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Cancer incidence attributable to lifestyle and environmental factors in Alberta in 2012: summary of results

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Abstract

Background: Estimates of the proportion of cancer cases that can be attributed to modifiable risk factors are not available for Canada and, more specifically, Alberta. The purpose of this study was to estimate the total proportion of cancer cases in Alberta in 2012 that could be attributed to a set of 24 modifiable lifestyle and environmental risk factors.

Methods: We estimated summary population attributable risk estimates for 24 risk factors (smoking [both passive and active], overweight and obesity, inadequate physical activity, diet [inadequate fruit and vegetable consumption, inadequate fibre intake, excess red and processed meat consumption, salt consumption, inadequate calcium and vitamin D intake], alcohol, hormones [oral contraceptives and hormone therapy], infections [Epstein–Barr virus, hepatitis B and C viruses, human papillomavirus, *Helicobacter pylori*], air pollution, natural and artificial ultraviolet radiation, radon and water disinfection by-products) by combining population attributable risk estimates for each of the 24 factors that had been previously estimated. To account for the possibility that individual cancer cases were the result of a combination of multiple risk factors, we subtracted the population attributable risk for the first factor from 100% and then applied the population attributable risk for the second factor to the remaining proportion that was not attributable to the first factor. We repeated this process in sequential order for all relevant exposures.

Results: Overall, an estimated 40.8% of cancer cases in Alberta in 2012 were attributable to modifiable lifestyle and environmental risk factors. The largest proportion of cancers were estimated to be attributable to tobacco smoking, physical inactivity and excess body weight. The summary population attributable risk estimate was slightly higher among women (42.4%) than among men (38.7%).

Interpretation: About 41% of cancer cases in Alberta may be attributable to known modifiable lifestyle and environmental risk factors. Reducing the prevalence of these factors in the Alberta population has the potential to substantially reduce the provincial cancer burden.

This paper is the last in a series of manuscripts estimating the proportion of cancer cases attributable to modifiable lifestyle and environmental risk factors in the general population of Alberta in 2012. The methodologic framework for this series has been previously described,[1] and detailed exposure-specific results are given in individual articles in this journal.[2–11]

A total of 16 330 new cancer cases were diagnosed and 5817 cancer deaths occurred in Alberta in 2012. Cancer was the second-leading cause of death in the province in 2012, accounting for 27% of all deaths.[12]

Population attributable risk is used to estimate the proportion of cases of a disease that can be attributed to an individual risk factor, and when multiple population attributable risk estimates are considered together, they can provide an estimate of the total disease burden attributable to a group of risk factors. In the cancer context, data on population attributable risk can inform cancer-prevention activities by identifying exposures that have the largest impact on disease incidence as well as estimating the proportion of cases that can be attributed to groups of known risk factors. Previously, Parkin and colleagues[13–27] estimated individual population attributable risks for several modifiable lifestyle and environmental cancer risk factors in the United Kingdom and estimated that, overall, 42.7% of cancer cases diagnosed in the UK in 2010 were

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attributable to these risk factors.[28] A similar exercise in Australia showed that 32% of cancer cases in 2010 were attributable to established causal cancer risk factors.[29] To our knowledge, no similar systematic approach has been used in Canada or, more specifically, Alberta.

In the current analysis, we aimed to estimate the proportion of cancer cases in Alberta in 2012 attributable to past exposure to 24 different lifestyle and environmental factors: smoking (both passive and active), overweight and obesity, inadequate physical activity, diet (inadequate fruit and vegetable consumption, inadequate fibre intake, excess red and processed meat consumption, salt consumption, inadequate calcium and vitamin D intake), alcohol, hormones (oral contraceptives and hormone therapy), infections (Epstein–Barr virus, hepatitis B and C viruses, human papillomavirus, *Helicobacter pylori)*, air pollution, natural and artificial ultraviolet radiation, radon and water disinfection by-products. The objective of the analysis was to combine information on the estimated population attributable risk for each of these 24 risk factors to estimate the total proportion of cancer cases in Alberta in 2012 that could be attributed to modifiable lifestyle and environmental risk factors.

Methods

Detailed methods for the individual risk factors have been previously published.[1] As some factors were considered protective for cancer and others were cancer risk factors, Table 1 summarizes what we consider to be the theoretical minimum risk level of exposure for each lifestyle and environmental factor based on our research (unpublished data).[2–11] We estimated the total number of cancer cases attributable to the 24 risk factors by summing the number of cases of cancer at individual sites attributable to each individual exposure. Additional methods for the exposures included in this summary paper but not presented in separate exposure-specific papers are presented in Appendix 1, available at www.cmajopen.ca/content/5/3/E540/suppl/DC1.

Estimation of overall population attributable risks

The proportion of incident cancer cases at individual sites estimated to be attributable to each exposure is presented in Table 2.[2–11] However, some cancers are caused by multiple factors considered in this analysis, and, thus, summing the proportions for each cancer site in Table 2 to obtain overall estimates by cancer site and for all cancers combined would overestimate the total burden of cancer attributable to the 24 exposures. A formal analysis of potential interactions between risk factors was not possible because of the lack of prevalence data for Alberta that included the joint distributions of all risk factors being considered. Therefore, to estimate the proportion of all incident cancer cases attributable to any of the exposures in Alberta in 2012, we employed a method proposed and used by Parkin and colleagues.[28] Briefly, this method takes into account the overlap between various exposures so that the attributable fraction for a specific cancer site for all risk factors combined is less than the sum of the individual population attributable risks for each exposure and associated cancer site. To estimate the proportion of incident cancer cases due to all exposures for each cancer site (final row of Table 2), we subtracted the population attributable risk for the first exposure (active tobacco smoking) from 100% and then applied the population attributable risk for the second exposure (physical inactivity) to the remaining proportion that was not attributable to tobacco. We repeated this process in sequential order for all relevant exposures, with the final result estimating the proportion of

Table 1: Theoretical minimum risk levels of exposures

Exposure	Theoretical minimum risk exposure level
Active smoking	None
Passive smoking	None
Energy imbalance	
Overweight and obesity	Body mass index < 25 kg/m^2
Inadequate physical activity	> 2.9 kcal/kg per d
Diet	
Inadequate fruit and vegetable consumption	≥ 5 servings/d
Inadequate fibre intake	≥ 23 g/d
Red meat	None
Processed meat	None
Salt	≤ 5.75 g/d
Inadequate calcium intake	≥ 1100 mg/d
Inadequate vitamin D intake	≥ 600 IU/d
Alcohol	None
Hormones	
Oral contraceptive	None*
Hormone replacement therapy	None*
Infection	
Epstein–Barr virus	None
Hepatitis B virus	None
Hepatitis C virus	None
Human papillomavirus	None
Helicobacter pylori	None
Environment	
Air pollution	< 7.5 µg/m^3 annual average exposure
Natural ultraviolet radiation	No sunburn in lifetime
Artificial ultraviolet radiation	No use of tanning equipment in past year
Water disinfection by-products (trihalomethanes)	< 50 µg/L
Radon	None

*Ever use of oral contraceptives and ever/current use of hormone replacement therapy are protective for endometrial and ovarian cancer.

Table 2: Proportion of incident cancer cases in Alberta in 2012 attributable to lifestyle and environmental factors*

	Site; % of cases																			
Exposure	Lung	Breast	Larynx	Colorectum	Liver	Esophagus	Oral cavity and pharynx	Pancreas	Kidney	Endometrium	Gall bladder	Bladder	Stomach	Ovary	Prostate	Cervix	Leukemia	Malignant melanoma	Hodgkin's lymphoma	All
Active smoking	75.6		74.3	11.4	26.4	45.4	42.6	19.3	19.7			41.6	20.9	3.6		25.9	12.3			15.7
Physical inactivity	20.7	17.4		16.1						20.4				12.5	2.9					7.2
Excess body fat		8.0		12.2		30.9		6.7	17.3	30.3	20.3									4.3
Occupation†																				4.0
Radon	16.7																			2.6
Human papillomavirus‡							25.4									100.0				2.0
Inadequate fruit and vegetable consumption	3.3		18.2			40.0	24.7						18.6							1.8
Alcohol		3.0	11.4	5.5	4.1	11.3	16.6													1.7
Ever hormone replacement therapy use		15.5								–11.2				8.9						1.7
Inadequate vitamin D intake		1.9		9.2																1.4
Current hormone replacement therapy use		12.0								–5.4				7.8						1.3
Medical radiation[24]																				1.0
Inadequate calcium intake				7.1																0.9
Oral contraceptive use		6.4								–57.4				-29.1						0.9
Excess red meat consumption				9.5																0.8
Inadequate fibre intake				6.0																0.7
Excess processed meat consumption				2.9																0.6
Natural ultraviolet radiation‡																		12.5		0.5
Helicobacter pylori‡													22.6							0.4
Hepatitis B virus‡					26.7															0.4
Epstein–Barr virus‡																			31.1	0.3
Air pollution	1.9																			0.2
Excess salt													11.7							0.2
Hepatitis C virus‡					15.7															0.2
Disinfection by-products‡												2.5								0.1
Passive smoking	5.2																			0
Artificial ultraviolet radiation‡																		1.9		0
All exposures	85.5	49.7	81.4	57.0	56.4	79.9	73.1	24.7	33.6	80.1	20.3	43.1	56.0	49.8	2.9	100.0	12.3	14.2	31.1	40.8

*Cancers of the anus, penis, vagina, vulva and nasopharynx were also included in the summary analysis but are not displayed in the table.
†Paul Demers, Occupational Cancer Research Centre, Cancer Care Ontario: personal communication, 2015.
‡Unpublished data.

cancer cases attributable to all exposures combined. We used the same sequential process to estimate the proportion of all cancer cases attributable to each exposure.

Specific to the estimation of the proportion of all cancer cases attributable to lifestyle and environmental risk factors, we made 2 key assumptions to facilitate comparison between our estimates and those of Parkin and colleagues.[28] The latter analysis included population attributable risks associated with medical radiation[24] and occupation,[26] which were not included in our project for reasons that have been previously described.[1] Briefly, the Occupational Cancer Research Centre at Cancer Care Ontario is investigating the cancer burden associated with occupational exposures, and we did not wish to duplicate this work. Furthermore, there were insufficient data on population-level exposure to medical radiation in Alberta. To directly compare the summary results of our analysis with those from Parkin and colleagues,[28] we used approximate values for the population attributable risk associated with each exposure. No Alberta- or Canada-specific data were available regarding population attributable risks associated with medical radiation exposure, and, as such, we used Parkin and colleagues'[24] estimates of 0.9% for men and 1.2% for women. For occupation, we used an approximate value of 4.0% for both men and women (Paul Demers, Occupational Cancer Research Centre, Cancer Care Ontario: personal communication, 2015).

Ethics approval

Ethics approval was obtained from the Conjoint Health Research Ethics Board, University of Calgary.

Results

Based on data from the Alberta Cancer Registry, there were 15 836 incident cases of cancer among adults aged 18 years or older in the province in 2012. The registry has been certified by the North American Association of Central Cancer Registries and has consistently achieved Gold Certification for "completeness of the data, timely reporting and other measures that judge data quality."[12] Overall, we estimated that 40.8% of incident cancer cases were attributable to exposure to the 24 factors included in the analysis (Table 2). Tobacco smoking was responsible for the greatest cancer burden, accounting for an estimated 15.7% of all incident cancer cases (2485 cases), followed by physical inactivity and excess body weight, which were responsible for an estimated 7.2% and 4.3% of incident cancer cases, respectively. All other exposures of interest were estimated to be responsible for less than 4.0% of incident cancer cases each.

The estimated proportion of cancer cases attributable to exposure to the 24 factors was slightly higher among women (42.4%) than among men (38.7%). As when men and women were considered together, the largest proportion of cancer cases in both men and women were estimated to be attributable to tobacco smoking (17.7% and 13.7%, respectively), followed by physical inactivity (5.4% and 9.1%, respectively) and excess body weight (3.6% and 5.0%, respectively). Full summary results for men and women are shown in Appendix 2, Supplementary Tables 1 and 2, available at www.cmajopen.ca/content/5/3/E540/suppl/DC1.

Interpretation

Overall, we estimated that 40.8% of cancer cases diagnosed in Alberta in 2012 (38.7% in men, 42.4% in women) were attributable to modifiable lifestyle and environmental risk factors. The factors estimated to be associated with the highest proportion of cases were tobacco smoking, physical inactivity and excess body weight.

The estimated overall attributable proportions for Alberta are similar to (although slightly lower than) those observed in the UK.[28] Parkin and colleagues[28] estimated that, overall, 42.7% of cancer cases in the UK in 2010 were attributable to a similar but not identical list of modifiable lifestyle and environmental risk factors. Unlike in Alberta, the estimated proportion of attributable cases in those authors' analysis was higher among men (45.3%) than among women (40.1%). As in our analysis, tobacco was responsible for the largest proportion (19.4%) of cancer cases. However, the risk factors with the next largest impact for the 2 sexes combined were overweight and obesity (5.5%), insufficient fruit and vegetable consumption (4.7%) and alcohol consumption (4.0%). There were also differences between men and women in Parkin and colleagues'[28] analysis. Following tobacco, the next most important cancer risk factors in men were insufficient fruit and vegetable consumption, occupation and alcohol consumption, whereas in women, they were overweight and obesity, infections and ultraviolet exposure from sunlight. In contrast, in Alberta, for the 2 sexes combined and for men and women separately, overweight/obesity and physical inactivity were the risk factors estimated to be responsible for the largest cancer burden following tobacco. We give comparisons between the UK and Alberta populations at the exposure-specific level in our previous articles.[2–11]

In Australia, about 32% of cancers in 2010 were estimated to be attributable to 13 modifiable factors.[29] This estimate is lower than both our estimate for Alberta and the UK estimate.[28] Although the Australian work also estimated that tobacco smoke was responsible for the highest proportion of cancer cases (13.4% overall, 15.8% in men, 10.1% in women), among men and women combined, the next leading risk factors were solar radiation, inadequate diet and overweight/obesity. Combined with our findings for Alberta and those from the UK,[28] these results show that, apart from tobacco use, the risk factors with a substantial impact on cancer burden are more population-specific.

Given the factors that are used to estimate population attributable risks, the observation that these attributable risks are different in geographically distinct regions is reasonable. The 2 main pieces of information used to estimate population attributable risk are risk estimates quantifying the magnitude of the association between a given risk factor and cancer site as well as estimates of the prevalence of the risk factor in the specific population under study.[30] As such, differences between jurisdictions such as Alberta and the UK in the prevalence of individual cancer risk factors may partially explain why the risk factors responsible for the largest proportions of cancer cases are different. For example, the same method was

used to estimate fruit and vegetable consumption in the analysis for Alberta and that for the UK.[16] However, the proportion of people who met the World Cancer Research Fund's cancer-prevention guideline of consuming 5 or more servings of fruit and vegetables per day[31] was systematically higher in Alberta[5] than in the UK.[16] Therefore, it is reasonable that insufficient fruit and vegetable consumption is responsible for a greater proportion of the cancer burden in the UK than in Alberta. It is thus also reasonable to suspect that some of the observed differences in the population attributable risks for major cancer risk factors across jurisdictions are the result of similar differences in the prevalence of individual risk factors.

Limitations

Although we made an effort to account for the fact that some cancers are caused by multiple risk factors, our summary estimates of population attributable risk did not include a formal analysis of potential interactions between risk factors. To fully consider interactions when generating summary estimates of population attributable risk, prevalence data that include the joint distributions of all risk factors being considered in the interaction analysis is required. As these types of data were not routinely available for Alberta, we were unable to explicitly consider interactions in this study when generating summary population attributable risk estimates. As such, if some cancer cases are caused by interactions between risk factors that are not captured in our current summary population attributable risk estimates, they might have been counted in reference to multiple risk factors, such that the summary population attributable risk estimates presented here may be overestimates of the true values and, thus, should be interpreted with caution. Ongoing work by our team funded by the Canadian Cancer Society to estimate population attributable cancer risks for Canada is beginning to address the issues related to interaction.

The validity of our individual population attributable risk estimates depends on the extent to which the prevalence data used in our estimations are truly representative of the Alberta population. For some exposures such as infectious diseases, Alberta-specific data were not available, and we approximated the prevalence based on values in other jurisdictions, whereas for other exposures, we used data from population-based cohort studies (specifically, Alberta's Tomorrow Project) to approximate prevalence in the general population. Any differences in exposure prevalence between these sources and the general Alberta population would produce errors in the exposure-specific population attributable risk estimates. These errors would be compounded when individual population attributable risk estimates are combined to create summary measures. However, given that our summary population attributable risk estimates are similar to those estimated for the UK by Parkin and colleagues,[28] who used methods similar to ours, it seems unlikely that this potential source of error had a major impact on the observed burden of cancer due to modifiable lifestyle and environmental risk factors in Alberta.

Finally, although we used a systematic approach to select exposures for inclusion in this study,[1] the strength of evidence in relation to cancer risk is stronger for some exposures (e.g., tobacco) than for others (e.g., disinfection by-products, vitamin D and breast cancer). If the relation between some of the lifestyle and environmental risk factors with weaker evidence and cancer are not in fact causal, their inclusion in summary population attributable risk estimates would lead to overestimation of these values. However, the overall contribution of these weaker risk factors to the summary total is quite small: disinfection by-products accounted for only 0.1% of all cancer cases in Alberta, and most of the cancer burden from inadequate vitamin D intake is due to colon cancer. As such, it is unlikely that the inclusion of these factors had a major impact on our summary estimates of the population attributable risk from modifiable lifestyle and environmental risk factors.

Conclusion

We estimate that 40.8% of cancers in Alberta in 2012 were attributable to modifiable lifestyle and environmental risk factors. The factors that were estimated to be the largest contributors to the cancer burden were tobacco smoking, physical inactivity and excess body weight, which marks them as important targets for future cancer-prevention initiatives. Furthermore, all the risk factors included in this project are considered modifiable, such that increasing the proportion of the population at the theoretical minimum risk level of exposure has the potential to reduce the provincial cancer burden.

References

1. Grundy A, Friedenreich CM, Poirier AE, et al. A methodologic framework to evaluate the number of cancers attributable to lifestyle and environment in Alberta. *CMAJ Open* 2016;4:E471-8.
2. Grundy A, Poirier AE, Khandwala F, et al. Cancer incidence attributable to alcohol consumption in Alberta in 2012. *CMAJ Open* 2016; 4:E507-14.
3. Poirier AE, Grundy A, Khandwala F, et al. Cancer incidence attributable to tobacco in Alberta, Canada, in 2012. *CMAJ Open* 2016;4:E578-87.
4. Grevers X, Grundy A, Poirier AE, et al. Cancer incidence attributable to oral contraceptives and hormone replacement therapy use in Alberta in 2012. *CMAJ Open* 2016;4:E754-9.
5. Grundy A, Poirier AE, Khandwala F, et al. Cancer incidence attributable to insufficient fruit and vegetable consumption in Alberta in 2012. *CMAJ Open* 2016;4:E760-7.
6. Grundy A, Poirier AE, Khandwala F, et al. Cancer incidence attributable to excess red and processed meat consumption in Alberta in 2012. *CMAJ Open* 2016;4:E768-75.
7. Grundy A, Poirier AE, Khandwala F, et al. Cancer incidence attributable to insufficient fibre consumption in Alberta in 2012. *CMAJ Open* 2017;5:E7-13.
8. Brenner DR, Poirier AE, Grundy A, et al. Cancer incidence attributable to excess body weight in Alberta in 2012. *CMAJ Open* 2017;5:E330-6.
9. Brenner DR, Poirier AE, Grundy A, et al. Cancer incidence attributable to inadequate physical activity in Alberta in 2012. *CMAJ Open* 2017;5:E338-44.
10. Poirier AE, Grundy A, Khandwala F, et al. Cancer incidence attributable to air pollution in Alberta in 2012. *CMAJ Open* 2017;5:E524-8.
11. Grundy A, Brand K, Khandwala F, et al. Lung cancer incidence attributable to residential radon exposure in Alberta in 2012. *CMAJ Open* 2017;5:E529-34.
12. *Surveillance & reporting: 2012 report on cancer statistics in Alberta*. Edmonton: CancerControl Alberta, Alberta Health Services; 2015.
13. Parkin DM. 1. The fraction of cancer attributable to lifestyle and environmental factors in the UK in 2010. *Br J Cancer* 2011;105(Suppl 2):S2-5.
14. Parkin DM. 2. Tobacco-attributable cancer burden in the UK in 2010. *Br J Cancer* 2011;105(Suppl 2):S6-13.
15. Parkin DM. 3. Cancers attributable to consumption of alcohol in the UK in 2010. *Br J Cancer* 2011;105(Suppl 2):S14-8.
16. Parkin DM, Boyd L. 4. Cancers attributable to dietary factors in the UK in 2010. I. Low consumption of fruit and vegetables. *Br J Cancer* 2011;105(Suppl 2): S19-23.
17. Parkin DM. 5. Cancers attributable to dietary factors in the UK in 2010. II. Meat consumption. *Br J Cancer* 2011;105(Suppl 2):S24-6.
18. Parkin D, Boyd L. 6. Cancers attributable to dietary factors in the UK in 2010. III. Low consumption of fibre. *Br J Cancer* 2011;105(Suppl 2):S27-30.
19. Parkin DM. 7. Cancers attributable to dietary factors in the UK in 2010. IV. Salt. *Br J Cancer* 2011;105(Suppl 2):S31-3.

20. Parkin DM, Boyd L. 8. Cancers attributable to overweight and obesity in the UK in 2010. *Br J Cancer* 2011;105(Suppl 2):S34-7.
21. Parkin DM. 9. Cancers attributable to inadequate physical exercise in the UK in 2010. *Br J Cancer* 2011;105(Suppl 2):S38-41.
22. Parkin DM. 10. Cancers attributable to exposure to hormones in the UK in 2010. *Br J Cancer* 2011;105(Suppl 2):S42-8.
23. Parkin DM. 11. Cancers attributable to infection in the UK in 2010. *Br J Cancer* 2011;105(Suppl 2):S49-56.
24. Parkin DM, Darby SC. 12. Cancers in 2010 attributable to ionising radiation exposure in the UK. *Br J Cancer* 2011;105(Suppl 2):S57-65.
25. Parkin DM, Mesher D, Sasieni P. 13. Cancers attributable to solar (ultraviolet) radiation exposure in the UK in 2010. *Br J Cancer* 2011;105(Suppl 2):S66-9.
26. Parkin DM. 14. Cancers attributable to occupational exposures in the UK in 2010. *Br J Cancer* 2011;105(Suppl 2):S70-2.
27. Parkin DM. 15. Cancers attributable to reproductive factors in the UK in 2010. *Br J Cancer* 2011;105(Suppl 2):S73-6.
28. Parkin DM, Boyd L, Walker LC. 16. The fraction of cancer attributable to lifestyle and environmental factors in the UK in 2010. *Br J Cancer* 2011;105 (Suppl 2):S77-81.
29. Whiteman DC, Webb PM, Green AC, et al. Cancers in Australia in 2010 attributable to modifiable factors: summary and conclusions. *Aust N Z J Public Health* 2015;39:477-84.
30. Levin ML. The occurrence of lung cancer in man. *Acta Unio Int Contra Cancrum* 1953;9:531-41.
31. World Cancer Research Fund/American Institute for Cancer Research. Food, nutrition, physical activity, and the prevention of cancer: a global perspective. Washington: American Institute for Cancer Research; 2007.

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