The Low Mortality of a Learned Society

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Abstract

This study addresses the mortality of the members of a learned society. Following the literature on the social gradient of mortality, members of a learned society should exhibit much lower death rates than other social groups. We use biographical records from the members of the Austrian Academy of Sciences between 1847 and 2005 and compare their mortality to Austrian life table death rates of the entire population and the population with tertiary education only, respectively. We find that the members of the Austrian Academy of Sciences experience far fewer deaths than if they were subject to the average Austrian life table mortality. The mortality differential even persists when comparing to the Austrian population with tertiary education, though to a smaller extent. Moreover, the mortality differential between the members of the Austrian Academy of Sciences and the Austrian population has widened over time, particularly since the mid-20$^{\text{th}}$ century.

1 Introduction

The oldest citizen of Austria, Prof. Leopold Vietoris, died shortly before his 111th birthday in Innsbruck. Vietoris is regarded as a pioneer of technical mathematics. His complete œuvre comprises 80 articles. Seven years ago, his last work was published. [...]

(Die Presse, April 12$^{\text{th}}$, 2002)

Leopold Vietoris was a professor of mathematics at the University of Innsbruck and a member of the Austrian Academy of Sciences. Although Prof. Vietoris' great age was exceptional, it illustrates the well-known fact that mortality decreases with increasing levels of education. More generally, death rates have been found to be lower in groups with higher socioeconomic status, i. e., more prestigious occupations, high educational level, or high income. This finding is universal across countries—mortality differences that are related to socioeconomic status have been found in each country

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where data were available (Kunst and Mackenbach 1994)—and holds for Austria as well (Doblhammer-Reiter 1996, Doblhammer et al. 2005, Schwarz 2005).

Research on mortality differentials serves at least three different purposes (Martelin 1996). First, it should identify particulary disadvantaged groups in order to better target health policies. Secondly, from an epidemiological point of view the analysis of mortality differentials may be used to construct hypotheses about the causes of specific diseases and changes in mortality. Thirdly, the study of differences in mortality may be utilized within the debate about the possibility of further extending life expectancy. One way to estimate the limit to life expectancy is to study the survival of populations living in favourable conditions (Manton et al. 1991) or, within a national population, subgroups with particularly good health profiles (Martelin 1996).

Following the social gradient argument of mortality, members of a learned society should exhibit much lower death rates than most other social groups. Members of a learned society not only have reached the highest educational level, they also occupy (or have retired from) prestigious positions with high income.

The mortality of members of a learned society has already previously attracted the attention of demographers. Houdaille (1980) studied the mortality of several groups of leaders of the French society in 18$^{\text{th}}$ and 19$^{\text{th}}$ century, among them the members of the Academie Française. He noted that the French Academicians exhibited a remarkable low mortality in comparison with their contemporaries. More recently, Leridon (2004) investigated the demography of the members of the French Academy of Sciences and he found that mortality differentials still persist (Leridon 2005). Furthermore, Matthiessen (1998) studied the demographic development of the Royal Danish Academy of Sciences and Letters and van de Kaa and de Roo (2006) analysed the Royal Netherlands Academy of Arts and Sciences from a demographic perspective. Matthiessen (1998) and van de Kaa and de Roo (2006) also identified a considerably lower mortality for Academicians in comparison to the corresponding national population.

However, socio-economic differences in mortality vary by country and time period (e. g., Kunst 1997, Valkonen 1997, 2001, Mackenbach et al. 1999, Kunst and Mackenbach 1994). Changing mortality differentials over time have also been identified for Austria. In particular, Doblhammer et al. (2005) observed a widening gap in educational and occupational differentials of Austrian men between 1981/82 and 1991/92. Similarly, Schwarz (2005) reported an increase in the relative index of inequality for men between 1981/82 and 1991/92 in Austria.

Most studies on time trends of differential mortality are limited to the second half of the 20$^{\text{th}}$ century. In one of the rare studies which extend to the time before 1950, Pamuk (1985) studies inequality in mortality by social class in England and Wales from 1921 to 1972. She finds that class inequality in mortality declined during the 1920s and increased between 1950 and 1970 among men.

Concerning the 18$^{\text{th}}$ and 19$^{\text{th}}$ centuries, there exist only few studies on differential mortality due to the lack of suitable data. By means of indirect estimation, Blum et al. (1989) and Blum and Houdaille (1989) investigate mortality differentials in France in the late 18$^{\text{th}}$ and early 19$^{\text{th}}$ centuries. They exploit data from marriage registers in

several communities, which contained the ages at death of the parents of the bride and groom. The expected social hierarchy in mortality is found; at age 40, about six years of life expectancy separated workers and day labourers from property owners (Blum et al. 1989, Blum and Houdaille 1989). However, linking the mortality of parents to the marriage of their children is subject to several types of selection biases (Blum et al. 1989).

Moreover, research on differences in mortality by socio-economic status is mostly limited to populations in working ages. There is evidence that socio-economic mortality differentials persist up to advanced ages. However, knowledge about the trends in the differences according to socio-economic status is scarce, largely due to the lack of comparable results for long time periods (Martelin 1996).

In this paper, we analyse the mortality of the members of the Austrian Academy of Sciences and compare their death rates to Austrian mortality. In particular, we use the biographic records of the members of the Austrian Academy of Sciences from 1847 to 2005. Hence, our period of analysis extends over more than 150 years! This allows us to examine the historical development of the mortality of the members of the Academy over more than one and a half century, during which Austria underwent the (first) demographic and epidemiological transition, characterised by a decline in the level of mortality and the changing main causes of death, i. e., from infectious to chronic and degenerative diseases.

The study addresses three main questions. First, do the members of the Austrian Academy of Sciences exhibit a lower mortality compared to the total population? Secondly, if differences in mortality exist, were they already prevalent before the onset of the demographic transition, and did the mortality differentials change over time? Did the Academicians benefit more or less from the epidemiological transition in the end of the 19^{th} century and more recently? Thirdly, we want to study the relative position concerning mortality of the members of the Austrian Academy of Sciences within the entire society by comparing their mortality to the mortality of the Austrian population by socio-economic status. Do Academicians constitute a so-called vanguard group, representing an advantaged group with low mortality (Martelin 1996)?

The paper is structured as follows. Section 2 presents the reconstruction of the data from biographical records of the members of the Austrian Academy of Sciences and the statistical methods used. In section 3, the results of the mortality comparison over time are shown. Moreover, international comparisons are drawn. Finally, section 4 discusses the results and proposes further extensions.

2 Methods

2.1 Reconstruction from biographical records

The data come from the biographic records from the members of the Austrian Academy of Sciences (Hittmair and Hunger 1997). The Austrian Academy of Sciences was founded in 1847 as the "Kaiserliche Akademie der Wissenschaften in Wien" under the

auspices of emperor Ferdinand I. The Academy is structured around two sections—the section for Mathematics and the Natural Sciences and the section for the Humanities and the Social Sciences. Membership is distinguished between honorary member, full member and corresponding member. The latter category further distinguishes between corresponding member residing in Austria and corresponding member abroad. Full membership requires residence in Austria. If a full member moves abroad, he is changed in status to a corresponding member abroad during his stay outside Austria.

In this study, we focus on full members and corresponding members residing in Austria, because honorary members are not necessarily scientists but were also politicians, cardinals, or members of the royal dynasty during the monarchy.[1] Moreover, we do not consider corresponding members abroad in our analysis in order to focus on the mortality of those members residing in Austria.

The biographic records include date of birth and death, year of election, class membership, membership status (i. e., full or corresponding member) and year of change of membership status. Exits from the Academy were mainly through death with few exceptions. Four full members, two corresponding members, and one corresponding member abroad voluntarily resigned from the Academy. During the Nazi period, several Jewish members were excluded from the Academy: between autumn 1938 and autumn 1940, six full members and 15 corresponding members (including corresponding members abroad) were expelled on "racial" grounds (Matis 1997). After the end of World War II, the excluded members were listed again in the membership directories. Nowadays membership directories do not state those exclusions. When reconstructing the member populations during that time, we decided to keep these excluded members in the member population because we do not want to replicate the injustice committed at the time.

In 1945 those members of the Academy who had been members of the NSDAP were suspended. With the amnesty law in 1948, however, the membership of almost all of them was restored again. Nowadays membership directories do not give any information about these suspensions either.[2]

For the purposes of reconstructing the membership population, we assumed that elections always took place in mid-May each year, which has been the case at least in recent years. If members moved abroad or returned to Austria, we coded the change in membership status to take place in middle of the year due to lack of information on the actual month of change.

2.2 Statistical methods

For mortality comparison between corresponding and full members, we applied the log-rank test (Clayton and Hills 1993) in order to test for the equality of the survival curves. Moreover, we derived risk ratios and standardised mortality ratios. The risk

[1] The statute of the Austrian Academy of Sciences specifies that persons may be elected to honorary members for their excellent services to science, state, or people.

[2] A thorough description of the activities of the Austrian Academy of Sciences from 1938–1945 can be found in Matis (1997).

ratio is defined as the ratio of death rates of the population under observation and the reference group. Since age may be a confounding factor, we stratify by age groups and use Mantel-Haenszel weights for computing the overall risk ratio (Clayton and Hills 1993, Rothman 2002).

Using age-specific reference death rates, an expected number of deaths is derived; the ratio of actual observed deaths to the latter gives the standardised mortality ratio (SMR). For comparison of the mortality of the members of the Austrian Academy of Sciences with the Austrian population in general and by socio-economic status, respectively, we used the corresponding life table death rates as reference rates. Unfortunately, life tables by socio-economic status have not been published yet for Austria. However, Doblhammer et al. (2005) report the number of deaths by occupational[3] and educational class based on linked death and census records for the Austrian population in the years 1981/82 and 1991/92, from which age-specific death rates can be constructed.[4]

As a further measure to describe mortality differentials, life expectancies were estimated. By assuming an exponential model, death rates were converted into probabilities and abridged life tables were estimated for the members of the Austrian Academy of Sciences. For the derivation of 95 % confidence intervals, bootstrapping techniques were applied.

For the Austrian population by occupational and educational class, life tables were similarly derived. Since the number of deaths by educational and occupational class are only given up to age 90 in Doblhammer et al. (2005), a Gompertz function was estimated for the older age groups (Preston et al. 2001).

The analyses were performed by using STATA 9.2 (StataCorp 2006).

3 Results

In the following, we aim to assess the mortality of the members of the Austrian Academy of Sciences and compare it with reference mortality rates from the Austrian population. As noted above, we leave out corresponding members abroad, focusing on full and corresponding members, the latter being supposed to reside in Austria. Due to the low number of women among the members of the Austrian Academy of Sciences,

[3]For retired people, their previous occupation was used.

[4]The death and census records were merged by date of births, residential address, and family status of the deceased, since a personal identification number does not exist in Austria and names are deleted from census records. With this merging procedure, around 92 % in 1981/82 and 90 % in 1991/92 of the deaths, respectively, could be linked to the corresponding census records (Doblhammer et al. 2005). In order to estimate death rates by occupational and educational class, the number of deaths have to be adjusted for the deaths that could not be linked to the census. In order to compute age-specific merging rates, the number of deaths by age group is estimated for the same time period as the linked death records from the age-specific monthly number of deaths of 1981/82 and 1991/92 (Statistics Austria 2006). Finally, age-specific death rates by occupational and educational class were derived by relating the adjusted number of deaths to the person-years of the population by education (Landler 2004) and occupation (Statistics Austria 2006).

we only consider male Academy members in the subsequent analysis.[5] In sum, we have 1322 male full and corresponding members residing in Austria between 1847 and July 2005. The person-years and number of deaths are given in Table 1.

Table 1: Person-years and number of deaths of full and corresponding members between 1847–2005.

	Person-years	Deaths
Corresponding members	12 814.1	411
Full members	11 942.9	495
Total	24757.0	906

We perform the subsequent analysis for full and corresponding members together, since preparatory investigations revealed that there are no statistically significant differences between the mortality of the corresponding and full members. Both the risk ratio and the standardised mortality ratio are close to unity over the whole investigation period. Moreover, the log-rank test does not reject the null of equal survivor functions of full and corresponding members at the 5 % level for each time period.

3.1 Comparison to average Austrian mortality

In order to explore the mortality differential of members of the Austrian Academy of Sciences, we compare their mortality with the average Austrian male mortality as derived from life tables, which are published regularly.

Table 2 displays the standardised mortality ratios of the full and corresponding members in ten-year periods with the corresponding death rates of the Austrian male population from the three most recent life tables (Max Planck Institute for Demographic Research 2005, Statistics Austria 2003, 2005a) as reference rates. Note that the SMR is below 1 for all age groups, which implies that Academy members experience fewer deaths than if they were subject to the average Austrian male mortality. Furthermore, the SMR values increase with age, hence mortality differentials decline in the older age groups.

Moreover, Table 2 displays 95 % confidence intervals. Statistical significance is verified by a score test. The SMR is statistically significantly different from unity for all age groups in all three periods shown. Summing up, the members of the Austrian Academy of Sciences aged between 50 and 90 experienced during 1996 to mid-2005 only about half as many deaths as would have been implied by the Austrian life table 2001/02. The same result holds for the years 1976 to 1985 relative to the life table 1981/82 and for the years 1986 to 1995 relative to that of 1991/92.

[5]Until 2005, there were only 46 female corresponding members: 26 were corresponding member abroad and twenty were residing in Austria. Among the twenty female corresponding members in Austria, eight became full members later and one was elected as a honorary member of the Austrian Academy of Sciences.

Table 2: Comparison of mortality of corresponding and full members for various periods with Austrian male life table death rates at census dates (years in brackets).

Period	Age	Person years	Observed deaths	Expected deaths	SMR	[95 % CI]	
1976–1985 (1981/82)	(50–70]	1137.73	11	22.71	0.48**	0.27	0.87
	(70–90]	784.35	38	78.01	0.49***	0.35	0.67
	Total	1922.08	49	100.72	0.49***	0.37	0.64
1986–1995 (1991/92)	(50–70]	1357.24	11	24.35	0.45***	0.25	0.82
	(70–90]	806.61	42	72.50	0.58***	0.43	0.78
	Total	2163.84	53	96.85	0.55***	0.42	0.72
1996–2005 (2001/02)	(50–70]	1614.08	6	21.40	0.28***	0.13	0.62
	(70–90]	971.70	36	64.96	0.55***	0.40	0.77
	Total	2585.79	42	86.36	0.49***	0.36	0.66

Legend: $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Figure 1 shows the standardised mortality ratio compared to Austrian life table male mortality over time in partly overlapping 10-year periods around the central years where life tables for Austria have been available (Max Planck Institute for Demographic Research 2005, Statistics Austria 2003, 2005a). For the time of the Austrian monarchy, life tables either for the Austrian Alpine regions or the Austrian part of the Austro-Hungarian empire (Cisleithania) were used. As evident from Figure 1, except of the first two periods, the SMR is always below 1. During the first periods of our comparison, the development of mortality was dominated by war and epidemics (Helczmanovszki 1979, p.391). In particular, the cholera epidemics in the years 1866 and 1873 resulted in pronounced peaks in the number of deaths among the Austrian population (Gisser 1979, p. 415). Urban regions like Vienna were most prone to infectious diseases and epidemics at the time. Indeed, Vienna and its suburbs had the highest mortality among the Austrian Alpine regions (Findl 1979, p.429). The fact that the bye-laws of the Academy required a large part of the full members to live in Vienna or its suburbs[6] may explain the high mortality of Academy members compared to the general Austrian population in 1866–75.

Starting in the mid-1870s, the demographic and epidemiological transition started

[6]In 1847, when the Academy was founded the statute required that 24 out of 48 full members had to live in Vienna or its suburbs. One year later the number of full members was increased by 6 members per class in order to include further fields. In 1922 the minimum number of full members to reside in Vienna or its suburbs was fixed at 15 per class. The latter number increased by two per class in 1925 together with the increase of the class sizes from 30 to 33 full members. During the Third Reich, the number of full members had to live in Vienna or its suburbs increased to 22. After the end of World War II in 1945, the bye-law of 1922 and its amendments from 1925 became operative again, i.e. 17 out of 33 members per class had to live in Vienna or nearby. Although the Academy experienced further increases in the number of members per class, the minimum number of full members to reside in Vienna or its suburbs remained at 17 until its abolishment in 2002.

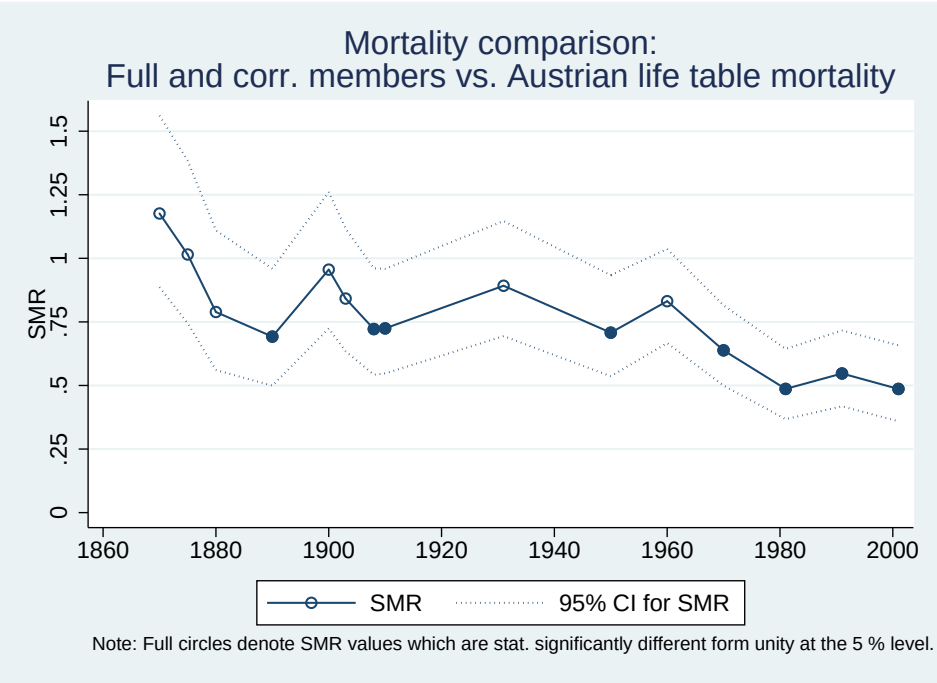

Figure 1: Standardised mortality ratio of members compared to Austrian life table mortality over time.

in the Austrian Alpine regions and mortality levels fell rapidly due to medical and social-hygienical progress (Gisser 1979, p. 415). One of the contributing factors to the decline in mortality was the extensive implementation of sewer systems during that time as well as the improvement of water quality by the completion of the first "Wiener Hochquellenwasserleitung" (Vienna spring water supply system) in 1873. Vienna particularly benefited from the medical and hygienical improvement; at the turn of the century, Lower Austria including Vienna exhibited the lowest mortality within the Austrian part of the Austro-Hungarian empire (Findl 1979, p. 429).

Simultaneously with the onset of the epidemiological transition, the mortality of Academy members declined with respect to the Austrian total population. In 1886–95, the members of the Academy aged 50–90 experienced just about 70 % as many deaths as when they had been subject to Austrian mortality conditions according to the life table 1889/92, which is also statistically significantly different from unity as verified by a score test (Clayton and Hills 1993). It seems that Academicians particularly benefited from the medical and hygienical progress. However, at the turn of the century, the members of the Academy lost ground again relative to the total population in the development of mortality. Inspection of the differences within broad age groups in the periods 1896–1905 and 1899–1908, respectively, reveals that not all age groups show higher mortality levels in this periods. However, because of the small sample size, the increase in the SMR value close to 1 at the beginning of the 20^{th} century may be due to chance variation.

From the period 1904–13 onwards until the 1956–1965, the standardised mortality

ratio remains around 0.75. In the late 1960s the SMR declines to about 0.5. Since the early 1970s, a decrease in mortality levels particularly in older age adults was observed in the Austrian total population (Österreichisches Statistisches Zentralamt 1998). It seems that once more the members of the Austrian Academy of Sciences benefited more than the average population from the general decline in mortality. Hence, the mortality differentials between the members of the Austrian Academy of Sciences and the Austrian population have widened in the last 50 years.

3.2 Comparison to Austrian population by socio-economic status

In the next step, we want to refine our analysis and compare the mortality of the members of the Austrian Academy of Sciences to the population by socio-economic status. In particular, we want to compare the death rates of Academicians to the death rates of those sub-populations identified as exhibiting the lowest mortality within Austria in order to assess whether the members of the Austrian Academy of Sciences indeed constitute a vanguard group concerning mortality. The most common indicators of socio-economic position in past research have been mainly occupational group, level of education, and household or personal income (Valkonen 1997).

Table 3: Comparison of mortality of corresponding and full members for various periods with life table death rates for Austrian male non-manual/civil servants (years in brackets).

Period	Age	Person years	Observed deaths	Expected deaths	SMR	[95 % CI]	
1976–1985 (1981/82)	(50–70]	1137.73	11	18.64	0.59*	0.33	1.07
	(70–90]	784.35	38	74.39	0.51***	0.37	0.70
	Total	1922.08	49	93.03	0.53***	0.40	0.70
1986–1995 (1991/92)	(50–70]	1357.24	11	20.44	0.54**	0.30	0.97
	(70–90]	806.61	42	69.56	0.60***	0.45	0.82
	Total	2163.84	53	90.00	0.59***	0.45	0.77

Legend: $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Doblhammer et al. (2005) report that in Austria non-manual workers and civil servants experience the lowest mortality among all occupational groups in 1981/82 as well as 1991/92. Using the number of deaths among non-manual workers and civil servants published in Doblhammer et al. (2005), we constructed the death rates as outlined above, which are then used as reference rates.

Table 3 summarises the SMR in comparison to non-manual workers and civil servants. The members of the Austrian Academy experienced only about 53 % and 59 % of the expected deaths had they been subject to the death rates of Austrian male non-manual workers and civil servants in 1981/82 and 1991/92, respectively. Hence,

the SMR values over all age groups are only slightly higher than in comparison with the total population. The biggest changes are visible in the age group 50–70 years, where the SMR increased by about 0.1. For the advanced age group, 70–90 years, the increase of the SMR is negligible. Hence, job-specific effects related to non-manual activity only partly account for the low mortality of the members of the Academy, and only for the pre-retirement ages. Although retired people were assigned according to their former profession in the study of Doblhammer et al. (2005), Academicians still have a relative mortality advantage of 50 % and 40 % fewer deaths in the age group 70–90 over Austrian male non-manual workers and civil servants in 1981/82 and 1991/92, respectively. Moreover, this difference is of similar magnitude as relative to the total male population in this age group.

Table 4: Comparison of mortality of corresponding and full members for various periods with life table death rates for Austrian male population with tertiary educations (years in brackets).

Period	Age	Person years	Observed deaths	Expected deaths	SMR	[95 % CI]	
1976–1985 (1981/82)	(50–70]	1137.73	11	15.35	0.72	0.40	1.29
	(70–90]	784.35	38	61.66	0.62***	0.45	0.85
	Total	1922.08	49	77.01	0.64***	0.48	0.84
1986–1995 (1991/92)	(50–70]	1357.24	11	13.01	0.85	0.47	1.53
	(70–90]	806.61	42	58.80	0.71**	0.53	0.97
	Total	2163.84	53	71.81	0.74**	0.56	0.97

Legend: $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

However, Austrian non-manual workers and civil servants are quite a large and heterogenous group. Thus, we use the mortality of the population by education for comparison in a further step. In particular, we compare the mortality of members of the Austrian Academy of Sciences to the entire population with tertiary education (see Table 4). We find that the SMR is higher than in the previous comparison but still less than 1. At any rate, the differences in the lower age group declined remarkably, and are no longer different from 1 with statistical significance. In contrast to the comparison with non-manual workers/civil servants, the SMR increased also in the advanced age group, 70–90 years, relative to the Austrian population with tertiary education. But the rise in the age group 70–90 is still less than in the younger age group 50–70, implying an increasing mortality differential over age between 50 to 90 years of age. Summing over the age groups, the corresponding and full members experienced about 36 % and 26 % less deaths in the years 1976–1985 and 1986–1995, respectively, than they would have had if they had been subject to the age-specific mortality rates of the Austrian population with tertiary education in 1981/82 and 1991/92. Hence, the lower mortality among members of the Austrian Academy of Sciences in comparison to the total population can be explained partly by the higher education of the Academicians.

However, a significant part of the differences remains unexplained since Academicians also show a statistically significantly lower mortality than the population with tertiary education.

3.3 Life expectancy

Finally, we estimated the life expectancy at age 60 of the members of the Academy by computing period life tables for 10-year periods with 5-year age groups (cf. Figure 2). In the starting period of 1847–1855 members of the Austrian Academy of Sciences exhibited a life expectancy at age 60 of about 12 years. Over the next century, Academicians' life expectancy at age 60 slowly rose to about 15 years in 1926–1935, i. e., an increase by one quarter over 80 years or an annual growth of 1.8 weeks per year.

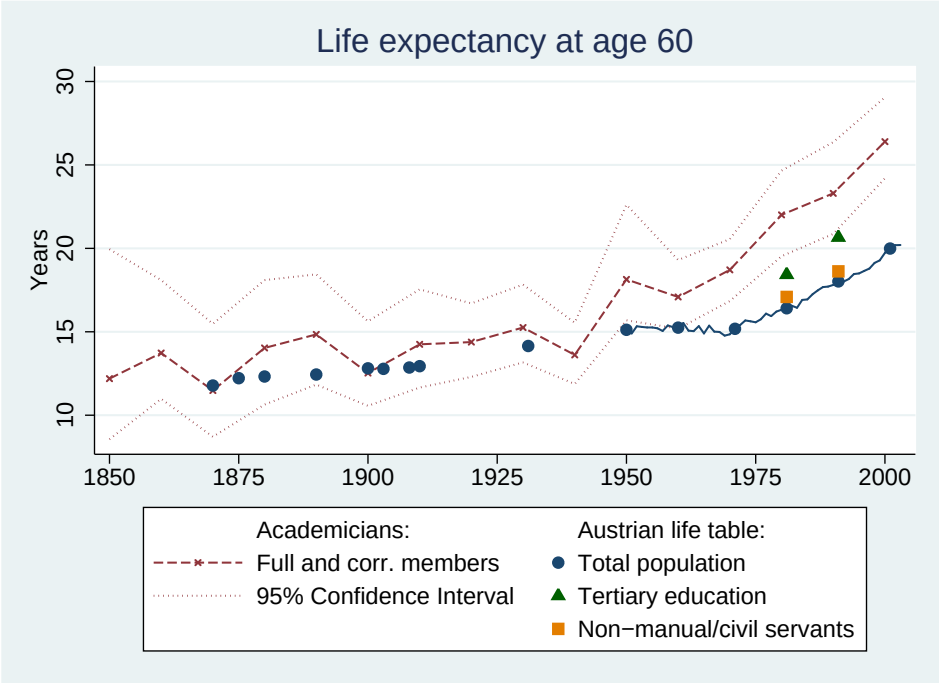

Figure 2: Life expectancy at age 60 of members compared to Austrian life table estimates.

However, the increase in life expectancy over time is not smooth, which may be due to either mortality crises or the small sample size. Indeed, the 95 % confidence intervals, derived by bootstrapping techniques, extend over several years of further life expectancy, particularly in the earlier periods. The lower (upper) limit of the 95 % confidence intervals, respectively, is 2.6 years below (3.7 years above) the estimated life expectancy from the periods 1847–1855 to 1936–1945. In the second half of the 20$^{\text{th}}$ century, the limits of the 95 % confidence interval narrow to 2.2 and 2.8 years, respectively.

Aside from being possibly caused by the small sample size, the drop in life expectancy in 1936–1945 may be due to World War II. Moreover, our data also include

Jewish members who were excluded from the Academy in the beginning of the Nazi regime. Indeed, six out of the 60 observed deaths during the period 1936–1945 were members who were excluded or "voluntarily" resigned from the Academy between 1938 and 1940. Two of them, Ernst Brücke (1880–1941) and Alfred Francis Pribram (1859–1942), were able to emigrate to the U. S. and Great Britain, respectively. Berthold Hatschek (1854–1941), Hans Horst Meyer (1853–1939), Franz Eduard Suess (1867–1941), and Alfred Hettner (1859–1941) stayed in the Third Reich until their death. Although it seems that they did not have to share the fate of millions of Jewish contemporaries in the Holocaust, the events of these days will certainly have not increased their survival chances.

From the period 1956–1965 onwards, life expectancy at age 60 of the members of the Austrian Academy of Sciences rose at an increasing rate. While Academicians exhibited a life expectancy at age 60 of about 17.1 years in 1956–1965, it increased to 26.4 years in 1996–2005, which implies an improvement in life expectancy of 54 % over four decades. This means that the members of the Academy annually gained 2.2 months of life expectancy at age 60.

Figure 2 compares life expectancy estimates at age 60 with those available for the Austrian Alpine regions or Cisleithania during the monarchy and for the Austrian Republic (Max Planck Institute for Demographic Research 2005). Annual estimates of the life expectancy at age 60 are available from 1950 onwards (Statistics Austria 2005b).

The earliest Austrian life table available gives a value of 11.8 years of life expectancy at age 60 for the Austrian male population during the period 1865–1875. Until the turn of the century, male life expectancy at age 60 slowly rose to 12.9 years, since the strongest gains in male life expectancy were concentrated in infant and child mortality during the demographic transition (Findl 1979, p. 438).

For the time during World War I as well for World War II, there are no life tables for Austria. The only available life table for the first Austrian Republic is from 1930–33 and indicates a further progress in life expectancy, with a male life expectancy at age 60 of about 14.2 years. In the mid-20$^{\text{th}}$ century, the increase in male life expectancy levelled off at about 15 years, and there was a common belief that the epidemiological transition was completed and no further gains in life expectancy could be expected (Österreichisches Statistisches Zentralamt 1998, p.23). However, since the beginning of the 1970s, a remarkable further increase in life expectancy can be observed, primarily concentrated in older adult ages (Österreichisches Statistisches Zentralamt 1998). Indeed, male life expectancy at age 60 steeply increased from 15.2 years in 1970/72 to about 20 years in 2001/02.

Comparing the life expectancy at age 60 of Academy members to the Austrian male population, we find that the two estimates were quite close to each other until the mid-20$^{\text{th}}$ century. It is only after 1950 that life expectancy at age 60 of Academy members has risen markedly above the corresponding Austrian life table estimate. Moreover, it seems that life expectancy at age 60 increased much stronger among the members of the Academy than for the total male population. Since the mid-20$^{\text{th}}$ century, the gap

Table 5: International comparison of period life expectancy of the members of the Austrian Academy of Sciences, the Royal Danish Academy of Sciences and Letters, and the French Académie de Sciences with the corresponding life expectancy from national period life tables.

Countries	Life expectancy at age 50		Difference
	Academy	Total population	
Austria (1970–95)	30.5	24.5	5
(1970–99)	31.1	24.8	5.3
Denmark (1970–95)	29.5	25.1	4.4
Netherlands (1970–99)	33.5	26	7.5
France (1993–96)[a]	33	27.7	5.3

[a] Based on SMR=0.6 observed from 1960–95.

in life expectancy at age 60 between members of the Austrian Academy of Sciences and the total male population has more than doubled from 2–3 years to about 6 years for the latest periods available.

We estimated also the life expectancy for non-manual/civil servants and population with tertiary education. As expected, the estimated life expectancy at age 60 for the population with tertiary education and for the non-manual workers and civil servants in the year 1981/82 and 1991/92 lie between the corresponding estimates of the members of the Academy and the Austrian total population. However, the life table death rates were extended by using a Gompertz function at older ages in order to close the life table. Since the Gompertz function tends to overestimate old age mortality (Preston et al. 2001), life expectancy estimates for the population with tertiary education and for non-manual workers and civil servants may be too conservative.

3.4 International comparison

It has been demonstrated that mortality inequality associated with socioeconomic status varies over countries (e. g., Kunst and Mackenbach 1994, Mackenbach et al. 1999). Hence, we compare the mortality differential of the Austrian Academy of Sciences to that of other learned societies in Europe, if and where information is available. In particular, Matthiessen (1998) investigated the demography of the Royal Danish Academy of Sciences and Letters, Leridon (2004) analysed the French Academy of Sciences, and van de Kaa and de Roo (2006) studied the Royal Netherlands Academy of Arts and Sciences. Table 5 summarises life expectancy at age 50 for these Academies given in Matthiessen (1998), Leridon (2005), and van de Kaa and de Roo (2006) and compares them with the Austrian Academy of Sciences and with the corresponding national life tables.

Matthiessen (1998) reports an estimated period life expectancy at age 50 of about 29.5 for the members of the Royal Danish Academy of Sciences and Letters between 1970–95. In contrast, life expectancy at age 50 of members of the Austrian Academy

of Sciences amounts to 30.5 years. The corresponding general male life expectancy at age 50 in Austria and Denmark was on average 24.3 and 25.1 years, respectively, in 1970–95.[7] Thus, there is a difference of about 4–5 years in life expectancy at age 50 in favour of Austrian as well as Danish Academicians.

For the Royal Netherlands Academy of Arts and Sciences, van de Kaa and de Roo (2006) report that life expectancy of ordinary members at age 50 equals 33.5 years for the period 1970–99. The latter number compares to 31.1 years of life expectancy at age 50 for Austrian Academicians in the same period. Hence there is a difference in life expectancy at age 50 of about two years between Dutch and Austrian Academicians. In contrast, the arithmetic averages over the general male life expectancy at age 50 for the period 1970–99 in the Netherlands and Austria differ much less, i. e., lying at 26 and 24.8 years, respectively. However, cross-country mortality differentials of the national populations changed considerably over the last three decades. While in 1970, Dutch males had an advantage of about 2 years in life expectancy to Austrian males at age 50, the Austrian male life expectancy at age 50 surpassed that of the Netherlands in 2000 (European Communities 1995–2006).

Leridon (2005) reports an estimated life expectancy at age 50 of about 33 years for members of the French Académie de Sciences, which compares to 27.7 for the general French male population in 1993–96. However, Leridon (2005) uses indirectly standardised death rates for the computation of the life expectancy, while in Matthiessen (1998), van de Kaa and de Roo (2006) and also in this paper the life table is derived from the observed rates. In particular, Leridon (2005) assumes a standardised mortality rate of 0.6, observed from 1960–95, and applies it to French life table death rates from 1993–96. Since mortality differentials decrease with age, he may have underestimated old age mortality. Nevertheless, he derives a mortality advantage of about 5.3 years of the French Academicians compared to the general French male population, which is of similar magnitude as the mortality differences in Austria and Denmark.

4 Discussion

The members of the Austrian Academy of Sciences indeed exhibit a much lower mortality than the Austrian population. The mortality differential even persists, though to a smaller extent, when comparing to Austrian non-manual workers and civil servants and to the population with tertiary education. Hence, members of the Austrian Academy of Sciences show even lower levels of mortality than the sub-populations which have been identified to exhibit the lowest mortality levels in the research of social differences in mortality (Doblhammer et al. 2005). Thus, the members of the Austrian Academy of Sciences do constitute a vanguard group with respect to mortality in Austria.

Comparing the mortality of members of the Austrian Academy of Sciences to the Austrian life table death rates back to the second half of the 19$^{\text{th}}$ century, we find that

[7]The latter numbers constitute average life expectancies at age 50 from single-year life tables during the period 1970–95, available in the Human Life Table Database (Max Planck Institute for Demographic Research 2005).

except for the 1870s the Academy members had a lower mortality than the average population.

Mortality conditions of the second half of the 19th century in Austria were still characterised by infectious diseases. For most of these diseases, social differences in mortality were recognised (Vasold 1991, p. 241). However, members of the Austrian Academy of Sciences did not show the expected low mortality relative to the total population. One explanation could be the requirement that a large part of the full Academy members had to live in Vienna or its suburbs, areas which—like all urban regions—were much more prone to infectious diseases, and this may have offset the Academicians' social advantage.

With the onset of the epidemiological transition in the mid-1870s the mortality of Academy members fell relative to the total population. It seems that Academicians particularly benefitted from the medical and social-hygienical improvements at the time.

The mortality gap widened further in the second half of the 20th century. Nowadays, the members of the Austrian Academy of Sciences experience only half as many deaths as they would if they were subject to the general Austrian life table death rates. In terms of life expectancy, the mortality differential amounts to six years of life expectancy at age 60 in favour of Academy members, which is twice the difference of the mid-20th century. Widening social gaps of mortality have also been identified by other studies (e. g., Marmot and McDowall 1986, Pamuk 1985). In particular, Pamuk (1985) finds that the social gradient has been increasing in England and Wales since the 1950s, which is consistent with our findings.

Mortality differentials, however, vary with age. In particular, the relative differences in death rates of Academy members compared to the Austrian population decrease with age. Declining social differences in mortality with age have been widely reported (e. g., Marmot and Shipley 1996, Crimmins 2005). One of the reasons that mortality differentials are lower at older ages than at younger ages is a selection effect. "As cohorts of persons of different socioeconomic status proceed through life, the force of mortality reduces the number of survivors in each group but at very different rates. Far fewer people in the lowest status group survive to old age; a much higher proportion of high status people survive. Mortality produces a more selected group among those with the lowest status; a group which has been selected against mortality risk" (Crimmins 2005, p. 165f).

Interestingly, in the comparison with the population with tertiary education, members of the Academy show a higher mortality differential in the older age group 70–90 than in the younger age group 50–70, which is contrary to the usually found decreasing mortality differential with age. This result requires further investigation.

In particular, hypotheses for the higher mortality differential in the advanced age groups need to be formulated. Does the higher mortality differential in higher age groups indicate further gains in life expectancy in these age groups in the future, with Academy members being vanguards in the development; or do Academicians have a lower mortality in the advanced age groups because they remain productive for longer

times, even after their retirement, which keeps them healthier? In the first case, the gap may narrow, when a comparison for the most recent period is added, while in the latter case the differences should persist. Unfortunately, the merging of the death records with the most recent census in May 2001 has not been finished yet. As soon as the merging results become available, we may further explore the mortality differential of members of the Austrian Academy of Sciences relative to the population with tertiary education.

Several authors have previously investigated the mortality of other national Academies of Sciences: Denmark (Matthiessen 1998), France (Leridon 2005), and the Netherlands (van de Kaa and de Roo 2006). The members of the French Academy, similar to the Austrian Academy of Sciences, exhibited a mortality advantage of about 5 years of life expectancy at age 50 relative to the national male population. While the mortality differential of Danish Academicians is slightly lower at 4.4 years of life expectancy at age 50, the life expectancy of Dutch Academy members at age 50 surpasses the national male life expectancy by about 7.5 years! Thus, there is also a considerable variation in the mortality differentials of Academicians across these countries! However, for a better evaluation of the mortality differences of members of learned societies, further countries will have to be added.

In an ongoing project, we aim to compare the demography of learned societies of various European countries including the Academy of Sciences of Russia, Berlin-Brandenburg, the Netherlands, Belgium, Hungary, France and Austria. Within this project, we will be able to compare also time trends in the mortality differentials of members of learned societies from an international comparative perspective.

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