Income Differences in Life Expectancy

The Changing Contribution of Harmful Consumption of Alcohol and Smoking

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Background: Social differences in mortality have increased in high-income countries, but the causes of these changes remain unclear. We quantify the contribution of alcohol and smoking to trends in income differences in life expectancy from 1988 through 2007 in Finland.

Methods: An 11% sample from the population registration data of Finns 25 years and older was linked with an 80% oversample of death records. Alcohol-attributable mortality was based on underlying and contributory causes of death on individual death certificates and smoking-attributable mortality on an indirect method that used lung cancer mortality as an indicator for the impact of smoking on mortality.

Results: Alcohol- and smoking-attributable deaths reduced life expectancy by about 4.5 years among men. Alcohol-attributable mortality increased and smoking-attributable mortality decreased over the period 1988–2007, leaving the joint contribution stable. Among women, the contribution of these risk factors to life expectancy over the same period increased from 0.7 to 1.2 years. In 2003–2007, life expectancy differentials between the lowest and highest income quintile were 11.4 years (men) and 6.3 years (women). In the absence of alcohol and smoking, these differences would have been 60% less for men and 36% less for women. Life expectancy differentials increased rapidly over the study period; without alcohol and smoking, the increase would have been 69% less among men and 85% less among women.

Conclusions: Alcohol and smoking have a major influence on income differences in mortality and, with the exception of smoking among men, their contribution is increasing. Without alcohol and smoking, there would have been little change in life expectancy differentials.

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Major socioeconomic differences in mortality are observed in all high-income countries.[1,2] At 35 years of age, men at the top of the social hierarchy have a life expectancy 5–10 years longer than men at the bottom of the social hierarchy,[3,4] a difference comparable with that of being a lifetime smoker as opposed to being a never-smoker.[5,6] These disparities are observed for all-cause mortality and for most specific causes. In many European countries and the United States, these disparities have grown dramatically over the past 20 years.[3,4,7,8] In Finland, life expectancy differences between the top and bottom income quintiles have increased from 7.4 years in 1988 to 12.5 years in 2007 among men and from 3.9 years to 6.8 years among women.[3]

Of the many hypotheses proposed to explain socioeconomic differences in mortality, a prominent one is that people in lower socioeconomic groups have higher mortality because they are more likely than people in higher socioeconomic groups to engage in health-damaging behaviors.[9–12] Many behavioral risk factors, such as harmful consumption of alcohol or smoking, are well-established causes of higher mortality.[6,13] In most settings, smoking is more common in the lower social groups. Harmful alcohol consumption among men is generally more widespread in lower social strata, while among women there is less consistency in this pattern.[14] Generally speaking, the more extreme the drinking behavior, the more systematic and larger the socioeconomic differences. Accordingly, it is widely accepted that the unequal distribution of behavioral risks plays a role in social differences in mortality.[4,15] However, the overall contribution of behavioral risk factors to these social differences and, in particular, their changes remains unclear.

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Editors' Note: *A commentary on this article appears on page* 191.

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Many population-based studies on the behavioral causes of socioeconomic differentials in mortality have made important contributions to our understanding, but there continue to be important limitations to previous work. First, many of the prior explanatory studies are restricted in their generalizability,[16] as they are based on samples from specific age groups or areas or they focus on employed people or on men only.

Second, explanatory studies rely to a large extent on self-reported measures of individual-level behavioral factors for socioeconomic differentials. Typically, these factors are measured only once or a few times, and lifetime exposure to risk is difficult to estimate. For example, questions at a single point in time about prior smoking status and typical alcohol consumption in the preceding year—typical survey questions in population-based health studies—underestimate true exposure because of recall bias, preferential reporting, single measurement in time, and nonresponse.[17] Furthermore, the health effects of binge drinking may not be fully captured in surveys, which typically use only one relatively low threshold (eg, six drinks), while a higher threshold would probably yield higher risks and larger socioeconomic differences.[18] In addition, surveys do not assess the effects of situational risk factors (eg, driving while intoxicated).

Third, although social inequalities in mortality have widened,[3,4,7] few studies have estimated the contribution of risk factors to changes in socioeconomic differentials in mortality over time. Consequently, little is known about the changing contribution of various behavioral or other explanatory factors over a longer period. However, rapid changes in cohort histories of smoking and in the overall levels of alcohol consumption have occurred in many countries. These have differentially affected socioeconomic groups and men and women.

We analyze longitudinal data covering the population of Finland of age 25 years and older, with consistent measurement of household income and mortality over time. We estimate the contribution of alcohol and smoking to changes in income differentials in total mortality for men and women for the period 1988 to 2007. We combine estimates for the contribution of alcohol that are based on underlying and contributory causes of death from alcohol-related conditions, with estimates for smoking based on an indirect method[19] that uses lung cancer mortality to index population exposure to smoking.

METHODS

We used a linked register-based 11% random sample of the population permanently residing in Finland at the end of any of the years between 1987 and 2007, obtained from the longitudinal population data file of the Statistics Finland. Because of data protection regulations, Statistics Finland does not provide individual-level data records for the whole population. To maintain statistical power in the mortality analyses, we supplemented the sample with a random oversample of people who died, so that we included 80% of all deaths during our mortality follow-up from 1 January 1988 to 31 December 2007. The analysis used sampling weights for people from the two-part sample—obtained from the known sampling probabilities—to account for the unequal sampling probability. Statistics Finland used unique personal identification codes to link information from different administrative registers.

Analyses were restricted to people of age 25 years or more, and young adults were included in the data when they turned 25 years. Times spent emigrated and in institutions (about 2%) were excluded because there was no associated information on household income. Altogether, we followed 1,147,602 people and observed 625,895 deaths in the unweighted data.

Household taxable income was assessed at the beginning of each study year. The information on income is from the registers of the Finnish Tax Administration and Social Insurance Institution and consists of wages, capital income, and taxable income transfers of everyone living in the same household; it excludes some nontaxable transfers such as child benefits and certain housing allowances. Household income was divided by the sum of consumption units using the following weighting: 1 unit for the first adult, 0.7 units for each person older than 17 years, and 0.5 units for children 17 years or younger.[20] We calculated cutpoints for the income quintiles separately for each year and for men and women.

Estimation of Alcohol- and Smoking-attributable Deaths

On the basis of information on the death certificate, we defined alcohol-attributable deaths as: (1) diseases caused by alcohol (specified below) or accidental poisoning (International Classification of Diseases, Tenth Edition [ICD-10] code X45) recorded as the underlying cause and (2) causes not directly alcohol-attributable, but with alcohol-attributable disease or alcohol intoxication (ICD-10 code F100) as one of the three contributory causes (judged by the coroner as being relevant). Alcohol-attributable diseases included the following: mental and behavioral disorders due to alcohol use (F10); degeneration of the nervous system due to alcohol (G312); epileptic seizures related to alcohol (G4051); alcoholic polyneuropathy, myopathy, cardiomyopathy, gastritis, and liver disease (G621, G721, I426, K292, K70); and alcoholic diseases of the pancreas (K852, K860 in the Finnish version of ICD). The most common among the deaths with alcohol as the underlying cause were alcoholic liver disease (21% of all alcohol-attributable deaths as defined above), fatal alcohol poisoning (12%), alcohol dependence syndrome (6%), and alcoholic cardiomyopathy (3%). The most common underlying causes among the deaths with alcohol as only the contributory cause were accidents (15%), self-harm (11%), and cardiovascular diseases (17%). Of the deaths with alcohol as a contributory cause, about two-thirds are related to alcohol intoxication. In Finland, the frequent use of medicolegal autopsy enables the proper attribution of alcohol intoxication

as a contributory cause of death.[21] Among people younger than 65 years, autopsies in the early 2000s were carried out in >90% of all cases of accidental or violent death and in >60% of deaths from all causes.[22,23]

Smoking-attributable mortality was estimated using an indirect method developed by Preston and colleagues.[19,24] The method uses age-, sex- and year-specific lung cancer death rates as an indicator of the damage from smoking and a regression model that uses these lung cancer death rates to predict mortality from other causes of death. We used the coefficients from this regression model, together with information on expected lung cancer death rates among nonsmokers and the observed lung cancer mortality rates in the Finnish population, to estimate the proportion of deaths attributable to smoking. In this article, we used the refined coefficients published by Preston et al,[24] as they are more appropriate for older women. The original method was developed for ages 50 years and above. To simultaneously estimate the joint contribution of alcohol and smoking, we extended the method to ages 25–49 years. To achieve this, we estimated nonsmokers' lung cancer mortality at ages from 25–29 to 44–49 years by first assuming that nonsmokers' lung cancer mortality is zero at ages 25–29 years—a common assumption in lung cancer epidemiology[25,26]—and by setting nonsmokers' lung cancer death rate at age 50–54 years to 0.06/1,000.[19] We then used log-linear interpolation between ages 25–29 and 50–54 years to obtain other age-specific rates. Furthermore, we used the original model coefficients for ages 50–85 years given by Preston et al[24] to extrapolate with a linear model the age-, sex-, and year-specific model coefficients for ages 25–49 years. The model coefficients and assumed lung cancer death rates among nonsmokers are given in the eAppendix (http://links.lww.com/EDE/A760). Sensitivity analyses show that alternative specifications below age 50 years had little effect on our results—mainly because lung cancer mortality at these ages is very low.

For the analyses, we set the data in annual period format. In the first stage of the analysis, individual-level data from death certificates were used to identify all alcohol-related deaths. In the second stage, we estimated smoking-attributable deaths from the remaining deaths using the method developed by Preston et al.[24] We present the results in terms of proportions of deaths attributable to alcohol and smoking at ages 25 years and above, life expectancies[27] at age 25 years, and age-adjusted death rates with and without alcohol- and smoking-attributable deaths. To account for random variation in the Finnish data, 95% confidence intervals (CIs) were calculated for the proportions, death rates, and life expectancies.[28]

RESULTS

During the study period, both alcohol and smoking had a major impact on mortality, and this impact varied by age, sex, and income. We observed about 2500 alcohol-attributable and 4000 smoking-attributable deaths annually. As a proportion of all deaths, alcohol-attributable deaths peaked at around 40 years of age, with approximately 40% of all deaths being attributable to alcohol among men and 15–20% among women (Figure 1). In the lowest income group, this contribution was 55% among men and 33% among women. Smoking-attributable deaths peaked at around 65 years of age for men and 60 years of age for women, with particularly large income group differentials among men. Ninety-five percent CIs around these estimates are relatively tight (eFigure 1, http://links.lww.com/EDE/A760).

Over the study period, trends in alcohol- and smoking-attributable mortality rates varied strongly by income group. In the lowest income quintile, age-adjusted mortality rates for alcohol-attributable mortality increased substantially from 1988–1992 to 2003–2007 for both men and women (about 50% and 100%, respectively), with much smaller or no increase among higher income levels (Figure 2, eFigure 2, http://links.lww.com/EDE/A760). For smoking-attributable mortality in the same period, the rate declined rapidly for men, while the rate increased for women in the lowest quintile and remained rather stable in the other quintiles. Rate differences

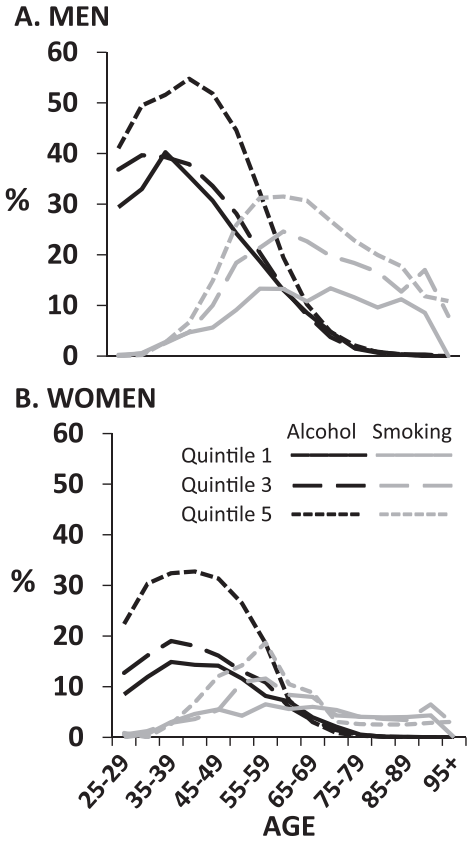

FIGURE 1. Proportion (%) of deaths attributable to alcohol and smoking by income quintile and age. Finnish (A) men and (B) women of age 25+ years in 1988–2007.

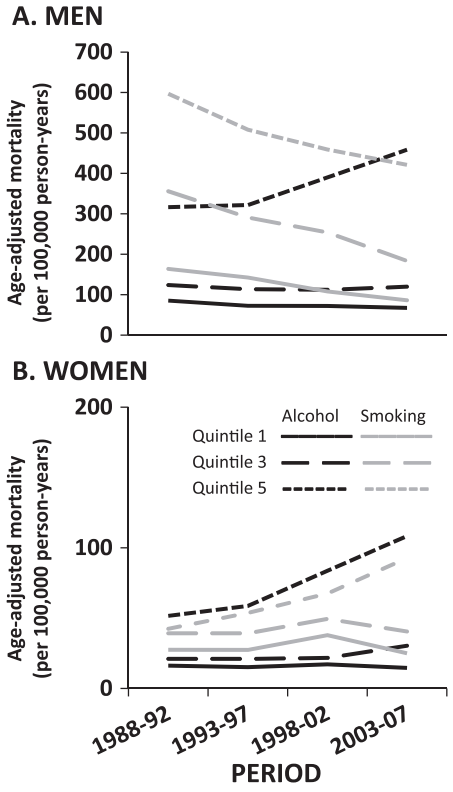

FIGURE 2. Age-adjusted mortality rates from causes attributable to alcohol and smoking per 100,000 person-years by income quintile and period. Finnish (A) men and (B) women of age 25+ years in 1988–2007.

among income quintiles remained for both sexes, but declined slightly among men and increased among women.

From 1988–1992 to 2003–2007, life expectancy grew by about 4.2 years among men and 3.3 years among women (Table 1). Without alcohol and smoking, life expectancy of men would have been 4.6 years longer in the period 1988–1992 and 4.3 years longer in 2003–2007. The relative impact of smoking declined, while that of alcohol increased. Among women, life expectancy without alcohol and smoking would have been about 0.7 years higher in 1988–1992; and this increased to about 1.2 years in 2003–2007.

Among men, both alcohol- and smoking-attributable mortality made a substantial contribution to the level and trends in income differences in life expectancy. In 1988–1992, male life expectancy differential between the highest and the lowest income quintile was 8.8 years. Without alcohol-attributable mortality, this difference would have been 6.5 years, and without alcohol- and smoking-attributable mortality it would have been about 3.7 years—together, alcohol and smoking accounted for almost 60% of the life expectancy difference by income (Table 2). After 1988–1992, life expectancy increased in all income quintiles among men, but the increase was more rapid in the higher quintiles, and thus, the life expectancy difference between the highest and the lowest quintile increased to 11.4 years. The joint contribution of alcohol and smoking to these differentials remained about 60%, with the contribution of alcohol-attributable mortality increasing and smoking-attributable mortality declining (Figure 3).

Among women, the contribution of alcohol- and smoking-attributable mortality was smaller for the income differences in life expectancy than among men, but these risk factors nonetheless contributed strongly to trends in life expectancy differentials. In 1988–1992, women with the highest income could expect to live about 4.4 years longer than women with the lowest income (Table 2). Alcohol-attributable mortality contributed 12% of these differentials, and together alcohol and smoking accounted for 15% of these differentials. Because of a more rapid mortality decline among women with high income, the life expectancy difference between the highest and the lowest income groups grew to 6.3 years by 2003–2007. Simultaneously, the contribution of both alcohol and smoking to these differentials increased, and together they accounted for 36% of the life expectancy gap by income in 2003–2007. For both women and men, life expectancy differentials by income would have grown even without alcohol- and smoking-attributable mortality, although at a much slower pace. Without alcohol and smoking, income differences in life expectancy would have been very similar among men and women.

DISCUSSION

We provide a comprehensive analysis of the joint contribution of alcohol and smoking to both the level of and the changes in income differences in mortality. These analyses are based on longitudinal register data covering the total population of Finland, with consistent measurement of income. The cause of death data used here is of exceptional quality,[29] and our estimation techniques of attributable mortality avoid the potentially serious biases in estimating lifetime exposure to alcohol and smoking based on survey data, such as nonresponse, loss to follow-up, preferential reporting, single measurement in time, and difficulties in capturing binge drinking.

For the period from 1988–1992 to 2003–2007, we show considerable increase in life expectancy differentials by income, particularly after 1993–1997. Without alcohol and smoking, this increase in mortality differentials would have been 69% less among men and 85% less among women, and the level of income differentials would have been very similar among men and women. These patterns of life expectancy trends and differentials are driven by declining smoking-attributable mortality among men in all income groups but increasing alcohol-attributable mortality among those with lowest incomes. Among women, mortality for both causes is stable in the higher income groups but increasing rapidly in the lowest category.

These results are likely to be relevant for other high-income countries with comparable levels and history of alcohol use and smoking. In Finland, alcohol consumption per

TABLE 1. Life Expectancy at Age 25 and Sex Difference in Life Expectancy With and Without Deaths Attributable to Alcohol or Smoking by Period

		Life Expectancy at Age 25 Years[a]			Loss of Life Expectancy (Years) due to:	
Period	No. Deaths[b]	Observed (95% CI)	Without Alcohol (95% CI)	Without Alcohol and Smoking (95% CI)	Alcohol (95% CI)	Alcohol and Smoking (95% CI)
Men						
1988–1992	85,730	47.6 (47.5 to 47.7)	49.3 (49.3 to 49.4)	52.1 (52.1 to 52.2)	1.7 (1.6 to 1.9)	4.6 (4.4 to 4.7)
1993–1997	84,050	49.1 (49.0 to 49.2)	50.8 (50.8 to 50.9)	53.3 (53.3 to 53.4)	1.7 (1.6 to 1.9)	4.2 (4.1 to 4.4)
1998–2002	83,706	50.4 (50.3 to 50.5)	52.3 (52.2 to 52.3)	54.5 (54.4 to 54.6)	1.9 (1.8 to 2.0)	4.1 (4.0 to 4.2)
2003–2007	83,139	51.8 (51.7 to 51.9)	53.9 (53.9 to 54.0)	56.1 (56.1 to 56.2)	2.1 (2.0 to 2.3)	4.3 (4.2 to 4.4)
Change[c]		4.2 (4.1 to 4.3)	4.6 (4.5 to 4.7)	4.0 (3.9 to 4.1)	0.4 (0.3 to 0.6)	–0.2 (–0.4 to –0.1)
Women						
1988–1992	73,807	55.5 (55.4 to 55.6)	55.9 (55.8 to 55.9)	56.2 (56.1 to 56.3)	0.3 (0.2 to 0.5)	0.7 (0.6 to 0.8)
1993–1997	73,854	56.6 (56.5 to 56.6)	56.9 (56.9 to 57.0)	57.3 (57.3 to 57.4)	0.4 (0.3 to 0.5)	0.8 (0.7 to 0.9)
1998–2002	72,126	57.6 (57.5 to 57.7)	58.1 (58.0 to 58.1)	58.6 (58.5 to 58.7)	0.5 (0.4 to 0.6)	1.0 (0.9 to 1.1)
2003–2007	69,483	58.8 (58.7 to 58.9)	59.4 (59.3 to 59.4)	60.0 (59.9 to 60.1)	0.6 (0.5 to 0.7)	1.2 (1.1 to 1.3)
Change[c]		3.3 (3.2 to 3.4)	3.5 (3.4 to 3.6)	3.8 (3.7 to 3.9)	0.2 (0.1 to 0.4)	0.5 (0.4 to 0.6)
Sex difference in life expectancy and the contribution of alcohol or smoking to that difference						
1988–1992	1,59,537	7.9 (7.8 to 8.0)	6.5 (6.4 to 6.6)	4.1 (4.0 to 4.2)	1.4 (1.2 to 1.5)	3.8 (3.7 to 4.0)
2003–2007	1,52,622	7.0 (6.9 to 7.1)	5.4 (5.3 to 5.5)	3.9 (3.8 to 4.0)	1.6 (1.4 to 1.7)	3.1 (3.0 to 3.3)
Change[c]		–0.9 (–1.1 to –0.8)	–1.1 (–1.2 to –0.9)	–0.2 (–0.3 to 0.0)	0.2 (0.0 to 0.4)	–0.7 (–0.9 to –0.5)

Finnish men and women aged 25+ years in 1988–2007.

[a]Life expectancies were calculated using period life table functions and age- and sex-specific death rates with and without alcohol- or smoking-attributable deaths for age intervals: 25–29, 30–34, … 95+. For details of the formulas used in the life expectancy calculation see: Preston et al.[27(p 48–50)]

[b]Unweighted deaths.

[c]Change (in years) from 1988–1992 to 2003–2007.

capita increased by about one-third between the mid-1980s and 2010. Finland has transformed from a spirits-drinking country to a mostly beer-drinking country with an average European consumption level. Chronic effects of drinking have become as important as acute effects.[30] Similar increasing alcohol consumption trends have been observed in several Nordic and Baltic countries, Russia, the United Kingdom, and Ireland.[31] The smoking history of Finnish men—typical of many other Northern European and Anglo-Saxon countries—is characterized by high levels of ever having been a regular smoker among men born before the Second World War and lower levels in younger men. Among women, smoking prevalence has increased in successive birth cohorts because of increasing initiation.[32,33] Compared with many other high-income countries, the level of smoking-related mortality and its trends after 1980 have been rather similar for Finnish men but somewhat lower among women.[24]

Interpretation of the Results

The period of observation included the largest economic recession in post-war Finland and a subsequent reorganization of welfare services—changes that may have important repercussions on health. The 1980s can be characterized as a period of exceptional growth in prosperity and disposable income, and extremely low unemployment (3.5%). The Gini coefficient for income inequality was about 0.20 for disposable income at the turn of the 1980s and 1990s—one of the lowest figures ever recorded for any country in the Luxemburg Income Study.[34,35] This period was followed by a severe recession, with unemployment rates increasing to about 19% in 1994 and a 15% decline in gross domestic product.[36]

However, these economic changes seem to be mainly disassociated with changes in mortality differentials. During the crisis, there was an acceleration of mortality decline and a more moderate increase of social inequalities in mortality than before.[37] For smoking-attributable mortality, this is not surprising because the damage from smoking takes decades to accumulate; accordingly, smoking-attributable mortality is mainly characterized by cohort effects rather than abrupt period effects.[38] Changes in alcohol-related mortality, in contrast, have shown stronger period effects,[39] which may be driven partly by economic fluctuations (eg, changes in the affordability of alcohol or the strain related to unemployment). Alcohol consumption in Finland declined by about 10% during the recession and alcohol-related mortality declined.[37] However, other than during the early 1990s recession, bad economic times seem to have more moderate and adverse effects on mortality.[40]

In addition to long-term cultural changes, the public health interventions and policy changes of the Finnish welfare state appear to have had a differential effect on the overall level of alcohol and tobacco consumption. More

TABLE 2. Life Expectancy at Age 25 Years With and Without Deaths Attributable to Alcohol or Smoking, by Income Quintile

Period	No. Deaths[b]	Life Expectancy at Age 25[a]			Life Expectancy at Age 25 Years Without Alcohol[a]			Life Expectancy at Age 25 Years Without Alcohol and Smoking[a]			% Attenuation[c] in the Income Difference due to:	
		Lowest Income. Quintile (95% CI)	Highest Income. Quintile (95% CI)	Difference (Years) (95% CI)	Lowest Income. Quintile (95% CI)	Highest Income. Quintile (95% CI)	Difference (Years) (95% CI)	Lowest Income. Quintile (95% CI)	Highest Income. Quintile (95% CI)	Difference (Years) (95% CI)	Alcohol	Alcohol and Smoking
Men												
1988–1992	44,798	42.9 (42.7 to 43.1)	51.6 (51.4 to 51.9)	8.8 (8.4 to 9.1)	46.2 (46.0 to 46.4)	52.7 (52.5 to 53.0)	6.5 (6.2 to 6.9)	50.2 (50.1 to 50.4)	54.0 (53.7 to 54.3)	3.7 (3.4 to 4.1)	25[c]	57
2003–2007	39,786	45.1 (44.9 to 45.2)	56.4 (56.2 to 56.7)	11.4 (11.1 to 11.7)	49.9 (49.8 to 50.1)	57.3 (57.1 to 57.6)	7.4 (7.1 to 7.7)	53.7 (53.5 to 53.8)	58.2 (58.0 to 58.5)	4.5 (4.2 to 4.8)	35	60
Change[d]		2.2 (1.9 to 2.4)	4.8 (4.4 to 5.1)	2.6 (2.2 to 3.0)	3.7 (3.5 to 4.0)	4.6 (4.3 to 5.0)	0.9 (0.4 to 1.3)	3.4 (3.2 to 3.7)	4.2 (3.9 to 4.6)	0.8 (0.3 to 1.2)	67	69
Women												
1988–1992	40,094	53.3 (53.1 to 53.5)	57.7 (57.5 to 58.0)	4.4 (4.1 to 4.8)	54.1 (53.9 to 54.3)	58.0 (57.7 to 58.3)	3.9 (3.6 to 4.2)	54.6 (54.4 to 54.7)	58.3 (58.0 to 58.6)	3.8 (3.4 to 4.1)	12	15
2003–2007	35,547	54.9 (54.7 to 55.1)	61.2 (61.0 to 61.5)	6.3 (6.0 to 6.6)	56.5 (56.4 to 56.7)	61.5 (61.2 to 61.7)	4.9 (4.6 to 5.2)	57.8 (57.6 to 57.9)	61.8 (61.6 to 62.1)	4.0 (3.7 to 4.3)	22	36
Change[d]		1.6 (1.3 to 1.9)	3.5 (3.1 to 3.8)	1.9 (1.4 to 2.3)	2.4 (2.2 to 2.7)	3.5 (3.1 to 3.8)	1.0 (0.6 to 1.5)	3.2 (3.0 to 3.5)	3.5 (3.1 to 3.9)	0.3 (–0.2 to 0.7)	45	85

Finnish men and women of age 25 years and older in 1988–1992 and 2003–2007.

[a]Life expectancies were calculated using period life table functions and age- and sex-specific death rates with and without alcohol- or smoking-attributable deaths for age intervals: 25–29, 30–34, … 95+. For details of the formulas used in the life expectancy calculation see: Preston et al.[27(p 48–50)]

[b]Unweighted deaths.

[c]For example, 100 ×((8.8–6.5)/8.8) = 25%.

[d]Change (in years) from 1988–1992 to 2003–2007 in the columns showing life expectancies and their differences.

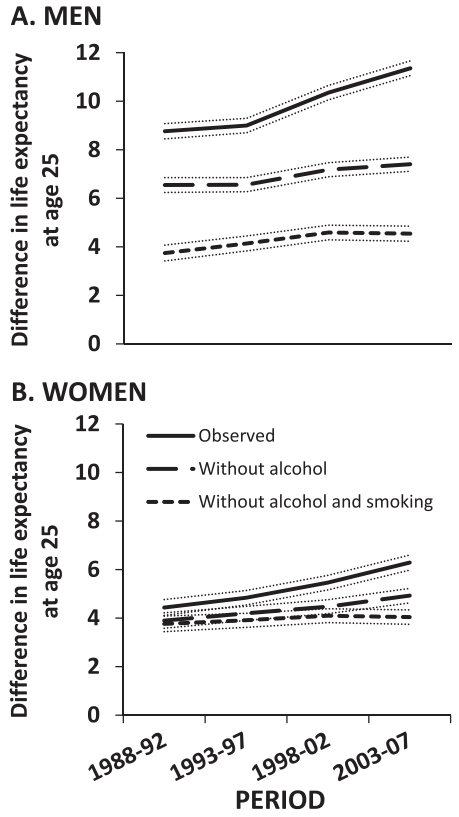

FIGURE3. The difference (in years) between the highest and the lowest income quintile in life expectancy at age 25 with and without causes attributable to alcohol or smoking and 95% confidence intervals (dotted lines) by period. Finnish (A) men and (B) women of age 25+ years in 1988–2007.

restrictive tobacco policies have contributed to decreasing smoking trends, while alcohol policies have become less restrictive, contributing to increasing consumption. Antismoking activities began in Finland in the mid-1960s, and the Tobacco Control Act of 1976 is thought to have made a major contribution to reduced smoking among men and capped the increasing trend among women.[32] In Finland, availability of alcohol is controlled by the state monopoly and prices by high excise taxes. Increasing availability and affordability of alcohol have occurred because of abrupt liberalizations of alcohol policies and more gradual increase in both physical and economic availability.[41,42] Alcohol consumption increased abruptly in 1995, when the new Alcohol Act increased availability within borders and through travellers' tax-free imports. In 2004, excise taxes on alcohol were cut by one-third on average, with a resulting increase in both alcohol consumption and alcohol-related harm.[39]

The trends in smoking and the alcohol consumption and harm related to the above-mentioned social policies appear to have been strongly socially patterned. Overall, it appears that population-level antismoking campaigns and alcohol tax reductions have had unintended distributional health effects. For alcohol, there have been adverse changes particularly among the middle-aged population and those from lower social strata. Alcohol-related mortality after the tax reduction of 2004 increased by 16% among men and 31% among women, with the largest effects observed among the nonemployed population and those from lower social and income groups.[39] These findings are echoed in the results of this study; we show that changes in alcohol-related mortality have had a substantial effect on increasing income differentials in mortality.

Finland has also experienced large and long-lasting social differentials in smoking, which have increased in the past three decades. Among men, these increases are due to a rapid decline in smoking in the higher social groups not matched in other groups and among women to the increasing prevalence of smoking in the lowest social strata. It appears that the active antismoking policies have contributed to these increasing differentials among men but not women.[32] Although the level of smoking is declining (which will ultimately reduce social inequalities in mortality in the future), the ever-stronger social patterning of smoking may partly offset this positive development for the birth cohorts most influenced by the antismoking activities. This is particularly likely for women.[43]

Methodological Considerations

Our overall estimates of alcohol-attributable deaths are about one-third larger than those estimated for the WHO Global Health Risks[13,44] for the European Region on average, with large variations among regions within Europe. These international estimates are based on estimated total alcohol consumption and meta-analytical estimates of disease-specific relative risks and alcohol-attributable fractions for accidents and violence, roughly adjusted for drinking patterns. Those estimates rely on the assumption that period estimates of exposure to alcohol have remained constant for a considerable length of time.[45] Our larger estimates are likely to reflect true differences in alcohol-related harm. Mean alcohol consumption in Finland is close to the European average, but the relatively high prevalence of binge drinking[30] is likely to lead to increased levels of alcohol-attributable accidental and violent deaths in particular.

However, differences in the methods used may also contribute to the differences in estimates. In particular, we did not include the potential protective effects of alcohol use, as these cannot be observed in the cause of death certificates. The magnitude of this effect is difficult to assess, but globally, Rehm et al[13] estimate that the number of deaths saved by moderate consumption is about 10% of the number of deaths caused by alcohol. Had we incorporated this protective effect in our analyses, the differences in alcohol-attributable deaths among income quintiles would most likely have been greater, as moderate use of alcohol is more prevalent in the higher social strata.[46] Furthermore, although the individual-based assessment may overestimate the causal role of alcohol for

accidental and violent deaths in some cases, overall this method is likely to be more accurate and is preferred by other researchers when data are available.[47] For some other causes, our method may underestimate alcohol-attributable mortality. In particular, methods based on relative risk estimates and alcohol consumption data are more accurate than ours for cancer mortality because cancer deaths cannot typically be identified as alcohol attributable using death certificates. However, with only 4% of all cancer deaths due to alcohol in high-income countries,[48] this underestimation is unlikely to strongly bias life expectancy estimates by social status.

Our estimates of smoking-attributable deaths are consistent with previous estimates for Finland based on the Peto-Lopez method[15] and somewhat lower than estimates based on the cause of death-specific population-attributable fractions and estimates of smoking prevalence by Martelin et al.[49] The indirect method we use has also been shown to be valuable for analyses of population subgroup differentials in mortality.[43,50] Although our estimates of the contribution of alcohol and smoking to social differences in mortality are obviously crude, we are confident in our main findings. It is a strength that our analysis does not rely on survey-based assessments of smoking and alcohol use. Moreover, we have no reason to believe that any inaccuracies in our estimation would be strongly socially patterned.

Double counting of deaths (ie, counting the same death as being attributable to both alcohol and smoking) could in principle lead to an overestimation of mortality attributable to alcohol or smoking. However, we estimated smoking-attributable deaths in a subset of deaths from which alcohol-related deaths had been removed, thus avoiding this problem. In general, allocating deaths as attributable to either alcohol or smoking is unlikely to be a major problem[49] because deaths from these causes occur at different ages. Furthermore, the majority of alcohol-attributable causes[39] are causes not attributable to smoking.

In conclusion, high-income countries have experienced persistent and often increasing socioeconomic differentials in mortality.[3,4,7] We demonstrate that alcohol and smoking in Finland have a major influence on income differences in mortality among men and women, and—with the exception of smoking among men—their contribution to income disparities in mortality is increasing. The causes of these trends are likely to be related to the increasing availability of alcohol in Finland, as well as the long-term maturation of the smoking epidemic among men and later uptake of smoking among women—the adverse effects of which have been felt most strongly in the lower social groups. Were it possible to remove all deaths due to alcohol and smoking, mortality differences by income could be reduced by about 60% among men and 35% among women, and the increase in differentials, would be abated.

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