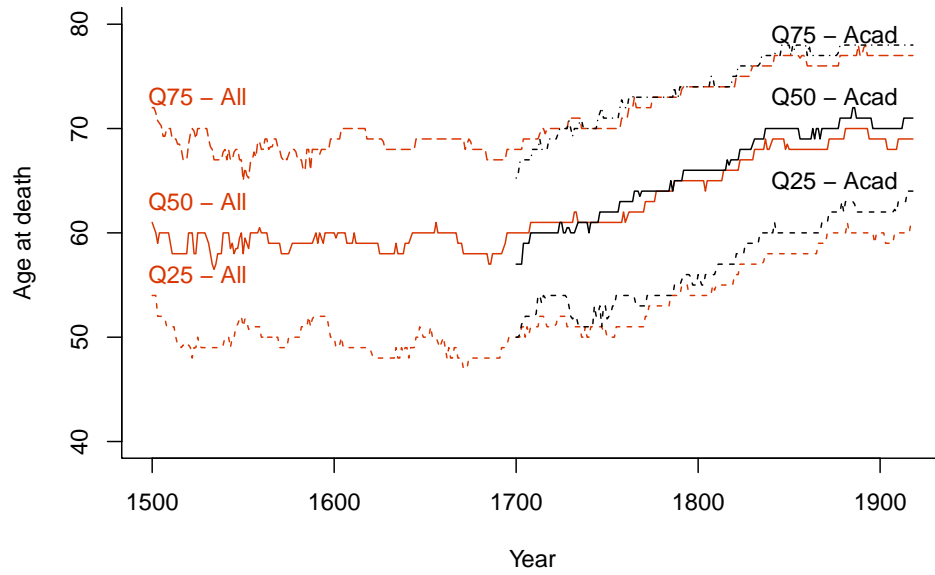
An alternative approach for determining the optimal  $x$  relates the difference between upper and lower 95% confidence intervals,  $CI_{x,t}^{\text{low}}$  and  $CI_{x,t}^{\text{high}}$ , to the corresponding life expectancy  $E_{x,t}$  and, then computes the age that minimizes this value:

$$\operatorname{argmin}_x \left\{ \frac{1}{T} \sum_t \frac{CI_{x,t}^{\text{high}} - CI_{x,t}^{\text{low}}}{E_{x,t}} \right\}, \quad (1)$$

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 1875–1899. 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.

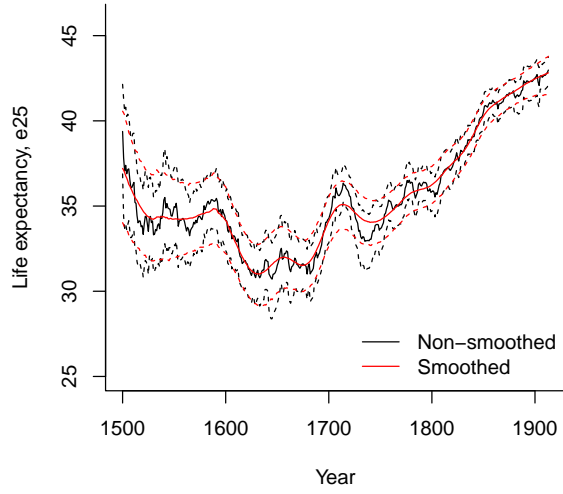


(a) Age at first appointment

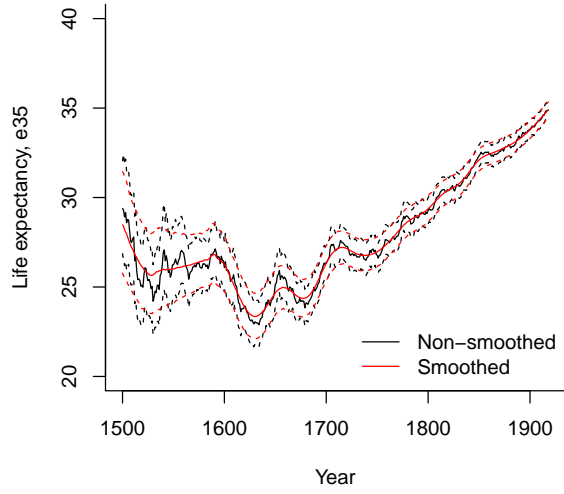


(b) Age at death

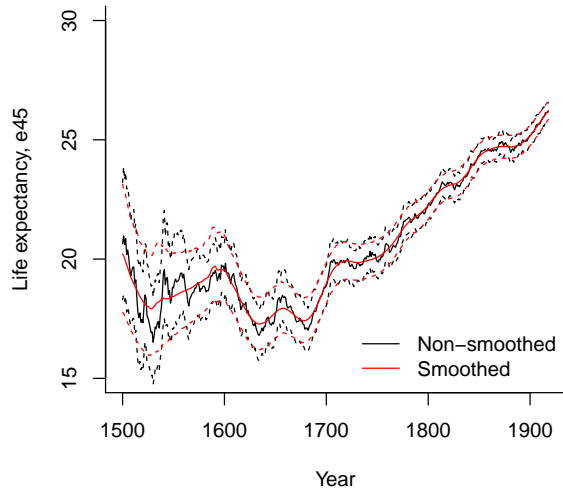
**Fig. A6.** The dynamics of age at appointment and age at death in 25-year rolling intervals



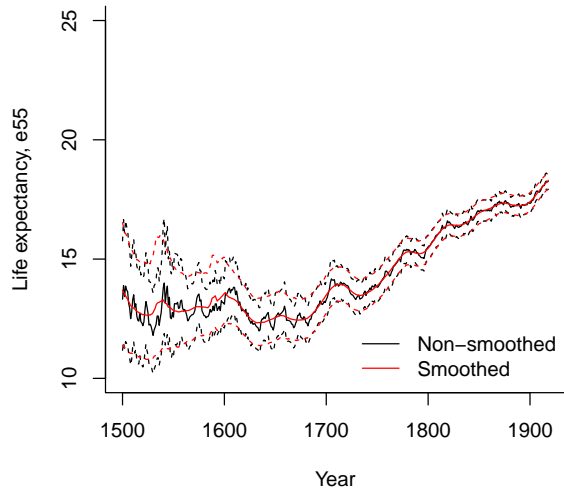
(a) Life expectancy at age 25



(b) Life expectancy at age 35



(c) Life expectancy at age 45



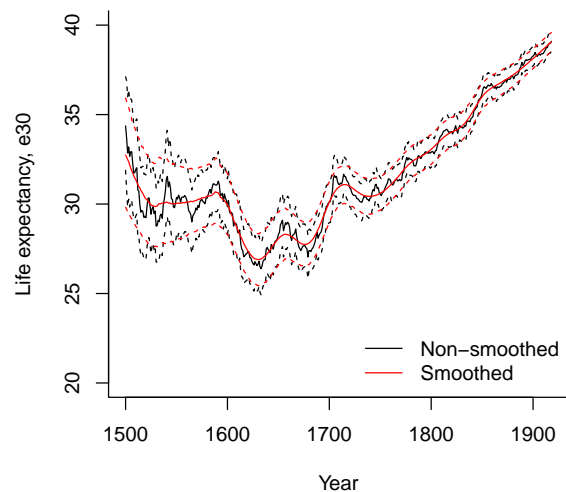
(d) Life expectancy at age 55

**Fig. A7. Dynamics of life expectancy at various ages**

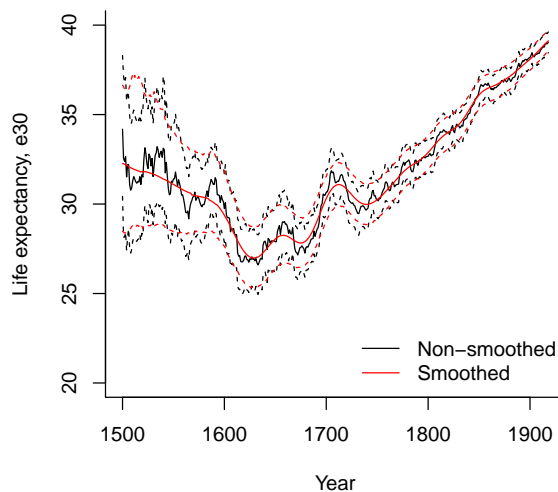
Figure A7 applies 25-year rolling intervals and two-dimensional smoothed data. Dashed lines mark 95% confidence intervals.

In addition to the baseline age 30, which is presented from the period perspective in Section 3.1 and from the cohort perspective in Section 3.2, Fig. A7 illustrates the mortality dynamics for life expectancy conditional to ages 25, 35, 45, and 55.

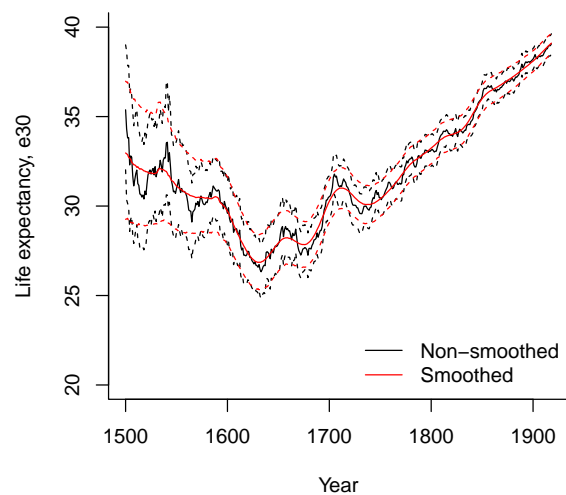
### A.3.2 Additional Figures on the Robustness of Life Expectancy Dynamics



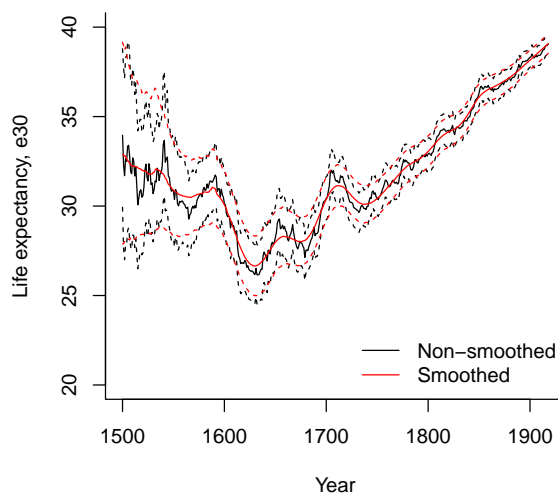
(a) Baseline estimation



(b) Estimation including only observations with certain birth year



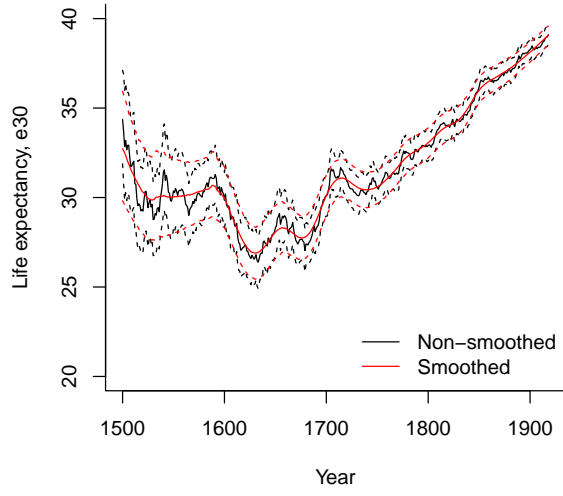
(c) Estimation including only observations in Cat. 1 & 2



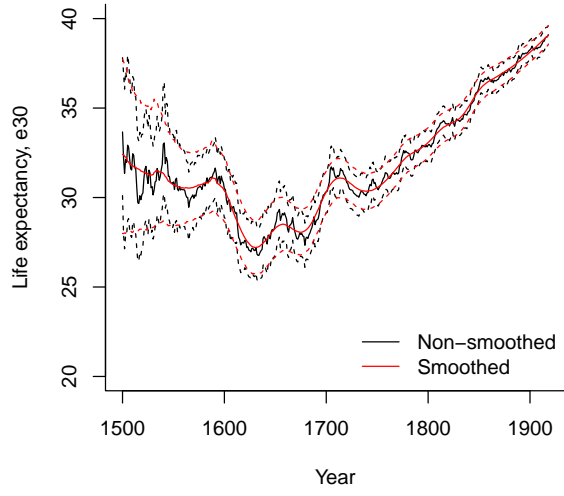
(d) Estimation including only observations in Cat. 1 & 2 with certain birth year

**Fig. A8. Dynamics of life expectancy according to the data quality**

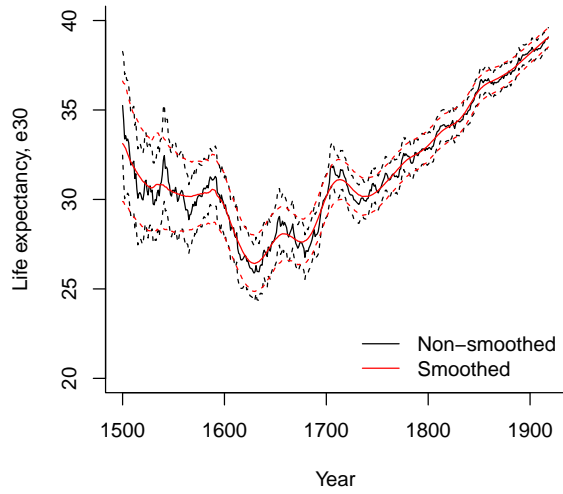
Figure A8 applies 25-year rolling intervals and two-dimensional smoothed data. Dashed lines mark 95% confidence intervals.



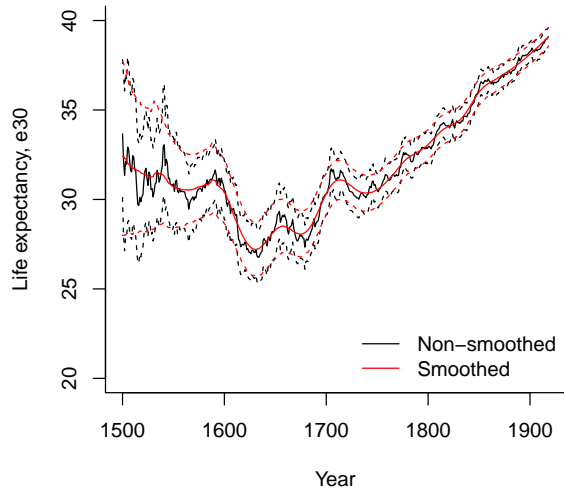
(a) Baseline estimation



(b) Estimation without birth years ending on zero



(c) Estimation without birth years ending on five

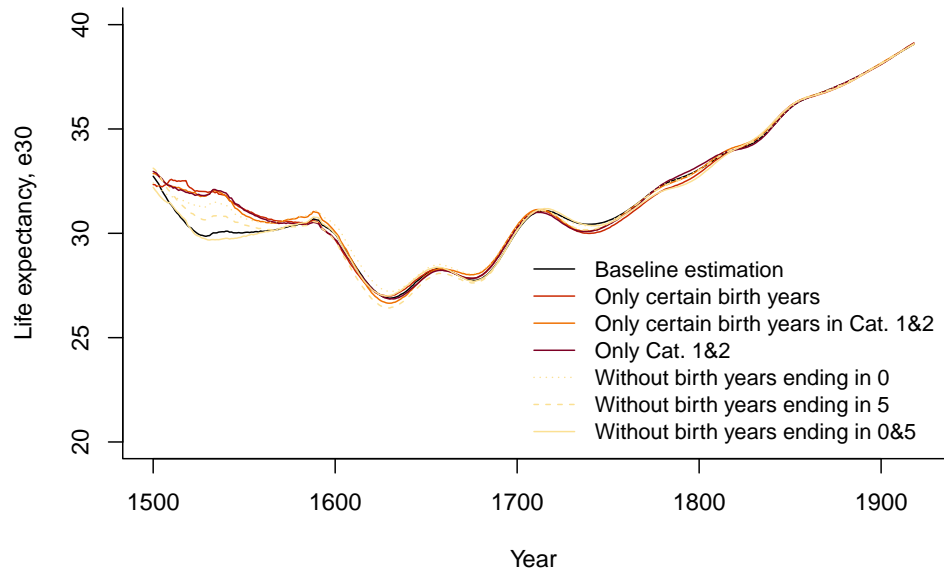


(d) Estimation without birth years ending on zero and five

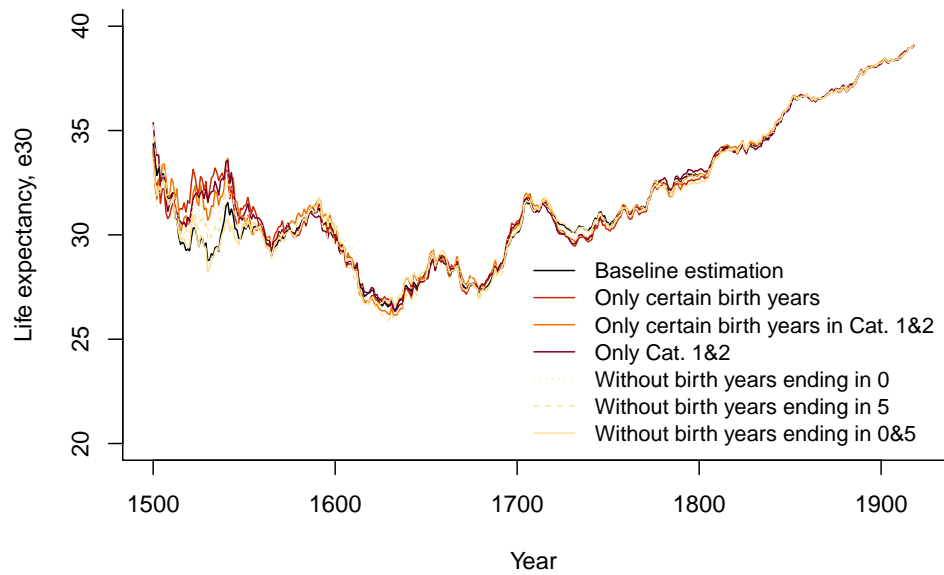
**Fig. A9. Dynamics of life expectancy excluding potential birth year heaping**

Figure A9 applies 25-year rolling intervals and two-dimensional smoothed data. Dashed lines mark 95% confidence intervals.





(a) Smoothed life expectancy

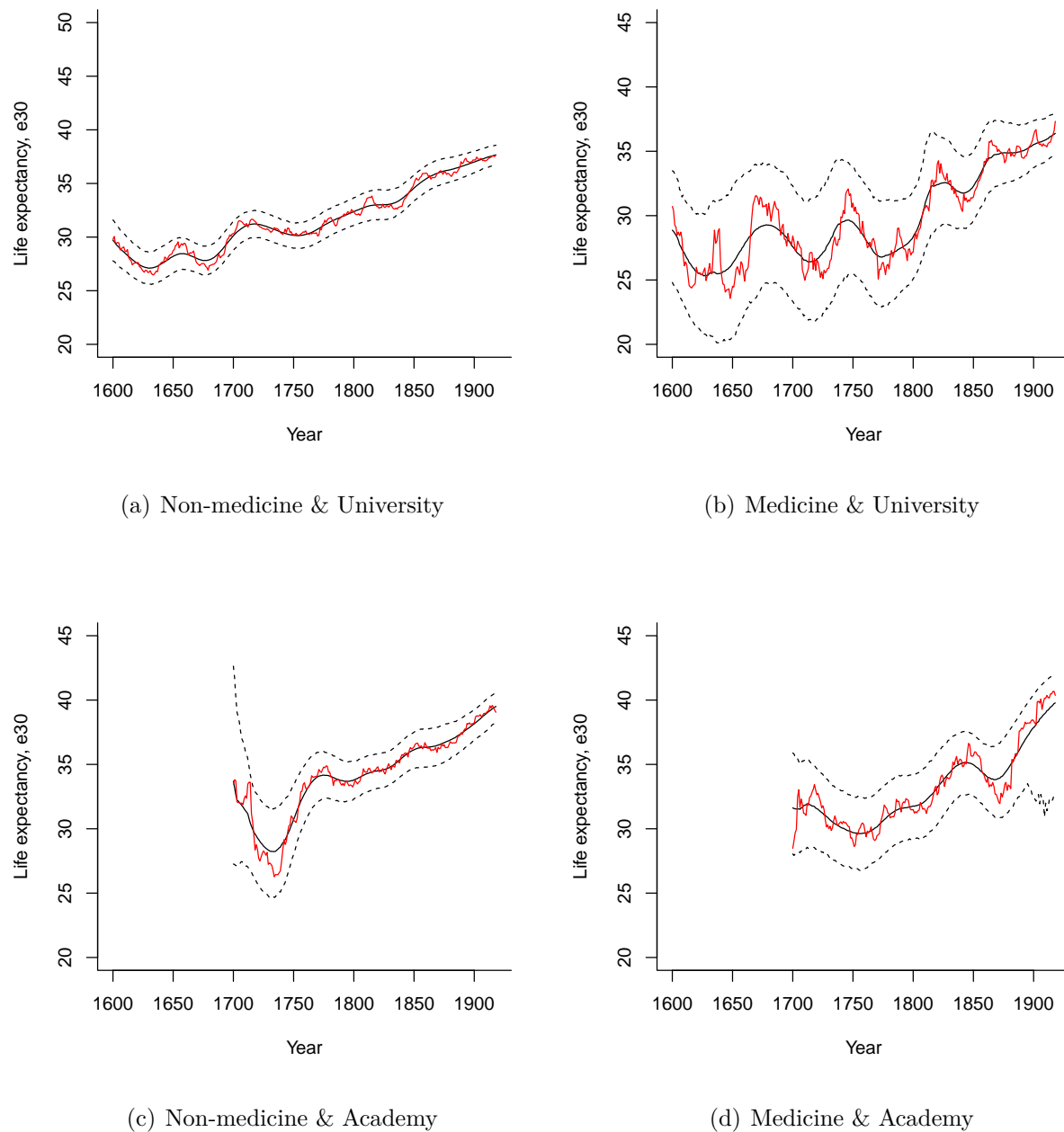


(b) Non-smoothed life expectancy

**Fig. A10. Summary of life expectancy at age 30 according to data quality**

Figure A10 applies 25-year rolling intervals and two-dimensional smoothed data.

### A.3.3 Additional Figures on Medicine, Academies, and Life Expectancy



**Fig. A11. Dynamics of life expectancy according to social status and field of science**

Figure A11 applies 25-year rolling intervals and two-dimensional smoothed data. Dashed lines mark 95% confidence intervals.

## A.4 A Brief History of Universities

The characteristics of our institutions and their members evolved over time. At the very beginning of our study period, in the late medieval age, the structure of universities differed considerably from that of modern institutions, which had consequences for the income and social status of scholars. The characteristics of scholars evolved accordingly.

A typical full university had a lower faculty of Arts and three higher faculties: Medicine, Theology, and Law. Scholars in the higher faculties also had higher incomes. While universities were rather independent at that time, it was common for teachers at the theological faculty to belong to a religious order. Academic titles mainly signaled that a person was a master in his field, and was linked to prestige and high social status. However, the incomes of scholars were generally rather low (Verger, 2003).

Until the end of the eighteenth century, a variety of positions, such as ordinary and extraordinary professors, doctors, and lectors, existed. These positions came with different obligations and responsibilities, and with different privileges and salaries. While all scholars enjoyed a variety of privileges – such as a special jurisdiction, tax and dress privileges, or the right to carry weapons – they lost much of their medieval freedom. Salaries remained generally low, and were often not paid regularly. Thus, it was quite common for scholars from higher faculties to work in the profession they taught. Scholars from lower faculties often held positions at schools. Incomes and privileges varied across universities. Moreover, a doctoral degree was not always required for academic positions, and the obligation to publish varied considerably. Appointments driven by kinship were rather common at universities like 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 emergence 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 regularly. Thus, working at a university became a full-time job. The introduction of scientific standards in the process of appointments gradually reduced the role of kinship. However, kinship was still important at several universities, such as the University of Kiel. Thus, it was a period of social change toward the emergence of an academic elite. Scholars were envisioning themselves as scientists. Privileges and the role of professor dynasties declined, while the social status of tenured professors increased (Klinge, 2004; McClelland, 1988).

## A.5 Online Professor Catalogs

**Tab. A3: Overview of the professor catalogs available online and used**

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

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