Which Causes of Death Contribute to the Widening Gap in Socioeconomic Inequalities in Austrian Adult Male Mortality?

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Abstract

Previous research for Austria has shown that socioeconomic inequalities in mortality exist and that they have increased over time for men at working ages. We studied which causes of death are responsible for this development. The data for our analysis are linked census and death records from Austria for the years 1981/82 and 1991/92. They have been analyzed for mortality differentials by education and cause of death using relative measurements (logistic regression), absolute measurements (age-standardized crude death rates) and decomposition methods. We discovered that the effect of education is not homogeneous across various causes of death. While some causes, such as respiratory diseases, show a decrease in inequality over time, an increasing social gradient has been found for circulatory diseases which account for about 50% of all deaths. Our analysis shows that differential development in ischaemic heart disease has been the main contributor to the widening gap in socioeconomic inequalities in Austrian adult mortality.

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1 Introduction

Research Question Socioeconomic mortality differentials in Austria were increasing between the 1980s and 1990s as two papers have recently shown (Doblhammer et al., 2005; Schwarz, 2005). While an increasing gap in *relative* mortality has been observed in several European countries (Mackenbach et al., 2003), the development for men at working ages in Austria was most striking: *relative* as well as *absolute* differences in mortality between socio-economic groups measured by education became more pronounced during the observation period (Doblhammer et al., 2005). In the present paper we would like to follow the suggestion of Kunst et al. (2004, p. 231) to "go beyond the simple assessment such as "the gap is widening"" by examining which causes of death triggered this development for the most affected group in Austria, men between 35 and 64 years of age.

Choice of Education as Indicator for SES One of the few findings in mortality research which hold over time and geographic location are differentials by socio-economic status (SES). Regardless whether SES is measured via income, wealth, education or occupation, an inverse relationship is found (Goldman, 2001): Mortality is typically lower with higher income, more wealth, and more time spent in education (e.g. Kitagawa and Hauser, 1973; Kunst, 1997).

Although education-based, income-based and occupation-based indicators for socio-economic class are not independent, they can capture different dimensions and mechanisms for increased mortality (Davey Smith et al., 1998). According to Goldman (2001, p. 10068–10069), differential mortality by SES can be explained be the following, interrelated, processes which can be ascribed to one of those indicator-groups: access to medical care, access to health information, health behaviour (smoking, drinking, unhealthy diet), housing conditions, occupational hazards, pollution, exposure to stress, ...

Education is the most often used indicator in the United States — partly at least due to the assessment of Kitagawa and Hauser (1973, p. 23): "In our judgment, the education differentials probably provide more reliable indicators of socioeconomic differentials in mortality in the United States in 1960 than do the income differentials." In other countries, such as Britain for instance, occupational indicators are widely used. We have chosen to use education as measured by educational degree as an indicator for SES for our analysis of Austrian men at working ages. Besides the practical reason that educational differences were more pronounced than occupational differences in mortality in the previous study (Doblhammer et al., 2005), there are also several advantages of using education as pointed out by Valkonen (Valkonen, 1989, 1997): education applies to employed as well as unemployed people, level of education does not change with a possible deterioration of health, education is more comparable over time than occupational class.

2 Data & Methods

2.1 Data

Our data are constructed by linking the census records from 1981 and 1991 with the subsequent death records for one year: 12 May 1981 to 11 May 1982 and 15 May 1991 to 14 May 1992. Mortality data as well as information on socioeconomic characteristics on the individual level for the whole population are only available for those two time periods in Austria. Since Austria has no population registers like the Nordic countries do, the linkage has been conducted by the following four variables: birth date (day, month, year), marital status (if married also: year of marriage), residential address, dwelling number within the municipality. More than 90% out of the 89,304 correctly coded death records for 1981/82 and 83,324 for 1991/92 could be linked successfully to the census records. Details of the linkage such as the scoring algorithm for matching death and census records are explained explicitly in Doblhammer (1997) and Doblhammer et al. (2005).

For comparability of results with previous studies we have chosen to break down the census-based coding of seven educational levels into five groups: Basic, Apprenticeship, Lower Secondary, Upper Secondary, and Tertiary. As shown in Table 1 (page 4) roughly 1.2 Mio. men (1,385,423) were between 35 and 64 years of age at the time of the census in 1981, 10 years later almost 1.4 Mio. men (1,385,423) were in that age-range. During both observation intervals most men completed an apprenticeship whereas the least number of people can be found among men with tertiary education.

Causes of death were coded for both observation periods using ICD-9. The codes for the causes of death we have investigated is given in Table 2 (page 4). The numbers of deaths by cause and educational group are given together with the number of survivors by educational level in Table 3 on page 5.

Table 1: Distribution of Austrian Men By Age-Group and Educational Level[†] in 1981/82 and 1991/92

1981/82						
Agegroup	Basic	Apprentice-ship	Lower Secondary	Upper Secondary	Tertiary	$\sum$
35–39	67,473	117,825	19,376	21,887	18,795	245,356
40–44	88,663	113,865	19,480	17,424	14,662	254,094
45–49	84,519	83,320	12,913	11,247	8,538	200,537
50–54	87,399	86,716	14,063	15,859	9,668	213,705
55–59	80,402	67,269	13,078	15,136	10,315	186,200
60–64	55,405	40,773	9,125	9,938	7,740	122,981
$\sum$	463,861	509,768	88,035	91,491	69,718	1,222,873

1991/92						
Agegroup	Basic	Apprentice-ship	Lower Secondary	Upper Secondary	Tertiary	$\sum$
35–39	60,444	130,137	22,249	26,999	27,745	267,574
40–44	63,934	136,332	20,854	22,701	24,285	268,106
45–49	58,075	119,085	20,239	21,617	20,653	239,669
50–54	74,398	114,655	19,749	17,402	15,593	241,797
55–59	69,125	81,590	12,665	10,957	8,861	183,198
60–64	68,473	79,245	13,082	14,690	9,589	185,079
$\sum$	394,449	661,044	108,838	114,366	106,726	1,385,423

[†] The original German titles for the educational levels are: Tertiary: Hochschule, hochschulverwandte Ausbildung; Upper Secondary: Berufs-/Allgemeinbildende höhere Schule; Lower Secondary: Fachschule; Apprenticeship: Lehre; Basic: Allgemeinbildende Pflichtschule.

Table 2: ICD-9 Cause of Death Codes

#	Cause of Death	ICD-9 Code
1	Cancers	1400–2399
2	Ischaemic Heart Disease	4100–4149
3	Cerebrovascular Diseases	4300–4389
4	All Other Circulatory Diseases without Categories 3 & 4	3900–4599
5	Respiratory Diseases	4600–5199
6	Diseases of the Digestive System	5200–5799
7	Rest	All Others

Table 3: Numbers of Survivors and Deaths (All Causes and Selected Causes) Among Austrian Men Aged 35–64 in 1981/82 and 1991/92

1981/82

Education	Surv	Deaths	Canc	%	IHD	%	Cereb	%	Circ	%	Resp	%	Digest	%	Rest	%
Tertiary	69,422	296	93	31	97	33	19	6	23	6	3	1	18	6	43	15
Upper Secondary	90,981	510	126	25	152	30	29	6	49	6	10	2	51	10	93	18
Lower Secondary	87,490	545	143	26	137	25	43	8	51	8	13	2	54	10	104	19
Apprenticesip	506,097	3,671	945	26	840	23	247	7	319	7	100	3	420	11	800	22
Basic	459,254	4,607	1,225	27	835	18	298	6	444	6	187	4	568	12	1,050	23
$\sum$	1,213,244	9,629	2,532	26	2,061	21	636	7	886	9	313	3	1,111	12	2,090	22

1991/92

Education	Surv	Deaths	Canc	%	IHD	%	Cereb	%	Circ	%	Resp	%	Digest	%	Rest	%
Tertiary	106,455	271	93	34	57	21	15	6	17	6	9	3	25	9	55	20
Upper Secondary	113,909	457	157	34	112	25	22	5	29	5	13	3	37	8	87	19
Lower Secondary	108,312	526	184	35	115	22	41	8	33	8	15	3	47	9	91	17
Apprentice	656,719	4,325	1,347	31	872	20	335	8	284	8	116	3	547	13	824	19
Basic	390,652	3,797	1,155	30	679	18	294	8	256	8	137	4	522	14	754	20
$\sum$	1,376,047	9,376	2,936	31	1,835	20	707	8	619	7	290	3	1178	13	1,811	19

Surv = Survivors, Canc = Cancer, IHD = Ischaemic Heart Disease, Cereb = Cerebrovascular Disease, Circ = Remaining Circulatory Diseases, Resp = Respiratory Disease, Digest = Digestive Disease (incl. Liver Cirrhosis), Exter = External Causes, Rest = Remaining Deaths (e.g. Infectious & Parasitic Diseases, External Causes of Death)

2.2 Method

Relative mortality differentials have been estimated using a logistic regression framework. Our model was of the following form:

$$\log\left(\frac{P_i}{1-P_i}\right) = \alpha + \sum_{\mathrm{ag}=40-44y}^{60-64y} \beta_{\mathrm{ag}} x_{\mathrm{ag},i} + \sum_{\mathrm{edu}=\mathrm{Apprentice}}^{\mathrm{Tertiary}} \gamma_{\mathrm{edu}} x_{\mathrm{edu},i} \qquad (1)$$

The log-odds-ratio of the probability of dying P of individual i is estimated via an intercept α, the β regression parameters which control for age (via dummy variables for five-year age-groups; the youngest ages, 35–39, serve as reference category) and the γ regression parameters which estimate the effect of education (via dummy variables, the lowest educational group, "Basic", served as reference category). The regression analysis was performed separately for 1981/82 and 1991/92 and for each cause of death.

Absolute mortality rates were estimated by age-standardizing crude death rates with the mean population between 1981/82 and 1991/92. This approach follows Preston et al. (2001, p. 27)

In a last step, we wanted to compare the difference between the absolute mortality rates of people with tertiary and basic education in 1981 with the difference between the absolute mortality rates of people with tertiary and basic education in 1991. Using methods from **decomposition analysis** allow us to specify how much of the observed difference of those differences is due to compositional factors (changing cause of death composition and/or age composition over time) and direct factors (i.e. change in the mortality rate of each cause). Our decomposition analysis follows closely the notation and methods outlined in Vaupel and Canudas Romo (2001, 2002, 2003) and Canudas Romo (2003).

First we sketch the notation used in the remainder of this section:

- a, age
- e_j, educational level, $j = 1, 2$, (i.e. tertiary education and basic education)
- t_k, time (year), $k = 1, 2$
- i, the ith cause of death (COD)
- $N(a, e_j, t_k)$, the age-specific size of population at age a with e_j at time t_k

- $a \frown b$, the covariance between a and b

With this notation we can write the crude death rate (CDR) of population with e_j at time t_k as

$$d(e_j, t_k) = \sum_i \bar{d}_i(e_j, t_k), \tag{2}$$

where the death rate of people with e_j who died of the ith COD at time t_k, $\bar{d}_i(e_j, t_k)$, is actually the average of age-education-time-specific death rate for the $i$the COD, that is,

$$\bar{d}_i(e_j, t_k) = \frac{\sum_a d_i(a, e_j, t_k) N(a, e_j, t_k)}{\sum_a N(a, e_j, t_k)}. \tag{3}$$

With (2) and (3), and assuming the independence of causes of death, we can write the CDR of population with some educational level at time t. For example, the CDR of population with educational level 1 (e_1) at time t_2 will be given by

$$\begin{aligned} d(e_1, t_2) &= \sum_i \left[\frac{\sum_a d_i(a, e_1, t_2) N(a, e_1, t_2)}{\sum_a N(a, e_1, t_2)} \right] \\ &= \sum_i \bar{d}_i(e_1, t_2). \end{aligned} \tag{4}$$

Now we turn to decompose the difference of differences in CDR between different educational levels over time. Firstly, the difference of CDR between different educational levels at time t_k is

$$\Delta d(t_k) = d(e_1, t_k) - d(e_2, t_k), k = 1, 2 \tag{5}$$

Then the difference of differences in CDR is

$$\Delta d(t_1) - \Delta d(t_2) = [d(e_1, t_1) - d(e_2, t_1)] - [d(e_1, t_2) - d(e_2, t_2)]. \tag{6}$$

Using the formula for decomposition of averages (see, for example, Canudas Romo, 2003; Vaupel and Canudas Romo, 2002)

$$\dot{\bar{v}} = \bar{\dot{v}} + v \frown \acute{N},$$

where $\bar{v} = \dfrac{\int v(x,y) N(x,y) dx}{\int N(x,y) dx}$. To utilise this formula, the right side (6) can be rewritten in a more meaningful way as follows

$$
\begin{aligned}
\Delta d(t_1) - \Delta d(t_2) &= [d(e_1, t_1) - d(e_1, t_2)] - [d(e_2, t_1) - d(e_2, t_2)] \\
&= \sum_i [\bar{d}_i(e_1, t_1) - \bar{d}_i(e_1, t_2)] - \sum_i [\bar{d}_i(e_2, t_1) - \bar{d}_i(e_2, t_2)] \\
&= \sum_i [\dot{\bar{d}}_i(e_1)] - \sum_i [\dot{\bar{d}}_i(e_2)] \\
&= \sum_i [\bar{\dot{d}}_i(e_1) + d_i(e_1) \frown r(e_1)] - \sum_i [\bar{\dot{d}}_i(e_2) + d_i(e_2) \frown r(e_2)] \\
&= \sum_i [\bar{\dot{d}}_i(e_1) - \bar{\dot{d}}_i(e_2)] + \sum_i [d_i(e_1) \frown r(e_1) - d_i(e_1) \frown r(e_2)].
\end{aligned}
\tag{7}
$$

The first term in (7) is the direct component in decomposition, and represents the contribution of survival improvement to the difference of differences of the CDR. The second term in (7) is the contribution of compositional changes of COD's over time on the difference of differences of the CDR.

3 Results

3.1 Relative Mortality Differentials

Figure 1 on pages 10–11 show the results from our investigation of relative mortality differentials using logistic regression. Each panel shows for all causes and the selected causes, respectively, the relative mortality risks[1] of men with a specific educational level in relation to the reference category "Basic" education. Results are shown in red for 1981/82 and in blue for 1991/92.

The upper left panel on page 10 iterates the finding from Doblhammer et al. (2005): with increasing educational level, the relative mortality differentials in comparison to the reference category become more and more pronounced. This trend can be observed for the year 1981/82 (in red) as well as for the year 1991/92 (in blue). One can also recognize by the longer blue bars, that the relative mortality differentials have increased over time. While in 1981/82 the mortality risk of men at working ages with tertiary education was about 48% of their peers with basic education, this proportion was only

[1] To be precise: we are estimating odds-ratios and not relative risks. As shown, for example by Woodward (1999) or Rau (2005), these two entities are almost equivalent in the case of relatively rare events.

36% ten years later. By looking at the remaining seven panels in Figure 1 on pages 10 and 11 one can see that the development over time was not the same across all causes of death. While respiratory diseases show a decrease in class differentials over time, the relative risks of dying from ischaemic heart disease and cerebrovascular diseases are more strongly related to educational status in 1991/92 than in 1981/82. For instance, the relative risk for men with tertiary education to die of ischaemic heart disease was 89% of the mortality of men with basic education in 1981/82. In 1991/92, however, this value was 47%.

Figure 1: Relative Mortality Differentials for Austrian Men, Aged 35–64 for All Causes of Death, Ischaemic Heart Disease, Cerebrovascular Diseases and Other Circulatory Diseases by Educational Level

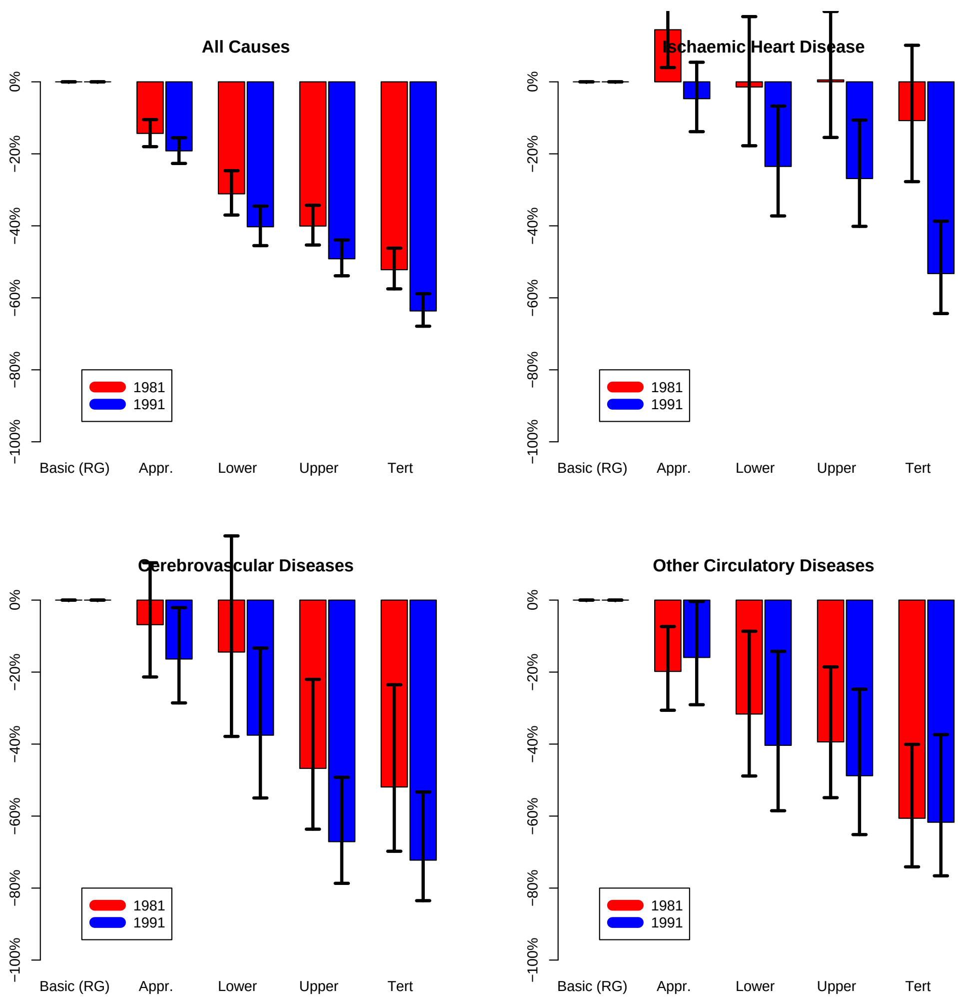
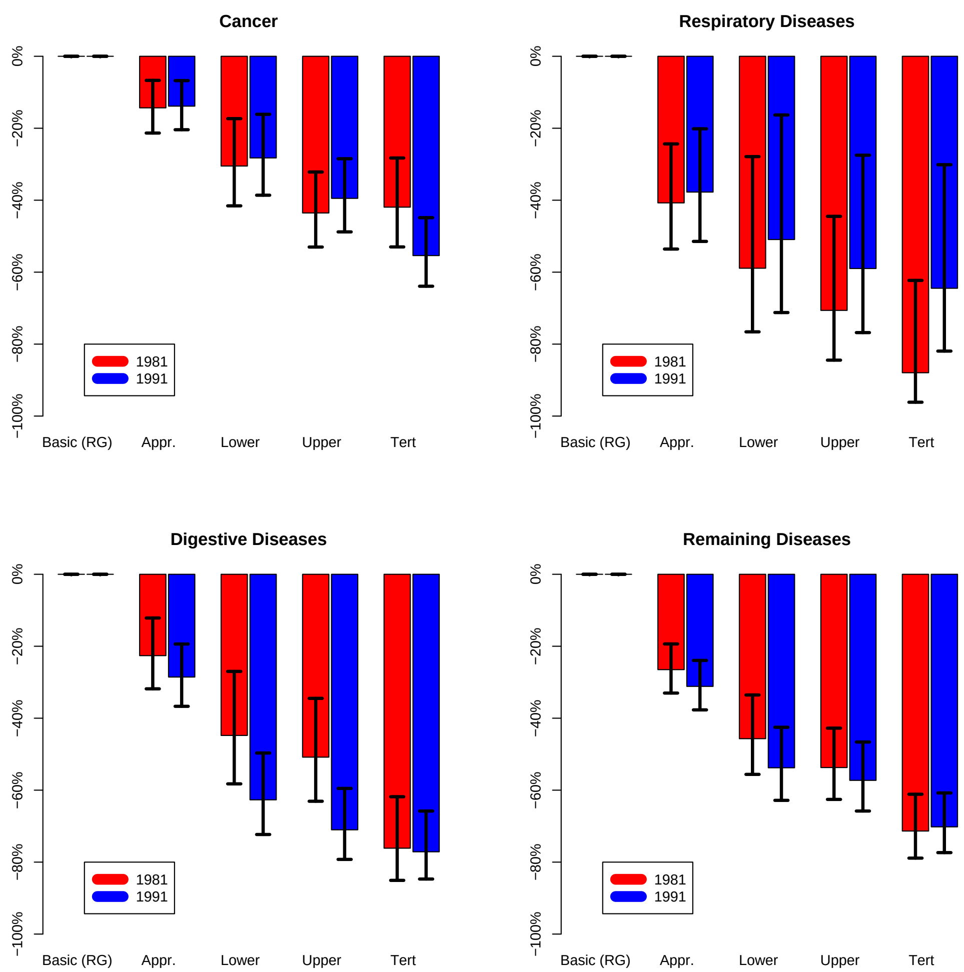


Figure 1: (Continued) Relative Mortality Differentials for Austrian Men, Aged 35–64 for Cancer, Respiratory Diseases, Digestive Diseases and Remaining Diseases by Educational Level



3.2 Absolute Mortality Differentials

So far we have only looked at *relative* mortality differentials. *Absolute* mortality levels allow us to determine whether the increase in relative mortality differentials was due to

- an increase in mortality levels across all educational groups but at a slower pace for men with higher education or
- a decrease in mortality levels across all educational groups but faster for men with higher education
- or something in between those two extremes.

Table 4 on page 13 shows age-adjusted death rates for Austrian men aged 35–64 by educational level and cause of death for 1981/82 and 1991/92.[2] One can recognize that absolute mortality dropped from 10.45 in 1981/82 for men with basic education to 9.25 in 1991/92. During this 10-year period, mortality dropped for men with tertiary education from 3.96 to 2.67. The column at the right hand side of those values indicate that men with tertiary education had an absolute mortality risk which was 38% of their peers with basic education. 10 years later the proportion was less than 30%. That implies that mortality fell for all educational groups but this decrease was faster the higher the education.

The most remarkable drop is again to be found for ischaemic heart disease. Mortality levels dropped from 1.91 to 1.62 for men with basic education between 1981/82 and 1991/92. Men with tertiary education started already at a lower rate (1.29); in 1991/92 their absolute mortality risk was only 0.56. This translates roughly into a drop from a 2/3 mortality risk in comparison to basic education in 1981/82 to about 1/3 of the mortality risk in 1991/92. Not all causes of death showed a decrease in mortality over time. Digestive diseases, for example, remained relatively constant for men with basic education and for men with tertiary education between the two time periods (Basic 1.26 → 1.29, Tertiary 0.25 → 0.23).

[2] Our results differ from Doblhammer et al. (2005) because of a different standardizing population.

Table 4: Absolute Mortality Differentials for Austrian Men, Aged 35–64, By Educational Level for All Causes of Death and Selected Causes of Death Measured via Age Adjusted Death Rates per 1,000 Person Years (*Rate*) and as Proportion of Mortality Rate in Relation to Basic Education (*Pct.*)

		Cause of Death							
		All Causes		IHD		Cereb		Circ	
Education	Year	Rate	Pct	Rate	Pct	Rate	Pct	Rate	Pct
Basic	1981/82	10.45	100	1.91	100	0.68	100	1.01	100
	1991/92	9.25	100	1.62	100	0.70	100	0.60	100
Apprentice	1981/82	7.61	73	1.76	92	0.52	76	0.67	66
	1991/92	6.28	68	1.24	76	0.48	68	0.40	67
Lower Sec.	1981/82	6.25	60	1.59	83	0.49	72	0.58	57
	1991/92	4.78	52	1.03	64	0.37	52	0.30	49
Upper Sec.	1981/82	5.46	52	1.62	85	0.33	48	0.51	50
	1991/92	4.12	45	1.01	62	0.21	29	0.26	43
Tertiary	1981/82	3.96	38	1.29	67	0.25	37	0.30	30
	1991/92	2.67	29	0.56	34	0.16	22	0.17	28

		Cause of Death							
		Canc		Resp		Digest		Rest	
Education	Year	Rate	Pct	Rate	Pct	Rate	Pct	Rate	Pct
Basic	1981/82	2.78	100	0.43	100	1.26	100	2.31	100
	1991/92	2.77	100	0.32	100	1.29	100	1.88	100
Apprentice	1981/82	1.97	71	0.21	48	0.85	68	1.59	69
	1991/92	1.93	70	0.16	51	0.80	62	1.24	66
Lower Sec.	1981/82	1.64	59	0.15	35	0.61	48	1.17	51
	1991/92	1.69	61	0.14	43	0.43	33	0.82	43
Upper Sec.	1981/82	1.34	48	0.11	25	0.55	44	0.98	43
	1991/92	1.42	51	0.12	36	0.33	26	0.77	41
Tertiary	1981/82	1.23	44	0.04	8	0.25	20	0.59	25
	1991/92	0.93	33	0.09	28	0.23	18	0.53	28

Causes of Death: IHD: Ischaemic Heart Disease, Cereb: Cerebrovascular Diseases, Circ: Remaining Circulatory Diseases, Canc: Cancer, Resp: Respiratory Diseases, Digest: Digestive Diseases, Rest: Remaining Causes of Death (e.g. External Causes, Infectious & Parasitic Diseases, ...)

3.3 Decomposition

Looking at changes in demographic rates always bears the risk that there is not only a direct change in the phenomenon of our interest (i.e. mortality changes) but also the composition (i.e. age-structure and composition of causes of death) can change over time. To be able to compare such rates anyway, one can standardize the rates as we did via age-standardization in the previous section. Another possibility is to decompose the rates "into components which reflect differences in specific rates of the two groups, on the one hand, and differences in their composition, on the other hand" (Kitagawa, 1955, p. 1172).

Our results from the decomposition analysis are presented in Table 5 on page 15. Columns 2–4 show the decomposition of the crude death rates for men with tertiary education between 1981/82 and 1991/92 into a compositional component ("Comp"), a direct component ("Direct") and the sum of both ("Total") which is equivalent to the difference in the crude death rates between the two time points.[3] Columns 5–7 display the same decomposition for men with basic education; the last three columns take the difference of the respective columns of men with tertiary and with basic education.

If we focus only on the direct effect, i.e. the change in mortality without the distortion of compositional factors, we can see that cancer and and even more ischaemic heart disease contributed mainly to the decrease in mortality over time for Austrian men with tertiary education. Ischaemic heart disease appears to be also an important factor among men with basic education. Remaining circulatory diseases, however, appear to be even more important for the change in mortality over time for them. When one investigates now the difference between the results from tertiary education and basic education, one can recognize that the decomposition analysis supports our previous findings: the changes in ischaemic heart disease contributed most to the widening gap in educational mortality differentials over time among Austrian men. This analysis sheds also light on the fact that one might investigate further the categories "Cancer" and "Rest" to detect other influential causes of death which played an important role in the development of socioeconomic mortality differentials in Austria over time.

[3] If we had not age-standardized the absolute mortality rates in Table 4, the differences between those death rates and the column "Total" in Table 5 would be equivalent.

Table 5: Cause of Death Decomposition of the Change over Time (1981/82 minus 1991/92) in the Crude Death Rate for Austrian Men with Tertiary Education (Columns 2–4), with Basic Education (Columns 5–7), and Tertiary minus Basic Education (Column 8–10)

Cause	Tertiary Education			Basic Education			Tertiary minus Basic		
	Comp.	Direct	Total	Comp.	Direct	Total	Comp.	Direct	Total
Cancer	-0.161	-0.305	-0.466	0.303	-0.013	0.290	-0.464	-0.292	-0.756
Cerebrovascular Diseases	-0.034	-0.098	-0.132	0.083	0.020	0.103	-0.117	-0.118	-0.235
Circulatory Diseases	-0.037	-0.135	-0.172	0.103	-0.414	-0.311	-0.140	0.279	0.139
Digestive Diseases	-0.003	-0.021	-0.024	0.071	0.028	0.099	-0.074	-0.049	-0.123
Ischaemic Heart Disease	-0.129	-0.733	-0.862	0.210	-0.290	-0.080	-0.339	-0.443	-0.782
Respiratory Diseases	-0.013	0.054	0.041	0.054	-0.110	-0.056	-0.067	0.164	0.097
Rest	-0.048	-0.055	-0.103	0.078	-0.434	-0.356	-0.126	0.379	0.253
$\sum$	-0.425	-1.293	-1.718	0.902	-1.213	-0.311	-1.327	-0.080	-1.407

4 Summary

We have detected as previously shown by Doblhammer et al. (2005) that relative and absolute mortality differentials have increased for Austrian men at working ages. The various causes of death did not show a uniform pattern as demonstrated via relative mortality measurements, absolute mortality risks and decomposition methods. Gaps are closing, for example, for respiratory diseases. But more important is the widening gap which has been detected for ischaemic heart disease. In all three empirical approaches of our study we discovered that ischaemic heart disease had the biggest impact on the widening gap in socioeconomic mortality differentials. This cause of death has also been singled out by Valkonen (1999) for other European countries.

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