Cancer Incidence Attributable to Excess Body Weight in Alberta, Canada in 2012

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Abstract:	Background: Excess body weight has been consistently associated with colorectal, breast, endometrial, esophageal, gallbladder, 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 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. Individuals with a body mass index (kg/m2) of >25-<30 and ≥30 were categorized as overweight and obese, respectively. Results: Approximately 48 – 64% of men and 27 – 55% of women in Alberta were classified as either overweight or obese, where these proportions increased with age in both sexes. We estimate that approximately 17% and 11% 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 is seen for breast cancer among women and for colorectal cancer among men. Overall, approximately 5% of all cancers in Alberta in 2012 were attributable to excess body weight among adult Albertans 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 Canadians may have a notable impact

	on cancer incidence in the future.

Cancer Incidence Attributable to Excess Body Weight in Alberta, Canada in 2012

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ABSTRACT

Background: Excess body weight has been consistently associated with colorectal, breast, endometrial, esophageal, gallbladder, 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 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. Individuals with a body mass index (kg/m^2) of >25-<30 and ≥30 were categorized as overweight and obese, respectively.

Results: Approximately 48 – 64% of men and 27 – 55% of women in Alberta were classified as either overweight or obese, where these proportions increased with age in both sexes. We estimate that approximately 17% and 11% 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 is seen for breast cancer among women and for colorectal cancer among men. Overall, approximately 5% of all cancers in Alberta in 2012 were attributable to excess body weight among adult Albertans 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 Canadians may have a notable impact on cancer incidence in the future.

INTRODUCTION

This manuscript is the third in a series of exposure-specific manuscripts concerning the proportion of cancer 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.[1]

In 2002, the International Agency for Research on Cancer 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.[2] 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.[3] The most commonly suggested candidates for the mechanistic pathways linking obesity to cancer risk are : Insulin resistance and insulin-like growth factors, altered levels of sex steroids, altered levels of leptin and adiponectin, obesity-related inflammatory cytokines, altered immune functions and oxidative stress.[4]

Substantial research has evaluated the association between excess body weight and cancer risk at various sites. In the United Kingdom, Parkin and Boyd (2011) estimated that 5.5% of all incident cancers in 2010 were attributable to excess body weight.[5] Based on these efforts, it was determined that those sites with the most consistent associations were: breast (post-menopausal), colon, esophageal (adenocarcinoma), kidney, endometrium, gall bladder and pancreas.[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 (body mass index >25).[6] We did not, however, estimate the number or proportion of cancer cases attributable to excess body weight at the provincial level and expect the potential for 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, Canada in 2012 attributable to overweight and obesity. We included the seven 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.

METHODS

Latency Period

The effect of obesity on cancer risk is understood to be the result of past exposure. Therefore, a biologically meaningful latency period of 10-12 years between exposure and subsequent cancer was identified from previous prospective cohort studies (Table 1). As has been previously described [1], 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. A 10-12 year latency period was estimated by applying the estimates of exposure prevalence in 2000-2003 to cases occurring in 2012 and assuming that those exposed in 2000-2003 would have transitioned into the subsequent 10-year cancer incidence group by the time of diagnosis. Data from the Canadian Community Health Survey were obtained to estimate the prevalence of overweight and obese adults in Alberta. The cycle of the Canadian Community Health Survey used corresponded to the

midpoint of the latency period suggested by prospective cohort studies for each cancer site of interest (Supplementary Table 1).

Prevalence of Exposure

Body mass index (kg/m^2) was estimated for the Alberta population aged 18 and over, excluding pregnant females and persons less than 3 feet (0.914 meters) tall or greater than 6 feet 11 inches (2.108 meters) from the Canadian Community Health Survey. Cut-points were used according to Health Canada classifications for body weight [7]: less than 18.50 (underweight); 18.50 to 24.99 (normal weight); 25.00 to 29.99 (overweight); 30.00 to 34.99 (obese, class I); 35.00 to 39.99 (obese, class II); 40.00 or greater (obese, class III). Descriptions of the survey methods used to generate the sampling strategy for the Canadian Community Health Survey have been published previously.[8] The proportions of overweight and obese Albertans are shown in Table 2.

Risk Estimates

Risk estimates used for estimating population attributable risks were taken from the comprehensive meta-analysis of excess body weight and cancer risk by Renehan et al. 2008 [9] (Table 1). Estimates of RR for an increase in body mass index of 5 kg/m^2 were used for the overweight group and, assuming a constant rate of increase in risk, the square of this value was used for the obese category.

Population Attributable Risk Estimation

To estimate the number of attributable of cases in Alberta associated with excess body weight, we used the following formula for the population attributable risk:

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

The population attributable risk was estimated 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.

To estimate 95% confidence intervals around population attributable risk estimates, Monte Carlo simulation methods were used 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 confidence intervals. 10,000 samples were drawn and the 2.5th and 97.5th percentiles of the resulting population attributable risk distribution used as the lower and upper limits of a 95 % confidence interval. Similar techniques were used by two previous studies that estimated population attributable risk.[10, 11] Wherever possible and appropriate, these estimations were performed for individual sex and age groups.

Cancer Incidence Data

To determine the number of cancer cases attributable to excess body weight in Alberta, age-sex-site-specific cancer incidence strata for 2012 were obtained from the Alberta Cancer Registry. Age and sex incidence strata were created to match the strata available for the risk factor prevalence data. The year with the most up-to-date complete data (2012) for all cancer sites available was used.

Of the esophageal cancers, only the number of adenocarcinomas diagnosed in 2012 were included in our attributable case estimates, since only adenocarcinomas are consistently associated with overweight/obesity. In this population, 67% and 41% of esophageal cancers

were adenocarincomas in men and women, respectively. We used this approach since information on histology by cancer site was not available for these analyses. Only post-menopausal breast cancers were included in attributable estimates by including those breast cancers occurring after 55 years of age as the median age at menopause among North American women is 50-52. [12, 13]

Sensitivity Analysis

As data on overweight and obesity were derived from self-reported measures of body mass index in the Canadian Community Health Survey, self-report bias had to be considered. To adjust the Canadian Community Health Survey self-reported prevalence of overweight/obesity, a sensitivity analysis was conducted. Shields et al. (2011) [14] reported that overweight prevalence was underestimated by 1.9% among males and 3.9% among females and obesity was underestimated by 6.4% among males and 6.7% among females in the 2008 Canadian Health Measures Survey when applied to the 2005 Canadian Community Health Survey estimates. These correction factors were applied to the Canadian Community Health Survey estimates for the 2000-2001 cycle to adjust for potential bias (Supplementary Table 1).

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, both overweight and obesity levels were higher among older age groups, with the highest prevalence observed in the 65-74 year age group. In this age group, the total population prevalence of overweight was 41.1% (95% confidence interval (CI) = 37.3, 44.9) and obesity was 18.7% (95% CI = 15.9, 21.5). When examining the combined prevalence of overweight and obesity (data not shown), adult Albertan men had the highest prevalence of

excess body weight. For men, >60% of all age groups >35 years reported a body mass index >25.

Cancer site-specific population attributable risk results

The attributable proportions of cases across different cancer sites varied widely, with the highest estimates observed for adenocarcinomas of the esophagus and endometrial cancers ranging from 24.4%-31.8% and 19.6%-34.1% across age groups respectively. Table 4 presents the numbers and proportion 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 population attributable risk estimates are in 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. When examining the absolute number of cases, the sites most impacted by excess body weight were colorectum for men and women and breast among women. This higher number is a result of the greater total incidence of these cancers in the province despite a smaller population attributable risk, which is demonstrated in Figure 1.

Overall population attributable risk results

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. Examining the impact on those cancer sites associated with excess body weight, 13.3% of these cancers can be attributed to overweight and obesity. This number equals 4.3% (n=673) of all cancer cases in Alberta in 2012. Table 5 presents the age- and sex-specific proportions of cancers attributable to excess body weight in Alberta in 2012. When prevalence estimates were adjusted to account for

self-reported bias, the proportion of incident cancers in 2012 attributable to overweight/obesity increased to 5.0% (798 excess cases) (Supplementary Table 3).

DISCUSSION

We have estimated that at least 4.3% of all cases of adult cancers in 2012 in Alberta were attributable to excess body weight. These estimates also suggest that the burden of cancer incidence attributable to these risk factors 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. The analysis by Brenner (2014) 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 gallbladder and 9.2% pancreatic cancers in Canadians in 2007 could be attributed to overweight/obesity.[6] An analysis by Luo et al (2007) estimated that 22.1% of endometrial, 12.1% of breast and 9.5% of colon cancers in adults age 20 and older could be attributed to obesity in Canada. The authors used six national population-based health surveys conducted between 1970 and 2004, including the 2004 Canadian Community Health Survey to obtain data on body mass index. The surveys covered the 10 Canadian provinces. These estimate are similar to the 26.4%, 7.5% and 9.8%, for these same cancer sites, that we found in our analyses. Neutel and Morrison (2010) used data on women between the ages of 50 and 69 between the years 1994-2006 from the National Population Health Survey in Canada for body mass index estimates. They estimated that 8.8% of breast cancers in 2006 could be attributed to obesity [15]. When examining overall attributable burden, our analyses are directly

comparable to the work of Parkin (2011) who estimated that, in the UK for 2010, 5.5% of all cancers were attributed to excess body weight.[5]

Limitations

Our analyses are limited by the use of self-reported data for exposure prevalence estimates. Validations of Canadian data have shown self-reported measures to underestimate the prevalence of obesity by 4-7%. [16] When we used adjusted prevalence estimates for overweight and obesity, the proportion of incident cancers attributable to overweight/obesity increased from 4.3% to 5.0%. These analyses may also be limited since cancer sites for which the evidence of an etiologic role of obesity is only suggestive were excluded. The cancers not considered were: cancers of the thyroid [17], ovary [18], malignant melanoma (men only) [19], leukemia, non-Hodgkin lymphoma and multiple myeloma.[20] Hence, the burden of overweight and obesity on cancers in Alberta and the actual number of attributable cases was likely underestimated.

In separate analyses [21] we have estimated the burden of cancer attributable to physical inactivity. Since these two 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 thoughtful commentaries and editorials [22], the use of the population attributable risk has limitations and combining population attributable risks is discouraged.[23]

One of the strengths of this investigation is the use of provincially representative prevalence estimates. Although the Canadian Community Health Survey has limitations, since it does not capture some specific populations such as aboriginal Canadians or those living on

crown land or military facilities, their sampling frames represent over 96-98% of the Canadian adult population.

To quantify the precision of our population attributable risk estimates, we used 95% confidence intervals. Although including measures of uncertainty was a strength of our study, these 95% confidence intervals also highlight the lack of precision around our population attributable risk estimates (Supplementary table 2). For example, in men aged 56-64, we estimate that 5.8% of pancreatic cancer could be attributable to overweight and obesity, but the 95% confidence interval for the population attributable risk estimate ranges from 0-14.4%. As such, the lack of precision of our population attributable risk estimates 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 modeling 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. With the alarmingly high rates of obesity among adult Albertans, additional targeted prevention strategies aimed to promote weight loss and maintenance of a healthy body weight are recommended. These measures are likely to reduce cancer incidence and subsequent mortality at the population level in Canada.

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Table 1. Predetermined latency periods by cancer site and cycle of prevalence data used for population attributable risk calculations

Exposure	Cancer site	Latency period	Corresponding CCHS cycle (year)
Overweight and Obesity	Esophagus	11-12 years	1.1 (2000/2001)
	Pancreas	9 years	2.1 (2003)
	Colorectum	9 years	2.1 (2003)
	Kidney	11-12 years	1.1 (2000/2001)
	Gallbladder	11-12 years	1.1 (2000/2001)
	Breast	9 years	2.1 (2000/2001)
	Endometrium	11-12 years	1.1 (2000/2001)

Abbreviations: CCHS = Canadian Community Health Survey

Table 2. Risk estimates[a] for risk associated with overweight/obesity by cancer sites of interest

Cancer site	Sex	Relative Risk (95% CI) [b]
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)
Colon-rectum	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)
Gallbladder	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)

[a]Risk estimates from Renehan et al., 2008 [9]

[b]Risk estimates are for an increase in body mass index of 5 kg/m^2

Table 3. Prevalence of overweight and obese adults in Alberta, 2000-2001

Age (years)	Prevalence (95% CI)	
	Overweight (≥ 25 kg/m^2)	Obese (≥ 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)
65-74	47.2 (41.9,52.6)	17.2 (13.5,20.9)
≥ 75	38.2 (32.4,44.0)	17.7 (13.9,21.5)
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)
65-74	35.2 (29.8,40.6)	20.2 (15.8,24.6)
≥ 75	35.1 (29.8,40.3)	17.3 (13.6,21.0)
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)
65-74	41.1 (37.3,44.9)	18.7 (15.9,21.5)
≥ 75	36.6 (32.5,40.7)	17.5 (14.7,20.3)

*Data from the Canadian Community Health Survey Cycle 1.1 (2000/2001)

Table 4. Adult cancer cases and proportions attributable to overweight and obesity in Alberta (2012)

Age at Exposure	Age at Outcome	Esophagus[a]			Pancreas			Colorectum			Kidney			Gallbladder			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	-	-	-						
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	<5						
55-64	65-74	25	32	8	50	5.6	3	304	17.6	54	79	17.1	13	6	7	<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						
Tota		<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	-	-	-	60	8.4	5	214	6.4	14	22	20.4	4	8	32	3	321	8.4	27	55	32	18
≥ 75	≥85	-	-	-	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	<21		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	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	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	18
≥ 75	≥85	6	27	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	<38		25	1955		239	482		83	55		11	1545		124	504		153

Abbreviations: 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

Table 5. Summary of cases and proportions of cancer in Alberta adults in 2012 attributable to overweight/obesity[a]

Cancer Site[b]	Total			Men			Women		
	Observed Cases	Excess Attributable Cases	% Attributable	Observed Cases	Excess Attributable Cases	% Attributable	Observed Cases	Excess Attributable Cases	% Attributable
Esophagus[f]	123	38	30.9	110	35	31.4	13	3	26.8
Pancreas	380	25	6.7	172	9	5.5	208	16	7.7
Colorectum	1955	239	12.2	1107	191	17.2	848	48	5.7
Kidney	482	83	17.3	326	54	16.5	156	29	18.8
Breast[g]	1545	124	8.0				1545	124	8.0
Endometrium	504	153	30.3				504	153	30.3
Gall Bladder	55	11	20.3	24	2	6.5	31	10	30.9
All Associated Cancers[h]	5044	673	13.3	1739	290	16.7	3305	383	11.6
All Cancers[i]	15836	673	4.3	8155	290	3.6	7681	383	5.0

[a] Overweight and obesity measured using body mass index measures from the Canadian Community Health Survey.
[b] Cancer incidence data for the year 2012 from the Alberta Cancer Registry.
[c] Number of observed cancer cases in Alberta in 2012 at individual cancer sites.
[d] Number of cancer cases at individual cancer sites that can be attributed to overweight/obesity.
[e] Proportion of cancers at individual cancer sites attributable to overweight/obesity.
[f] Adenocarcinomas only.
[g] Postmenopausal breast cancer only. Defined as cancers diagnosed at age 55 or older.
[h] Represents all cancers with a known association with overweight/obesity, as listed in table.
[i] Represents all incident cancers in Alberta in 2012 in all age groups.

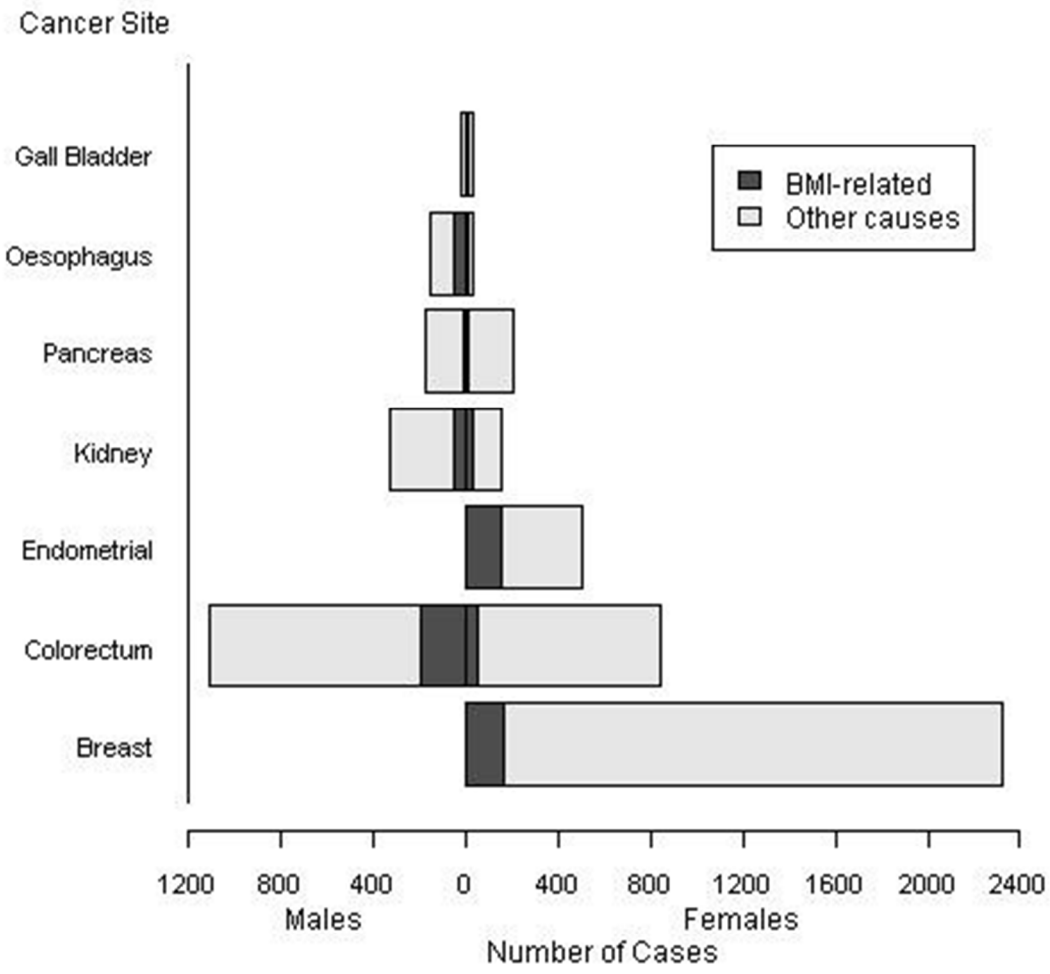

Figure 1 Cancer cases attributable to overweight or obesity and other causes

Supplementary Table 1. Prevalence of overweight and obese adults in Alberta used in sensitivity analyses of self-reported CCHS estimates

Age (years)	Prevalence	
	Overweight	**Obese**
Men		
18-34	35.6	20.2
35-44	43.8	25.4
45-54	45.1	25.8
65-74	49.1	23.6
≥ 75	40.1	24.1
Women		
18-34	21.1	16
35-44	30.5	21.4
45-54	31.6	24.2
65-74	39.1	26.9
≥ 75	39	24

*Self-reported estimates from 2000 Canadian Community Health Survey (CCHS) adjusted for reporting bias based on validation study by Shields et al. [14] where overweight prevalence was underestimated by 1.9% among males and 3.9% among females while obese was underestimated by 6.4% among males and 6.7% among females when applying measured body mass index from 2008 Canadian Health Measures Survey (CHMS) to the 2005 CCHS self-reported estimates.

Supplementary Table 2. Cancer cases and proportions in 2012 attributable to overweight or obesity in Alberta by age and sex

Age Group at Exposu	Age Group at Outcom	Cancer Site	Total Obs. Cases	Total PAR (%)	Obs. Cases Men	Men PAR (%) (95% CI)	Obs. Cases Women	Women PAR (%) (95% CI)
18-34	28 - 44	Esophagus	5	24.4	<5	26.3	<5	17.1 (12.4,22.6)
		Pancreas	<10	4.2	5	4.2 (0,10.4)	<5	4.5 (1.9,7.4)
		Colon-rectum	76	8.5	39	13.4	37	3.4 (2.3,4.6)
		Kidney	42	12.8	28	13.4	14	11.7 (9.3,14.3)
		Gallbladder	<5	19.6	-	-	<5	19.6 (5.8,37.9)
		Breast						
		Endometrium	26	19.6			26	19.6 (17.0,22.4)
35-44	45 - 54	Esophagus	<25	31.2	20	31.8	<5	24.5 (18.1,31.4)
		Pancreas	45	5.6	19	5.4 (0,13.5)	26	5.8 (2.5,9.5)
		Colon-rectum	233	11.1	125	16.8	108	4.4 (2.9,5.9)
		Kidney	84	17	56	16.9	28	17.2 (13.9,20.7)
		Gallbladder	<5	20.7	<5	6.8 (1.2,12.5)	<5	27.6 (9.7,48.6)
		Breast						
		Endometrium	83	27.6			83	27.6 (24.3,31.1)
45-54	55 - 64	Esophagus	44	31.6	38	32.4	6	26.8 (19.8,34.3)
		Pancreas	75	6.6	33	5.8 (0,14.4)	42	7.1 (3.1,11.5)
		Colon-rectum	480	13.4	301	18.1	179	5.4 (3.6,7.3)
		Kidney	150	17.7	109	17.2	41	18.9 (15.3,22.8)
		Gallbladder	<12	25	<5	7.0 (1.3,12.9)	7	30.1 (9.7,52.7)
		Breast	577	7.1			577	7.1 (5.3,9.0)
		Endometrium	195	30.1			195	30.1 (26.4,34.0)
55-64	65 - 74	Esophagus	29	31.8	25	32.0	4	30.5 (22.7,38.6)
		Pancreas	104	7.4	50	5.6 (0,13.9)	54	9.1 (3.9,14.5)
		Colon-rectum	502	13.4	304	17.6	198	6.9 (4.7,9.4)
		Kidney	119	18.7	79	17.1	40	21.9 (17.7,26.4)
		Gallbladder	15	23.2	6	7.0 (1.3,12.7)	9	34.1 (11.5,56.8)
		Breast	541	9.1			541	9.1 (6.9,11.5)
		Endometrium	127	34.1			127	34.1 (29.7,38.4)
65-74	75 – 84	Esophagus	17	30.1	17	30.1	-	-
		Pancreas	108	7.1	48	5.6 (0,13.8)	60	8.4 (3.7,13.3)
		Colon-rectum	478	12.4	264	17.3	214	6.4 (4.3,8.5)
		Kidney	70	17.2	48	15.7	22	20.4 (16.6,24.5)
		Gallbladder	20	16.6	12	6.3 (1.3,11.8)	8	32.0 (11.8,53.9)
		Breast	321	8.4			321	8.4 (6.3,10.6)
		Endometrium	55	32.0			55	32.0 (28.0,36.2)
≥ 75	≥ 85	Esophagus	6	27.9	6	27.9	-	-
		Pancreas	42	5.6	17	4.6 (0,11.5)	25	6.2 (2.6,10.1)
		Colon-rectum	186	8.6	74	14.4	112	4.7 (3.2,6.4)
		Kidney	17	16.2	6	14.5	11	17.2 (13.8,21.0)
		Gallbladder	<5	16.7	<5	5.8 (1.0,11.1)	<5	27.6 (9.5,48.4)
		Breast	106	6.2			106	6.2 (4.5,8.1)
		Endometrium	18	27.6			18	27.6 (23.7,31.6)

Abbreviations: 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

Supplementary Table 3. Cancer cases and proportions attributable to overweight and obesity in Alberta (2012) using prevalence estimates adjusted for bias

Age at Exposure (years)	Age at Outcome (years)	Esophagus[a]			Pancreas			Colorectum			Kidney			Gallbladder			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	31.0	< 5	5	5.1	0	39	16.2	6	28	16.3	5	0	6.5	-						
35-44	45-54	20	35.9	7	19	6.3	1	125	19.4	24	56	19.5	11	< 5	8	-						
45-54	55-64	38	36.4	14	33	6.8	2	301	20.6	62	109	19.8	22	< 5	8.2	-						
55-64	65-74	25	36.1	9	50	6.6	3	304	20.2	61	79	19.7	16	6	8.1	-						
65-74	75-84	17	34.4	6	48	6.5	3	264	19.9	53	48	18.4	9	12	7.5	2						
≥ 75	≥85	6	32.5	2	17	5.5	1	74	17.2	13	6	17.3	1	2	7	-						
Total		<111		< 43	172		11	1107		219	326		62	< 30		2						
Women																						
18-34	28-44	<5	23.8	-	< 5	6.5	0	37	4.9	2	14	16.6	2	< 5	27	-	26	27	7			
35-44	45-54	<5	30	< 5	26	7.7	2	108	5.8	6	28	21.5	6	< 5	33.6	< 5	83	33.6	28			
45-54	55-64	6	32	2	42	8.9	4	179	6.8	12	41	23.1	9	7	35.7	3	195	35.7	70	577	8.9	52
55-64	65-74	<5	35.2	< 5	54	10.9	6	198	8.3	16	40	25.8	10	9	39.1	4	127	39.1	50	541	10.9	59
65-74	75-84	-	-	-	60	10.1	6	214	7.8	17	22	24.4	5	8	37.4	3	55	37.4	21	321	10.1	33
≥ 75	≥85	-	-	-	25	8.1	2	112	6.2	7	11	21.5	2	2	33.6	1	18	33.6	6	106	8.1	9
Total		<15		4	< 212		20	848		60	156		36	31		< 15	504		181	1545		152
Total																						
18-34	28-44	5	29.6	< 5	6	5.4	0	76	10.7	8	42	16.4	7	< 5	27	-	26	27	7			
35-44	45-54	<25	35.4	< 12	45	7.1	3	233	13.1	31	84	20.1	17	6	25.1	2	83	33.6	28			
45-54	55-64	44	35.8	16	75	8	6	480	15.5	74	150	20.7	31	9	29.6	3	195	35.7	70	577	8.9	52
55-64	65-74	<30	36	< 14	104	8.8	9	502	15.5	78	119	21.7	26	15	26.7	4	127	39.1	50	541	10.9	59
65-74	75-84	17	34.4	6	108	8.5	9	478	14.5	69	70	20.3	14	20	19.5	4	55	37.4	21	321	10.1	33
≥ 75	≥85	6	27	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		< 47	<384		25	1955		239	482		83	55		11	1545		124	504		153

Abbreviations: 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. Adjusted prevalence estimates shown in Supplementary Table 1.