Socio-demographic and geographic analysis of overweight and obesity in Canadian adults using the Canadian Community Health Survey (2005)

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Abstract

Using the 2005 Canadian Community Health Survey, this study examined how overweight and obesity in Canadian adults are distributed across socio-demographic and geographic groupings. Overweight and obesity prevalence were modeled against socio-demographic indicators using Poisson regression and were assessed geographically using choropleth maps. The Gini coefficient was used to assess the distribution of prevalence across risk groups. The potential impacts of high risk versus population-based prevention approaches on the population prevalence of obesity were also examined. Of adults aged 25 to 64 years, 17% were obese and 53% were overweight or obese, with the highest proportions observed in older age groups, among those who were physically inactive, white or non-immigrant, with low educational levels, and living in the prairie and east coast regions. Recalculation of obesity rates under the different prevention scenarios demonstrated that population-based approaches could achieve a four-fold greater decrease in obesity cases than high risk approaches, highlighting the need for broader population strategies for obesity prevention in Canada.

Keywords: *obesity, prevalence, prevention, policy, population-based, geographic trend*

Introduction

Overweight and obesity continue to be major public health issues in Canada.[1,2] Studies conducted over the past several decades show that body mass index (BMI) for both adults and children have increased significantly[3,4] despite efforts to address increasing body weights.[5,6] This upward trend calls for a re-assessment of current approaches to understanding the phenomenon of population overweight and obesity. To date, public health interventions have tended to focus on high risk individuals and the promotion of "healthy lifestyles" to change individual behaviours.[5-7] Given the dramatic growth in population body weights in recent decades, a re-examination of the distribution of overweight and obesity in the population is warranted. Our objective is to examine how overweight and obesity in Canadian adults are distributed across socio-demographic and geographic groupings. The study results will provide important information for public health policy and program planners to use in designing effective strategic interventions to decrease the population prevalence of overweight and obesity.

Methods

Data sources

Our analysis is based on data derived from the Public Use Microdata File (PUMF) of the 2005 Canadian Community Health Survey (CCHS), Cycle 3.1, obtained through the Data Liberation Initiative[8] at the University of Manitoba. The methodology of the survey has been detailed elsewhere.[9] BMI measures were derived from self-reported height and weight. While the 2005 CCHS does provide a sub-sample of measured height and weight, this sub-sample was too small to allow the predictive modeling and geographic analysis used by the study. Our study was restricted to adults 25 to 64 years of age: the secondary education variable used to model overweight/obesity rates is only meaningful in adults 25 years and older and the BMI measure is valid only in adults younger than 65 years of age.

For geographic mapping, an electronic map file (shape file) was obtained from the Statistics Canada web site.[10] Since the PUMF collapses the number of health regions from 122 to 101 in order to protect data confidentiality, the health region shape file was similarly modified to contain only 101 health region polygons. This was accomplished using ArcGIS 9.1.[11]

Data preparation and analysis

CCHS data was imported into STATA version 9[12] and a program was written to extract records for individuals 25 to 64 years of age and to code survey variables into the categorical variables required for the study. Individuals with a BMI greater than or equal to 30 were categorized as obese, while those with a BMI greater than or equal to 25 were categorized as overweight/obese.

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All statistical calculations were undertaken in STATA version 9[12] using the Survey Data Analysis module, which used the survey weight on the CCHS record to compute correct parameter estimates for calculated statistics. Since the CCHS is based upon a complex sampling design, the standard error required for an assessment of statistical significance may not be estimated properly using standard statistical techniques that do not take into account a complex sampling design.[9] In order to accurately estimate standard errors associated with output statistics, survey design details are required, including the strata and primary sampling units. The impact of a complex survey design on variance estimates can be summarized as the survey design effect, which is the ratio of the true variance associated with the survey to a comparable variance estimate from a simple random sample of the population.[13] Statistics Canada suggests using the bootstrap resampling method in order to calculate accurate standard errors for the CCHS which take into account the survey design effect. However, the bootstrap method is not available for use with the PUMF and does not support two of the statistical routines employed in this study (Poisson regression and Gini coefficient).

An approximate method[13] was used to incorporate the survey design effect into the calculation of 95% confidence interval estimates for all statistical routines employed in the study. First, the survey design factor was derived by taking the square root of the average survey design effect for the 2005 CCHS of 2.51.[9] Standardized variables (z-scores) used in the calculation of 95% confidence intervals were then re-scaled by the survey design effect ($z = 1.96 * \sqrt{2.51} = 3.10$). In order to streamline this calculation within STATA, confidence intervals were set to 0.998, which is functionally equivalent to using a z-score of 3.10.

In order to describe the demographic and geographic distribution of overweight and obesity, rates were calculated by age, gender and geography and standardized (where appropriate) by age and/or gender using the 2005 CCHS sample population as the standard population. Geographic patterns were visualized through choropleth maps, with rates of overweight and obesity classified into quintiles using the Jenks natural breaks algorithm in ArcGIS 9.1.[11] To model the population characteristics associated with overweight and obesity, categorical Poisson regression analysis was used to generate comparative rate ratios, which are more easily interpretable than the odds ratio generated by logistic regression.[14,15] Model predictor variables included age group, gender, education, fruit and vegetable consumption, physical activity level, immigration status, visible minority status, household income and food security.

The public health significance of the variability in rates of overweight and obesity by immigrant status, education, income and geography was assessed using the Gini coefficient,[16] a measure of inequality ranging from 0 (absolute equality in rates) to 1 (absolute inequality in rates), which has been used previously to examine the geographic variability of infant mortality,[16] sexually transmitted diseases[17] and *campylobacter*.[18] It is calculated by ordering risk categories from lowest to highest rank by case rate, calculating a Lorenz curve which is a plot of the cumulative proportion of the population (x axis) against the cumulative proportion of cases in each risk category (y axis), and then calculating the area between the axis of equality and the Lorenz curve as a percentage of the total area below the axis of equality (Figures 2a and 2b). The greater the degree to which cases are concentrated in a small number of risk categories (i.e. distributed disproportionately in relationship to the population at risk), the greater the deflection of the Lorenz curve downwards from the axis of equality and the higher the Gini coefficient. A high Gini coefficient indicates that the majority of cases are located in a small proportion of the population, and a public health intervention would only need to focus on factors affecting this high risk population in order to be successful in treating or preventing the majority of cases. Alternatively, a low Gini coefficient indicates that cases are spread out relatively evenly across all population groups (despite there being some small groups with very high rates); a public health intervention that focused on these small high-risk groups would end up treating or preventing only a very small percentage of total cases.

We calculated the Gini coefficients and associated confidence intervals for geography (health regions), immigration, education and income for both obesity and overweight/obesity using the *Ineqerr* program in Stata,[12] with associated Lorenz curves produced in EpiDat version 3.1.[19]

To explore how the success of high risk versus population-based prevention strategies may be constrained or enabled by the statistical distribution (Gini coefficient) of obesity cases in the population, we developed two high risk scenarios and two population-based prevention scenarios and calculated their potential impacts on population obesity prevalence. Prevention scenarios were developed for adult obesity (both genders) across health regions and for adult obesity in women by income quintile. The high risk prevention scenarios assumed that public health interventions would successfully prevent 50% of the cases of obesity in the 10% of the population at highest risk for obesity, with the number of cases prevented ascertained directly from the Lorenz curve plot. The population-based scenarios assumed that the obesity prevalence of all population groups could be reduced to the same level as the best performing/lowest risk groups in the study. In the health region analysis, we applied age-specific obesity rates in the three lowest rate health regions (making up 11% of the study population) to the total study population; in the women by income analysis, we applied age-specific obesity rates in the lowest rate quintile (household income > $80,000; 35% of the population) to the total study population. For all scenarios, we calculated the number of obesity cases prevented and the percentage reduction in obesity prevalence.

Results

In 2005, based on self-reported data, almost 3 million (17.31%) of Canadians aged 25 to 64 years were obese, while close to 9 million (52.74%) were overweight/obese (Table 1). Rates of both obesity and overweight/obesity were the highest in men and increased significantly with age for both genders.

Poisson regression analysis revealed that rates of both obesity and overweight/obesity were significantly graded by the demographic characteristics of the study population. This relationship was more pronounced for obesity than for overweight/obesity and for women as compared to men. Tables 2a and 2b express the outputs of the Poisson regression analysis in terms of rate ratios. A rate ratio (RR) is the ratio of the prevalence rate in the category of interest compared to the prevalence rate in the reference or comparison category. As illustrated in Table 2a, rates of obesity were 1.52 times higher in women in the oldest age group (55 to 64 years) compared to the youngest age group (25 to 34 years) and 2.01 times higher in the most physically inactive group compared to the most physically active group. Similarly, in comparison to the reference category, significantly higher rates of obesity were observed in women who were white (RR = 1.35), were non-immigrant (RR = 1.98), had less than a secondary grade level of education (RR = 1.69), an annual household income of less than $15,000 (RR = 1.95) and moderate levels of food insecurity (RR = 1.99). For men, rates of obesity varied significantly and in the same direction as for women, but only for age (RR = 1.43), physical activity levels (RR = 1.48), non-immigrant status (RR = 2.09) and white racial status (RR = 1.53). For both sexes combined, significant rate ratios were observed for age, sex, physical activity, non-immigration and white racial status, education, household income and food security. Paradoxically, the relationship between obesity and education did not vary in a linear fashion, with higher obesity rates (RR = 1.32) occurring in those with some post-secondary education than in those who had completed only secondary education. Directionally similar but weaker trends were observed for overweight/obesity (Table 2b).

Rates of obesity (Figure 1a) varied by health region from a low of 8.90% to a high of 32.24%. The highest rates of obesity were observed in Saskatchewan, south central Manitoba and the east coast (Newfoundland, Labrador and New Brunswick) and the lowest in southern British Columbia, central Alberta, southern Ontario and Quebec. The major urban centers of Vancouver and lower mainland British Columbia, Calgary, Ottawa, Montreal and Toronto were included in the lowest rate regions. Similar geographic patterns were observed for rates of overweight/obesity (Figure 1b), which ranged from a low of 36.28% to a high of 71.11%.

Although obesity and overweight/obesity varied significantly by immigration status, education, income and geography, the very low Gini coefficient values observed (Table 3) suggest that, for the population as a whole, the cumulative number of cases of obesity and overweight are distributed relatively equally in relation to the cumulative population in each risk category. The highest Gini coefficients observed in the study were for obesity by geography (0.153 to 0.169) and for female obesity by income (0.129), however these values are much closer to 0 (absolute equality) than to 1 (absolute inequality). The Lorenz curves (Figures 2a and 2b) show that in the case of geography (both genders), with a Gini coefficient of

TABLE 1
Prevalence of obese* and overweight/obese† adults (25–64 years), Canadian Community Health Survey, 2005

OBESE						
	Women		Men		Both sexes	
Age Group	Cases	Cases/ 100 (95% CI)	Cases	Cases/100 (95% CI)	Cases	Cases/100 (95% CI)
25–34	242 903	12.81 (11.45–14.18)	312 594	15.42 (13.81–17.02)	555 497	14.16 (13.10–15.22)
35–44	329 047	13.83 (12.32–15.34)	453 461	17.76 (16.11–19.41)	782 508	15.86 (14.74–16.99)
45–54	410 160	17.55 (15.64–19.46)	474 471	20.36 (18.20–22.52)	884 630	18.95 (17.51–20.40)
55–64	333 358	19.42 (17.74–21.10)	388 590	21.98 (19.88–24.08)	721 948	20.72 (19.37–22.07)
All Ages	1 315 467	15.79 (14.96–16.63)	1 629 116	18.77 (17.82–19.72)	2 944 583	17.31 (16.68–17.95)

OVERWEIGHT AND OBESE						
	Women		Men		Both sexes	
Age Group	Cases	Cases/ 100 (95% CI)	Cases	Cases/100 (95% CI)	Cases	Cases/100 (95% CI)
25–34	637 572	33.63 (31.57–35.68)	1 090 256	53.78 (51.51–56.05)	1 727 828	44.05 (42.47–45.62)
35–44	922 299	38.76 (36.53–40.98)	1 585 951	62.11 (58.95–64.27)	2 508 250	50.85 (49.26–52.44)
45–54	1 080 994	46.25 (43.61–48.89)	1 511 101	64.83 (62.21–67.45)	2 592 095	55.53 (53.63–57.44)
55–64	955 247	55.65 (53.37–57.93)	1 187 170	67.10 (64.68–69.63)	2 142 417	61.50 (59.80–63.19)
All Ages	3 596 112	43.17 (41.98–44.36)	5 374 478	61.92 (60.72–63.13)	8 970 590	52.74 (51.88–53.61)

* BMI ≥ 30
† BMI ≥ 25

Abbreviations: BMI, body mass index; CI, confidence interval

TABLE 2a
Poisson regression analysis, obese* adults (25-64 years), Canadian Community Health Survey, 2005

	Women		Men		Both sexes	
Predictor	**RR (95% CI)**	**Cases**	**RR (95% CI)**	**Cases**	**RR (95% CI)**	**Cases**
Age group†						
25–34‡	1.00	242 903	1.00	312 549	1.00	555 497
35–44	1.08 (0.93–1.26)	329 047	1.15 (1.10–1.32)§	453 461	1.12 (1.04–1.24)§	782 508
45–54	1.37 (1.17–1.60)§	410 160	1.32 (1.14–1.53)§	474 471	1.34 (1.20–1.49)§	884 630
55–64	1.52 (1.32–1.74)§	333 358	1.43 (1.24–1.64)§	388 590	1.46 (1.32–1.62)§	721 948
Sex‖						
Male‡	–	–	–	–	1.00	1 629 116
Female	–	–	–	–	0.84 (0.78–0.91)§	1 315 467
Fruit & veg‖,#						
< 5 times/day	1.15 (0.78–1.69)	423 385	1.22 (0.78–1.91)	667 688	1.19 (0.88–1.59)	1 091 073
5–10 times/day	1.02 (0.69–1.52)	317 615	0.98 (0.62–1.55)	246 134	1.00 (0.74–1.35)	563 749
> 10 times/day‡	1.00	29 008	1.00	20 571	1.00	49 579
Physical activity‖,#						
Active‡	1.00	181 269	1.00	303 724	1.00	484 992
Moderately active	1.39 (1.16–1.66)§	300 577	1.23 (1.05–1.45)§	383 320	1.29 (1.14–1.45)§	683 896
Inactive	2.01 (1.72–2.36)§	823 720	1.48 (1.29–1.70)§	916 999	1.68 (1.52–1.87)§	1 740 719
Immigration‖,#						
≤ 9 years‡	1.00	39 324	1.00	48 298	1.00	
≥ 10 years	1.47 (0.90–2.41)	173 104	1.29 (0.75–2.21)	179 361	1.37 (0.95–1.99)	87 622
Non-immigrant	1.98 (1.24–3.15)§	1 103 039	2.09 (1.26–3.47)§	1 401 458	2.04 (1.44–2.89)§	352 465
Culture/race‖,#						
Visible minority‡	1.00	160 140	1.00	180 998	1.00	341 138
White	1.35 (1.12–1.64)§	1 138 427	1.53 (1.25–3.47)§	1 410 287	1.45 (1.26–1.66)§	2 548 713
Education‖,#						
Less than secondary school graduation	1.69 (1.44–1.99)§	108 941	1.15 (0.96–1.38)	85 064	1.40 (1.24–1.58)§	194 005
Secondary school graduation	1.42 (1.21–1.66)§	154 345	1.18 (1.02–1.37)§	166 622	1.29 (1.15–1.43)§	320 967
Some post-secondary school	1.53 (1.25–1.87)§	90 428	1.15 (0.93–1.43)	88 776	1.32 (1.14–1.52)§	179 204
Post-secondary graduation‡	1.00	883 344	1.00	1 132 957	1.00	2 016 301
Household income‖,#						
< $15,000	1.95 (1.59–2.39)§	89 606	0.92 (0.73–1.15)	51 960	1.33 (1.15–1.54)§	141 566
$15-29,999	1.72 (1.44–2.06)§	158 826	0.98 (0.82–1.17)	106 427	1.27 (1.13–1.44)§	265 253
$30-49,999	1.69 (1.42–2.00)§	288 184	0.97 (0.84–1.12)	248 683	1.23 (1.11–1.37)§	536 866
$50-79,999	1.39 (1.18–1.64)§	337 446	1.10 (0.97–1.25)	457 773	1.20 (1.08–1.32)§	795 219
≥ $80,000‡	1.00	301 465	1.00	597 414	1.00	898 879
Food security‖,#						
Food secure‡	1.00	972 905	1.00	1 286 838	1.00	2 259 743
Insecure-no hunger	1.76 (1.40–2.22)§	67 940	0.98 (0.70–1.38)	33 550	1.39 (1.15–1.69)§	101 490
Insecure-moderate	1.99 (1.52–2.60)§	40 183	1.00 (0.68–1.48)	15 296	1.56 (1.24–1.95) §	55 479
Insecure-severe	1.73 (0.90–3.33)	7 858	1.11 (0.57–2.15)	6 312	1.39 (0.88–2.19)	14 170

* BMI ≥ 30
† adjusted for sex for "Both sexes" category only
‡ reference group
‖ adjusted for age
\# adjusted for age and sex for "Both sexes" category only
§ significant at $p < 0.002$

Abbreviations: BMI, body mass index; CI, confidence interval; RR, rate ratio

TABLE 2b
Poisson regression analysis, overweight/obese* adults (25-64 years), Canadian Community Health Survey, 2005

	Women		Men		Both sexes	
Predictor	**RR (95% CI)**	**Cases**	**RR (95% CI)**	**Cases**	**RR (95% CI)**	**Cases**
Age group†						
25–34‡	1.00	637 572	1.00	1 090 256	1.00	1 727 828
35–44	1.15 (1.06–1.25)§	922 299	1.15 (1.09–1.22)§	1 585 951	1.15 (1.10–1.21)§	2 508 250
45–54	1.38 (1.27–1.50)§	1 080 994	1.21 (1.14–1.28)§	1 511 101	1.26 (1.20–1.32)§	2 592 095
55–64	1.65 (1.54–1.78)§	955 247	1.25 (1.18–1.32)§	1 187 170	1.39 (1.33–1.46)§	2 142 417
Sex‖						
Male‡	–	–	–	–	1.00	5 374 478
Female	–	–	–	–	0.70 (0.67–0.72)§	3 596 112
Fruit & veg‖,#						
< 5 times/day	1.02 (0.84–1.25)	1 139 785	1.09 (0.91–1.29)	2 154 975	1.05 (0.92–1.20)	3 294 758
5–10 times/day	0.97 (0.80–1.19)	913 057	1.04 (0.87–1.24)	940 696	1.00 (0.87–1.14)	1 853 753
> 10 times/day‡	1.00	87 329	1.00	74 918	1.00	162 246
Physical activity‖,#						
Active‡	1.00	647 576	1.00	1 268 731	1.00	1 916 308
Moderately active	1.18 (1.08–1.28)§	910 129	1.04 (0.99–1.10)	1 351 167	1.09 (1.04–1.14)§	2 261 296
Inactive	1.37 (1.27–1.48)§	2 009 411	1.04 (0.99–1.09)	2 679 689	1.15 (1.11–1.20)§	4 689 100
Immigration‖,#						
≤ 9 years‡	1.00	145 252	1.00	249 879	1.00	395 130
≥ 10 years	1.21 (0.97–1.50)	533 770	1.13 (0.97–1.31)	776 447	1.16 (1.02–1.31)§	1 310 217
Non-immigrant	1.40 (1.15–1.71)§	2 917 090	1.29 (1.13–1.48)§	4 348 153	1.33 (1.19–1.49)§	7 265 242
Culture/race‖,#						
Visible minority‡	1.00	475 260	1.00	710 468	1.00	1 185 728
White	1.21 (1.10–1.34)§	3 049 991	1.27 (1.18–1.37)§	4 534 480	1.25 (1.17–1.33)§	7 584 470
Education‖,#						
Less than secondary school graduation	1.36 (1.25–1.47)§	255 474	0.98 (0.91–1.05)	241 266	1.15 (1.09–1.21)§	496 740
Secondary school graduation	1.21 (1.12–1.31)§	379 298	1.03 (0.97–1.10)	495 401	1.11 (1.05–1.16)§	874 699
Some post-secondary school	1.23 (1.10–1.37)§	207 534	0.99 (0.90–1.08)	260 348	1.08 (1.01–1.16)§	467 882
Post-secondary graduation‡	1.00	2 524 264	1.00	3 874 291	1.00	6 398 556
Household income‖,#						
< $15,000	1.27 (1.14–1.43)§	195 229	0.76 (0.68–0.86)§	154 021	0.97 (0.89–1.05)	349 250
$15-29,999	1.21 (1.10–1.33)§	371 437	0.79 (0.73–0.87)§	309 627	0.96 (0.90–1.02)	681 064
$30-49,999	1.25 (1.15–1.36)§	706 962	0.86 (0.81–0.92)§	792 320	1.00 (0.95–1.05)	1 499 283
$50-79,999	1.15 (1.06–1.24)§	911 915	0.97 (0.92–1.01)	1 444 676	1.02 (0.98–1.07)	2 356 590
≥ $80,000‡	1.00	985 790	1.00	2 140 754	1.00	3 126 544
Food security‖,#						
Food secure‡	1.00	2 782 467	1.00	4 341 777	1.00	7 124 244
Insecure-no hunger	1.31 (1.15–1.49)§	145 053	0.94 (0.81–1.08)	110 069	1.12 (1.01–1.23)§	255 122
Insecure-moderate	1.45 (1.25–1.68)§	83 672	0.90 (0.75–1.07)	46 576	1.18 (1.05–1.33)§	130 248
Insecure-severe	1.39 (1.01–1.93)§	17 943	0.85 (0.63–1.13)	16 371	1.07 (0.84–1.35)	34 314

* BMI ≥ 25
† adjusted for sex for "Both sexes" category only
‡ reference group
‖ adjusted for age
\# adjusted for age and sex for "Both sexes" category only
§ significant at $p < 0.002$

Abbreviations: BMI, body mass index; CI, confidence interval; RR, rate ratio

FIGURE 1a

Adult obesity (BMI ≥ 30) prevalence by health region, age and sex standardized to the 2005 Canadian population (25-64 years), Canadian Community Health Survey, 2005

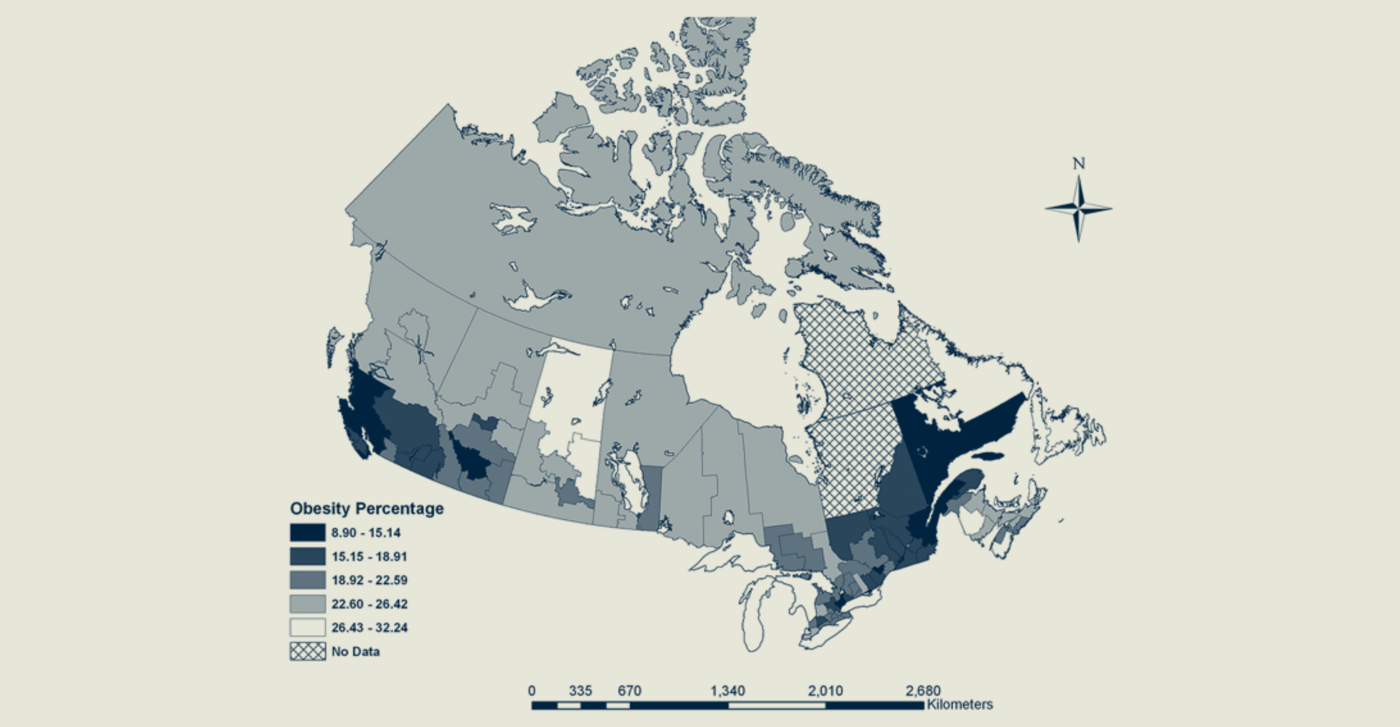


FIGURE 1b

Adult overweight/obesity (BMI ≥ 25) prevalence by health region, age and sex standardized to the 2005 Canadian population (25-64 years), Canadian Community Health Survey, 2005

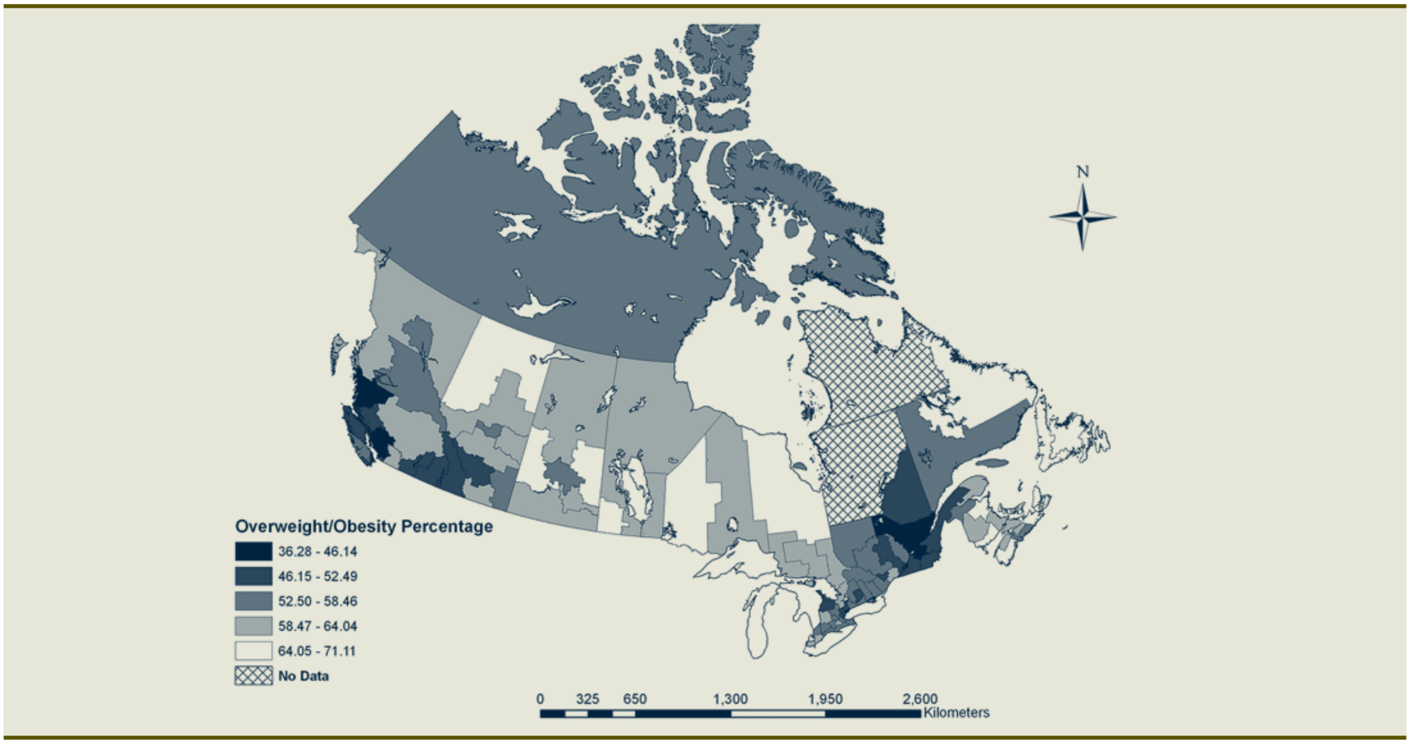


TABLE 3
Gini coefficient analysis for adult (25–64 years) obese* and overweight/obese† prevalence, Canadian Community Health Survey, 2005

	OBESE			OVERWEIGHT/OBESE		
	Women (95% CI)	Men (95% CI)	Both sexes (95% CI)	Women (95% CI)	Men (95% CI)	Both sexes (95% CI)
Immigration	0.060 (0.000–0.160)	0.078 (0.000–0.170)	0.070 (0.000–0.167)	0.032 (0.000–0.107)	0.026 (0.000–0.065)	0.029 (0.000–0.082)
Education	0.086 (0.003–0.169)	0.030 (0.000–0.064)	0.055 (0.000–0.113)	0.049 (0.000–0.102)	0.004 (0.000–0.016)	0.022 (0.001–0.043)
Income	0.129 (0.011–0.247)	0.026 (0.000–0.057)	0.052 (0.000–0.104)	0.056 (0.006–0.106)	0.040 (0.003–0.077)	0.011 (0.000–0.024)
Geography	0.169 (0.134–0.204)	0.156 (0.105–0.207)	0.153 (0.120–0.186)	0.094 (0.069–0.119)	0.066 (0.043–0.089)	0.076 (0.053–0.099)

* BMI ≥ 30
† BMI ≥ 25

Abbreviations: BMI, body mass index; CI, confidence interval

TABLE 4
Potential impact of obesity* prevention scenarios: high risk vs. population-based

	Geographic (health region) analysis	Female income analysis
No prevention (from CCHS)		
Observed cases	2 944 583	1 315 467
Observed rate	17.3/100	15.8/100
Prevention scenarios		
High risk†		
Cases prevented	265 012	85 505
Cases remaining	2 679 571	1 229 961
Rate	15.8/100	14.8/100
% decrease in rate	9%	6.5%
Population-based‡		
Cases prevented	1 064 341	333 040
Cases remaining	1 880 242	982 426
Rate	11.1/100	11.8/100
% decrease in rate	36.1%	25.3%

* BMI ≥ 30
† Preventing 50% of obesity cases in 10% of population at highest risk
‡ Reducing obesity prevalence of all population groups to the level of lowest risk group

0.153, only 18% of the cases of obesity are contained in the 10% of the geographically defined population having the highest risk of obesity; in the case of income, with a Gini coefficient of 0.129, only 13% of the cases of obesity are contained in the 10% of the income classified population at highest risk of obesity.

Recalculating obesity rates under the different prevention scenarios showed that the population-based scenarios could achieve a four-fold greater decrease in obesity cases than the high risk scenario. As illustrated in Table 4, the population prevention approach led to a decrease of 1 064 341 and 330 040 cases in the geographic and female income scenarios respectively, compared to 265 012 and 85 505 cases in the high risk prevention scenarios. These translated into only modest decreases in prevalence for the high risk scenarios (geographic: 17.3% to 15.8%; female income: 15.8% to 14.8%), with more substantial decreases observed for the population prevention scenarios (health region: 17.3% to 11.1%; female income: 15.8% to 11.8%).

Discussion

In this study we demonstrated that there is significant variability in rates of overweight and obesity across geographic and socio-demographic groupings. Age, physical inactivity, income, education, non-immigrant status, white racial status and moderate food insecurity predicted varying degrees of overweight and obesity in both men and women. The lowest rates of overweight and obesity were observed in major urban centers.

For both men and women increasing age was a strong predictor of higher rates of both overweight and obesity. This is not surprising given that metabolism slows with advancing age, increasing risk of weight gain.[20,21] What is notable, however, are the dramatically higher rates of obesity and overweight in younger age groups than previously reported.[3,22] Katzmarzyk has also demonstrated that there are now more men and women moving into the highest classes of obesity, i.e. class II (BMI = 35–39.99) or class III (BMI ≥ 40) than before,[23] suggesting that Canadians are experiencing an accelerated weight gain in younger ages, a conclusion supported by the increasingly high rates of childhood obesity.[2]

Although household income was a strong predictor of overweight and obesity for women, with the highest rates of obesity and overweight among those in the lowest income quartile, low income for men was not associated with high rates of overweight and obesity and appeared to be protective. The reason for this is not clear and requires further study.

Food insecurity was also predictive for overweight and obesity, but only for women. Food insecurity is directly related to low income,[24] and the situation for poor women is frequently exacerbated by being

FIGURE 2a
Gini coefficient, adult (males and females, 25-64 years) obesity (BMI ≥ 30) by health region

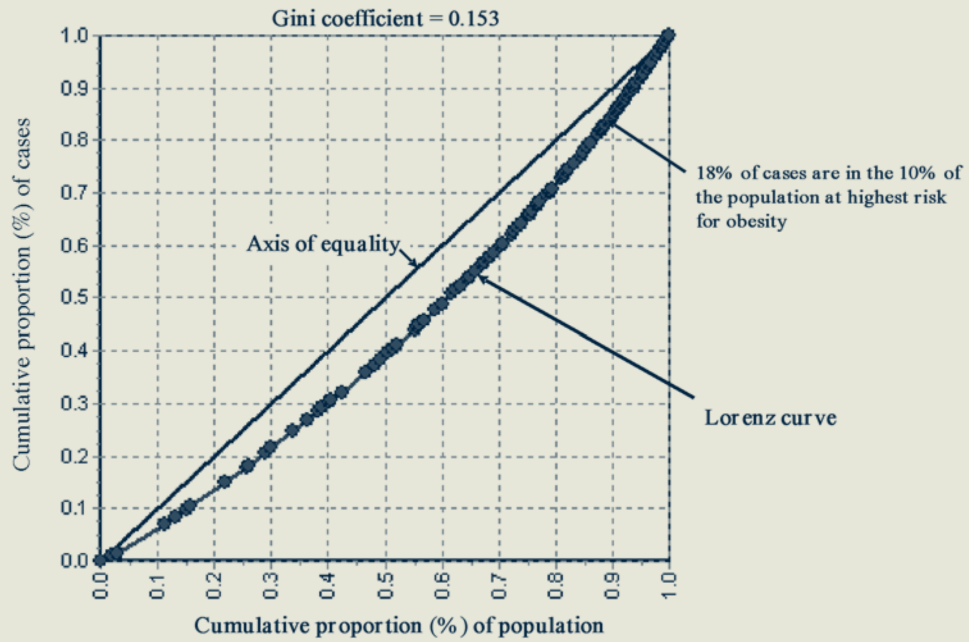
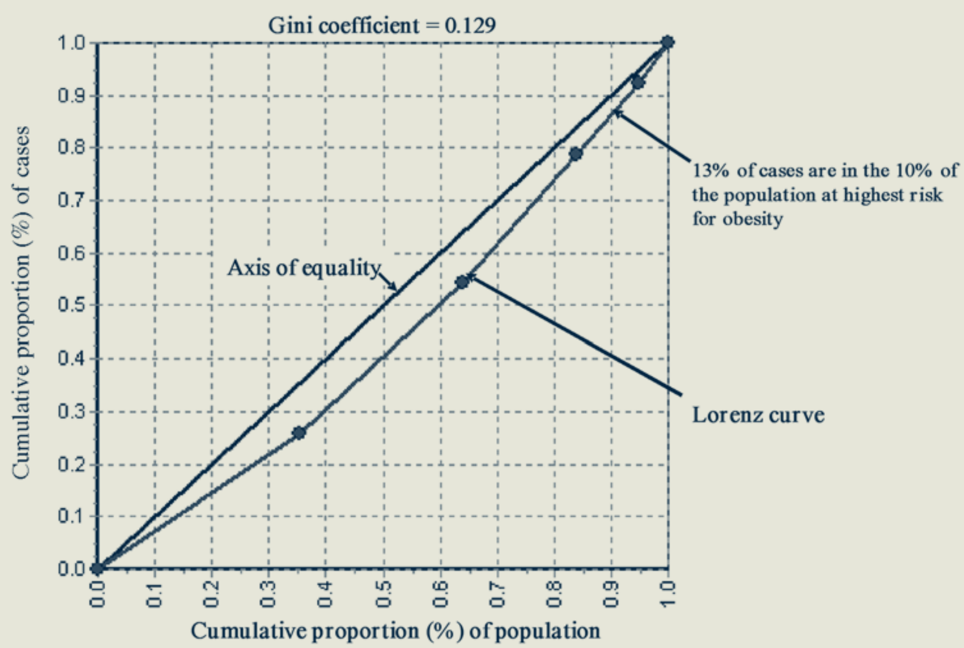


FIGURE 2b
Gini coefficient, adult (females 25-64 years) obesity (BMI ≥ 30), by income



a single parent. Paradoxically, this has been shown to increase BMI. Low income and food insecurity may lead to a reliance on food assistance, such as food banks, where food procured is often energy-dense and of low nutritional quality, which contributes to overweight, obesity and other poor health outcomes.[25]

Low education was predictive of overweight and obesity only for women. This may be linked with low income, as women with low education levels earn significantly less money than men with similar education levels.[26]

Recent immigrant status appeared to be protective against both overweight and obesity. This may be because many new arrivals come from countries with low levels of overweight and obesity. For example, 57.7% % of new arrivals to Canada in 2001 were from Asian countries just entering the "nutrition transition,"[27] a phenomenon where countries rapidly adopt a Western-style diet with high levels of energy-dense animal-source and processed foods.[28] These transitional countries are currently experiencing rapid increases in population BMI, but have not reached the current Canadian levels. This immigration pattern may explain the low rates of overweight and obesity observed in the major urban centres of Vancouver and the lower mainland of British Columbia, Calgary, Toronto, Ottawa and Montreal, where the majority of new arrivals to Canada (80% in 2001) settle.[27]

Visible minority status was also a significant predictor of low BMI. This contradicts findings which show that black and Hispanic populations in the United States are at higher risk of overweight and obesity.[29] This may be because recent non-white immigrants to Canada have lower BMIs and foodways that pre-date the nutrition transition in their countries of origin. Black and Hispanic populations have resided in the U.S. for much longer and tend to experience higher rates of poverty.

Not unexpectedly, low rates of physical activity were also predictive of overweight and obesity for both genders, since sedentary behaviour is associated with weight gain.[30,31] However, low consumption of fruits and vegetables was not associated with higher BMI. Further studies are required to determine the role of fruits and vegetables in maintaining body weight.

Although this study has demonstrated variations across socio-demographic groupings and geography, the Gini analysis suggests these differences are less significant than they may initially appear. While there may be pockets of more susceptible groups with very high rates of obesity and overweight, the high rates across all socio-demographic and geographic groupings suggest that the "causes" of overweight and obesity are also widely dispersed, affecting all population groups. This observation is consistent with Rose's population approach.[32] Rose argued it is imperative to know how much of the burden of ill-health (i.e. absolute number of cases) is compressed within an identifiable group where increased exposure carries increased personal risk. If the burden is not highly concentrated in identifiable high risk sub-populations which are small in size (resulting in a low Gini coefficient), then a high risk targeted prevention approach will do little to affect the population prevalence of the health issue since most cases are outside the high risk group. Our study results empirically confirmed that this is the case currently in Canada. Prevention scenarios focusing on high-risk populations, even if successful (i.e. 50% of cases prevented), would decrease the population prevalence of obesity much less than broad population-based approaches. The lack of clear and often paradoxical patterns of obesity observed (e.g. high rates of overweight/obesity in high income men) also supports the notion that prevention programs focusing on identifiable high risk groups (e.g. low income) will likely fail to achieve significant decreases in the population prevalence of obesity.

Looking at trends over time may be a useful adjunct to the study of cross-sectional variability (as was undertaken in this study) for understanding the dynamics of the obesity epidemic and identifying opportunities for intervention. Rates of overweight and obesity were high in all sub-populations and significantly higher than previously observed. These significant upward temporal trends in obesity prevalence suggest that there are strong forces driving rates upward in almost all population groups. This is not surprising, considering the obesogenic environment that has emerged in Canada over the past several decades which encourages overeating and minimizes opportunities for physical activity.[33-35] It has become very easy to consume excess kilocalories through convenience, snack and fast foods, including soft drinks. These food products tend to be low in fibre and high in sodium, sugar and fat,[36,37] and the resultant excess energy intake, coupled with decreased activity, provides the right circumstances to promote overweight and obesity.[38]

Although the results of this study are consistent with others' which have shown moderately graded relationships between socio-demographic predictors and obesity/overweight,[39-42] when interpreted from this wider perspective, they cast doubt on the importance that has been placed on high risk sub-populations and poor lifestyle choices as major explanations for overweight, obesity and related chronic diseases.[43-46] These analyses highlight why it is important to move beyond statistically significant risk differences in population-based health surveys in order to generate policy and program relevant insights into prevention approaches. As the results of this study have shown, examining the degree to which cases are distributed across risk groups using tools such as the Gini coefficient and prevention scenarios can facilitate an analysis of whether proposed prevention efforts could realistically achieve their goals over time.

These study results bring into question the emphasis on intervention strategies targeted to high risk individuals and groups. They suggest alternatively that prevention efforts should focus on the emerging obesogenic environment which affects all population groups. This perspective does not invalidate or deny that some identifiable social groups (i.e. low income women) are at elevated risk of obesity; however, it argues that the primary cause of the obesity epidemic is the obesogenic environment to which all population groups are exposed, with some populations being more vulnerable for various reasons. This reframing of the disparities argument, supported empirically by the results of this study, strongly suggests that a population-wide approach to prevention of overweight and obesity is warranted. Further research is required to explore effective program and policy mechanisms.

This study has a number of limitations. First, the research was conducted using cross-sectional data and does not model factors over time. Cross-sectional studies may be blind to significant etiological factors which may have developed over time. The Gini analysis, however, highlighted the limitations of exclusively cross-sectional predictors and explanations for the obesity epidemic.

Second, the CCHS data set has a limited number of socio-demographic variables available for analysis. There may be other important predictors of elevated BMI such as family structure, neighbourhood characteristics or work status which were not covered by the survey.

Third, self-reported height and weight were used with the result that the reported rates of obesity and overweight were most likely underestimated.[47,48] For the 2005 CCHS, self-reported versus measured height and weight underestimated BMI by 1.3 kg/m^2;[49] however, as indicated, the measured height and weight sample was too small to allow the predictive modeling and geographic analysis used by the study.

A fourth limitation was the size of the geographic areas used in the analyses. This may have masked variability in overweight and obesity rates within geographic areas. However, this problem was unavoidable as the samples in the 2005 CCHS were too small to allow defensible small-area parameter estimates. Other studies have used even larger areas, conducting geographic analysis of BMI at the provincial level.[41,50]

A fifth limitation is that the 2005 CCHS does not contain information for the on-reserve Aboriginal population, a group shown to be at high risk for obesity.[51] This omission may have biased the geographic patterns observed, especially in northern areas of Canada where there are a large number of reserve communities.

Finally, the assumptions underlying the high risk and population-based scenarios created in this study were likely overly optimistic. It is unlikely that a prevention strategy focusing only on high risk populations would be able to achieve a 50% reduction in obesity prevalence given the obesogenic environment in which high risk groups (and most of the Canadian population) live. Two key influences on body weight, the food system and the built environment, are difficult to modify at the level of the individual or local community, and initiatives which have attempted to do so have had limited success in decreasing BMI.[52] Even in the population-based scenario, which assumed that all population groups could obtain the prevalence rates already being achieved in the lowest rate geographic and demographic groups, a "scaling up" of preventive processes for the entire Canadian population would be necessary, which would require significant political will to address broader determinants of elevated BMI. The implication is that within the short term the effectiveness of the high risk and the population-based prevention scenarios would likely be less than reported in this study. However, our scenario assumptions may become more realistic over the long term if governments begin to make a serious and concerted effort to prevent obesity, although we do not know what outcomes would actually be possible. No country to date has ever implemented a serious and successful obesity prevention strategy, with most efforts restricted to social marketing campaigns, labelling regulations and voluntary adoption of dietary guidelines by schools and other institutions.[5,6] We believe that these scenarios can provide strategic guidance to policy processes by quantifying the constraints impacting the potential success of alternative prevention initiatives. In addition, these scenarios provide a basis from which to critique studies which seek to highlight the importance of sub-populations at statistically higher risk of obesity, without also examining the population distribution of obesity and the implication this may have for successful prevention efforts.

A potential criticism of the scenarios in this paper is that they assume an overly modest prevention effect for the high risk scenarios, with the effect of stacking the analysis in favour of the population-based prevention approaches. However, as illustrated in Table 4, the high risk scenarios assume a much greater prevention success rate (50% decrease in cases) than do either of the population-based approaches (36.1% and 25.3%) respectively. If we recalculated the analysis so that the high risk scenarios had the same prevention success as the population based prevention approaches, the high risk approaches would perform even more poorly in comparison to the population based prevention approaches.

Despite the limitations, this research has highlighted the need to examine the implications of different prevention approaches through methods that go beyond merely establishing statistical significance between risk groups. The Gini analysis and the prevention scenarios used in this study have been shown to be a useful heuristic for exploring the potential impacts of different prevention approaches and for empirically demonstrating which approaches could make a difference over the long-term, and which would be less likely to do so.

The study highlights that further research is required to understand the dimensions of this obesogenic environment and how these have evolved over time to impact the body weight of Canadians. This will require committed, comprehensive surveillance of the Canadian diet and physical activity levels, and on-going surveys of population weight status using measured height and weight. This research will be important in building the empirical argument for population-based preventions efforts in order to turn the page on this insalubrious phase in Canadian public health.

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