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The Impact of a Changing Smoking Rate on Population-Level Mortality Improvement

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The analysis of historical mortality improvement has traditionally focused on population-level experience segmented by age and gender, with little or no consideration given to smoker status as a potential confounder. It can be tempting to extend population-level results to one's own actuarial application without accounting for differences in smoking behavior between the study and target groups. However, as I discuss in this article, failing to understand and reflect differences in smoking behavior between groups can result in overstated (or understated) estimates of mortality improvement.

POPULATION SMOKING TRENDS

Smoking trends vary significantly by geography and a number of sociodemographic factors. These variations notwithstanding, there is little doubt that the overall proportion of Canadians and Americans who smoke has been in steady decline. According to data compiled by Statistics Canada, the prevalence of daily or occasional cigarette smoking in Canada for ages 12+ has declined from 23.0 percent in 2003 to 18.1 percent in 2014.[1] Similarly, data from the Centers for Disease Control and Prevention (CDC) in the U.S. indicates that the prevalence of daily or occasional cigarette smoking in the U.S. for ages 18+ has declined from approximately 20.9 percent in 2005 to 15.1 percent in 2015.[2] These aggregate trends translate into average annual cigarette smoking declines of approximately 2 percent to 3 percent per year on a relative basis.

The trends are even more stark when examined by age and gender. The tables in Figure 1 and Figure 2 illustrate cigarette smoking trends by gender and age group for each of Canada and the U.S., respectively. Note that cigarette smoking rates have declined more precipitously for adults under 45 than for adults 45+, after controlling for gender.

Figure 1
Proportion of Canadian Adults Who Smoke Cigarettes Daily or Occasionally (2003 vs 2014)[1]

Segment	2003 (%)	2014 (%)	Annualized Rate of Change (% Per Annum)
Males 20–34	33.5	29.6	–1.1
Males 35–44	31.2	25.9	–1.7
Males 45–64	24.5	22.9	–0.6
Males 65+	11.5	10.7	–0.7
Females 20–34	26.5	19.4	–2.8
Females 35–44	25.4	15.5	–4.4
Females 45–64	21.7	17.5	–1.9
Females 65+	10.5	8.4	–2.0

Figure 2
Proportion of U.S. Adults Who Smoke Cigarettes Daily or Occasionally (2005 vs 2015)[2]

Segment	2005 (%)	2015 (%)	Annualized Rate of Change (% Per Annum)
Males 18–24	28.0	15.0	–6.1
Males 25–44	26.8	19.8	–3.0
Males 45–64	25.2	17.9	–3.4
Males 65+	8.9	9.7	0.9
Females 18–24	20.7	11.0	–6.1
Females 25–44	21.4	15.8	–3.0
Females 45–64	18.8	16.1	–1.5
Females 65+	8.3	7.3	–1.3

IMPLICATIONS OF A CHANGING SMOKING RATE ON MORTALITY IMPROVEMENT

Having established that the overall cigarette smoking rate across Canada and the U.S. has been in decline over at least the past decade or so, I now discuss the implications of a changing smoking rate in the context of mortality improvement modeling.

The key implication of a changing smoking rate is that it alone can give rise to population-level mortality improvement (or deterioration). In other words, as the proportion of smokers in the group decreases, one can expect to observe mortality improvement by age and gender over time, simply by virtue of the flows between the higher mortality smoker and lower mortality non-smoker sub-groups. Conversely, as the proportion of smokers in the group increases, one can expect to observe mortality deterioration, all else being equal.

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It is easy to overlook this type of smoking rate change-induced mortality improvement, and as we will see, it can be material. One danger of overlooking this component is that the practitioner models historical mortality improvement based on population-level data and subsequently extrapolates the results without adjustment to one or more groups with different smoking rates. In the event that population-level results are extrapolated without adjustment to smoker and non-smoker distinct groups—each of which by definition must have zero smoking rate change-induced mortality improvement—the practitioner risks using a materially overstated historical mortality improvement estimate *for each* of the smoker and non-smoker groups.

ESTIMATING THE MORTALITY IMPROVEMENT ARISING FROM A CHANGING SMOKING RATE

The component of population-level mortality improvement (MI) arising over one year from a changing smoking rate can be calculated using formula (1) below.

$$\text{One Year Population Level MI Arising from Change in Smoking Rate} = \frac{r}{\frac{1}{p(1-m)} - 1} \quad (1)$$

where:

- r = Relative change in smoking rate (% per annum)
- p = Proportion of smokers at year start (i.e., smoking rate at year start)
- m = Smoker mortality as a multiple of non-smoker mortality (i.e., smoker mortality / non-smoker mortality)

Note that formula (1) depends only on the assumed annual change in smoking rate (r), the proportion of smokers at year start (p), and the smoker/non-smoker mortality ratio (m); it is independent of the smoker and non-smoker mortality rates themselves.

While formula (1) is defined for a one-year period, it can be extended (approximately) to a multi-year period by replacing p = *proportion of smokers at year start* with p^* = *proportion of smokers at mid period*, so long as it is reasonable to assume constant r and m over the multi-year period. The shorter the multi-year period, typically the better the approximation.

The results of applying formula (1) to nine different test cases are presented in Figure 3. For example, in the first case, we model a 1 percent annual decline in smoking, a 30 percent smoking rate at year start, and a 2:1 smoker to non-smoker mortality ratio. For this test case, we calculate that the changing smoking rate alone will give rise to 23 basis points (bps) of population-level mortality improvement (per annum) over the period. Based on these test cases, we see that it is not unreasonable to expect smoking rate change-induced mortality improvements of 25, 50, or even 75 bps per annum, depending on the group under consideration.

Figure 3
Impact of a Changing Smoking Rate on Population-Level MI—Select Cases

Case	r	p	m	Population-Level MI from a Changing Smoking Rate (Per Annum)
1	–1%	30%	2	0.23%
2	–2%	30%	2	0.46%
3	–3%	30%	2	0.69%
4	–1%	20%	2	0.17%
5	–2%	20%	2	0.33%
6	–3%	20%	2	0.50%
7	–2%	10%	2	0.18%
8	–2%	20%	3	0.57%
9	–2%	30%	3	0.75%

These smoking rate change-induced impacts are indeed material given that overall mortality improvement rates (i.e., from all sources, including medical advances) are often estimated to be in the low single percentage digits. For example, if under Case

6, one estimated an overall population-level mortality improvement of 2 percent per annum, the smoking rate change-induced component alone would account for one-quarter of the overall rate. If the practitioner subsequently extrapolated the 2 percent per annum population-level estimate to (say) a group of nonsmokers, he/she would implicitly be carrying over 50 bps per annum of smoking rate change-induced mortality improvement, likely resulting in an overstatement of mortality improvement for the target group.

CONCLUSION

When estimating and setting mortality improvement assumptions, it is critical that the practitioner model only the relevant sources of mortality improvement for the intended application. As I have discussed in this article, a changing smoking rate alone can give rise to material population-level mortality improvement. To the extent that this smoking rate change-induced component of mortality improvement exists in the practitioner's study representation, it is important that he/she quantify its impact and determine how much of it, if any, should be reflected in the target application. ■

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ENDNOTES

1 Statistics Canada. *Table 105-0501*, April 22, 2016: *http://www5.statcan.gc.ca/cansim/a26?lang=eng&retrLang=eng&id=1050501&&pattern=&stByVal=1&p1=1&p2=37&tabMode=dataTable&csid=*

2 Jamal A, King BA, Neff LJ, Whitmill J, Babb SD, Graffunder CM. Current Cigarette Smoking Among Adults—United States, 2005–2015. MMWR Morb Mortal Wkly Rep 2016;65:1205–1211. DOI: *https://www.cdc.gov/mmwr/volumes/65/wr/mm6544a2.htm?s_cid=mm6544a2_w*