The changing contribution of smoking to educational differences in life expectancy: estimates for Finnish men and women from 1971 to 2005

Martikainen Pekka[1], Ho Jessica[2]

1. Population Research Unit, University of Helsinki
2. Population Studies Center, University of Pennsylvania

ABSTRACT

Introduction: Major socioeconomic differences in mortality are observed in high income countries. While smoking remains one of the major single causes of mortality, its contribution to levels and trends in socioeconomic differences in mortality remains unclear. We present estimates of the contribution of smoking to educational differences in mortality and life-expectancy between 1971 and 2005.

Methods: Census records linked with death records for 1971–2005 for all Finnish men and women aged 50+ years were studied. Our estimates of smoking-attributable mortality are based on an indirect method developed by Preston et al in 2010 that uses lung cancer mortality as a proxy for the impact of smoking on mortality from all other causes.

Results: In the early 1970s smoking attributable deaths constituted about 27% of all male deaths above age 50 and 17% in the early 2000s; 1% and 4% among women respectively. At age 50 life-expectancy differentials between men with basic versus high education increased from 3.4 to 4.4 years. In the absence of smoking these differences would have been 1.5 and 3.1 years, 60% and 25% less than those observed. About half of the increase in life-expectancy at age 50 among men with basic education was attributable to a decline in smoking-attributable mortality. Among women the contribution of smoking to educational differentials in mortality was negligible in the 1970s but increased to about 10% in the early 2000s.

Conclusion: Smoking continues to have a major influence on educational differences in mortality among men and its contribution is increasing among women. Active and successful anti-smoking efforts can achieve further gains in longevity among men and reverse the trend of increasing smoking-attributable mortality among women.

INTRODUCTION

Major socioeconomic differences in mortality are observed in the United States and in European countries[1-4]. These mortality differentials translate to life-expectancy differentials of 3-10 years between the extremes of the social hierarchy. While smoking remains one of the major single causes of mortality and disability in all Western countries, its contribution to social inequalities in mortality remains unclear and widely varying estimates have been presented[5-15]. Often these estimates are based on select populations that are non-representative of any national population, limited age-ranges or for men only. Although large changes in cohort smoking histories have been experienced in many countries, few of the previous studies focus on the contribution of smoking to changes in social differentials in mortality over time. Based on longitudinal data covering the total population of Finland with consistent measurement of educational attainment and mortality over time and no loss to follow-up, we present estimates of the contribution of smoking-attributable mortality to overall mortality differences by education for the period from 1971 to 2005. Our estimates are based on an indirect method developed by Preston, Glei and Wilmoth.[16-17]

DATA AND METHODS

Study population and mortality follow-up

Our data consist of seven datasets covering the entire population in Finland. The first subset is based on the population records of the 1970 census, which have been linked to death records in 1971-75 by Statistics Finland. The other datasets were constructed in the same way by linking the 1975, 1980, 1985, 1990, 1995 and 2000 census records to death records for 1976-80, 1981-85, 1986-90, 1991-95, 1996-2000 and 2001-2005 respectively. More than 99.5% of all death records were linked to the deceased persons' census records. Persons migrating from Finland in any of the 5-year periods were excluded from the analyses. This study is restricted to those aged 50 years and over because smoking-attributable mortality becomes non-negligible and selective migration is unlikely to influence our results. These data have been previously used to study social determinants of mortality.[3-4]

Measurement of education

Education was measured at the time of each census, with the same classifications used in every census. Three educational categories were based on the highest completed educational degree: (1) basic education lasting 9 years or less, (2) secondary education lasting 10-12 years, and (3) tertiary education lasting 13+ years.

Methods

We estimate the magnitude of smoking-attributable mortality by education in Finland using an indirect estimation method developed by Preston, Glei, and Wilmoth.[16-17] The method is based on data from 20 high income countries for the period 1950 to 2006. Finland was one of the countries used to develop this method. The method uses age- and sex-specific lung cancer death rates as an indicator of the damage from smoking and a regression model that uses lung cancer mortality to predict mortality from other causes of death. The coefficients from this regression model and information on expected lung cancer death rates among non-smokers are used to estimate the fraction of deaths attributable to smoking. The method is restricted to ages 50 and above, ages at which most lung cancer deaths occur. Preston, Glei, and Wilmoth demonstrate that the method produces results very similar to those obtained from an older widely used method developed by Peto and Lopez. In this paper we use the coefficients published in Preston et al (Table 1)[17] to estimate smoking-attributable mortality by educational attainment.

The results are presented in terms of proportion of death attributable to smoking at ages 50 and above and life-expectancies at age 50. We further decomposed the total change in life expectancy at age 50 by age and cause of death (smoking and non-smoking) within each education group for two periods - from 1971-75 to 1986-90 and from 1986-90 to 2001-2005[18]. All analyses are presented separately for men and women as smoking patterns in Finland differ substantially between men and women.

RESULTS

In the early 1970s smoking-attributable deaths constituted about a quarter of all male deaths above age 50 (Figure 1). This translated to a loss of life-expectancy of 3.0 years (Table 1). By the early 2000s this proportion had declined to less than 20% and to a loss of life-expectancy of about 1.7 years. Among women smoking-attributable deaths increased from less than 1% to 4% in the same period (Figure 2) and contributed to a loss of about 0.4 years in life-expectancy in the early 2000s.

Among men clear educational differentials in the contribution of smoking were observed in the 1970s; 28% of all deaths among the basic educated were attributed to smoking and 14% among the most highly educated. These proportions declined to about 20% and 9% by the early 2000s (Figure 1). Life expectancy differentials between the basic and higher educated increased in this period from 3.4 years to 4.4 years. Without smoking these life-expectancy differences would have been 1.5 and 3.1 years, 60% and 25% less than those observed (Figure 2 and Table 1).

Among women smoking-attributable deaths were extremely rare in all educational groups in the 1970s and their contribution to educational differences in life expectancy was negligible (Figure 2). By the early 2000s, the contribution of smoking attributable deaths to educational differences in life-expectance at age 50 had increased to about 0.3 years of a total difference of about 2.7 years (Table 1).

In Figure 3, the total change in life-expectancy from 1971-75 to 2000-05 within each education group is decomposed in such a way that the contributions of each age group, cause of death (smoking and non-smoking) and two sub-periods 1971-75/1986-90 and 1986-90/2000-05 for the total change are estimated. Among men decline in smoking-attributable deaths contributed to increases in life-expectancy at all ages both in the period 1971-75 to 1986-90 and in the period 1986-90 to 2000-05, with the exception of the 75+ in the first period. Over the follow-up period gains in life expectancy from reductions from smoking shifted to older ages among the basic educated; while in the other educational groups this effect was less clear or took place at more advanced ages. The small negative contributions of smoking-attributable deaths among basic educated women were mostly observed in younger ages, but were more concentrated in older ages among higher educated women. Over the follow-up period the contribution of mortality decline form causes other than smoking to life expectancy has also shifted to older ages among men and women.

DISCUSSION

Summary of the main results

This is the first study to quantify the contribution of smoking to educational differences in mortality and life expectancy over time. We show a large but declining contribution of smoking to life expectancy at age 50 among Finnish men and a small but increasing contribution among Finnish women. We observe that at age 50 life-expectancy differentials between the basic and higher educated men have increased from 3.4 years in 1971-75 to 4.4 years in 2001-2005. Without smoking these life-expectancy differences would have been 60% and 25% less than those observed. Among

women the contribution of smoking to educational differentials increased in the same period but remained small.

Strengths and weaknesses

Compared to studies which rely on self-reported measures of smoking status at a single point in time, the indirect method employed here results in a more accurate estimate of the damage from smoking because it avoids issues concerning difficulty of accurately measuring individual life-time smoking exposure under conditions of recall bias, preferential reporting, individual variability in smoking intensity (e.g. inhalation), single measurement in time and loss to follow-up. For example, national survey data in Finland imply a level of tobacco consumption that captures only about half of the cigarettes sold based on cigarette sales statistics (authors' calculation).

Our estimates are, however, vulnerable to possible changes in coding practices of lung cancer deaths over time. The coding of deaths over the time period covered were based on the 8th, 9th and 10th versions of the International Classification of Causes of Deaths (ICD). The cause of death coding is, however, unlikely to have a major impact on our results because we used a harmonized cause of death data file and coding changes for lung cancer deaths were minor. More importantly, our method may overestimate the contribution of smoking in populations where factors other than smoking have a substantial impact on lung cancer mortality, and if the estimate of lung cancer mortality among non-smokers was incorrect. For men the first is unlikely in Finland and alternative calculations that assume 50-100% higher lung cancer mortality among non-smokers indicate the results to be robust. Furthermore, our sex-specific estimates are broadly consistent with previous estimates for Finland based on the Peto-Lopez –method[16] and estimates based on cause of death specific population attributable fractions and estimates of smoking prevalence by Martelin et al[19], thus giving credibility to estimates based on these different methods. Analyses not presented here on differentials by occupation based social class confirm the main pattern of results.

Comparisons to previous research and interpretation

A range of estimates for the contribution of smoking to social inequalities have been presented in the literature. What these estimates have in common is that for men they are non-trivial. There are both methodological and substantive reasons for the varying estimates. These estimates are mainly based on either attenuation percentages from cohort studies or indirect methods based on aggregate data. In cohort studies regression based measures of association (e.g. hazard ratios) between the top and bottom of SES are adjusted for observed smoking behaviour. In such studies the attenuation of the association after adjustment is taken as the contribution of smoking. *Calculated this way the contribution of smoking can be re-phrased as the hypothetical reduction in the social gradient under the assumption of no social differences in smoking exposure at a level of overall smoking exposure defined by the observed smoking variables.* Typically these estimates are presented in terms of relative differentials. On the other hand, estimates based on indirect methods – such as those presented here - provide an estimate of the contribution under a hypothetical situation in which a population and all its social strata have no exposure to smoking at all. By definition these different estimates of contribution are different and in a given population the latter estimate will typically be larger.

Bearing these methodological differences in mind – and concentrating on the analysis of the impact of eradication of smoking – we show a smaller contribution of smoking to educational differences in mortality among men below age 70 than Jha at al. for England and Wales, USA, Canada and Poland based on a method similar to ours and on data from the mid-1990s. Our estimates for the contribution of smoking is about 40% in the same period while Jha et al estimate a contribution of about 50-60%. Rather than differences in the method of estimation we believe that these differences reflect country differences in the smoking epidemic. Results from Preston et al.[16-17] indicate that overall smoking attributable mortality has declined rapidly in Finland from the 1980s

while progress has been less favourable in USA, Canada and UK, and at the turn of the millennia smoking-attributable mortality is higher in all these three countries than it is in Finland. Jha et al show no data for women, but our results indicate than among women below the age of 70 the contribution of smoking to educational differences in mortality is about 25%.

However, focussing at ages below 70 is insufficient. Although each death at older ages contributes less to life expectancy, they are still very significant because of their sheer volume; in the last period covered by our data about 60% of deaths among men and 80% among women occur at ages above 70 years. Of the overall contribution of smoking to educational differentials in life-expectancy at age 50 about 40-50% is due smoking-attributable mortality at these ages. The significant contribution of older ages is also compounded by cohort replacement, with heavy smoking birth cohorts born before the second-world war entering old age and a simultaneous shift of age at death of smoking related deaths to older ages. A possible countervailing process is the increasing educational differentials in smoking over time in recent decades, the effect of which may however be observed in years to come.

Generalisability of the results

The results obtained from the Finnish context are likely to be relevant and can be generalised to many high income Northern European and Anglo-Saxon countries with broadly similar cohort smoking histories. In particular, the Finnish experience may be closely comparable to that of the United States as previous studies have demonstrated similar mortality levels and educational mortality differentials in the two countries.[20] Furthermore, the two countries also share relatively similar cohort smoking histories, characterized by high levels of ever smoking among men born before the Second World War and declining prevalence of smoking among later cohorts, and a later initiation of smoking among women that has stabilized at levels similar to men in the cohorts born after the 1950s.[21-23] However, smoking started to decline slightly earlier in Finland than in the United States. Both countries have also had wide and long-lasting social differentials in smoking. The large contribution of smoking to total mortality and educational differentials in mortality in the 1970s and subsequent decline are also consistent with these trends. However, it is noteworthy that although smoking rates are high in many Southern European countries, social differentials in smoking are much smaller[24]. Smoking thus continues to have a major contribution to life-expectancy in these countries but its contribution to social differentials is modest.

Implications

The contribution of smoking to life-expectancy and educational differences in life-expectancy are substantial among Finnish men but at present modest among women. Although this is likely to be true for many high-income countries the exact magnitude of the effects will vary depending on the stage of the smoking epidemic. Trend data on smoking in many other European countries and the US imply that as younger cohorts age the contribution of smoking to life-expectancy and also life-expectancy differentials is likely to continue to diminish among men but increase among women.

Active and successful anti-smoking efforts can achieve further gains among men and slow down or reverse adverse trends among women. It is likely that these efforts will be only partially successful if solely based on price and availability. We show major educational differences in smoking-attributable mortality and thus our results imply that more distal socio-structural determinants of smoking also need to be tackled. Active and successful anti-smoking efforts can achieve further gains in longevity among men and reverse the trend of increasing smoking attributable mortality among women – particularly among those less educated.

Figure 1. Proportion of deaths above age 50 attributable to smoking. Finnish men (left panel) and women (right panel) aged 50 in 1971-2005.

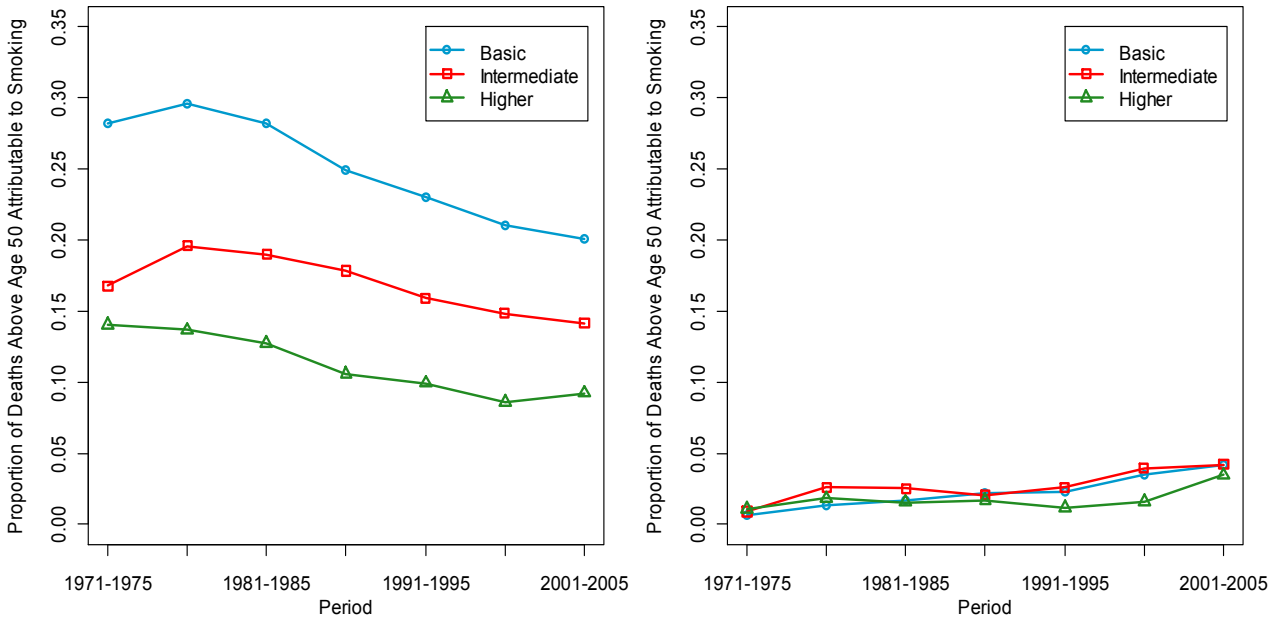


Figure 2. Life-expectancy by education with and without smoking. Finnish men (left panel) and women (right panel) aged 50 in 1971-2005.

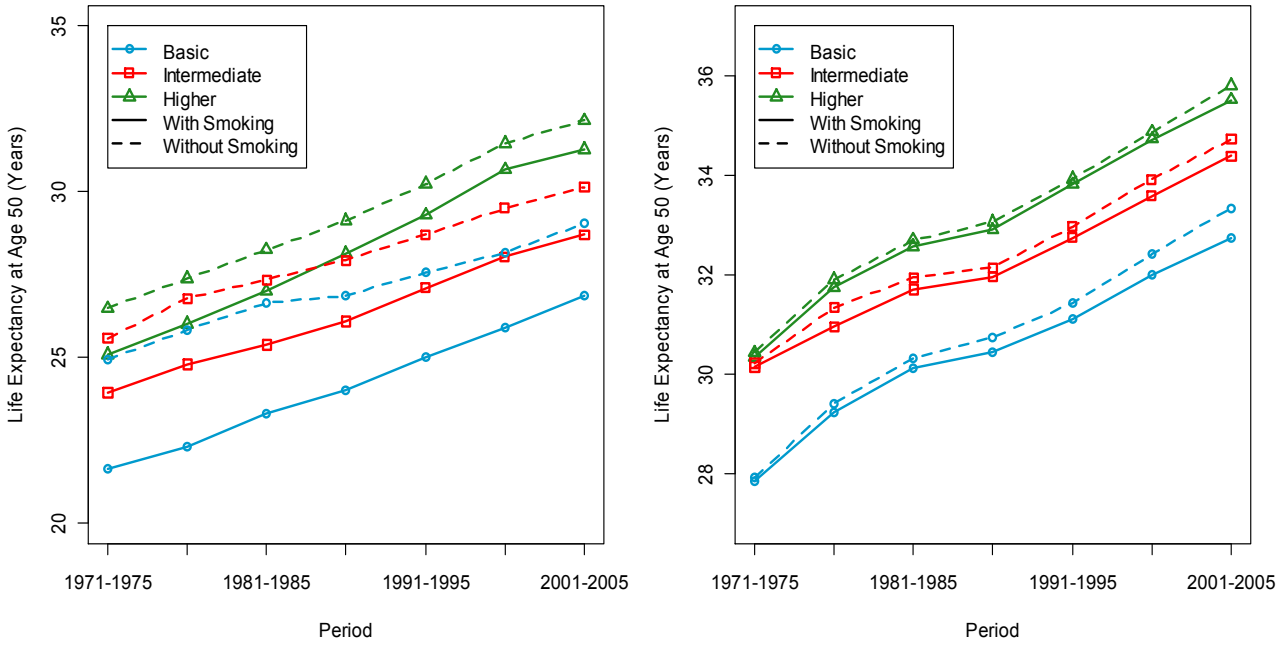
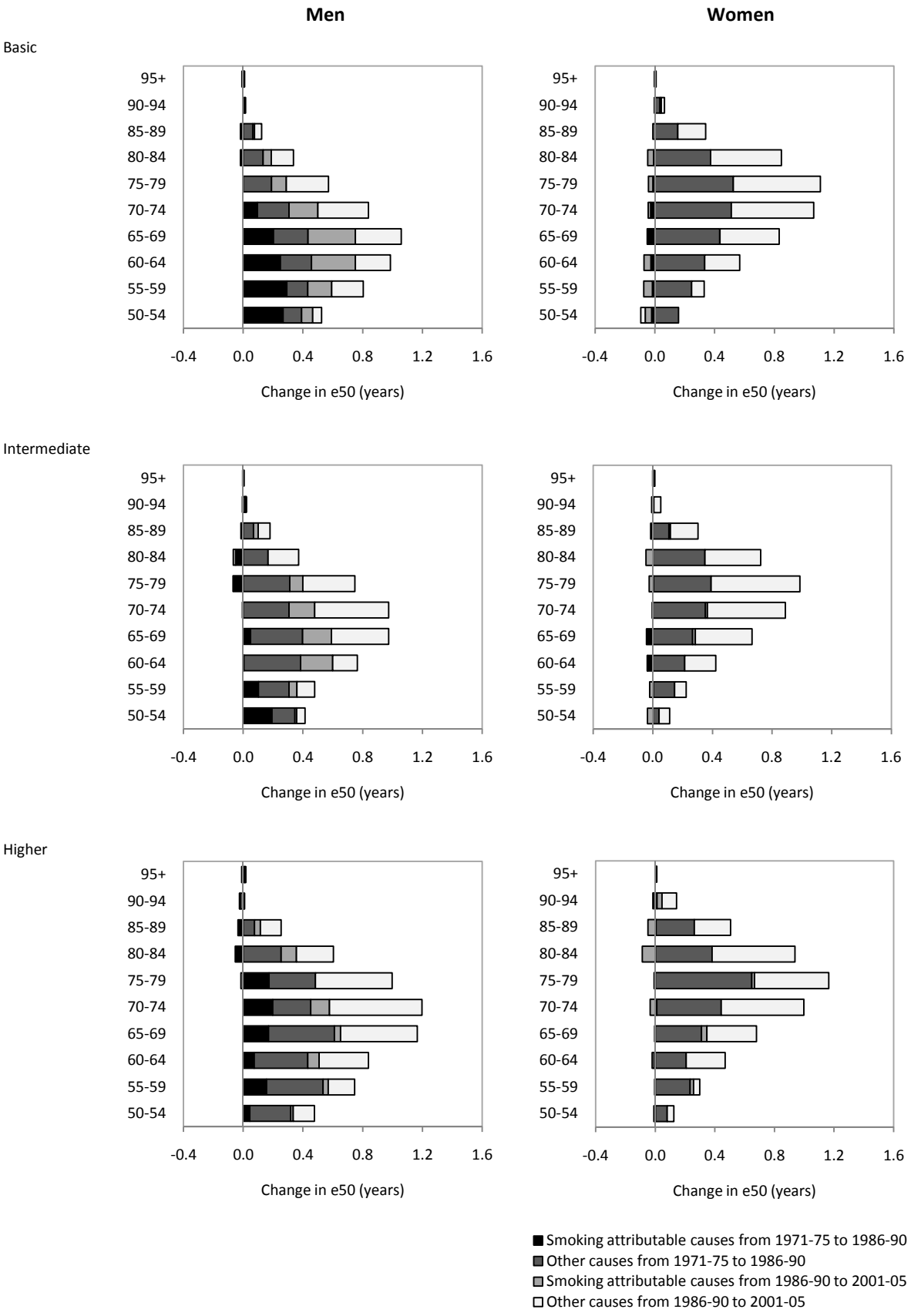


Table 1. Life-expectancy at age 50 by education with and without smoking. Finnish men and women aged 50+ in 1971-2005.

MALES	With smoking					Without smoking					Δ in e_{50} without – with smoking	% attenuation in education gap (H-B) due to smoking
Year	Total	Basic	Intermediate	Higher	Gap (H-B)	Total	Basic	Intermediate	Higher	Gap (H-B)	Total	
1971-1975	22.029	21.645	23.939	25.093	3.447	25.045	24.938	25.576	26.476	1.538	3.016	55.4
1976-1980	22.775	22.313	24.795	26.018	3.705	25.971	25.817	26.771	27.380	1.563	3.196	57.8
1981-1985	23.814	23.321	25.383	27.003	3.682	26.799	26.636	27.327	28.247	1.611	2.985	56.2
1986-1990	24.634	24.018	26.089	28.136	4.118	27.162	26.852	27.921	29.127	2.274	2.528	44.8
1991-1995	25.743	25.021	27.101	29.295	4.274	27.962	27.556	28.705	30.237	2.680	2.219	37.3
1996-2000	26.828	25.888	28.040	30.666	4.779	28.762	28.149	29.502	31.454	3.305	1.934	30.8
2001-2005	28.066	26.868	28.696	31.274	4.406	29.814	29.029	30.130	32.141	3.112	1.748	29.4

FEMALES	With smoking					Without smoking					Δ in e_{50} without – with smoking	% attenuation in education gap (H-B) due to smoking
Year	Total	Basic	Intermediate	Higher	Gap (H-B)	Total	Basic	Intermediate	Higher	Gap (H-B)	Total	
1971-1975	28.082	27.844	30.146	30.341	2.498	28.150	27.919	30.218	30.431	2.512	0.068	-0.6
1976-1980	29.463	29.224	30.953	31.743	2.519	29.624	29.397	31.334	31.894	2.497	0.160	0.9
1981-1985	30.367	30.112	31.701	32.567	2.455	30.566	30.329	31.934	32.695	2.365	0.200	3.7
1986-1990	30.740	30.444	31.957	32.902	2.457	30.985	30.725	32.136	33.056	2.331	0.245	5.1
1991-1995	31.507	31.110	32.744	33.816	2.707	31.775	31.421	32.961	33.925	2.504	0.268	7.5
1996-2000	32.491	31.990	33.581	34.721	2.731	32.843	32.423	33.910	34.867	2.444	0.352	10.5
2001-2005	33.450	32.728	34.381	35.506	2.778	33.888	33.323	34.717	35.794	2.472	0.438	11.0

Figure 3. Decomposition of change in life expectancy at age 50 by cause of death (smoking and non-smoking) and age within each education group for two periods - from 1971-75 to 1986-90 and from 1986-90 to 2001-2005



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