The role of smoking on mortality compression: an analysis of Finnish occupational social classes, 1971-2010

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Abstract

Adult lifespan variation has been stagnant since the 1960s in most countries, despite increases in longevity. We investigated the role that smoking has played in this stagnation using Finnish register data by occupational social class (1971-2010). We expected stronger mortality compression in the absence of smoking and expected smoking-attributable mortality to explain divergences in compression by occupational group. Instead we only found a modest impact on lifespan variation from smoking, despite it having a large impact on life expectancy. Among men, diverging trends in lifespan variation by occupational class would have widened even further in the absence of smoking, while among women trends in lifespan variation were mostly unaffected by smoking. The maturation of the smoking epidemic is not expected to bring about strong reductions in the uncertainty in the timing of death, nor is it expected to reduce inequalities in this dimension by occupational class in Finland.

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Introduction

Uncertainty in the timing of death, or lifespan variation, is possibly the most fundamental distributional issue we face (Tuljapurkar 2010). This uncertainty reduces the value of public and private investment and savings (Edwards 2008). It also impedes the planning of life's events. At the societal level high lifespan variation may signal failing social policies (van Raalte et al. 2011), particularly if caused by high levels of premature mortality (Sen 1998).

With uneven age patterns of mortality decline, lifespan variation is becoming a more important dimension to examine. Divergences in mortality distributions between high income countries increasingly come from differences in adult lifespan variation, defined as variation in ages-at-death conditional upon surviving childhood, instead of differences in mean ages at death (Edwards and Tuljapurkar 2005). Although a strong inverse relationship used to exist between these two domains, increases in life expectancy since the 1960s have not uniformly been met with compression in the adult lifespan distribution – if anything stagnation in adult lifespan variation has become the norm in high income countries (Edwards 2011; Edwards and Tuljapurkar 2005; Smits and Monden 2009; Wilmoth and Horiuchi 1999).

For adult lifespan variation to decrease, mortality reduction at younger ages must outpace mortality reduction at older ages. Thus it might be expected that the observed stagnation in lifespan variation is owing to harmful personal behaviour that has led to high levels of premature mortality. Smoking is the most obvious example, and one that has yet to be investigated.

It is well established that a history of smoking is associated with higher mortality. The long-running prospective British cohort study on medical doctors has shown an average 10-year difference in mean age at death between lifelong smokers and non-smokers (Doll et al. 2004). This study also showed that a quarter of cigarette smokers died while still in middle age (ages 35-69) – ages to which indices of lifespan variation have been shown to be especially sensitive (van Raalte and Caswell in press). As such, we would expect smokers to have a longer left tail of the age-at-death distribution than non-smokers, and consequently to have higher lifespan variation.

Additionally, since smoking is heavily socially patterned, different SES groups have different cohort smoking patterns. Peaks in smoking-attributable mortality occur in different years for these different groups. Modelling the impact of smoking at the population level can hide these dynamics. Moreover, different SES groups have been shown to have diverging trends in lifespan variation, with manual workers experiencing increases in lifespan variation and non-manual workers mortality compression since the early 1970s (van Raalte, Martikainen and Myrskylä 2012). An important question is to what extent these diverging trends in lifespan variation by SES can be explained by smoking.

In this study we model the impact of smoking on the lifespan variation of Finnish occupational social classes from 1971 to 2010. Finland was chosen because of the high quality of its data, the relatively long time series available, and because it has a smoking history that is similar to that found in many other western countries (Pampel 2011). In contrast to what was expected, we find only a modest impact from smoking on overall levels of lifespan variation.

Data

The dataset is comprised of individual level register data of all Finns linked by personal identification codes to the death registry, covering the period 1971-2010. The death and exposure counts were aggregated by Statistics Finland by single year of age (50-100+), sex, cause of death, and occupational-based social class before being delivered to the researchers. In each year person days and deaths were allocated to one year age intervals between exact birthdays. The death rates and mortality differences by occupational class have been published elsewhere (Martikainen, Valkonen and Martelin 2001; Valkonen 1993; van Raalte et al. 2012).

We used occupational-based social class as our SES indicator because unlike education, the proportion of individuals in each class remained rather stable over time (van Raalte et al. 2012). Occupation-based socioeconomic status was measured at the time of each census updated in every 5th year. Four groups were distinguished: 1) upper non-manual, 2) lower non-manual, 3) manual workers and 4) others. We only present results for the first 3 classes due to large compositional changes within the fourth group. The classification is retroactive i.e. for pensioners, unemployed persons and for those whose socioeconomic status was unknown information was retrieved from earlier censuses. Those whose main activity was household work were classified according to the occupation of the head of the household. Immigrants were dropped from the data set since we did not have any baseline information on occupational class, while emigrants were censored at emigration.

Statistics Finland classified all causes of death into 54 groups, which were harmonized over various revisions of the International Classification of Diseases and Causes of Death (ICD). One of these causes of death is a combined lung and larynx cancer death category (161-162 ICD-8 and ICD-9; C32-C34 ICD-10). Since our estimation method of smoking-attributable mortality (described in the next section) uses deaths from lung cancer only, we had to separate the two forms of cancer. Using data from the WHO database we calculated the proportion of deaths owing to larynx cancer in the combined larynx and lung cancer category for the national population. We assumed that this proportion would have been the same for all occupational groups. Larynx cancer was a much smaller cause of death overall, accounting for about 3.5 percent of the combined deaths in the early 1970s and around 2 percent in the early 2000s. No discernable difference was found in the age pattern between larynx cancer and lung cancer among men. Finnish women experienced an average of only 4 larynx deaths per year during this period, making further differentiation by age impossible. Thus we used the proportion of larynx cancer deaths over all ages (50+) in the combined larynx and lung cancer group to estimate the yearly larynx cancer death counts for each occupational class. These deaths were then subtracted from the combined larynx and lung cancer death count, to give us estimates of lung cancer deaths per sex, age, year and occupational class.

Methods

Life tables, life expectancy and lifespan variation

We created life tables (ages 50+) for each sex, occupational class and period by conventional methods (Wilmoth et al. 2007). This included smoothing mortality with a Kannisto model, from the first age when the death counts fell below 100 in any sex or occupational group for each period. By doing so, we were able to extend our life tables up to a 110+ age category. We aggregated data into five year intervals (1971-1975, 1976-1980, 1981-1985, 1986-1990, 1991-1995, 1996-2000, 2001-2005, 2006-2010). This was done to produce smoother age at death distributions and yielded us small confidence intervals around our life expectancy estimates, even for the smallest occupational groups (van Raalte et al. 2012).

Lifespan variation was measured using the $e^{\dagger}_{50}$ measure (Vaupel and Canudas Romo 2003; Vaupel, Zhang and van Raalte 2011) because of its ease of interpretation as the average number of life years lost due to death, conditional upon survival to age 50. It is calculated as,

$$e^{\dagger}_{50} = \sum_{x=50}^{\omega} d_x \left[\frac{1}{2} \left(e_x + e_{x+1} \right) \right], \qquad (1)$$

where d_x and e_x are respectively the number of life table deaths and the remaining life expectancy at age x for all causes, calculated from age 50 to age ω (110+). To understand how $e^{\dagger}_{50}$ functions as a lifespan variation measure, when deaths are spread out over many ages, the remaining life expectancy at early ages is high and remains considerable even over more common ages at death. As deaths become concentrated into a shorter age interval, the distance lowers between a death at a certain age and the number of years that would have been gained by saving this death. Thus $e^{\dagger}_{50}$ can alternatively be interpreted as the average remaining life expectancy at death (Vaupel and Canudas Romo 2003). Moreover, lifespan variation and life expectancy have a unique relationship. The product of $e^{\dagger}$ and the rate of progress at reducing age-specific mortality is exactly equal to the change in life expectancy (Vaupel and Canudas Romo 2003). The ease of interpretation of $e_{50}^{\dagger}$ and its mathematical properties have made it a popular alternative to other common indices of lifespan variation such as the standard deviation or the interquartile range (Beltrán-Sánchez and Soneji 2011; Kibele 2012; Nusselder and Mackenbach 1996; Popham, Dibben and Bambra 2013; Shkolnikov et al. 2011; van Raalte et al. 2012; Vaupel et al. 2011). In any case, indices of lifespan variation are highly correlated with one another (van Raalte and Caswell in press; Vaupel et al. 2011; Wilmoth and Horiuchi 1999) and exhibit similar sensitivities to changes in age-specific mortality (van Raalte and Caswell in press).

Measuring smoking-attributable mortality

An estimated 85-90% of deaths from lung cancer are among smokers (CDC 2005). For this reason, the stage of the smoking pandemic in a population can reasonably be estimated by the number of lung cancer deaths. Techniques have been developed that make use of this relationship to indirectly estimate the mortality attributable to smoking, notably the Peto-Lopez (PL) method (Peto et al. 1992) and the relatively newer Preston, Glei and Wilmoth (PGW) method (Preston, Glei and Wilmoth 2010; Preston, Glei and Wilmoth 2011). Although both methods use lung cancer deaths to estimate the population's cumulative smoking exposure, they differ on techniques to assess the share of deaths caused by such exposure. The PL method borrows the excess relative risk of mortality for most other causes of death among smokers obtained from American survey data, and assumes that half of this excess mortality is directly attributable to smoking. The PGW method uses a negative binomial regression model to determine the association between lung cancer and other causes of death to predict the number of deaths attributable to smoking. While both methods tend to produce similar estimates of smoking attributable mortality (Blue and Fenelon 2011; Preston et al. 2010; Rostron 2010), we prefer the PGW method because it eliminates the arbitrary step of determining the proportion of excess mortality risk found among smokers that is caused by smoking.

The PGW model was built using data from 20 high-income countries, Finland included, covering the period 1950 to 2006 for ages ≥ 50. We used the regression coefficients from Preston et al. (2011).

Estimating the effects of smoking on life expectancy and lifespan variation

We estimated what e_{50} and $e^{\dagger}_{50}$ would have been like in the absence of smoking by multiplying the death rate (M_{scxy}) for sex *s*, occupational class *c*, age *x*, and year interval *y*, by the factor ($1-A_{scxy}$), where A_{scxy} is the proportion of deaths attributable to smoking in the age interval that includes *x*. This assumes that the same attributable fraction applies to all ages in each 5-year age interval, as well as in the open age category (85+). With these new death rates we recalculated the life tables using the methods described above.

Finally, we decomposed the change over time (1971-75 to 2001-10) in e_{50} and $e^{\dagger}_{50}$ into contributions from smoking-attributable mortality and non-smoking-attributable mortality. To do so we treated each of these contributions as competing causes of death (Preston et al. 2011), allowing us to use standard cause-of-death decomposition techniques, which are easily extended to the decomposition of $e^{\dagger}_{50}$ (Andreev, Shkolnikov and Begun 2002; Shkolnikov and Andreev 2010; Shkolnikov et al. 2011).

Results

Between the earliest period (1971-1975) and the latest period (2006-2010) the overall proportion of deaths attributable to smoking declined for men of all occupational classes, while it rose for women.

The breakdown for these periods by age and occupational class is given in Figure 1. In the earlier period a higher proportion of deaths to adults under age 75 were smoking-related than deaths over age 75. This reversed itself for men by 2006-2010, but not for women, reflecting the later initiation of smoking by women. Manual workers had the highest proportion of smoking-attributable mortality for most age and year combinations.

In Figure 2 we plotted the male age-at-death distribution calculated for both all-cause mortality and mortality not attributable to smoking for the earliest and latest periods among the manual and upper non-manual workers. In all cases, removing smoking-attributable mortality did not fundamentally change the shape of the distribution but rather shifted the distribution to older ages. Thus smoking appeared to primarily influence the level, rather than the age spread of mortality. The largest shift was seen among male manual workers in the earlier period. Producing the same figure for women resulted in few visible differences in the age-at-death distributions, apart from a small but noticeable increase in age-at-death variation among manual workers in the later period (appendix Figure 1).

Table 1 presents the impact of smoking on life expectancy and confirms that smoking-attributable mortality was having a greater impact on the e_{50} of manual workers than it was for the non-manual classes, over all time periods. Among men, manual workers reached a peak of 3.6 years of e_{50} lost due to smoking in 1976-1980. This contrasted to a peak of 1.4 years among upper non-manual workers, and 2.1 years among lower non-manual workers in the same period. Trends in the losses in e_{50} attributable to smoking were similar for all occupational groups, though the level was different. Among women, an upward trend in life expectancy losses due to smoking was present for all occupational groups, with the sharpest rise among manual workers, who by the last period shared the same absolute loss in life expectancy attributable to smoking as the upper non-manual male workers (0.7 years).

Table 2 presents the impact of smoking on lifespan variation. Over the observation window, $e^{\dagger}_{50}$ decreased for the non-manual workers but increased for manual workers of both sexes. Removing smoking led to increased lifespan variation for men and slightly decreased lifespan variation for women, but overall the impact of smoking on $e^{\dagger}_{50}$ was minor.

In Figure 3 we plotted the class gap in e_{50} and in $e^{\dagger}_{50}$ between the upper non-manual and the manual classes, based both on observed data and with smoking-attributable mortality removed. The class gap in e_{50} (panel A) was increasing over time for both sexes. Smoking was responsible for a shrinking share of this gap over time for men, while the opposite was true for women. In the absence of smoking, the class gap in e_{50} would actually have been larger for women than for men beginning in the early 1990s. The class gap in $e^{\dagger}_{50}$ (panel B) was also growing over time, from near-negligible differences to differences of over 1 year among men, and half a year among women. The larger class gap in $e^{\dagger}_{50}$ found among men was unrelated to their higher smoking levels. In fact, smoking-attributable mortality decreased the class gap in $e^{\dagger}_{50}$ for men by around 0.2 years on average. For women smoking had little impact on the gap until the mid-1990s, after which it led to a small increase in the class gap in lifespan variation.

Next we decomposed changes in e_{50} and $e^{\dagger}_{50}$ over time (1971-75 to 2006-10) into components attributable and not attributable to smoking. Among men, changes in e_{50} were mainly driven by non-smoking-attributable causes for the non-manual workers, who also experienced the largest gains in e_{50} over the 30-year time period (Figure 4). Manual workers experienced larger gains in e_{50} from smoking-attributable causes, but smaller gains from non-smoking-attributable causes. Gains in e_{50} among women were entirely resulting from reductions in non-smoking-attributable mortality.

The decomposition pattern is more complicated for $e^{\dagger}_{50}$. In order for lifespan variation to decrease, reductions in mortality must be greater at early ages which compress the age-at-death distribution than they are at later ages which expand the distribution. In Figure 5 we show that among males, decreases in smoking-related mortality were concentrated in ages that compress mortality. Male manual workers especially showed strong reductions in smoking-related causes over this time frame.

However, the compression of mortality caused by reductions in smoking-related mortality was not enough to balance the expansion in the age-at-death distribution caused by reductions at older ages in non-smoking-related mortality among this group, which caused $e^{\dagger}_{50}$ to increase overall. In contrast, non-manual workers experienced strong reductions in mortality from non-smoking-related causes over all ages. When combined with the reductions in smoking-related mortality at younger ages, this led to an overall compression of the age-at-death distribution (i.e., a reduction in $e^{\dagger}_{50}$). Among women, the patterns in $e^{\dagger}_{50}$ were overwhelmingly attributable to non-smoking-related causes.

Discussion

Summary of results

Smoking only had a modest impact on the total levels of lifespan variation, despite having a large impact on life expectancy levels. Among men, diverging trends in lifespan variation by occupational class would have further widened in the absence of smoking, while among women trends in lifespan variation were mostly unaffected by smoking. Instead, the diverging trends in lifespan variation were mostly explained by differences in early adult mortality by non-smoking related causes.

Methodological considerations

The earlier PGW model was found to overestimate smoking attributable mortality at the oldest ages, (85+) (Ho and Preston 2010; Preston et al. 2011), especially for women (Rostron 2010). We used the coefficients in the later PGW publication, which excluded ages 85+ from the model fit and proposed using the average of age coefficients 70-74, 75-79, and 80-84 as the regression coefficient for ages 85+ (Preston et al. 2011). This revision was found to be more robust for smoking-attributable mortality at older ages. We intend to conduct further sensitivity analysis to ensure that our results are not overly sensitive to this oldest age coefficient.

In addition, the PGW method makes the assumption that death rates attributable to smoking among never-smokers would be the same for each occupational group. However, it is possible that manual workers would have had greater exposure to ambient air pollution and passive smoking that might have put them at a greater risk of contracting lung cancer. Others who have tested this assumption for different population subgroups by increasing or decreasing these smoking-attributable death rates by half for different subgroups have found the results from the PGW method to be robust (Blue and Fenelon 2011; Martikainen et al. 2013). Moreover, the incidence rate of lung cancer among non-smokers was stable over a 20-year period in the United States, despite large differences in the smoking composition of the population (Thun et al. 2006).

Extending the age range back to age 31, which is possible with our dataset, reveals larger differences between occupational groups in all-cause lifespan variation (van Raalte et al. 2012). This is because mortality inequalities are larger among the age range (31-49) than among ages 50+, and because indices of lifespan variation are especially sensitive to early adult mortality (van Raalte and Caswell in press). We used only ages 50+ because these ages are the ages that corresponded to the PGW regression model. Yet smokers have excess mortality risks over non-smokers even from an age of 20, although much, but not all of which can be attributed to the higher risk-taking behaviour of smokers rather than directly attributable to smoking itself (Rogers et al. 2005). In general estimates of smoking-attributable mortality in the 35-49 age range made from the PL model tend to be low (Preston et al. 2011). Thus we would not expect smoking to have a larger impact on lifespan variation were we to extend our age range backward, though we intend to verify this.

There might also be some concern of using $e^{\dagger}_{50}$ as our index of lifespan variation, given that compared to other indices it is more sensitive to older adult mortality (van Raalte and Caswell in press), ages where smoking is less of a threat. To test this we measured lifespan variation by the standard deviation conditional upon survival to age 50 (S_{50}), the full results of which are available in the appendix. None of the patterns or conclusions changed.

At older ages the interaction of multiple underlying conditions can complicate the identification of the proximate cause of mortality (Manton 1986; Minaker and Rowe 1985). Lung cancer, however, tends to be more accurately identified than other causes of death (Kircher, Nelson and Burdo 1985; Modelmog, Rahlenbeck and Trichopoulos 1992; Percy and Muir 1989). Thus, we take the view that the uncertainty in our estimates resulting from misreporting of lung cancer should be minimal.

Implications

Why smoking has a larger impact on life expectancy than on lifespan variation has to do with the age pattern of smoking-attributable and non-attributable mortality. As we have shown in Figure 1, removing smoking-attributable mortality did not fundamentally alter the shape of the age-at-death distribution but rather shifted it to older adult ages.

To date, most of the research into socioeconomic inequalities in mortality has focused on men. This is in part because it is more difficult to determine the socioeconomic status of women, particularly among women who did not seek paid employment, but also because SES inequalities in mortality are larger among men (Mackenbach et al. 1999). It has long been assumed that this is because many determinants of premature mortality (which drives SES differences in life expectancy and lifespan variation) are more strongly socially patterned among men (Huisman, Kunst and Mackenbach 2005; MacIntyre and Hunt 1997; Mackenbach et al. 1999). However, an important element uncovered in this research is that in the absence of smoking, women had larger inequalities in life expectancy than men in the earlier periods, with the crossover happening in 1986-90. As the impact of smoking continues to fade among men and strengthen among women, it will be important to model the role of smoking in driving socioeconomic inequalities in mortality.

If smoking is not causing the large, and growing, lifespan variation among manual workers, what else could be the culprit? In other work with this same dataset, we showed that mortality from external causes was especially high among manual workers, particularly when compared to the other classes at similar life expectancy levels (van Raalte et al. 2012). Yet in a comparison across a range of high income countries, differences in external cause mortality did not drive trends in adult lifespan variation, although it did affect the levels (Edwards and Tuljapurkar 2005). In a comparison of USA with England & Wales, external mortality was more important for the between-population differences in lifespan variation at a given time than the within-population differences over time (Shkolnikov et al. 2011). Thus external mortality might be part of the explanation, but it is not the entire explanation. More research is needed into the mortality determinants driving trends in adult lifespan variation.

<u>Comparison to other work</u>

To our knowledge, this is the first study to examine the impact of smoking on lifespan variation. However the impact of smoking on life expectancy is well documented. In a comparison of 20 developed countries, Preston et al. (2011) estimated that smoking was reducing life expectancy by 2 years among men and 1 year among women in 2003. The harm from smoking in Finland was lower than this 20-country average, causing reductions in e_{50} of 1.7 years (men) and 0.5 years (women). If the Finnish occupational groups were compared to these countries, Finnish male manual workers experienced losses in life expectancy comparable to the entire United States population and the upper non-manual workers to Sweden (based on our results from 2006-10). For women the impact of smoking on e_{50} is comparable to Austria and Belgium (manual workers) and France (non-manual workers).

The extent to which differences in smoking behavior are responsible for socioeconomic differences in mortality has yielded conflicting results, depending in large part on the methodology used and the age range examined (Denney et al. 2010; Jha et al. 2006; Marmot 2006; Martikainen et al. 2013). Using direct methods, smoking was estimated to account for less than a quarter of the educational gap in male adult mortality in the UK (Marmot 2006) and the USA (Denney et al. 2010), although when further refined by age, the latter study found that this figure was as high as 44 % among middle-aged men. This is near to Jha et al's (2006) estimate that smoking accounts for about half of the excess mortality among low educated men (ages 36-69) in urban Canada, USA, England and Wales and Poland using the Peto-Lopez method. In Finland, Martikainen et al. (2013) found that the high to low educational gap in e_{50} would have attenuated by 29 % (men) and 11% (women) in the absence of smoking in 2001-05, using the PGW method.

Although Finland is a small and relatively homogeneous population, we would expect broadly similar results on the impact of smoking on lifespan variation in other populations with long cohort smoking histories. Finnish men adopted smoking habits early and consequently are estimated to have among the highest excess mortality attributable to smoking in Europe, with levels comparable to Belgium and just under the United Kingdom (Mackenbach et al. 2004) and the USA (Pampel 2011). Finnish women have smoked far less than British, American or Danish women, but have smoking histories comparable to other Scandinavian countries (Mackenbach et al. 2004, Pampel 2010). It is more difficult to determine whether smoking would have a greater impact on lifespan variation on countries with a higher smoking prevalence because it would depend on the underlying age patterns of mortality.

The high quality of the dataset drawn from the Finnish population register gives us confidence in the results from this analysis. This dataset is large, is harmonized over several revisions of the ICD coding practices, and includes the institutionalized population. These are major advantages over using successive waves of population surveys, which unfortunately in many countries remain the only available source of socioeconomic data.

Conclusion

Smoking remains an important determinant of mortality, currently attributed with about one-fifth (men) and one-tenth (women) of all deaths over age 50 in Finland. However, smoking is not responsible for the large and growing differences in adult lifespan variation between occupational classes in Finland. Instead, the stagnation in mortality compression appears to be driven by a lack of reduction in early adult mortality from non-smoking attributable causes among manual workers. The maturation of the smoking epidemic alone is not expected to bring about strong reductions in the uncertainty in the timing of death.

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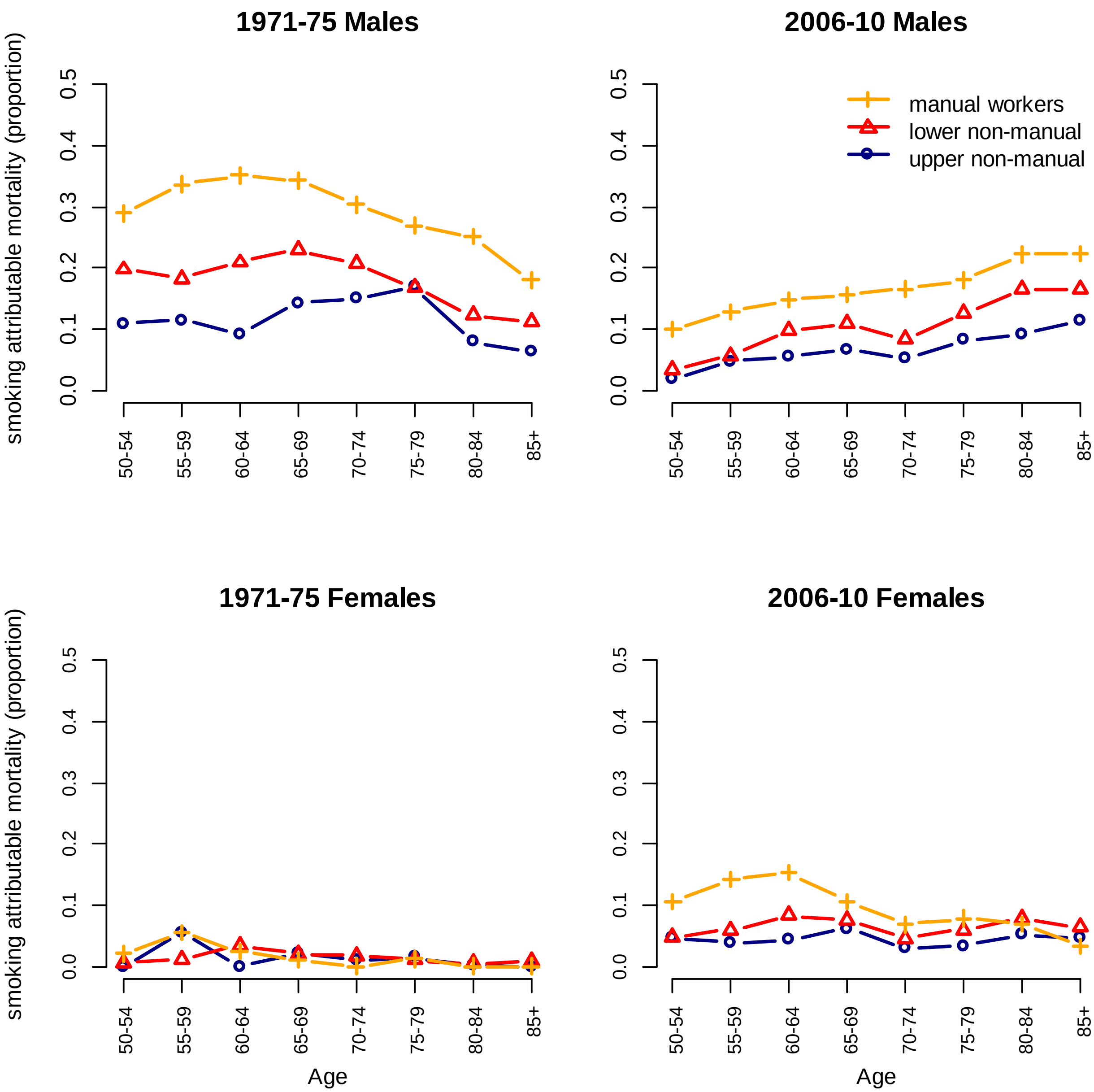


Figure 1: Smoking attributable mortality by age and occupational group in the earliest (1971-1975) and latest (2001-2010) periods.

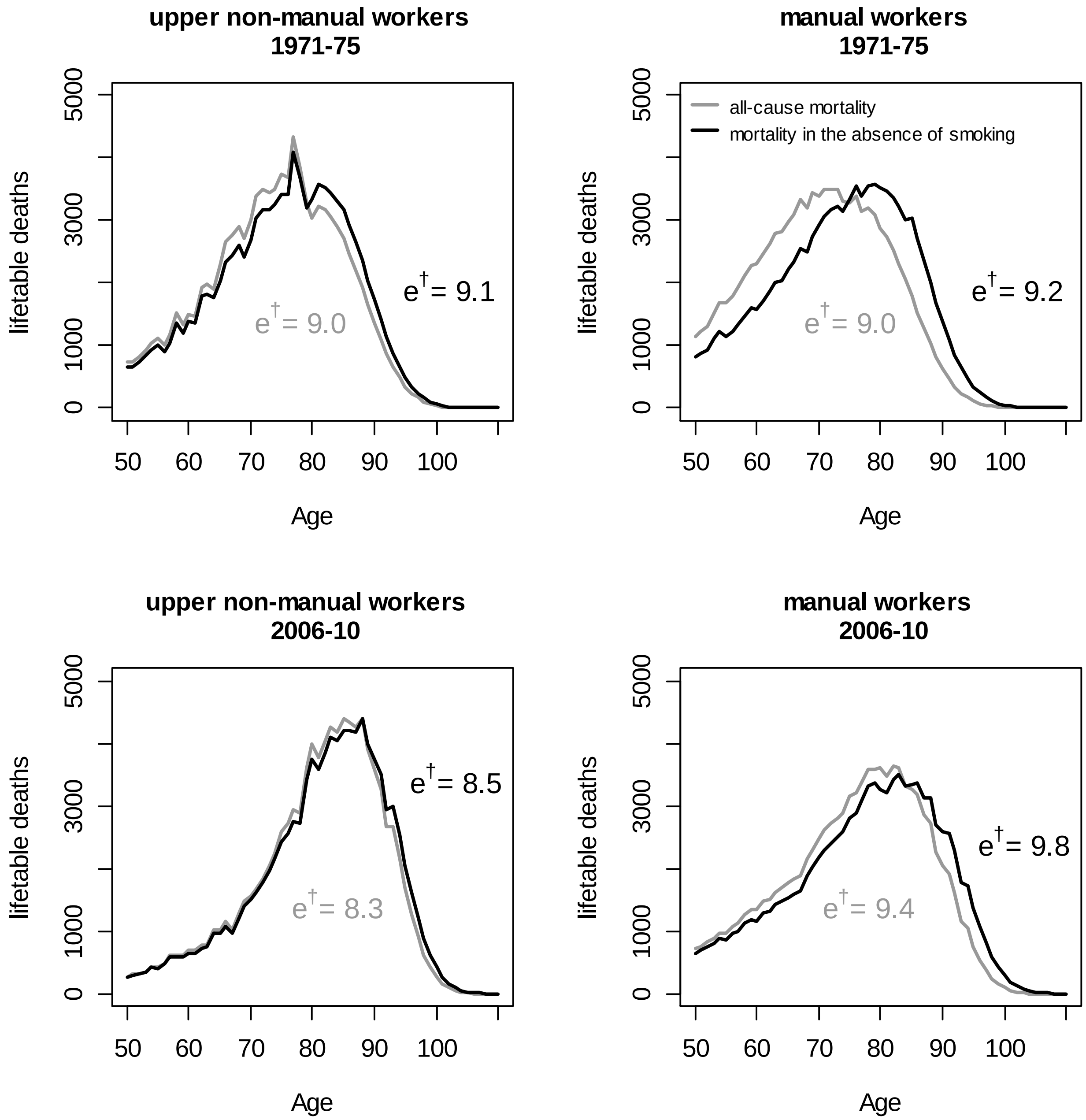


Figure 2: The male period life table death distributions of observed mortality (black line) and estimated mortality in the absence of smoking (grey line) for the lowest and highest occupational groups in the earliest and latest periods.

	Upper non-manual			Lower non-manual			Manual		
	Observed	Removing smoking	*Difference*	Observed	Removing smoking	*Difference*	Observed	Removing smoking	*Difference*
Men									
1971-1975	24.4	25.6	*1.2*	22.5	24.4	*1.9*	21.0	24.4	*3.4*
1976-1980	25.5	26.9	*1.4*	23.5	25.6	*2.1*	21.7	25.3	*3.6*
1981-1985	26.6	27.9	*1.3*	24.7	26.5	*1.8*	22.8	26.0	*3.2*
1986-1990	27.6	28.6	*1.0*	25.9	27.5	*1.6*	23.5	26.1	*2.7*
1991-1995	28.7	29.6	*0.9*	26.9	28.4	*1.4*	24.5	26.8	*2.3*
1996-2000	30.1	30.8	*0.7*	28.1	29.3	*1.2*	25.3	27.4	*2.1*
2001-2005	31.3	32.1	*0.8*	29.4	30.4	*1.1*	26.4	28.3	*1.9*
2006-2010	31.3	32.0	*0.7*	29.4	30.4	*1.1*	26.4	28.2	*1.7*
Women									
1971-1975	29.8	29.9	*0.1*	28.8	28.9	*0.1*	27.7	28.0	*0.1*
1976-1980	31.1	31.3	*0.2*	30.0	30.2	*0.2*	29.0	29.4	*0.2*
1981-1985	32.0	32.2	*0.3*	31.0	31.2	*0.2*	29.9	30.1	*0.3*
1986-1990	32.5	32.7	*0.1*	31.5	31.7	*0.3*	30.3	30.4	*0.3*
1991-1995	33.2	33.4	*0.2*	32.3	32.6	*0.3*	30.9	31.1	*0.4*
1996-2000	34.3	34.5	*0.2*	33.3	33.7	*0.4*	31.7	32.1	*0.4*
2001-2005	35.3	35.5	*0.2*	34.2	34.6	*0.4*	32.6	33.1	*0.6*
2006-2010	35.3	35.6	*0.3*	34.2	34.7	*0.5*	32.6	33.2	*0.7*

Table 1: Remaining life expectancy at age 50 for the different occupational classes in Finland. The observed e_{50} includes mortality from all causes, while 'removing smoking' is the estimated period e_{50} in the absence of smoking. The 'difference' category is the reduction in e_{50} attributable to smoking.

	Upper non-manual			Lower non-manual			Manual		
	Observed	Removing smoking	*Difference*	Observed	Removing smoking	*Difference*	Observed	Removing smoking	*Difference*
<u>Men</u>									
1971-1975	9.0	9.1	*0.1*	9.1	9.2	*0.0*	9.0	9.2	*0.2*
1976-1980	9.1	9.2	*0.2*	9.1	9.3	*0.2*	9.2	9.7	*0.4*
1981-1985	8.9	9.1	*0.2*	9.1	9.3	*0.3*	9.2	9.7	*0.5*
1986-1990	8.7	9.0	*0.2*	9.1	9.4	*0.3*	9.3	9.8	*0.5*
1991-1995	8.6	8.7	*0.1*	8.8	9.1	*0.3*	9.3	9.7	*0.5*
1996-2000	8.4	8.6	*0.2*	8.7	9.0	*0.2*	9.3	9.7	*0.4*
2001-2005	8.3	8.5	*0.2*	8.8	9.0	*0.2*	9.4	9.8	*0.4*
2006-2010	8.3	8.5	*0.2*	8.8	9.1	*0.3*	9.4	9.8	*0.4*
<u>Women</u>									
1971-1975	8.0	8.0	*0.0*	8.2	8.2	*0.0*	8.1	8.1	*0.0*
1976-1980	8.2	8.1	*-0.1*	8.2	8.2	*-0.1*	8.4	8.3	*-0.1*
1981-1985	8.1	8.1	*0.0*	8.2	8.2	*0.0*	8.3	8.2	*-0.1*
1986-1990	8.0	7.9	*-0.1*	8.0	8.0	*-0.1*	8.4	8.3	*-0.1*
1991-1995	7.9	7.8	*-0.1*	7.8	7.8	*-0.1*	8.1	8.0	*-0.1*
1996-2000	7.6	7.6	*0.0*	7.7	7.7	*0.0*	8.1	8.0	*-0.1*
2001-2005	7.5	7.5	*0.0*	7.8	7.7	*0.0*	8.2	8.0	*-0.2*
2006-2010	7.5	7.5	*0.0*	7.8	7.8	*0.0*	8.2	8.0	*-0.2*

Table 2: Life disparity at age 50 ($e^{\dagger}_{50}$) for the different occupational classes in Finland. The ‘difference’ category is the increase in $e^{\dagger}_{50}$ attributable to smoking.

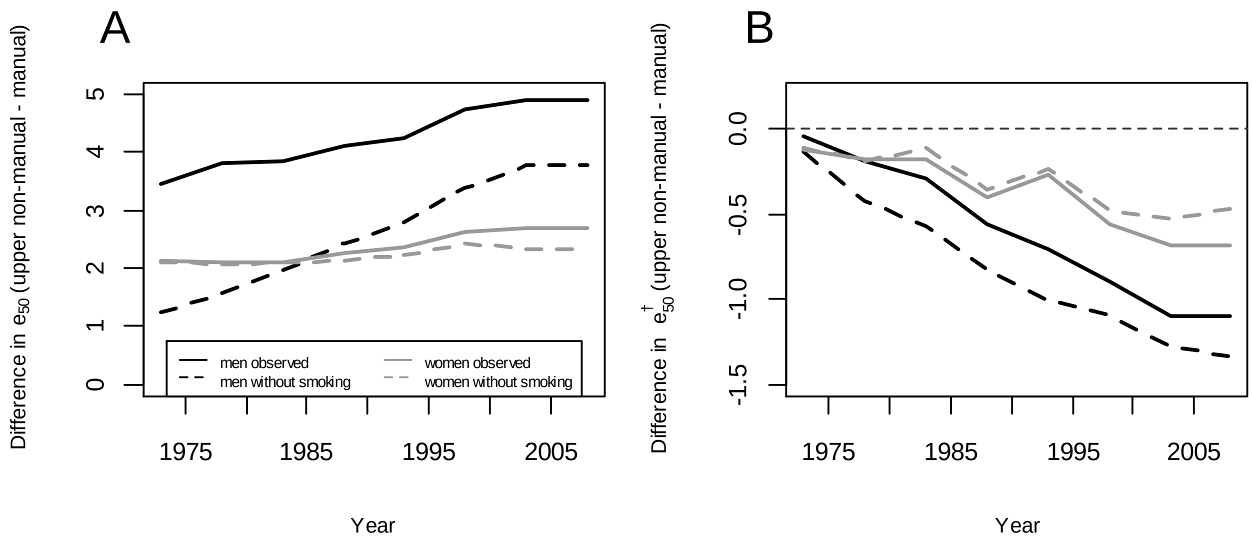


Figure 3: The difference between the upper non-manual classes and the manual classes in e_{50} (Panel A) and $e^{\dagger}_{50}$ (Panel B), based both on observed data (solid lines) and with smoking-attributable mortality removed (dashed lines).

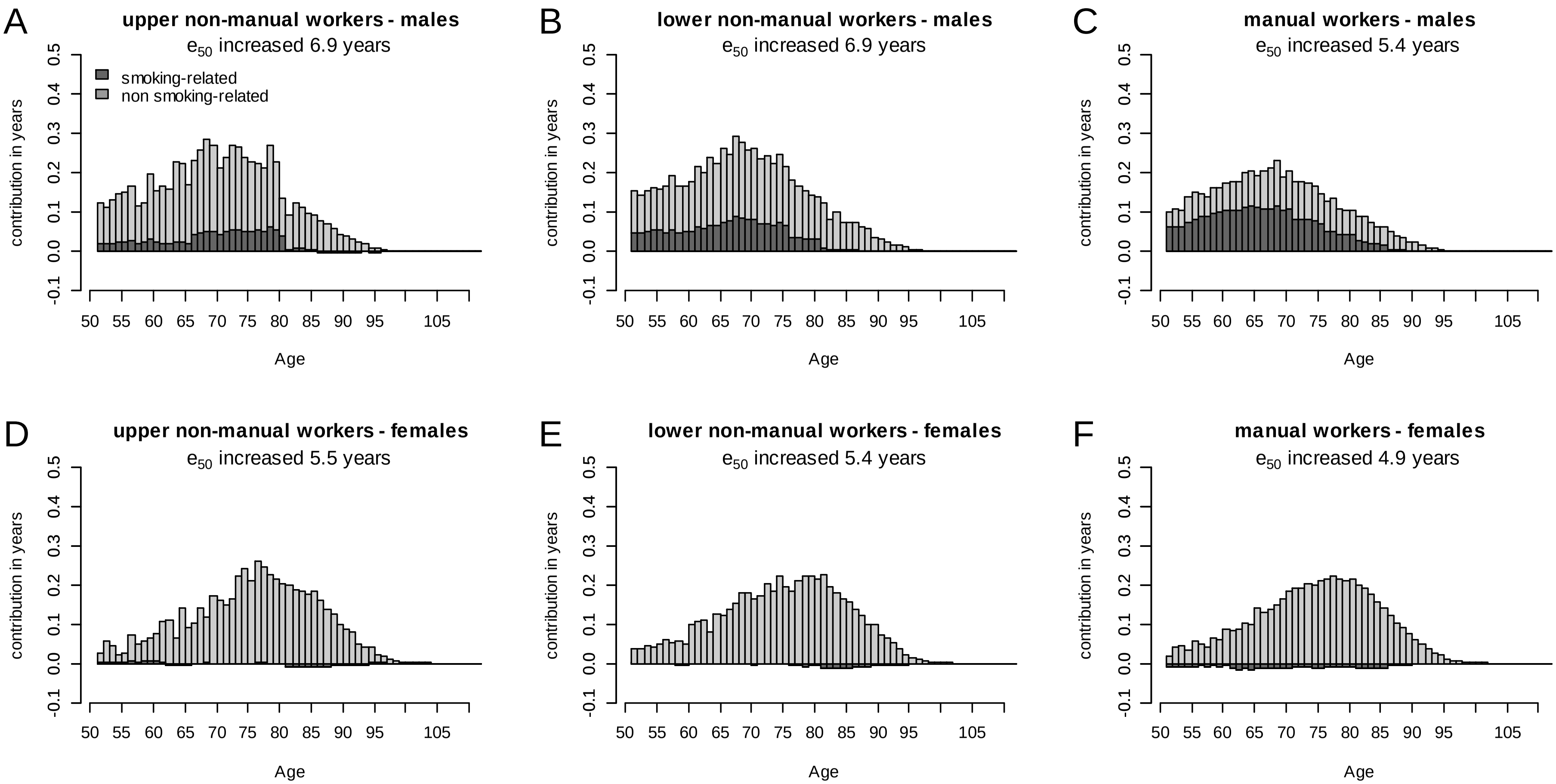


Figure 4: Decomposition of e_{50} increases between 1971-75 and 2006-10 into components reflecting changes in smoking-attributable mortality and non-smoking-attributable mortality, by sex and occupational class.

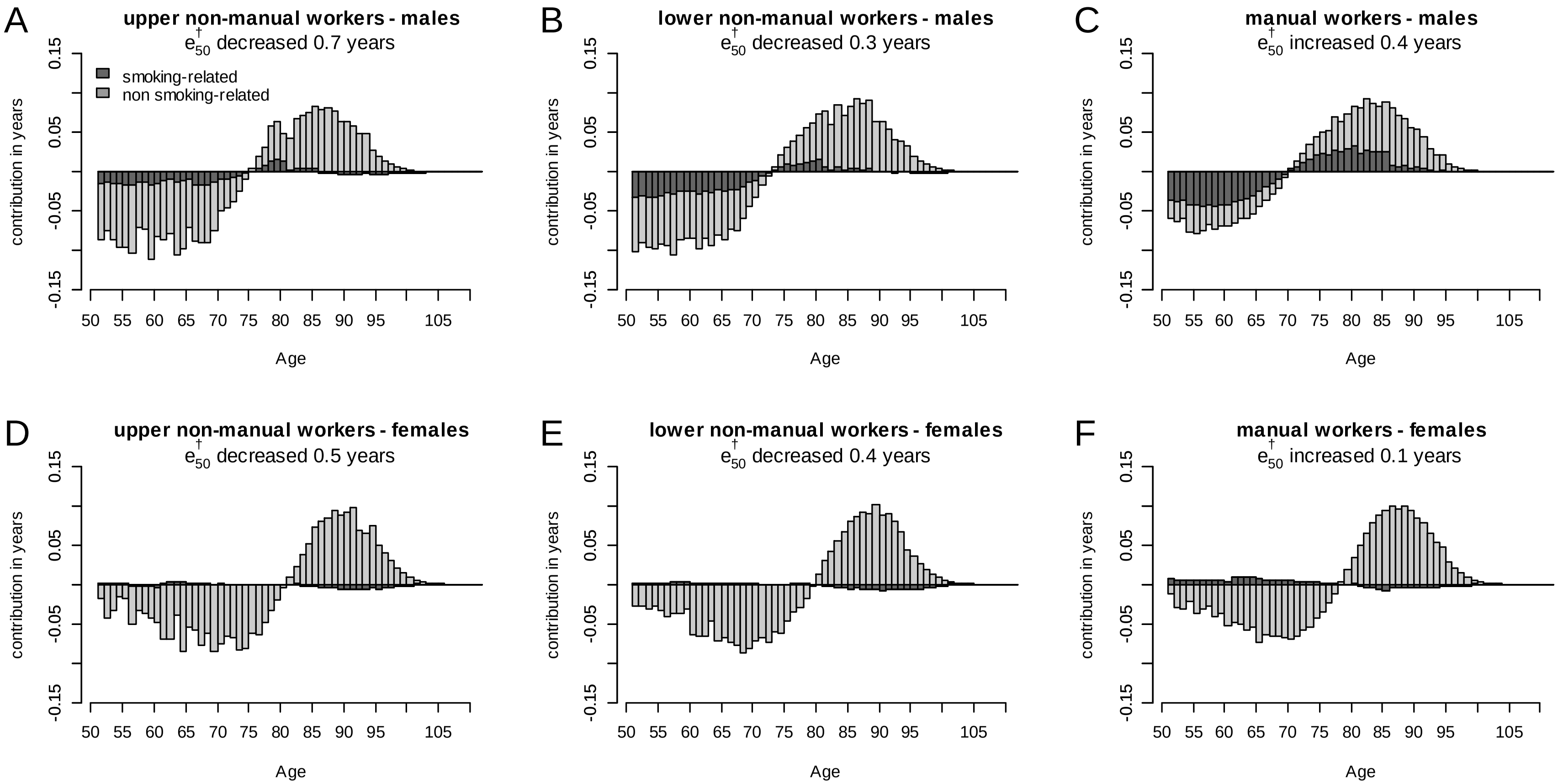
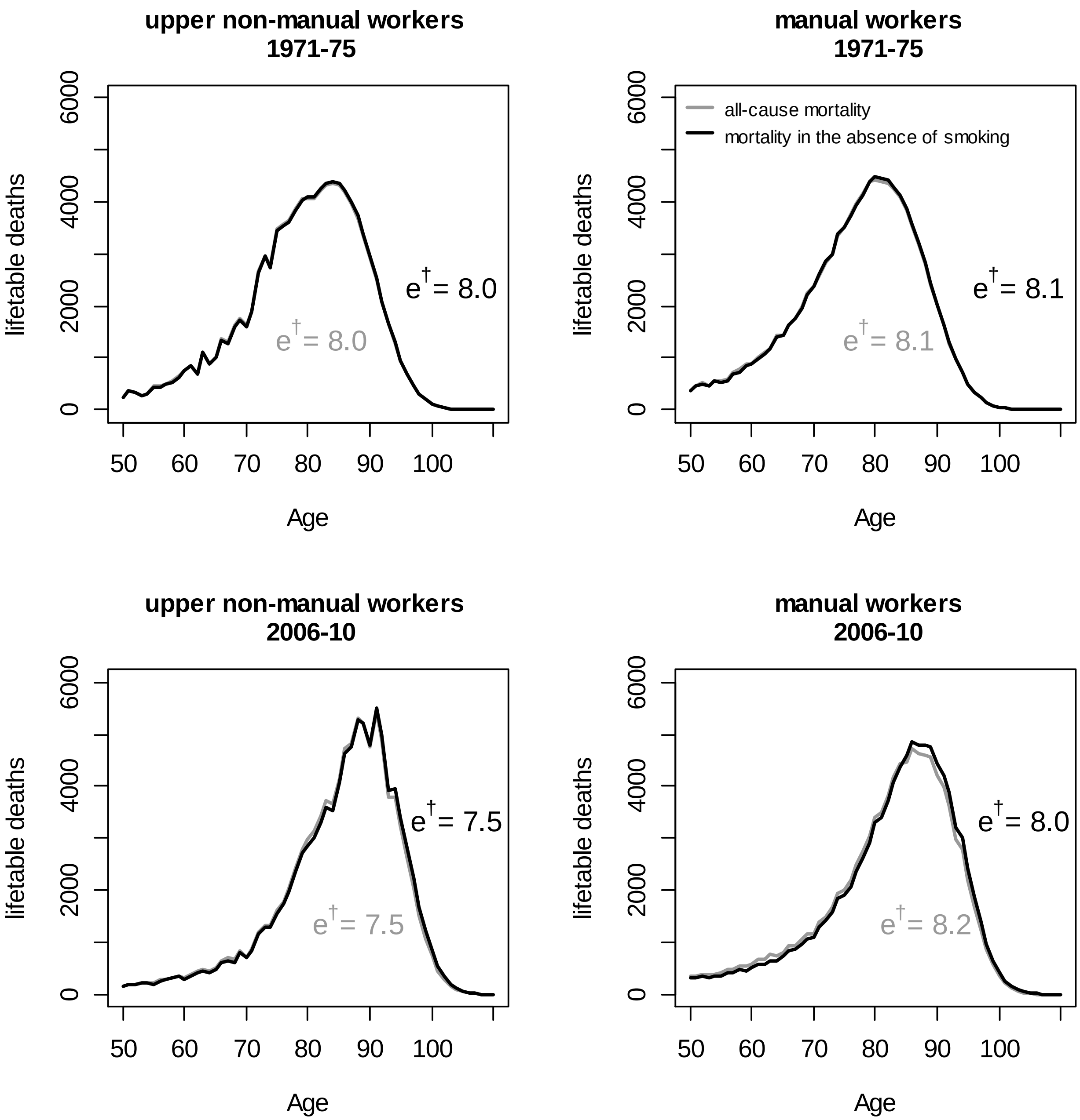


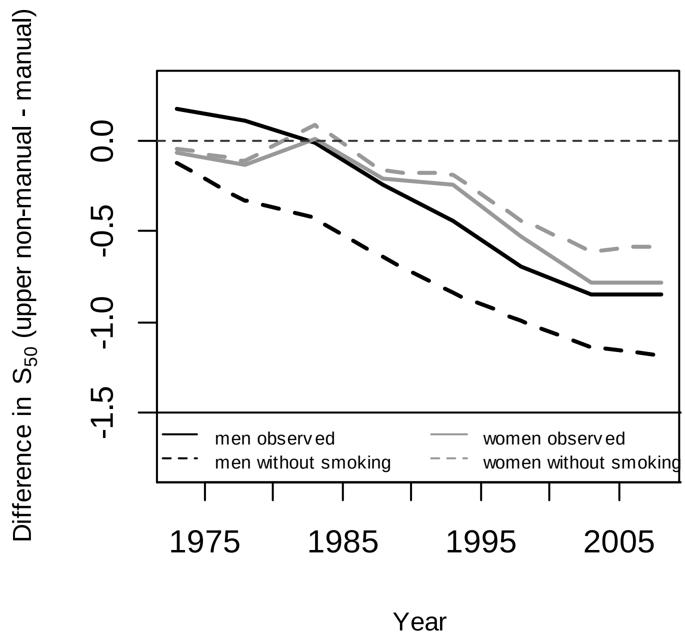
Figure 5: Decomposition of $e^{\dagger}_{50}$ changes between 1971-75 and 2006-10 into components reflecting changes in smoking-attributable mortality and non-smoking-attributable mortality, by sex and occupational class.



Appendix Figure 1: The female period life table death distributions of observed mortality (black line) and estimated mortality in the absence of smoking (grey line) for the lowest and highest occupational groups in the earliest and latest periods.

	Upper non-manual			Lower non-manual			Manual		
	Observed	Removing smoking	*Difference*	Observed	Removing smoking	*Difference*	Observed	Removing smoking	*Difference*
Men									
1971-1975	10.3	10.6	*0.2*	10.4	10.6	*0.3*	10.2	10.7	*0.5*
1976-1980	10.5	10.8	*0.3*	10.4	10.8	*0.4*	10.4	11.1	*0.7*
1981-1985	10.5	10.7	*0.3*	10.4	10.9	*0.4*	10.5	11.2	*0.7*
1986-1990	10.5	10.6	*0.3*	10.5	10.9	*0.4*	10.6	11.3	*0.7*
1991-1995	10.4	10.5	*0.2*	10.3	10.7	*0.4*	10.7	11.3	*0.6*
1996-2000	10.3	10.4	*0.2*	10.4	10.7	*0.3*	10.9	11.4	*0.5*
2001-2005	10.2	10.5	*0.2*	10.7	11.0	*0.3*	11.1	11.6	*0.5*
2006-2010	10.2	10.4	*0.2*	10.7	11.0	*0.3*	11.1	11.6	*0.5*
Women									
1971-1975	9.7	9.6	*0.0*	9.8	9.8	*0.0*	9.7	9.7	*-0.1*
1976-1980	9.9	9.8	*-0.1*	9.9	9.9	*-0.1*	10.0	9.9	*-0.1*
1981-1985	9.9	9.9	*0.0*	9.9	9.9	*-0.1*	9.9	9.8	*-0.1*
1986-1990	9.9	9.8	*0.0*	9.8	9.7	*0.0*	10.1	10.0	*-0.1*
1991-1995	9.8	9.7	*0.0*	9.7	9.6	*-0.1*	10.0	9.9	*-0.1*
1996-2000	9.6	9.6	*0.0*	9.7	9.7	*0.0*	10.1	10.1	*-0.1*
2001-2005	9.6	9.6	*0.0*	9.9	9.8	*0.0*	10.4	10.2	*-0.2*
2006-2010	9.6	9.6	*0.0*	9. 9	9.9	*0.0*	10.4	10.2	*-0.2*

Appendix Table 1: Standard deviation at age 50 (S_{50}) for the different occupational classes in Finland. The ‘difference’ category is the increase in S_{50} attributable to smoking.



Appendix Figure 2: The difference in years between the upper non-manual classes and the manual classes in S_{50}