

Cancer incidence attributable to excess body weight in Alberta in 2012

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Abstract

Background: Excess body weight has been consistently associated with colorectal, breast, endometrial, esophageal, gall bladder, pancreatic and kidney cancers. The objective of this analysis was to estimate the proportion of total and site-specific cancers attributable to excess body weight in adults in Alberta in 2012.

Methods: We estimated the proportions of attributable cancers using population attributable risk. Risk estimates were obtained from recent meta-analyses, and exposure prevalence estimates were obtained from the Canadian Community Health Survey. People with a body mass index of 25.00–29.99 kg/m² and of 30 kg/m² or more were categorized as overweight and obese, respectively.

Results: About 14%–47% of men and 9%–35% of women in Alberta were classified as either overweight or obese; the proportion increased with increasing age for both sexes. We estimate that roughly 17% and 12% of obesity-related cancers among men and women, respectively, could be attributed to excess body weight in Alberta in 2012. The heaviest absolute burden in terms of number of cases was seen for breast cancer among women and for colorectal cancer among men. Overall, about 5% of all cancers in adults in Alberta in 2012 were estimated to be attributable to excess body weight in 2000–2003.

Interpretation: Excess body weight contributes to a substantial proportion of cases of cancers associated with overweight and obesity annually in Alberta. Strategies to improve energy imbalance and reduce the proportion of obese and overweight Albertans may have a notable impact on cancer incidence in the future.

In 2002, the International Agency for Research on Cancer's handbook on weight control and physical activity concluded that overweight and obesity are related to cancers of the colon, endometrium, kidney and esophagus (adenocarcinomas) as well as postmenopausal breast cancer.¹ In 2007, a report by the World Cancer Research Fund Panel on Food, Nutrition, Physical Activity and the Prevention of Cancer concluded that there was also convincing evidence for associations between overweight and obesity and cancers of the pancreas and ovary as well as a probable association with cancers of the gall bladder.² Substantial research has evaluated the association between excess body weight and risk of cancer at various sites. The global burden of cancer attributable to high body mass index (BMI) (≥ 25 kg/m²) in 2012 was estimated to be 3.6%.³ In the United Kingdom, Parkin and Boyd⁴ estimated that 5.5% of all incident cancers in 2010 were attributable to excess body weight. Based on these efforts, it was determined that sites with the most consistent associations were breast (postmenopausal), colon, esophagus (adenocarcinoma), kidney, endometrium, gall bladder and pancreas.⁴

In Alberta in 2012, 3.2% (5044 cases) of incident cancer cases occurred at the 7 sites shown to be associated with over-

weight and obesity.⁵ We previously estimated that 2.6% and 4.6% of cancers among men and women, respectively, in Canada could be attributed to excess body weight (BMI > 25).⁶ We did not, however, estimate the number or proportion of cancer cases attributable to excess body weight at the provincial level, and we suspected that there might be substantial variation across provinces because of cross-provincial differences in prevalence of excess body weight. The purpose of this analysis was to estimate the proportion of incident cancers that occurred in Alberta in 2012 that were attributable to overweight and obesity. We included the 7 cancer sites previously shown to be positively associated with overweight/obesity (as described above) in our population attributable risk estimations for comparability of methods and results.

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Methods

This paper is part of a series of exposure-specific manuscripts concerning the proportion of cancer cases attributable to modifiable lifestyle and environmental risk factors in the general population of Alberta. The methodologic framework for this series' methods has been previously described.⁷

Cancer incidence data

To determine the number of cancer cases attributable to excess body weight in Alberta, we obtained age-, sex- and site-specific cancer incidence strata for 2012 from the Alberta Cancer Registry. We created age and sex incidence strata to match the strata available for the data on overweight/obesity prevalence. We used the year with the most up-to-date complete data (2012) for all cancer sites available.

For esophageal cancer, we included only the number of adenocarcinomas diagnosed in 2012 in our attributable case estimates, since only adenocarcinomas are consistently associated with overweight/obesity. In this population, 67% and 41% of esophageal cancers were adenocarcinomas in men and women, respectively. We used this approach because information on histology by cancer site was not available for these analyses. We included only breast cancers in postmenopausal women in attributable estimates by including breast cancers that occurred after 55 years of age, as the median age at menopause among North American women is 50–52 years.^{8,9}

Latency period

The effect of obesity on cancer risk is understood to be the result of past exposure. Therefore, we identified a biologically meaningful latency period of 10–12 years between exposure and subsequent cancer from previous prospective cohort studies (Table 1). As has been previously described,⁷ we considered the theoretical latency period to be the time between initiation of exposure and cancer diagnosis, and the measured latency period to be the time between exposure measurement and cancer diagnosis. We estimated a 10- to 12-year latency period by applying the estimates of exposure prevalence in 2000–2003 to cases that occurred in 2012 and assuming that

Table 1: Predetermined latency periods for calculations of population attributable risk for overweight/obesity, by cancer site and CCHS cycle of prevalence data used

Cancer site	Latency period, yr	Corresponding CCHS cycle (yr)
Esophagus	11–12	1.1 (2000–2001)
Pancreas	9	2.1 (2003)
Colorectum	9	2.1 (2003)
Kidney	11–12	1.1 (2000–2001)
Gall bladder	11–12	1.1 (2000–2001)
Breast	9	2.1 (2000–2001)
Endometrium	11–12	1.1 (2000–2001)

Note: CCHS = Canadian Community Health Survey.

people exposed in 2000–2003 would have transitioned into the subsequent 10-year cancer incidence group by the time of diagnosis. We obtained data from the Canadian Community Health Survey (CCHS) to estimate the prevalence of overweight and obese among adults in Alberta. The cycle of the CCHS used corresponded to the midpoint of the latency period suggested by prospective cohort studies for each cancer site of interest (Table 1).

Prevalence of exposure

We estimated BMI for the Alberta population aged 18 years or more (excluding pregnant women and people less than 0.9 m tall or greater than 2.11 m tall) using CCHS data. The BMI of survey respondents was based on the questions “How much do you weigh?” and “How tall are you without shoes on?” Cut-points were used according to Health Canada classifications for body weight:¹⁰ less than 18.50 kg/m² (underweight), 18.50–24.99 kg/m² (normal weight), 25.00–29.99 kg/m² (overweight), 30.00–34.99 kg/m² (obese class I), 35.00–39.99 kg/m² (obese class II) and 40.00 or greater (obese class III). The CCHS is considered representative of the general Canadian population, excluding full-time members of the Canadian Forces, people living on reserves or other Aboriginal settlements, and people living in institutions. Descriptions of the survey methods used to generate the sampling strategy for the CCHS have been published previously.¹¹

Risk estimates

We took risk estimates used for estimating population attributable risks from the comprehensive meta-analysis of excess body weight and cancer risk by Renehan and colleagues¹² (Table 2). We used estimates of relative risk (RR) for an

Table 2: Risk estimates* for risk associated with overweight/obesity, by cancer site of interest

Cancer site	Sex	Relative risk (95% CI)†
Esophagus	Men	1.52 (1.33–1.74)
	Women	1.51 (1.31–1.74)
Pancreas	Men	1.07 (0.93–1.23)
	Women	1.12 (1.02–1.22)
Colorectum	Men	1.24 (1.20–1.28)
	Women	1.09 (1.05–1.13)
Kidney	Men	1.24 (1.15–1.34)
	Women	1.34 (1.25–1.43)
Gall bladder	Men	1.09 (0.99–1.21)
	Women	1.59 (1.02–2.47)
Breast	Women	1.12 (1.08–1.16)
Endometrium	Women	1.59 (1.50–1.68)

Note: CI = confidence interval.

*Risk estimates from Renehan and colleagues:¹² meta-analysis of 76 studies including 67 cohort studies, 6 nested case–control studies and 3 randomized trials (with a total of 282 137 incident cancer cases reported) published between 1966 and 2007.

†Risk estimates are for an increase in body mass index of 5 kg/m².

increase in BMI of 5 kg/m² for the overweight group, and, assuming a constant rate of increase in risk, this value was squared for use in the obese category.

Estimation of population attributable risk

We used the method applied by Parkin¹³ to estimate the proportion of incident cancer cases in Alberta associated with excess body weight. We used the following formula for the population attributable risk:

$$\text{Population attributable risk} = (p_1 \times ERR_1) + (p_2 \times ERR_2) / 1 + [(p_1 \times ERR_1) + (p_2 \times ERR_2)]$$

We estimated the population attributable risk for the different sex and age groups using the prevalence estimates of overweight/obesity according to the formula where p_1 is the proportion of the population that is overweight, p_2 the proportion of the population that is obese, ERR_1 the excess relative risk (RR – 1) for overweight and ERR_2 the excess relative risk (RR – 1) for obesity. We then multiplied the population attributable risks by the incident cancer cases of interest in Alberta in 2012, obtained from the Alberta Cancer Registry, to determine the excess attributable cases for each cancer site. We backcalculated estimates of population attributable risk for men and women combined by adding the number of cases of cancer attributable to overweight/obesity in men and women and dividing by the total number of incident cancer cases at associated sites in Alberta in 2012.

To estimate 95% confidence intervals (CIs) around population attributable risk estimates, we used Monte Carlo simulation methods wherein the relative risk estimates were drawn from a log normal distribution, prevalence estimates were drawn from a binomial distribution, and incidence estimates were drawn from a Poisson distribution. Parameters for the distributions were defined by reported point estimates and CIs. A total of 10 000 samples were drawn, and the 2.5th and 97.5th percentiles of the resulting population attributable risk distribution were used as the lower and upper limits of a 95% CI. Similar techniques were used in 2 previous studies that estimated population attributable risk.^{14,15} Wherever possible and appropriate, we performed these estimations for individual sex and age groups.

Sensitivity analysis

As data on overweight and obesity were derived from self-reported measures of BMI in the CCHS, self-report bias had to be considered. To adjust the CCHS self-reported prevalence of overweight/obesity, we conducted a sensitivity analysis. Shields and colleagues¹⁶ reported that overweight prevalence was underestimated by 1.9% among males and 3.9% among females, and obesity was underestimated by 6.4% and 6.7%, respectively, in the 2008 Canadian Health Measures Survey when applied to the 2005 CCHS estimates. We applied these correction factors to the CCHS estimates for the 2000–2001 cycle to adjust for potential bias (Appendix 1, Supplementary Table 1, available at www.cmajopen.ca/content/5/2/E330/suppl/DC1). All analyses were conducted

with the use of R (version 3.2.3) and RStudio (version 0.98.1080) (R Studio, Inc.).

Ethics approval

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

Results

Prevalence of excess body weight

The prevalence of overweight and obesity in the Alberta adult population for 2000–2001 is presented in Table 3. In general, levels of both overweight and obesity were higher among older age groups, with the highest prevalence observed for those aged 65–74. In this age group, the total population prevalence of overweight was 41.1% (95% CI 37.3–44.9) and of obesity, 18.7% (95% CI 15.9–21.5). When the combined prevalence of overweight and obesity was examined (data not shown), adult men had the highest prevalence of excess body weight. Among men, more than 60% of respondents in all age groups over 35 years reported a BMI of 25 kg/m² or greater.

Table 3: Prevalence of overweight and obesity among adults in Alberta, 2000–2001

Sex; age, yr	Prevalence, % (95% CI)	
	Overweight (BMI ≥ 25 kg/m ²)	Obesity (BMI ≥ 30 kg/m ²)
Men		
18–34	33.7 (30.8–36.7)	13.8 (11.8–15.8)
35–44	41.9 (38.2–45.7)	19.0 (15.9–22.2)
45–54	43.2 (39.1–47.3)	19.4 (16.1–22.7)
55–64	47.2 (41.9–52.6)	17.2 (13.5–20.9)
65–74	38.2 (32.4–44.0)	17.7 (13.9–21.5)
≥ 75	41.0 (33.8–48.2)	13.3 (8.6–18.1)
Women		
18–34	17.2 (14.8–19.6)	9.3 (7.7–10.9)
35–44	26.6 (23.4–29.8)	14.7 (12.1–17.2)
45–54	27.7 (23.9–31.4)	17.5 (14.3–20.8)
55–64	35.2 (29.8–40.6)	20.2 (15.8–24.6)
65–74	35.1 (29.8–40.3)	17.3 (13.6–21.0)
≥ 75	28.5 (23.8–33.2)	13.9 (10.6–17.3)
Total		
18–34	25.9 (24.0–27.7)	11.7 (10.4–12.9)
35–44	34.4 (31.9–36.8)	16.9 (14.9–18.9)
45–54	35.7 (32.9–38.5)	18.5 (16.1–20.9)
55–64	41.1 (37.3–44.9)	18.7 (15.9–21.5)
65–74	36.6 (32.5–40.7)	17.5 (14.7–20.3)
≥ 75	33.7 (29.4–37.9)	13.7 (10.9–16.5)

Note: BMI = body mass index, CI = confidence interval.
Source: Canadian Community Health Survey cycle 1.1 (2000–2001).

Cancer-site-specific population attributable risk

The attributable proportions of cases across different cancer sites varied widely, with the highest estimates observed for adenocarcinomas of the esophagus and endometrial cancers (24.4%–31.8% and 19.6%–34.1% across age groups, respectively). Table 4 presents the numbers and proportions of incident cancer cases attributable to overweight and obesity by age and sex groups in Alberta in 2012. Measures of uncertainty (95% CIs) for the site-specific estimates of population attributable risk are given in Appendix 1, Supplementary Table 2. The lowest estimates of attributable proportions of cancer were observed for breast and pancreatic cancers, ranging from 6.2%–9.1% and 4.2%–7.4% across age groups, respectively. In terms of absolute number of cases, the sites most affected by excess body weight were the colorectum for men and women, and the breast for women. This higher number is a result of the greater total incidence of these cancers in the province despite a smaller population attributable risk (Figure 1).

Overall population attributable risk

The overall population attributable risks and number of excess attributable cases of each cancer type and for all associated and total cancers are presented in Table 5. A total of 13.3% of these cancers can be attributed to overweight and obesity. This number equals 4.2% ($n = 673$) of all cancer cases in adults in Alberta in 2012. When we adjusted prevalence estimates to account for self-report bias, the proportion of incident cancers in 2012 attributable to overweight/obesity increased to 5.0% (798 excess attributable cases due to overweight and obesity/15 836 observed cases) (Appendix 1, Supplementary Table 3).

Interpretation

We have estimated that at least 4.2% of all cases of cancers in adults in Alberta in 2012 were attributable to excess body weight. These estimates also suggest that the burden of cancer

Table 4: Numbers and proportions of incident cancer cases attributable to overweight and obesity in Alberta in 2012*†

Sex; age at exposure, yr	Age at outcome, yr	Cancer site																				
		Esophagus			Pancreas			Colorectum			Kidney			Gall bladder			Breast			Endometrium		
		Obs.	PAR, %	EAC	Obs.	PAR, %	EAC	Obs.	PAR, %	EAC	Obs.	PAR, %	EAC	Obs.	PAR, %	EAC	Obs.	PAR, %	EAC	Obs.	PAR, %	EAC
Men																						
18–34	28–44	< 5	26.3	< 5	5	4.2	0	39	13.4	5	28	13.4	4	0	5.3	0						
35–44	45–54	20	31.8	6	19	5.4	1	125	16.8	21	56	16.9	9	< 5	6.8	< 5						
45–54	55–64	38	32.4	12	33	5.8	2	301	18.1	54	109	17.2	19	< 5	7.0	< 5						
55–64	65–74	25	32.0	8	50	5.6	3	304	17.6	54	79	17.1	13	6	7.0	< 5						
65–74	75–84	17	30.1	5	48	5.6	3	264	17.3	46	48	15.7	8	12	6.3	1						
≥ 75	≥ 85	6	27.9	2	17	4.6	1	74	14.4	11	6	14.5	1	< 5	5.8	< 5						
Total		< 111		< 38	172		9	1107		191	326		54	24		2						
Women																						
18–34	28–44	< 5	17.1	< 5	< 5	4.5	0	37	3.4	1	14	11.7	2	< 5	19.6	< 5				26	19.6	5
35–44	45–54	< 5	24.5	< 5	26	5.8	1	108	4.4	5	28	17.2	5	< 5	27.6	< 5				83	27.6	23
45–54	55–64	6	26.8	2	42	7.1	3	179	5.4	10	41	18.9	8	7	30.1	2	577	7.1	41	195	30.1	59
55–64	65–74	< 5	30.5	< 5	54	9.1	5	198	6.9	14	40	21.9	9	9	34.1	3	541	9.1	49	127	34.1	43
65–74	75–84	0	28.6	0	60	8.4	5	214	6.4	14	22	20.4	4	8	32.0	3	321	8.4	27	55	32.0	18
≥ 75	≥ 85	0	24.4	0	25	6.2	2	112	4.7	5	11	17.2	2	< 5	27.6	< 5	106	6.2	7	18	27.6	5
Total		< 15		< 5	< 212		16	848		48	156		29	31		10	1545		124	504		153
Total																						
18–34	28–44	5	24.4	1	< 10	4.2	0	76	8.5	6	42	12.8	5	< 5	19.6	< 5				26	19.6	5
35–44	45–54	< 25	30.6	< 10	45	5.6	3	233	11.1	26	84	17.0	14	< 10	20.7	< 5				83	27.6	23
45–54	55–64	44	31.3	14	75	6.6	5	480	13.4	64	150	17.7	27	< 12	25.0	2	577	7.1	41	195	30.1	59
55–64	65–74	< 30	31.8	< 10	104	7.4	8	502	13.4	67	119	18.7	22	15	23.2	3	541	9.1	49	127	34.1	43
65–74	75–84	17	29.9	5	108	7.1	8	478	12.4	59	70	17.2	12	20	16.6	3	321	8.4	27	55	32.0	18
≥ 75	≥ 85	6	27.0	2	42	5.6	2	186	8.6	16	17	16.2	3	< 5	16.7	< 5	106	6.2	7	18	27.6	5
Total		123		38	< 384		25	1955		239	482		83	55		11	1545		124	504		153

Note: EAC = excess attributable cases due to exposure, Obs. = total number of observed cases per age–sex group, PAR = population attributable risk.

*Cell counts of less than 5 for observed cases were suppressed to comply with confidentiality requirements.

†95% confidence intervals for the population attributable risk estimates are presented in Appendix 1, Supplementary Table 2.

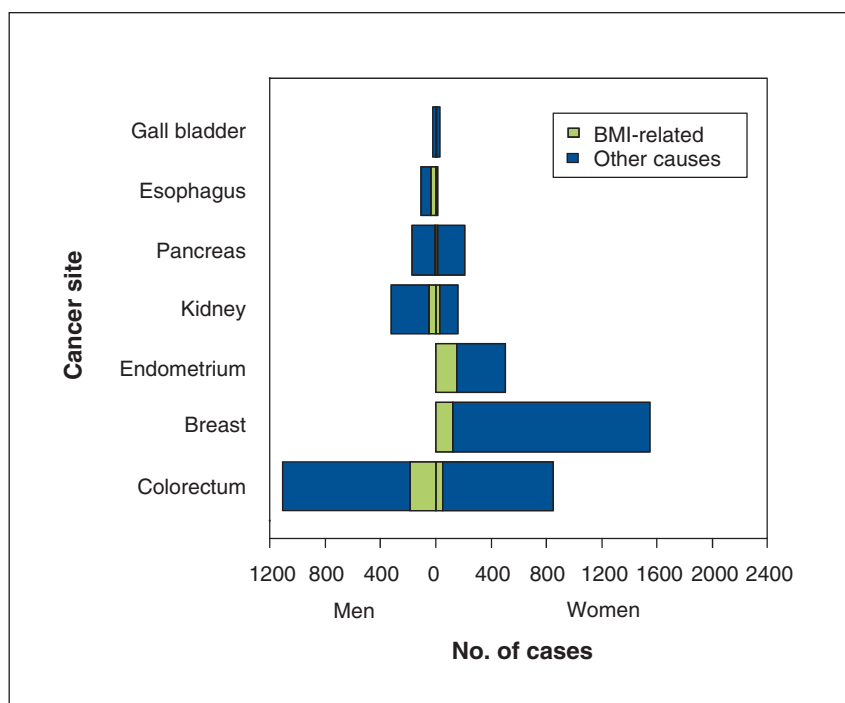


Figure 1: Number of cancer cases attributable to overweight/obesity and other causes in Alberta in 2012. BMI = body mass index.

incidence attributable to this risk factor is greater among women in Alberta, with larger absolute and relative numbers of cases among women attributable to both overweight and obesity.

Our site-specific estimates are comparable to previous estimates in Canada. Brenner⁶ estimated that 26.6% of endometrial, 7.5% of breast, 9.8% of colon, 15.6% of esophageal, 19.0% of kidney, 14.2% of gall bladder and 9.2% of pancreatic cancers in Canadians in 2007 could be attributed to overweight/obesity. Luo and colleagues¹⁷ estimated that 22.1% of endometrial, 12.1% of breast and 9.5% of colon cancers in adults aged 20 or more could be attributed to obesity in Canada. Those authors used 6 national population-based health surveys conducted between 1970 and 2004, including the 2004 CCHS, to obtain data on BMI. The surveys covered the 10 Canadian provinces. Their estimates are similar to the rates of 30.3%, 8.0% and 12.2% that we found for the same cancer sites in the current analysis. Using data for women aged 50–69 years between 1994 and 2006 from the National Population Health Survey in Canada for BMI estimates, Neutel and Morrison¹⁸ estimated that 8.8% of breast cancers in 2006 could be attributed to obesity.

In terms of overall attributable burden, our analyses are directly comparable to the work of Parkin,⁴ who examined the same cancer sites that we did and estimated that, in the United Kingdom in 2010, 5.5% of all cancers could be attributed to excess body weight, compared with 4.2% estimated in our analysis. In Australia, 3.4% of incident cancer cases in 2010 were estimated to be attributable to overweight/obesity.¹⁹ In addition to the sites included in the UK analysis and our analysis, the Australian study included ovarian cancer. The lower population attributable risk

estimate in the Australian study is likely due to the lower prevalence of overweight and obesity in Australia compared to Alberta. Congruent with our analyses, the population attributable risks estimates were highest for esophageal and endometrial cancer in the UK and Australian studies.^{4,19}

In the global burden of cancer study, it was estimated that 3.8% and 7.9% of cancer cases in Canada could be attributable to a BMI of 25 kg/m² or higher in men and women, respectively.³ Although the estimate for Canadian men was similar to ours in Alberta, the estimate for women was higher than our estimate of 5.0%. However, the global analysis used prevalence estimates only from the United States in their North American (US and Canada) estimates, and therefore the difference in estimates is likely due to a higher prevalence of overweight/obesity in the US than in Alberta. In addition, on a global scale, it was estimated that 25% of cancer cases related to high BMI in 2012 could have been avoided if the global distribution of BMI from 1982 had remained.³

Limitations

Our analyses are limited by the use of self-reported data for exposure prevalence estimates. Validation of Canadian data has shown self-reported measures to underestimate the prevalence of obesity by 4%–7%.²⁰ When we used adjusted prevalence estimates for overweight and obesity, the proportion of incident cancers attributable to overweight/obesity increased from 4.2% to 5.0%. These analyses may also be limited since we excluded cancer sites for which the evidence of an etiologic role of obesity is only suggestive. The cancers not considered were thyroid cancer,²¹ ovarian cancer,²² malignant melanoma (in men only),²³ leukemia, non-Hodgkin lymphoma and

Table 5: Summary of cases and proportions of cancer in Alberta in 2012 attributable to overweight/obesity

Cancer site	Total			Men			Women		
	No. of observed cases	No. of excess attributable cases*	% attributable†	No. of observed cases	No. of excess attributable cases	% attributable	No. of observed cases	No. of excess attributable cases	% attributable
Esophagus‡	123	38	30.9	110	35	31.8	13	3	23.1
Pancreas	380	25	6.6	172	9	5.2	208	16	7.7
Colorectum	1955	239	12.2	1107	191	17.2	848	48	5.7
Kidney	482	83	17.2	326	54	16.6	156	29	18.6
Breast§	1545	124	8.0	–	–	–	1545	124	8.0
Endometrium	504	153	30.4	–	–	–	504	153	30.4
Gall bladder	55	11	20.0	24	2	6.5	31	10	32.2
All associated cancers¶	5044	673	13.3	1739	290	16.7	3305	383	11.6
All cancers**	15 836	673	4.2	8155	290	3.6	7681	383	5.0

*Number of cancer cases at individual cancer sites that can be attributed to overweight/obesity.
†Proportion of cancers at individual cancer sites attributable to overweight/obesity.
‡Adenocarcinomas only.
§In postmenopausal women only (defined as cancers diagnosed at age 55 or more).
¶Represents all cancers with a known association with overweight/obesity, as listed in table.
**Represents all incident cancers in Alberta in 2012 in all age groups.

multiple myeloma.²⁴ Hence, the burden of overweight and obesity on cancers in Alberta and the actual number of attributable cases was likely underestimated.

In separate analyses²⁵ we estimated the burden of cancer attributable to physical inactivity. Since these 2 risk factors are highly related (i.e., a lack of physical activity leads to obesity when caloric intake surpasses the needs of the basal metabolic rate), it is likely that there is overlap in the estimated numbers of the attributable cases. Furthermore, as has been discussed in a thoughtful commentary,²⁶ the use of the population attributable risk has limitations, and combining population attributable risks is discouraged.²⁷

To quantify the precision of our estimates of population attributable risk, we used 95% CIs. Although including measures of uncertainty is a strength of our study, these 95% CIs also highlight the lack of precision around our estimates of population attributable risk. For example, in men aged 55–64, we estimated that 5.8% of pancreatic cancer could be attributable to overweight and obesity, but the 95% CI for the population attributable risk estimate ranged from 0%–14.4% (Appendix 1, Supplementary Table 2). As such, the lack of precision of our estimates of population attributable risk is a limitation of this analysis and should be considered when interpreting the proportion of cancers in Alberta attributable to overweight and obesity.

Conclusion

Although the estimates presented should be interpreted with caution, since they rely on several modelling assumptions and self-reported data, it is evident that many thousands of incident cases of cancer annually can be attributed to excess body weight

among Canadians. Given the alarmingly high rates of overweight/obesity among adult Albertans, additional targeted prevention strategies aimed to promote weight loss and maintain a healthy body weight are recommended. These measures are likely to reduce cancer incidence as well as the burden of various other chronic diseases associated with overweight and obesity.

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