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Original Investigation

The Role of Smoking in Country Differences in Life Expectancy Across Europe, 1985–2014

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Abstract

Introduction: Smoking contributes substantially to mortality levels and trends. Its role in country differences in mortality has, however, hardly been quantified. The current study formally assesses the—so far unknown—changing contribution of smoking to country differences in life expectancy at birth (e0) across Europe.

Methods: Using all-cause mortality data and indirectly estimated smoking-attributable mortality rates by age and sex for 30 European countries from 1985 to 2014, the differences in e0 between each individual European country and the weighted average were decomposed into a smoking- and a nonsmoking-related part.

Results: In 2014, e0 ranged from 70.8 years in Russia to 83.1 years in Switzerland. Men exhibited larger country differences than women (variance of 21.9 and 7.0 years, respectively). Country differences in e0 increased up to 2005 and declined thereafter. Among men, the average contribution of smoking to the country differences in e0 was highest around 1990 (47%) and declined to 35% in 2014. Among women, the average relative contribution of smoking declined from 1991 to 2011, and smoking resulted in smaller differences with the average e0 level in the majority of European countries. For both sexes combined, the contribution of smoking to country differences in e0 was higher than 20% throughout the period.

Conclusions: Smoking contributed substantially to the country differences in e0 in Europe, their increases up to 1991, and their decreases since 2005, especially among men. Policies that discourage smoking can help to reduce inequalities in mortality levels across Europe in the long run.

Implications: Smoking contributes substantially to country differences in life expectancy at birth (e0) in Europe, particularly among men, for whom the contribution was highest around 1990 (47%) and declined to 35% in 2014. In line with the anticipated progression of the smoking epidemic, the differences between European countries in e0 due to smoking are expected to further decline among men, but to increase among women. The role of smoking in mortality convergence since 2005 illustrates that smoking policies can help to reduce inequalities in life expectancy levels across Europe, particularly when they target smoking in countries with low e0.

Introduction

The recent European Health Report demonstrated that while life expectancy levels are increasing over time, differences in life expectancy at birth (e0) between European countries are still large, amounting to over 10 years between the countries with the highest and the lowest life expectancy levels.[1] Understanding the causes of these important international differences in life expectancy is essential for health policy makers seeking to reduce these inequalities.[2]

Smoking most likely explains a large share of these country differences in e0, as the timing and the impact of the smoking epidemic

vary considerably across European countries.[3–6] The smoking epidemic theory describes the rapid increase and subsequent decline in smoking prevalence, which results in similar patterns of smoking-attributable mortality appearing about 30–40 years later.[3,4] The smoking epidemic first emerged in North-Western European countries, and later spread to Southern European countries, then to Central European countries, and, finally, to Eastern European countries. The smoking epidemic started among men. It spread to women several decades later, among whom it had a smaller impact. The smoking epidemic in Europe importantly contributed to (sex differences in) all-cause mortality and life expectancy levels, and trends therein over time.[7–16]

While the contribution of smoking to country differences in life expectancy is hypothesized to be large,[17,18] it has rarely been quantified and then usually for a small selection of European countries. Östergren et al.[19] recently showed for the Nordic countries over the aggregated years 1995–2007 that smoking explained 41% of the substantially lower e25–79 values found for Danish men relative to their Swedish counterparts. The respective values found for Finnish men and Danish women were 21% and 54%.[19] Kelly and Preston[15] showed that smoking contributed 2.2 out of 2.5 years among women, and 1.0 years out of 1.6 years among men, to the differences in e50 in 2009 between Scotland and 15 high-longevity countries. Rostron and Wilmoth[11] observed that in 2000, smoking contributed 45% to the lower e65 found for US women relative to French women. Zatonski[20] assessed the contribution of smoking to all-cause mortality rate differences between the EU10 and EU15 for ages 35–44 (Men: 19%; Women: 15%) and ages 45–64 (Men: 53%; Women: 21%). Preston et al.[9] illustrated the increase in the ranking in e50 of the United States in 2003 among 21 high-income countries if smoking-attributable mortality was eliminated.

However, these studies did not quantify the change in the role of smoking in country differences in life expectancy over time. Previous studies that compared time trends in life expectancy or mortality with and without smoking-attributable mortality showed that smoking contributes substantially to the mortality divergence between selected countries. Staetsky[21] found that the mortality divergence among women aged at least 65 in the 1980s and 1990s in France and Japan on the one hand and Denmark, the United States, and the Netherlands on the other was to a large extent due to smoking. Kelly and Preston[15] showed that the divergence in e50 among men from 1950 onward between England & Wales and Scotland was almost solely due to smoking.

These studies illustrate that the contribution of smoking to country differences in life expectancy is likely to change over time. This is partly because of the large country differences in the timing of the smoking epidemic,[3,4] and partly because of the considerable variation over time in the country differences in e0 within Europe. That is, for Europe as a whole, differences in e0 increased up to 2005 and declined thereafter.[22] A comprehensive analysis of the changing contributions of smoking to country differences across Europe could greatly improve our understanding of the determinants of mortality inequalities in Europe and shed light on the potential role of smoking in future mortality convergence/divergence across Europe.

The current study, therefore, formally assesses the – so far unknown – changing contribution of smoking to country differences in life expectancy at birth (e0) across Europe.

It is hypothesized that smoking contributes to the smaller country differences in e0 in the phase of the smoking epidemic in which smoking-attributable mortality is increasing in North-Western European countries (with higher e0 values), but is not yet increasing in Central and Eastern European (CEE) countries (with lower e0 values). Especially in the phase of the smoking epidemic in which smoking-attributable mortality is—finally—increasing in countries with lower e0 values, but is already declining in countries with higher e0 values, smoking could contribute to increasing e0 differences between countries. After the peak in the smoking epidemic is reached in countries with lower e0 values, smoking should result in declining country differences in e0.

Data and Methods

Data

The analysis comprised the national populations (0 to ≥100) of 30 European countries, for which high-quality data on all-cause mortality and population exposures, by age and sex and calendar year, are available from the Human Mortality Database,[23] from 1985 onward.

In addition, for these countries, national lung cancer mortality death numbers by sex and 5-year age groups (0–4, …, 75–79, ≥80), necessary for estimating smoking-attributable mortality (See second paragraph of "Outcome Measures"), were—mostly—available from the WHO Mortality Database.[24]

See Supplementary Table S1 for the data availability by country.

Outcome Measures

Country differences in life expectancy at birth (e0) were assessed, by sex and year, by calculating the differences in e0 of each individual European country and the average for the 30 European countries. The national e0 values were estimated by applying standard demographic life table calculations to the all-cause death numbers and population exposures by single year of age and sex.[25] The (weighted) average is calculated by applying the life table calculations to the sum of the age-specific death numbers and the sum of the age-specific population exposures over the 30 countries.

Age- and sex-specific smoking-attributable mortality rates (35–100) by country and year were estimated by applying a simplified version of the indirect Peto–Lopez method.[26,27] See the Supplementary Information for more information. In summary, the method uses national lung cancer mortality rates, controlled for lung cancer mortality not due to smoking, as a proxy for lifetime smoking prevalence. Subsequently, the share of all-cause deaths due to smoking is assessed by applying the population-attributable fraction formula to this prevalence, and thereby using relative risks (RRs) of dying from smoking from the ACS-CPS-II study,[28] corrected for the exposure of smokers to other risk factors by reducing the excess risk by 30%.[29] Before applying the population-attributable fraction formula, the 5-year specific lifetime smoking prevalences and corrected RRs (up to ≥85) were transformed into single ages by smoothing. By multiplying these shares with age- and sex-specific all-cause mortality rates, smoking-attributable mortality rates were obtained.

Analysis

First, the contribution of smoking to life expectancy levels in each of the European countries is assessed by means of the potential gain in life expectancy (PGLE) if smoking-attributable mortality was eliminated. The PGLE is calculated by comparing the e0 value for all-cause mortality, with the e0 value based on life table calculations applied to nonsmoking-related mortality.

Secondly, the differences in e0 between each individual European country and the weighted average were decomposed into the part that is due to smoking-related mortality and the part that is due to nonsmoking-related mortality for separate years from 1985 to 2014, by sex, using the demographic decomposition technique described by Andreev et al.[30] See the Supplementary Information for more information. The contributions of smoking were assessed in both years and percentages.

Thirdly, the average overall contributions of smoking were estimated for all countries combined, for the countries with below-average e0 levels combined, and for the countries with above-average e0 levels combined. First, the average overall absolute contributions were calculated by treating the contributions of smoking that had a relative contribution with a negative sign (= contribution of smoking in the opposite direction of the difference with the average e0) as negative numbers and by treating the contributions of smoking that had a relative contribution with a positive sign (= contribution of smoking in a similar direction as the difference with the average e0) as positive numbers. Second, these average overall contributions of smoking were divided by the average difference with e0 to obtain the average overall relative contributions of smoking.

Results

For the 30 European countries combined, life expectancy at birth (e0) in 2014 was on average 77.8 years (74.3 for men, 81.2 for women) (Figure 1). The e0 values were lower than this average in all Eastern European countries, except the Czech Republic, Hungary, and Slovakia (Figure 1a; Supplementary Table S2). e0 ranged from 70.8 years in Russia (7.0 years lower than the average) to 83.1 years in Switzerland (5.3 years higher than the average) (Figure 1a; Supplementary Table S2). Country differences in e0 were substantially larger among men (range of 16.0 years; variance of 21.6 years) than among women (range of 9.6 years; variance of 7.2 years) (Table 1).

Smoking contributed substantially to the e0 values in the European countries in 2014, but the contribution varied by country (Figure 2). For men and for both sexes combined, the PGLE if smoking-attributable mortality was eliminated was highest among CEE countries and was lowest among North-Western European countries, with Hungary having the highest values (5.3 years among men) and Sweden having the lowest values (0.89 years among men). For women, however, the PGLE due to smoking was – generally – highest among North-Western European countries and lowest among CEE countries, with the exception of Hungary. The PGLE values for women were, on average, lower (unweighted average of 1.0 years) than those for men (unweighted average of 2.8 years).

Among men in 2014, smoking contributed 37% on average to the below-average e0 values in Russia, Ukraine, Belarus, Latvia, Lithuania, Bulgaria, Hungary, Estonia, Slovakia, and Poland. In addition, smoking contributed 34% on average to the above-average e0 values observed in the remaining European countries (Table 1).

Among women in 2014, smoking contributed "positively" only to the below-average e0 values in Hungary and Slovakia and to the above-average e0 values in Estonia, the four Southern European countries, Finland, France, and Switzerland (Table 1, Figure 1c, Supplementary Table S2). That is, without smoking, the e0 levels in these countries would have been closer to the average. In the remaining 6 countries with below-average e0 values and the remaining 14 countries with above-average e0 values, smoking contributed

"negatively" to these differences. That is, without smoking, the e0 levels in these 20 countries would have deviated from the average even more. The average contribution of smoking among women in the 30 countries combined is –7%.

However, neither the country differences in life expectancy nor the contribution of smoking to the country differences in life expectancy was stable over time. Overall, the country differences in life expectancy diverged up to 2005, with a temporal peak in 1995, and then converged from 2005 onward, especially for men (Supplementary Figure S1). The average contribution of smoking was highest in absolute terms in 1995, at 1.18 years (Table 1). However, the relative contribution of smoking increased for men from 42% in 1985 to about 47% in the 1988–1991 period, after which the contribution gradually declined to the 2014 average level of 35% (Figure 3). For women, the average relative contribution of smoking fluctuated around zero up to 1991, after which it gradually declined up to 2011 (–7.5%), and then increased slightly up to –6.9% in 2014. For both sexes combined, the average relative contribution of smoking was 24% in 1985, reached a peak of 29% in 1991, and had declined to 21% by 2014. Similar declines in the average contribution of smoking from 1990 to 1995 onward are observed when only the countries with below- or above-average e0 levels are considered (Table 1).

Discussion

Summary of Results

In 2014, e0 ranged from 70.8 years in Russia to 83.1 years in Switzerland. Men exhibited larger country differences than women (variance of 21.9 and 7.0 years, respectively). Country differences in e0 increased up to 2005 and declined thereafter. Among men, the average contribution of smoking to the country differences in e0 was highest around 1990 (47%) and declined thereafter to 35% in 2014. Among women, the average relative contribution of smoking declined from 1991 to 2011, and smoking resulted in smaller differences with the average e0 level in the majority of European countries. For both sexes combined, the contribution of smoking to country differences in e0 was higher than 20% throughout the period.

Discussion of Results

In 2014, smoking-attributable mortality contributed 21% on average to the differences in e0 between each individual European country and the weighted average of the 30 European countries studied. Especially among men, the contribution of smoking to the country differences in e0 was substantial, at 35% and was almost equal for countries with below-average e0 values (CEE countries) and countries with above-average e0 values (non-Eastern European countries). Thus, it appears that this substantial contribution of smoking was driven by both the above-average smoking-attributable mortality among men in most CEE countries, which resulted in high PGLE values (Figure 2) and the below-average smoking-attributable mortality among men in most North-Western European countries, which resulted in low PGLE values (Figure 2). These country differences in smoking-attributable mortality[6] represent the long-term mortality effects of country differences in past smoking prevalence.[31–33]

These large differences between North-Western European countries and most CEE countries in smoking prevalence and smoking-attributable mortality among men can be mostly explained by differences in the timing of the smoking epidemic.[3,4] The smoking epidemic started early in North-Western European countries, as the
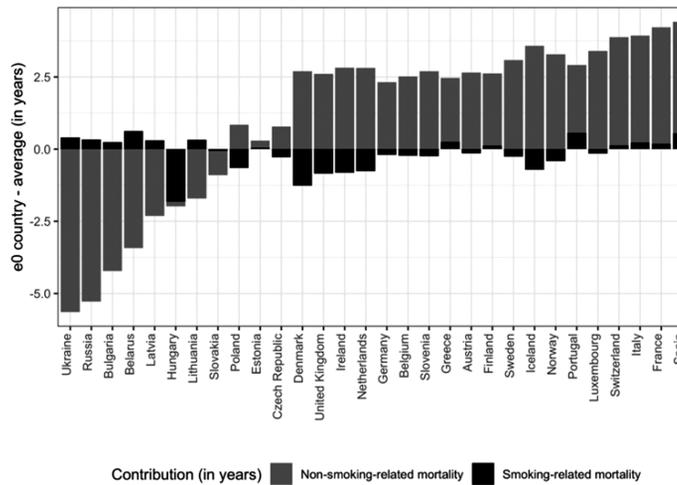
a) **Men and women (e0 for the 30 European countries combined = 77.79 years)**
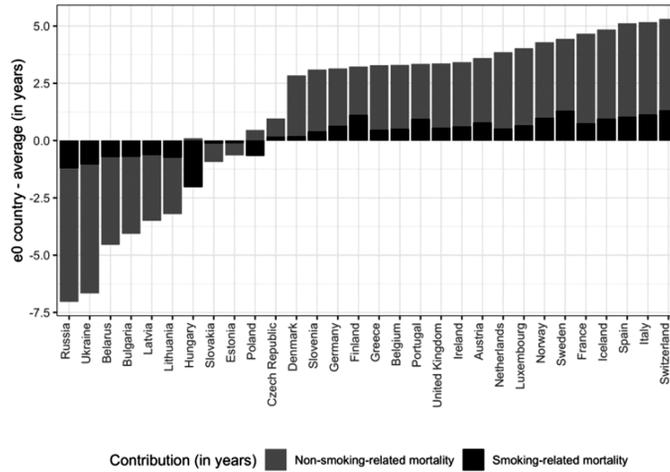
b) **Men (e0 for the 30 European countries combined = 74.26 years)**
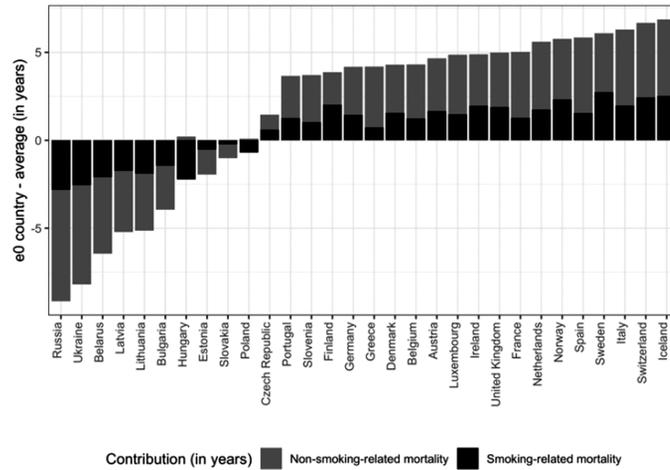
c) **Women (e0 for the 30 European countries combined = 81.24 years)**

Figure 1. The contribution of smoking (in years) to the difference in life expectancy at birth (e0) between the respective country and the weighted average over the 30 included European countries, 2014*, by sex. a) Men and women, b) men, c) women.* Or latest available year: Bulgaria 2010, Greece 2013, Russia 2013, Ukraine 2012.

Table 1. Trends Over Time in Country Differences in Life Expectancy at Birth (e0) in Europe, and the Contribution of Smoking, Selected Years in the Period 1985–2014*, 30 Countries, by Sex

| Sex | Year | Weighted average e0 | Country differences e0 | | | Average contribution smoking** | | | | | | | | |
| | | | Range e0 | Pop variance | Average absolute difference | All the countries | | | Countries with below-average e0 values | | | Countries with above-average e0 values | | |
						N	Years	%	N	Years	%	N	Years	%
Men and women	1985	72.41	[68.26, 77.52]	7.12	2.53	30	0.61	24.24	12	0.51	23.78	18	0.68	24.47
Men and women	1990	73.35	[69.22, 77.93]	8.39	2.78	30	0.78	28.20	11	0.79	27.48	19	0.78	28.64
Men and women	1995	72.44	[64.51, 78.83]	17.74	4.15	30	1.18	28.46	10	1.02	27.84	20	1.26	28.71
Men and women	2000	73.67	[65.29, 79.84]	15.70	3.97	30	1.02	25.64	9	0.87	25.11	21	1.08	25.83
Men and women	2005	74.44	[65.34, 81.37]	19.51	4.50	30	1.07	23.87	9	0.92	24.28	21	1.14	23.74
Men and women	2010	76.55	[68.93, 82.30]	15.18	3.84	30	0.87	22.66	10	0.87	25.61	20	0.87	21.41
Men and women	2014*	77.79	[70.75, 83.10]	13.40	3.60	30	0.77	21.31	10	0.80	24.31	20	0.75	20.01
Men	1985	68.39	[62.73, 74.81]	10.80	3.11	30	1.32	42.33	12	1.05	41.49	18	1.50	42.74
Men	1990	69.28	[63.76, 75.36]	13.10	3.49	30	1.59	45.52	11	1.54	44.80	19	1.62	45.92
Men	1995	67.97	[58.11, 76.18]	27.97	5.26	30	2.25	42.69	9	2.09	42.00	21	2.31	42.96
Men	2000	69.37	[58.98, 77.86]	25.01	5.07	30	2.08	41.12	9	1.76	41.41	21	2.22	41.02
Men	2005	70.19	[58.91, 79.47]	31.72	5.77	30	2.17	37.66	8	2.01	37.37	22	2.23	37.76
Men	2010	72.80	[63.07, 80.03]	24.96	4.94	30	1.84	37.28	10	1.76	39.48	20	1.89	36.34
Men	2014*	74.26	[65.11, 81.13]	22.61	4.70	30	1.65	35.23	10	1.62	37.10	20	1.67	34.38
Women	1985	76.21	[73.00, 80.35]	4.93	2.04	30	−0.04	−1.96	12	−0.01	−0.51	18	−0.06	−2.72
Women	1990	77.28	[73.77, 80.98]	5.14	2.09	30	−0.03	−1.33	11	0.03	1.23	19	−0.06	−3.00
Women	1995	77.00	[71.61, 81.91]	9.26	2.92	30	−0.04	−1.23	11	0.05	2.08	19	−0.09	−2.76
Women	2000	78.02	[72.23, 82.87]	8.34	2.77	30	−0.12	−4.48	10	0.02	0.71	20	−0.19	−6.60
Women	2005	78.76	[72.45, 83.82]	9.73	3.09	30	−0.16	−5.15	9	−0.01	−0.54	21	−0.22	−6.81
Women	2010	80.25	[74.87, 85.04]	8.10	2.76	30	−0.17	−6.13	8	−0.03	−0.99	22	−0.22	−8.30
Women	2014*	81.24	[75.99, 85.64]	7.16	2.57	30	−0.18	−6.87	8	−0.05	−1.57	22	−0.22	−9.16

*Or latest available year: Bulgaria 2010, Greece 2013, Russia 2013, Ukraine 2012.

**A positive sign for the relative contribution of smoking indicates that smoking resulted in larger country differences in e0 ("positive" contribution to country differences in e0); a negative sign for the relative contribution of smoking indicates that smoking resulted in smaller country differences in e0 ("negative" contribution to country differences in e0).

high-income levels in these countries facilitated the early automation of the cigarette production process.[3,6,31] Because of this early onset, these countries experienced the maximum mortality impact earlier than the CEE countries, and their smoking prevalence and smoking-attributable mortality levels have since declined to lower levels.[6,33]

For women, the contribution of smoking to the country differences in e0 had a negative sign in 2014, which indicates that the country differences would have been larger without the effect of smoking. In each country, the smoking epidemic among women lags behind the smoking epidemic among men by about 30–40 years.[4] Consequently, among women in North-Western European countries, smoking-attributable mortality is currently either around its peak or is still increasing,[6] which is resulting in high PGLE values (Figure 3); whereas among women in CEE countries (except Hungary), smoking-attributable mortality and PGLE values are still rather low.[6,33] Because North-Western European countries have higher e0 values than CEE countries, the greater impact of smoking in the former group of countries leads to smaller differences in e0 in Europe.

However, this does not mean that for women, smoking does not contribute to country differences in e0 in Europe for particular countries or sets of countries. Supplementary Table S2 shows that the contribution of smoking to differences in e0 between any European countries in 2014 can be assessed. For women, for example, smoking contributed 2.4 years (0.54 + 1.82) to the 6.4-year higher e0 in Spain (81.24 + 4.41 = 85.56) compared to Hungary (81.24 − 1.98 = 79.26),

which amounts to 37%. The Supplementary Excel file provides Supplementary Table S2 for 1985, 1990, …, 2010.

The important sex differences detected in the contribution of smoking to the country differences in e0 can also help to explain why larger country differences in e0 were observed among men than among women. Indeed, for nonsmoking-related mortality, the differences in e0 between countries were more similar for men and women; that is, in 2014/LAY, the range was 12.6 and 10.0 years, respectively, and the population variance was 14.4 and 8.8, respectively (see Supplementary Table S3).

The current results apply to life expectancy at birth (e0). Because smoking-attributable mortality is almost nonexistent before age 35 (and is set to zero in the analysis), the contribution of smoking to country differences at age 35 and age 50 is even higher for men (42.2% and 42.8%, respectively) and is, consequently, also higher for men and women combined (25.4% and 24.0%, respectively) (see Supplementary Table S5 and Supplementary Document). For the change in the contribution of smoking (see "Changing Contribution of Smoking"), similar considerations apply.

While smoking is certainly important, it cannot, of course, explain all of the observed country differences in life expectancy. Other – and partly related – contributors to the country differences in e0 are socioeconomic, health care-related, and political differences, as well as differences in the prevalence of other lifestyle-related factors, like excessive alcohol consumption.[17,34,35] Previous research showed

a)

b)

c)
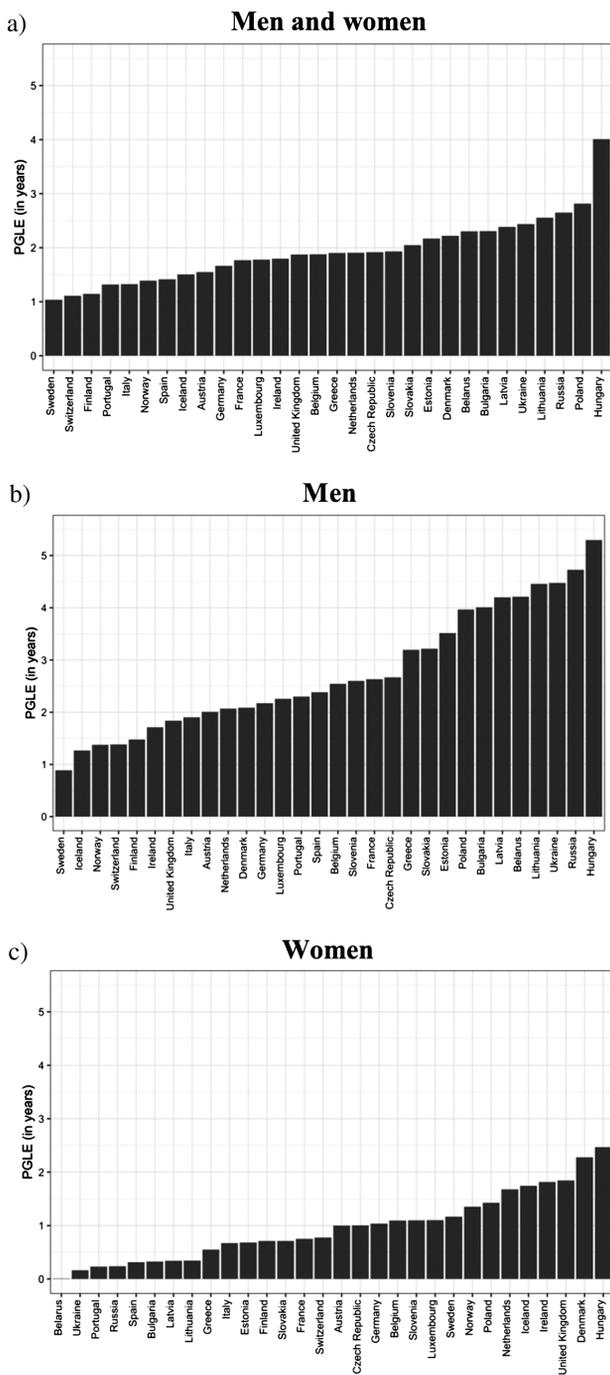
Figure 2. The potential gain in life expectancy (PGLE) when smoking-attributable mortality would be eliminated, 2014*, by country and sex. a) Men and women, b) men, c) women.* Or latest available year: Bulgaria 2010, Greece 2013, Russia 2013, Ukraine 2012.

that in 2012–2013, alcohol-attributable mortality contributed around 20% on average to the life expectancy differences between eight CEE countries and Western Europe for both men and women.[36] Thus it seems that, recently in Europe, smoking has been playing a bigger role than alcohol in country differences in e0 among men, while alcohol has been playing a bigger role than smoking in country differences in e0 among women.

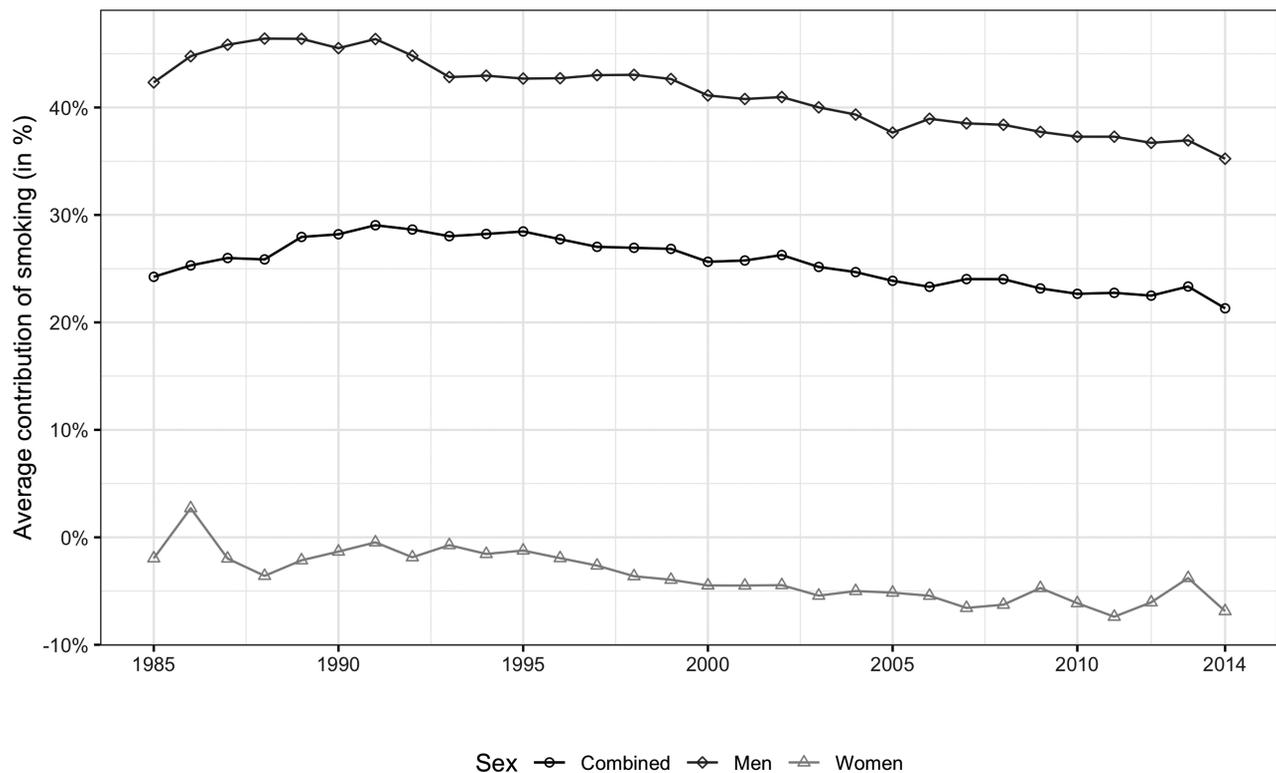## Changing Contribution of Smoking

The absolute contribution of smoking to country differences in e0 was highest in 1995. This is primarily because at that time the differences in e0 were greatest in Europe due to very low e0 levels in CEE, and especially in Russia, resulting from unfavourable political, societal, and economic changes.[34,37,38]

The relative contribution of smoking was highest around 1990 among men and was close to zero up to 1995 among women. Thereafter, the contribution of smoking declined among both men and women. These results are in line with the hypotheses outlined in the introduction, especially for men. That is, our finding that the highest relative contribution among men was around 1990 corresponds to evidence indicating that in 1990, smoking-attributable mortality among men was reaching its peak in most CEE countries, but had been declining for a number of years in the remaining countries.[6] After 1990, the contribution of smoking declined, as smoking-attributable mortality was decreasing in the CEE countries. The finding that the overall contribution of smoking was close to zero up to 1991 among women can be explained by evidence showing that in North-Western European countries – which have relatively high e0 levels – the e0 levels drew closer to the average e0 due to increases in smoking-attributable mortality; while in CEE countries – which have relatively low e0 levels – the e0 levels moved farther away from the average e0 due to increases in smoking-attributable mortality (see Table 1). From 1991 to 2011, the large increases in smoking-attributable mortality in North-Western European countries[6] helped to reduce the differences between the e0 levels in the North-Western European countries and the average e0 level (see Table 1), which resulted in a declining "negative" contribution of smoking for women overall. The recent slight increase in the average contribution of smoking to country differences among women could be the result of slightly increasing differences in e0 between North-Western European countries and the average level due to the onset of the decline in smoking-attributable mortality in selected North-Western European countries.[6]

The increasing relative contribution of smoking up until 1990 among men and the stable relative contribution of smoking up until 1991 among women indicate that smoking contributed to the divergence of e0 levels only up until 1990 among men. It thus appears that other factors were mainly responsible for the observed divergence in e0 from 1990 up to 2005, which was especially large among men. The decline in e0 levels in the former Soviet republics during this period has been attributed to important increases in alcohol consumption, particularly among adult men,[36] as well as increases in violent deaths resulting from political and economic instability in these countries.[34,37,38]

However, smoking contributed to the convergence of e0 levels from 2005 onward. For men, this trend is mainly attributable to the slightly larger decline in smoking-attributable mortality in the CEE countries than in the non-Eastern European countries.[6] For women, this trend is largely due to the high smoking-attributable mortality among North-Western countries,[6] which has diminished their advantage in e0.

The limited average contribution of smoking to life expectancy divergence (only among men up to 1991) does not mean that smoking was not responsible for growing differences in e0 between individual countries. In Supplementary Figure S1c, for example, it can be observed that smoking played an important role in the increasing difference in e0 from 1985 to 1990 between Danish women and French women.

Figure 3. The average contribution of smoking (in %) to the average difference in life expectancy at birth (e0) between the 30 included countries and the weighted average, 1985–2014*, by sex. *Or up to the latest available year: Bulgaria 2010, Greece 2013, Russia 2013, Ukraine 2012.

In line with the anticipated progression of the smoking epidemic,[3,4] it is expected that among men, the differences in e0 between European countries due to smoking will become smaller as smoking-attributable mortality continues to decline, especially in the CEE countries. Among women, however, the differences in e0 between European countries due to smoking are expected to become bigger, as smoking-attributable mortality among women in CEE countries is continuing to increase, and will reach maximum levels at a time when smoking-attributable mortality is declining among women in North-Western Europe.[6]

Evaluation Estimation Smoking-Attributable Mortality

In estimating smoking-attributable mortality, a simplified version of the indirect Peto–Lopez method was employed.[26,27] The use of an indirect method – which relies on high-quality cause-of-death information – overcomes quality issues related to the use of incomplete detailed objective smoking prevalence data and allows for the inclusion of the effects of smoking duration and smoking intensity, in addition to smoking prevalence.[39–42]

The indirect Peto–Lopez method is the most frequently applied indirect estimation technique[11,43] and its simplified version resulted in similar outcomes.[27] The differences between the Peto–Lopez method and a more recently developed indirect regression technique[40] are also small, at least for low-mortality countries in 2000[9] and 2009.[15]

Additional analysis revealed that own PGLE estimates for 2003 for people aged at least 50 were – for the vast majority of European low-mortality countries that could be compared – in between the generally lower estimates based on regression-based

smoking-attributable mortality[9] and similar PGLE calculations applied to the Global Burden of Disease 2017 smoking-attributable mortality estimates, which result from the combination of a direct and an indirect approach[44] (see Supplementary Table S4).

These differences could, however, be time-variant. That is, in the absence of (detailed) time series of national RRs of smoking across Europe, the estimation method employed relied on the use of RRs of dying from smoking from the American Cancer Survey study in 1982–1988.[28] Given that RRs are likely highest when smoking-attributable mortality reaches its peak,[45] the inability to use time-dependent national RRs could result in a potential underestimation of the contribution of smoking to country differences in e0. On the other hand, the use of the same ratio between nonsmoking-attributable lung cancer mortality and lung cancer mortality—again from the American Cancer Survey study—could point to an overestimation of smoking-attributable mortality in CEE countries, where lung cancer could also be caused by environmental factors.[46] This could result in a potential overestimation of the contribution of smoking to country differences in e0 when this contribution is driven mostly by smoking-attributable mortality in CEE countries.

All in all, the results should be interpreted with the employed indirect estimation method in mind.

Overall Conclusion and Implications

Smoking-attributable mortality was found to play an important role in country differences in e0 in Europe. These e0 differences were thus related to the long-term mortality effects of country differences in past smoking prevalence resulting from differences in the onset of the smoking epidemic, which were in turn driven mainly by differences in past economic circumstances.

Along with the progression of the smoking epidemic, the contribution of smoking to the country differences has gradually changed over time. For men, the highest contribution was around 1990, when the mortality impact of the smoking epidemic reached its peak in the CEE countries, and was already declining in the North-Western European countries. For women, the current country differences would have been larger without the contribution of smoking, but this trend is expected to reverse in the near future, as smoking-attributable mortality continues to increase among women in CEE countries, and continues or starts to decline among women in North-Western Europe.

The finding that smoking contributed to the divergence in e0 in Europe up to 1991 among men and to the convergence in e0 in Europe since 2005 indicates that policies that discourage smoking can help to reduce differences in mortality levels across Europe in the long run, particularly if they are successfully implemented in countries that have both a low life expectancy level and an increasing smoking prevalence.

Supplementary Material

Supplementary data are available at *Nicotine and Tobacco Research* online.

Declaration of Interests

None declared.

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