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Don't Change Much: The Economic Impact of Modest Health Behavior Changes in Middle-Aged Men

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Abstract

Few studies have assessed differences in the prevalence of and economic burden attributable to tobacco smoking, excess weight, physical inactivity, and alcohol use by gender. This article examines these gender differences in Canadians between the ages of 30 and 64 years. It also estimates the potential cost avoidance if the prevalence of the four risk factors (RFs) were reduced modestly in males. Data on the prevalence of the RFs and the relative risk of disease associated with each of the RFs were combined to calculate population-attributable fractions. A prevalence-based cost-of-illness approach was used to estimate the economic burden associated with the four RFs. Middle-aged Canadian males are more likely to smoke tobacco (26.4% vs. 20.2%), consume hazardous or harmful levels of alcohol (14.6% vs. 8.2%), and have excess weight (65.6% vs. 47.1%) than middle-aged Canadian females, resulting in an annual economic burden that is 27% higher in males than females. No significant differences were observed in the proportion of males who are physically inactive (48.4% vs. 49.4%). Modelling only a 1% annual relative reduction each year through to 2036 would result in a cumulative cost avoidance between 2013 and 2036 of $50.7 billion. The differences in RF prevalence between middle-aged males and females have an important effect on the population's economic burden. A modest annual reduction in the four RFs in males can significantly affect population health and the economy over time.

Keywords

economic burden of disease, risk factors, smoking, alcohol use, obesity, overweight, physical inactivity

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Introduction

When assessing the health of populations, gender matters (Salzman & Wender, 2006). Yet the historical approach to men's health has tended to focus primarily on issues of the prostate and sexual function (Sadovsky & Levine, 2005). The world's first Congress on Men's Health was held in 2001 and focused on broader issues such as men's shorter life expectancies and gender differences in accessing health information and seeking medical advice (Baker, 2001).

In Canada, male life expectancy is 79 years, compared with 83 years for females (Statistics Canada, 2012). The cause of death also varies substantially between males and females (Statistics Canada, 2015). For example, the age-standardized mortality rate for malignant neoplasms (ICD10 C00-C97) in Canadian males is 184 per 100,000 compared with 133 per 100,000 for Canadian females. Likewise, the mortality rate for major cardiovascular diseases (ICD10 I00-I78) is 159 per 100,000 for males compared with 97 per 100,000 for females (Statistics Canada, 2015). There is also evidence that the economic burden attributable to tobacco smoking, excess weight, and physical inactivity is higher in Canadian males than females (Krueger, Krueger, & Koot, 2015).

The Canadian Men's Health Foundation (2015b) is a national, nonprofit organization founded in June of 2014. The goal of the foundation is

> to raise social awareness of largely preventable health problems and to enable men, and their families to value men's health by providing them with information and healthy

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> lifestyle programs that will motivate them to truly hear, absorb and act on it. (Goldenberg, 2014)

The Canadian Men's Health Foundation's (2015a) *Don't Change Much* campaign is an innovative health promotion campaign and website created specifically to encourage men to make small changes toward healthier habits, including increasing physical activity, reducing excess weight, limiting alcohol consumption, and quitting tobacco smoking.

The purpose of this study is to assess four important modifiable risk factors (RFs): physical inactivity, excess weight, alcohol use, and tobacco smoking in Canadian men between the ages of 30 and 64 years. In particular, the following questions were investigated: (a) How does the prevalence and economic burden attributable to these RFs differ by sex in Canada? (b) What would the potential cost avoidance be if the prevalence of these RFs in Canadian men were reduced by a relative 1% per year between 2013 and 2036?

Method

The details of the base model, together with an update, have been previously published (Krueger et al., 2015; Krueger, Turner, Krueger, & Ready, 2014; Krueger, Williams, Ready, Trenaman, & Turner, 2013). In short, an approach based on population attributable fraction (PAF) was used to estimate the economic burden associated with the four RFs. This involved the following steps: (a) estimation of the RF prevalence; (b) estimation of the causal relationship between the RF and comorbidities; (c) calculation of the PAF for all ages in the population; (d) estimation of the direct costs of treating the comorbidities associated with the RFs; (e) adjustment of the direct costs for overlapping RFs in a given individual; (f) estimation of indirect costs; (g) allocation of costs to the population aged 30 to 64 years; and (h) modelling of the potential cost avoidance associated with a modest 1% annual relative reduction (ARR) in the prevalence of the RFs between 2013 and 2036.

Prevalence of the Risk Factors

Prevalence rates for tobacco smoking, excess weight, physical inactivity, and alcohol use were drawn from the 2011/2012 Canadian Community Health Survey (CCHS; Statistics Canada, 2013). Individuals were considered overweight if their body mass index (BMI) was between 25 kg/m^2 and 29.9 kg/m^2 and obese if their BMI was equal to or greater than 30 kg/m^2, calculated based on self-reported height and weight. Tobacco smokers were grouped as light (<10 cigarettes per day), moderate (10-19 cigarettes per day), and heavy (≥20 cigarettes per day) smokers based on the average number of cigarettes smoked per day. All current smokers who identified themselves as occasional smokers were included in the light smoking category. Physical inactivity rates were based on people categorized as "inactive" (leisure time energy expenditure of less than 1.5 kcal/kg/day) in the CCHS.

The prevalence of both chronic and binge alcohol use was estimated based on CCHS data adjusted for underreporting. Research has identified that it is common for alcohol use to be underreported, as individuals either report fewer drinks than are actually consumed or are unaware of the amount of alcohol present in their drinks (Kerr & Stockwell, 2012). Males were categorized as abstainer or very light (0-0.24 g/day), Category I—low (0.25-39.9 g/day), Category II—hazardous (40.0-59.9 g/day), and Category III—harmful (≥60.0 g/day). Females were categorized as abstainer or very light (0-0.24 g/day), Category I—low (0.25-19.9 g/day), Category II—hazardous (20.0-39.9 g/day), and Category III—harmful (≥40.0 g/day; Taylor et al., 2007). A female binge drinker was defined as a female who consumes at least four drinks (containing 13.6 g of ethanol) on one occasion at least once per month during the past 12 months. A male binge drinker was defined as a male who consumes at least five drinks on one occasion at least once per month during the past 12 months.

Estimating Relative Risks

The sources and values for the relative risks associated with excess weight (Pirie et al., 2013), tobacco smoking (Guh et al., 2009), and physical inactivity (Katzmarzyk & Janssen, 2004) remain the same as in the previously published model (Krueger et al., 2015). Relative risk values associated with alcohol use were assembled from a collection of studies that together describe the relative risk of all major comorbidities associated with both chronic and acute alcohol use (Bagnardi, Blangiardo, La Vecchia, & Corrao, 2001; Bagnardi et al., 2013; Baliunas et al., 2009; Fedirko et al., 2011; Islami et al., 2011; Lönnroth, Williams, Stadlin, Jaramillo, & Dye, 2008; Patra et al., 2010; Patra et al., 2011; Roerecke & Rehm, 2012; Samokhvalov, Irving, Mohapatra, & Rehm, 2010; Samokhvalov, Irving, & Rehm, 2010a, 2010b; Taylor et al., 2009; Taylor et al., 2010; Tramacere et al., 2010).

Calculating the Population Attributable Fraction

Sex-, RF-, and disease-specific PAFs were calculated for all ages combined in the population using the extension of Levin's formula (Levin, 1953):

$$PAF = \frac{\sum_{i=0}^{k} p_i \times \left(RR_i - 1\right)}{1 + \sum_{i=0}^{k} p_i \times \left(RR_i - 1\right)}$$

where i denotes a given exposure level, p_i is the prevalence of that exposure level in the population, and RR_i is the relative risk of a given disease for the given exposure level. Physical inactivity was regarded as a dichotomous exposure (no physical inactivity and physical inactivity), excess weight was regarded as a trichotomous exposure (no excess weight, overweight, and obesity), and tobacco smoking and alcohol use were regarded as tetrachotomous exposures (no smoking, light smoking, moderate smoking, and heavy smoking; abstaining, low alcohol use, hazardous alcohol use, and harmful alcohol use).

Estimating Costs

The economic burden (direct and indirect costs) associated with the RFs was estimated using a prevalence-based cost-of-illness approach. The cost estimates are expressed in 2013 Canadian dollars.

Direct Cost. Direct costs, including hospital care, physician services, other health care professionals (excluding dental services), drugs, health research, and "other" health care expenditures, were extracted from the National Health Expenditure Database (Canadian Institute for Health Information, 2013). Hospital care, physician care, and drug costs were allocated to each comorbidity, stratified by sex, based on 2008 data from the *Economic Burden of Illness in Canada* (EBIC) online tool (Public Health Agency of Canada, 2014).

EBIC 2008 does not allocate costs for other health care professionals (excluding dental services), health research, or "other" health care expenditures. These were estimated by allocating costs according to the same proportional distribution as hospital, physician, and drug costs.

These direct care costs were multiplied by the calculated RF-, sex-, and comorbidity-specific PAFs to calculate the direct care costs attributable to a given RF.

Adjusting Direct Costs in a Multifactorial System. To adjust for double counting, the combined PAF in a multifactorial system was calculated using the following formula (Krueger et al., 2013):

$$\text{Combined PAF} = 1 - \left[\left(1-\text{PAF}_{\text{TS}}\right)\left(1-\text{PAF}_{\text{EW}}\right)\left(1-\text{PAF}_{\text{PIA}}\right)\left(1-\text{PAF}_{\text{AU}}\right)\right]$$

where PAF_{TS} is the crude PAF of cost for tobacco smoking, PAF_{EW} is the crude PAF of cost for excess weight, PAF_{PIA} is the crude PAF of cost for physical inactivity, and PAF_{AU} is the crude PAF of cost for alcohol use.

A disaggregation step was applied at the end of the direct costing process to assign an economic burden to each RF. This was achieved by dividing the crude cost for each RF by the sum of costs for all the RFs (i.e., the crude total cost for the combined system), thereby generating a ratio which was applied to the adjusted total cost.

Estimating Indirect Costs. Indirect costs were calculated following the method used in *EBIC 1998* (a modified human-capital approach; Health Canada, 2002). The ratio of direct to indirect costs was determined for each diagnostic category within *EBIC 1998*, stratified by short-term disability, long-term disability, and premature mortality. Each ratio was applied to the previously identified direct costs within each diagnostic category attributable to individual RFs in order to generate the equivalent indirect cost data.

Distributing Costs Among Age Groups. Costs for individuals aged 30 to 64 years were calculated by distributing costs among age groups, proportional to the number of individuals in the population with each RF exposure level.

Modelling Cost Avoidance

A number of assumptions were made in modelling the economic benefits associated with future RF reduction (Krueger et al., 2014). First, population projections for the 24-year time frame from 2013 to 2036 by sex and 5-year age group were based on projections by Statistics Canada (2010). Second, the base model uses a 1% relative annual reduction in the RFs. Current trends of decreasing smoking prevalence and increasing weight and inactivity are not factored into the model. Third, constant 2013 dollars are used throughout the modelling process (i.e., no adjustments are made for projected inflation) to clearly identify changes in the economic burden associated with changing RF prevalence, rather than confusing these results with inflationary increases. Fourth, obese individuals who experience a reduction in excess weight move into the overweight category instead of immediately becoming a healthy weight. Last, the benefits associated with physical activity and healthy weights accrue within 1 year; however, the benefits of smoking cessation and reduced alcohol consumption accrue over time (Heckley, Jarl, Asamoah, & Ulf, 2011; Jarl & Gerdtham, 2012; Jarl, Gerdtham, Ludbrook, & Petrie, 2010; Kenfield, Stampfer, Rosner, & Colditz, 2008; Kiadaliri, Jarl, Gavriilidis, & Gerdtham, 2013).

Sensitivity Analysis

The point estimates for RR are used in the base model and a sensitivity analysis was performed using the lower and upper bounds of the 95% confidence interval (CI) for each RR value. The base model also assumes that there is no protective effect of low, chronic consumption of

Table 1. Prevalence of Tobacco Smoking, Excess Weight, Physical Inactivity, and Alcohol Use in Canada for Males and Females Ages 30 to 64, 2013.

	Females (%)	Males (%)	Absolute difference (%)	% Difference	p^a
Tobacco smoking					
Light	8.6	8.4	−0.3	−3.2	.886
Moderate	7.0	8.0	1.0	14.5	.144
Heavy	4.6	10.1	5.5	121.5	.002
Subtotal: Tobacco smoking	20.2	26.4	6.3	31.2	.006
Excess weight					
Overweight	27.0	44.3	17.2	63.8	<.001
Obese Class I (BMI of 30-34.9)	12.8	16.0	3.1	24.4	.025
Obese Class II (BMI of 35-39.9)	4.5	3.9	−0.6	−12.6	.217
Obese Class III (BMI ≥ 40)	2.8	1.5	−1.3	−47.1	.003
Subtotal: Obesity	20.1	21.4	1.3	6.3	.455
Subtotal: Excess weight	47.1	65.6	18.5	39.3	<.001
Physical inactivity	49.4	48.4	−1.1	−2.2	.378
Alcohol use					
Category I: Low	53.2	61.0	7.8	14.7	<.001
Category II: Hazardous	5.6	7.6	2.0	35.7	<.001
Category III: Harmful	2.6	7.0	4.4	170.1	<.001
Subtotal: Alcohol use	61.4	75.6	14.3	23.2	<.001
Percentage of drinkers who binge	30.8	41.8	11.0	35.7	.010

Note. BMI = body mass index.
[a]Two-tailed *t* test, α=0.05.

alcohol. This assumption was tested in the sensitivity analysis.

Results

A higher proportion of Canadian males aged 30 to 64 years smoke tobacco compared with females, with a major difference being the proportion of heavy smokers (10.1% of males vs. 4.6% of females, see Table 1). A higher proportion of males also use alcohol at every level of consumption, particularly at levels that are considered to be hazardous or harmful (14.6% of males vs. 8.2% of females), and of those who use alcohol, a higher proportion of males are binge drinkers (41.8% of males vs. 30.8% of females). A higher proportion of males also have excess weight (65.6% of males vs. 47.1% of females); however, there are a higher proportion of females than males with a BMI ≥40 (1.5% of males vs. 2.8% of females).

The total economic burden attributable to the four RFs in Canadian males aged 30 to 64 years is estimated at $22.8 (95% CI [$19.5, $25.9]) billion in 2013 (Table 2). This is $6.1 billion (27%) more than females in the same age group ($16.7 billion, 95% CI [$13.8, $19.6]).

In estimating the cost avoidance, a 1% ARR was modelled each year through to 2036 (1% scenario). With no change in the prevalence of the RFs, the annual economic burden would increase from $22.8 billion in 2013 to $26.9 billion in 2036, due to projected population growth. Applying the 1% scenario would reduce the projected annual economic burden in 2036 from $26.9 to $22.4 billion (Figure 1). The cumulative cost avoidance between 2013 and 2036 would total $50.7 billion. Of this cumulative cost avoidance, approximately 33% ($16.6 billion) would be attributable to direct costs and 67% ($34.1 billion) to indirect costs. The highest proportion (34% or $17.0 billion) of the cumulative cost avoidance would be due to a reduction in excess weight, with 31% ($15.6 billion) due to a reduction in tobacco smoking, 22% ($11.0 billion) due to a reduction in alcohol use and 14% ($7.0 billion) due to a reduction in physical inactivity.

Discussion

There are a number of key differences between middle-aged males and females in terms of tobacco smoking, excess weight, physical inactivity, and alcohol use in Canada, and these differences likely have an important effect on the health and economic burden in the population. Modelling a 1% relative annual risk reduction in middle-aged Canadian men suggests that there is the potential to reduce the projected annual economic burden in 2036 from $26.9 billion to $22.4 billion (17%), with a

Table 2. Estimated Annual Economic Burden Attributable to Tobacco Smoking, Excess Weight, Physical Inactivity, and Alcohol Use in Canada for Males and Females Ages 30 to 64 Years, 2013.

	% Population with RF	No. of Individuals with RF	Direct cost per individual with RF, $ [95% CI]	Indirect cost per individual with RF, $ [95% CI]	Total cost per individual with RF, $ [95% CI]	Total direct cost of RF, million $ [95% CI]	Total indirect cost of RF, million $ [95% CI]	Total cost of RF, million $ [95% CI]
Males								
Tobacco smoking								
Light	8.4	711,906	800 [732, 867]	1,561 [1,397, 1,725]	2,361 [2,129, 2,592]	570 [521, 617]	1,111 [995, 1,228]	1,681 [1,516, 1,845]
Moderate	8.0	679,508	1,322 [1,271, 1,374]	2,555 [2,463, 2,647]	3,877 [3,734, 4,020]	898 [864, 933]	1,736 [1,674, 1,798]	2634 [2,537, 2,732]
Heavy	10.1	861,961	1,625 [1,540, 1,714]	3,115 [2,957, 3,278]	4,740 [4,497, 4,992]	1,401 [1,328, 1,478]	2,685 [2,549, 2,825]	4,086 [3,876, 4,303]
Subtotal: Male tobacco smoking	26.4	2,253,376	1,273 [1,204, 1,344]	2,455 [2,315, 2,597]	3,728 [3,519, 3,941]	2,868 [2,713, 3,028]	5,533 [5,217, 5,852]	8,401 [7,930, 8,880]
Excess weight								
Overweight	44.3	3,774,383	203 [146, 253]	568 [417, 693]	771 [563, 946]	766 [550, 955]	2,144 [1,574, 2,617]	2,910 [2,125, 3,571]
Obese	21.3	1,819,411	737 [570, 897]	1,685 [1,285, 2,057]	2,422 [1,855, 2,954]	1,340 [1,037, 1,632]	3,066 [2,338, 3,743]	4,407 [3,374, 5,375]
Subtotal: Male excess weight	65.6	5,593,794	366 [284, 462]	908 [699, 1,137]	1,308 [983, 1,599]	2,107 [1,587, 2,586]	5,210 [3,912, 6,360]	7,316 [5,499, 8,946]
Physical inactivity	48.4	4,122,237	221 [175, 265]	394 [313, 474]	614 [488, 739]	910 [723, 1,093]	1,623 [1,290, 1,953]	2,533 [2,013, 3,046]
Alcohol use								
Category I: Low	61.0	5,202,459	78 [67, 88]	202 [173, 223]	280 [239, 311]	408 [347, 456]	1,051 [898, 1,162]	1,458 [1,246, 1,618]
Category II: Hazardous	7.6	648,815	493 [426, 569]	1,076 [956, 1,198]	1,569 [1,382, 1,767]	320 [276, 369]	698 [620, 777]	1,018 [896, 1,146]
Category III: Harmful	7.0	597,660	1,246 [1,141, 1,341]	2,254 [1,985, 2,524]	3,500 [3,126, 3,865]	744 [682, 801]	1,347 [1,186, 1,509]	2,092 [1,869, 2,310]
Subtotal: Male alcohol use	75.6	6,448,935	228 [203, 252]	480 [419, 535]	708 [622, 787]	1,472 [1,306, 1,627]	3,096 [2,705, 3,448]	4,568 [4,011, 5,074]
Subtotal: Males						7,357 [6,329, 8,334]	15,462 [13,124, 17,612]	22,818 [19,453, 25,946]
Females								
Tobacco smoking								
Light	8.6	736,735	610 [558, 663]	1,166 [1,053, 1,282]	1,776 [1,610, 1,945]	450 [411, 489]	859 [776, 944]	1,309 [1,186, 1,433]
Moderate	7.0	594,802	1,054 [1,008, 1,102]	2,037 [1,949, 2,128]	3,091 [2,958, 3,230]	627 [600, 656]	1,212 [1,160, 1,266]	1,838 [1,759, 1,921]
Heavy	4.6	389,818	1,665 [1,581, 1,759]	3,213 [3,056, 3,387]	4,878 [4,636, 5,147]	649 [616, 686]	1,252 [1,191, 1,320]	1,901 [1,807, 2,006]
Subtotal: Female tobacco smoking	20.2	1,721,355	1,002 [945, 1,063]	1,931 [1,816, 2,051]	2,933 [2,761, 3,114]	1,725 [1,626, 1,830]	3,323 [3,126, 3,530]	5,048 [4,753, 5,360]
Excess weight								
Overweight	27.0	2,308,326	297 [207, 383]	775 [583, 954]	1,072 [790, 1,337]	686 [477, 883]	1,789 [1,346, 2,202]	2,475 [1,823, 3,086]
Obesity	20.1	1,715,699	902 [678, 1,120]	1,963 [1,541, 2,371]	2,864 [2,219, 3,492]	1,547 [1,163, 1,922]	3,367 [2,644, 4,069]	4,914 [3,807, 5,991]
Subtotal: Female excess weight	47.1	4,024,025	366 [407, 697]	908 [991, 1,558]	1,836 [1,399, 2,256]	2,233 [1,640, 2,805]	5,156 [3,990, 6,271]	7,390 [5,629, 9,077]
Physical inactive	49.4	4,223,445	187 [143, 228]	432 [332, 525]	619 [474, 752]	789 [603, 962]	1,826 [1,400, 2,216]	2,615 [2,003, 3,177]
Alcohol use								
Category I: Low	53.2	4,542,791	36 [25, 42]	89 [73, 101]	125 [98, 143]	165 [114, 192]	405 [331, 458]	569 [445, 649]
Category II: Hazardous	5.6	479,167	282 [273, 309]	573 [545, 620]	855 [818, 929]	135 [131, 148]	275 [261, 297]	410 [392, 445]
Category III: Harmful	2.6	221,605	1,163 [1,013, 1,405]	1,981 [1,607, 2,467]	3,144 [2,621, 3,873]	258 [225, 311]	439 [356, 547]	697 [581, 858]
Subtotal: Female alcohol use	61.4	5,243,564	106 [90, 124]	213 [181, 248]	320 [270, 372]	557 [470, 651]	1,118 [948, 1,301]	1,676 [1,417, 1,953]
Subtotal: Females						5,304 [4,339, 6,248]	11,424 [9,464, 13,319]	16,728 [13,803, 19,567]

Note. RF = risk factor; CI = confidence interval. Adjusted for multiple RFs in one individual.

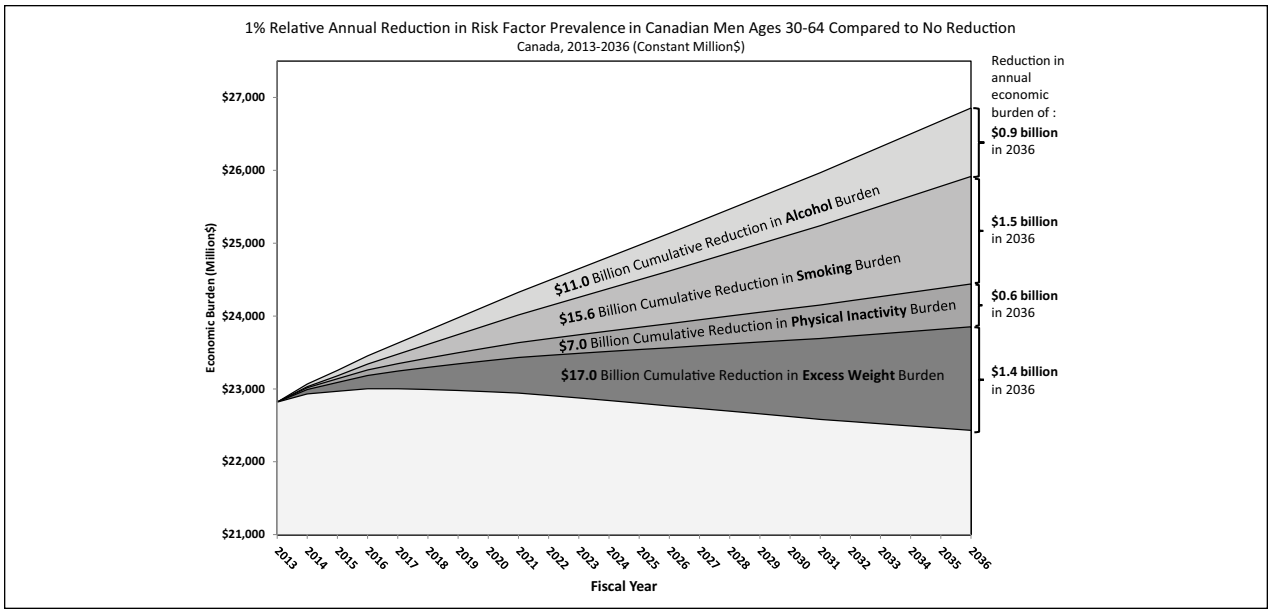

Figure 1. Changes in economic burden of smoking excess weight, physical inactivity, and alcohol use.

cumulative cost avoidance of $50.7 billion between 2013 and 2036.

Can this reduction reasonably be achieved? Between 2000 and 2013, the prevalence of tobacco smoking in Canadian men aged 30 to 64 years declined from 30.9% to 26.4%, an ARR of 1.2%. More important, the prevalence of heavy smoking declined by an ARR of 3.0%. The prevalence of physical inactivity has also declined from 55.4% in 2000 to 48.4% in 2013 (ARR of 1.0%). Unlike tobacco smoking and physical inactivity, however, the prevalence of obesity in Canadian males has increased from 17.7% in 2000 to 21.3% in 2013, an annual relative *increase* of 1.4%. The annual relative increase is 1.1% for those with a BMI of 30.0 to 34.9, 2.0% for a BMI of 35.0 to 39.9, and 4.5% for a BMI ≥40.0.

Trends in the prevalence of harmful or hazardous levels of alcohol consumption are more complicated than trends in the other three RFs. Between 2000 and 2008, the prevalence of harmful or hazardous levels of alcohol consumption increased from 12.5% to 15.9% (an annual relative increase of 3.1%) and then declined to 14.6% in 2009 and has remained relatively stable since then. The drop in prevalence coincides with the global recession in 2008/2009.

Recent trends in the prevalence of tobacco smoking and physical inactivity in middle-aged Canadian men have been positive and would simply need to continue to achieve the longer term results indicated in the 1% scenario. The negative trends in obesity, however, would need to be stopped and then reversed to be able to achieve results in the 1% scenario. The high relative annual *increase* in the prevalence of harmful or hazardous levels of alcohol consumption between 2000 and 2008 (3.1%) seems to have been reversed between 2009 and 2013. It is not clear why the observed reduction in 2009 occurred, followed by stability in prevalence between 2009 and 2013; however, it is possible that changes in the overall economy and a subsequent decrease in earning potential resulted in less disposable income for the purchase of alcoholic beverages. Nevertheless, the current trend would not only need to be maintained but would need to decline to achieve results in the 1% scenario.

In recent years, a debate has persisted over the evidence in favor and against the benefits of modest nonbinge alcohol use. Current evidence suggests that the observed protective effect may be exaggerated due to a number of methodological flaws in devising this association (Bergmann et al., 2013; Holmes et al., 2014; Stockwell, Greer, Fillmore, Chikritzhs, & Zeisser, 2012). As a result, the assumption in the base model is that there is neither increased nor decreased risk of those diseases for which some evidence suggests a protective effect. If the putative decreased risks in type 2 diabetes mellitus, ischemic heart disease, and ischemic stroke are included in the model, then the economic burden attributable to alcohol use in middle-aged Canadian males decreases from $4.6 billion to $4.0 billion (−12.7%) in 2013. Also note that the alcohol-attributable economic burden based on the model does not include increased costs associated with law enforcement or fire/traffic accident damage (Canadian Centre on Substance Abuse, 2006; Public Health Agency of Canada, 2016).

There are a number of limitations with this study. First, most studies categorize individuals with a BMI between 25 kg/m^2 and 29.9 kg/m^2 as overweight. This is also the approach taken in the current study. This range, especially the lower end, however, has been historically dynamic and some research has suggested that a more appropriate lower boundary with respect to negative health effects might be 27 kg/m^2 (Hu et al., 2004). Second, the method of scaling up from direct to indirect costs depends on the assumption that the ratios of costs have not changed over time. Third, the source for the RRs associated with smoking and physical inactivity adjust for known confounding factors in generating disease-specific RRs. The meta-analyses for the RRs associated with overweight and obesity, however, did not include physical inactivity as a potentially confounding RF which may lead to an overestimate of the economic burden attributable to excess weight. On the other hand, RRs calculated in this meta-analysis are based on a combination of studies including both self-reported and objective measures of BMI while the model uses the prevalence of excess weight based on self-reported height and weight, which may lead to an underestimate of the economic burden attributable to excess weight. Fourth, calculating the prevalence of alcohol use by sex, age, and consumption category is particularly challenging, given current data availability and issues of underreporting. Despite the best efforts to adjust for underreporting, the actual prevalence of alcohol use may vary from the current estimates. Fifth, the inclusion of indirect costs in any economic analysis is controversial, given that a variety of approaches exist, all of which generate very different results. This study uses a modified human capital approach as this approach places an economic value on time lost due to disability and premature mortality.

Conclusion

There are a number of key differences between middle-aged males and females in terms of tobacco smoking, excess weight, physical inactivity, and alcohol use in Canada, and these differences likely have an important effect on the health and economic burden in the population. A modest annual reduction in the RFs can have an important public health impact over time.

Declaration of Conflicting Interests

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