

# Trends in obesity across Canada from 2005 to 2018: a consecutive cross-sectional population-based study

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## Abstract

**Background:** Obesity is increasingly prevalent worldwide and is becoming an epidemic in many countries, including Canada. We sought to describe and analyze temporal obesity trends in the Canadian adult population from 2005 through 2018 at the national and provincial or territorial levels.

**Methods:** We conducted a consecutive, cross-sectional study using data from 7 sequential Canadian Community Health Survey (CCHS) cycles (2005 to 2017/18). We included data from Canadian adults (age  $\geq 18$  yr) who participated in at least 1 of the 7 consecutive CCHS cycles and who had body mass index values (calculated by Statistics Canada based on respondents' self-reported weight and height). Obesity prevalence (adjusted body mass index  $\geq 30$ ) was a primary outcome variable. We analyzed temporal trends in obesity prevalence using Pearson  $\chi^2$  tests with Bonferroni adjustment, and the Cochran–Armitage test of trend.

**Results:** We included data from 746 408 (403 582 female and 342 826 male) CCHS participants. Across Canada, the prevalence of obesity increased significantly between 2005 and 2017/18, from 22.2% to 27.2% ( $p < 0.001$ ). We observed increases across both sexes, all age groups and all Canadian provinces and territories ( $p < 0.001$ ). In 2017/18, the prevalence of obesity was higher among males than females (28.9% v. 25.4%;  $p < 0.001$ ); the prevalence among adults aged 40–69 years exceeded 30%. In 2017/18, Newfoundland and Labrador had the highest prevalence (39.4%), and British Columbia had the lowest (22.8%) prevalence of obesity. Over the 14-year study period, Quebec and Alberta exhibited the largest relative increases in obesity.

**Interpretation:** In 2017/18, more than 1 in 4 adult Canadians lived with obesity, and from 2005 to 2017/18, the prevalence of obesity among adults in Canada increased substantially across sexes, age groups and all Canadian provinces and territories to 27.2%. Our findings call for urgent actions to identify, implement and evaluate solutions for obesity prevention and management in all Canadian provinces and territories.

According to the World Health Organization (WHO), obesity continues to advance across every region, pervading all socioeconomic classes and becoming a global epidemic, with over 13% of adults worldwide affected.<sup>1</sup> Obesity is a progressive, multifactorial, chronic disease with high risks of relapse, recurrence<sup>2</sup> and multiple comorbidities, including type 2 diabetes, cardiovascular diseases, nonalcoholic fatty liver disease, osteoarthritis, chronic kidney disease, chronic back pain and many types of cancer.<sup>3–9</sup> All-cause mortality and premature mortality from adiposity-related complications are also substantially higher in people living with obesity and, as shown in many large population-based studies, increase linearly with body mass index (BMI) in this population.<sup>4,10–13</sup> From an economic standpoint, up to 12.0% of Canadian health expenditures are attributed to obesity, with aggregated annual costs exceeding \$11 billion.<sup>14</sup>

Population-wide studies of temporal obesity trends in Canadian adults using multiple sequential cross-sectional surveys at national and provincial or territorial levels are lacking, are outdated or do not include trend analyses.<sup>15–20</sup> Exploring the prevalence of obesity and its temporal trends may assist in

identifying current priorities for obesity prevention and management in Canada, including targeting geographic areas exhibiting the largest increases in obesity.

In this study, our aim was to describe and analyze temporal trends in obesity prevalence at the national and provincial or territorial levels in the adult Canadian population from 2005 through 2017/18.

## Methods

### Study design and data source

We conducted a consecutive cross-sectional study using data collected by Statistics Canada and obtained from 7 sequential cycles of the Canadian Community Health Survey (CCHS)

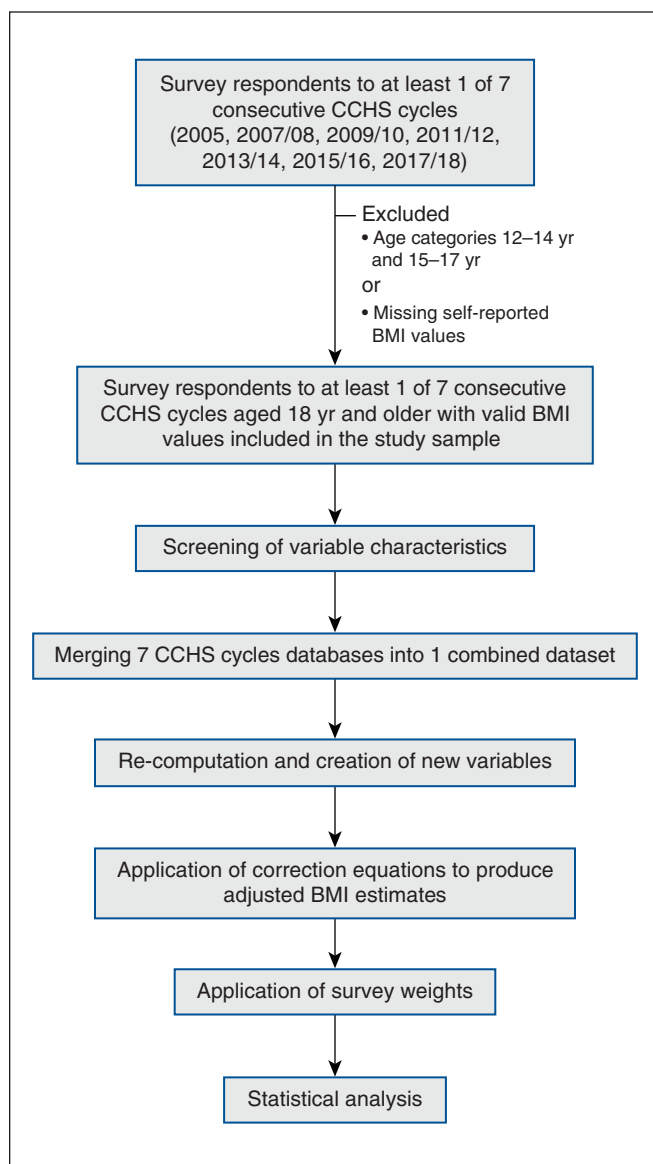
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from 2005 to 2017/18.<sup>21–27</sup> The CCHS is a Canada-wide, cross-sectional survey designed and conducted by Statistics Canada. The survey uses a complex, multistage, multiframe, stratified sampling design that collects information related to health status, health care use and health determinants from a large national sample of survey respondents to provide estimates for the whole Canadian population.<sup>28</sup> Estimates from Yukon, the Northwest Territories and Nunavut are combined. Surveys are conducted using computer-assisted telephone interviews, and responses are collected directly from participants. Further details about CCHS methodology and sampling strategy can be found elsewhere.<sup>28</sup> Our step-by-step methodological approach to the study is presented in Figure 1.



**Figure 1:** Flow chart outlining the data sources and step-wise methodological approach to the study. Note: BMI = body mass index, CCHS = Canadian Community Health Survey. Self-reported BMI refers to the BMI values precalculated by Statistics Canada based on self-reported weight and height.

### Study population

Eligibility criteria for our study participants included being an adult (age  $\geq 18$  yr) participant in at least 1 of the 7 CCHS cycles, with self-reported BMI values available (i.e., BMI values precalculated by Statistics Canada based on self-reported weight and height). Exclusion criteria were driven by CCHS coverage.<sup>28</sup> The CCHS sampling frame covers the Canadian population 12 years and older living in the 10 provinces and the 3 territorial capitals, representing about 98% of the Canadian population. The survey focuses on the population residing in private households; therefore, people who live on reserves and other Indigenous settlements, full-time members of the Canadian Armed Forces, institutionalized populations and those living in some remote areas are excluded. Self-reported BMI was not derived for pregnant people.

### Variables and outcomes

The variables used in our study consisted of self-reported sex, age, province of residence and BMI. Large international and Canadian studies have consistently shown the tendency of survey participants to overestimate self-reported height and underestimate self-reported weight, leading to a systematic underestimation of obesity prevalence and its relation with adiposity-related outcomes.<sup>29–31</sup> Therefore, to improve the estimation of obesity, we applied sex-specific correction equations developed by Gorber and colleagues (reduced Model 4) to self-reported BMI. This produces adjusted BMI estimates that yield estimates maximally in line with the measured ones.<sup>31–33</sup>

We used adjusted BMI (a number with 2 decimals) to categorize respondents into corresponding weight status categories.<sup>34–36</sup> We defined individuals with an adjusted BMI of 30.00 or higher as obese.<sup>35</sup> The prevalence of obesity was the primary outcome variable. A full list of CCHS questionnaire items and answer categories that were analyzed in our study can be found in Appendix 1, Supplementary Table S1, available at [www.cmajopen.ca/content/10/2/E439/suppl/DC1](http://www.cmajopen.ca/content/10/2/E439/suppl/DC1).

### Statistical analysis

For statistical estimates produced from the CCHS data to be accurate and representative of the Canadian population and not just the sample, we incorporated standardized survey weights in calculations before statistical analyses were performed.<sup>37</sup> Categorical data were presented as proportions (weighted) and counts (unweighted).

We compared the prevalence of obesity across CCHS cycles using the 2-tailed Pearson  $\chi^2$  test and adjusted the *p* values of posthoc paired comparisons on each pair of CCHS cycles according to the Bonferroni method for multiple pairwise comparisons. We analyzed trends in obesity prevalence over time using the Cochran–Armitage test of trend. We performed all statistical analyses and data visualization using SPSS 23.0, GraphPad Prism 6.0, and Tableau Public 2020.3, with a *p* value 0.05 or less indicating statistical significance.

### Ethics approval

Our study was exempt from need for review by the University of Alberta Research Ethics Board as CCHS public use micro-data files produced by Statistics Canada are publicly accessible via the Data Liberation Initiative.

## Results

The initial sample size in the 2005–2017/18 CCHS cycles was 862 810 survey respondents. We excluded 72 469 respondents who were younger than 18 years and 43 933 who were missing BMI values. This resulted in a final sample of 746 408 CCHS survey respondents, more than half of whom were female ( $n = 403\,582$ , 54.1%).

The main demographic characteristics of study participants are presented in Table 1. Respondents aged 50–59 years had the largest share in the study population compared with other age categories for the first 3 CCHS cycles, shifting to people aged 60–69 years in more recent years. Geographic area distributions were consistent throughout cycles.

## Prevalence and temporal trends

In 2005, the prevalence of obesity across Canada was 22.2% and increased significantly over 14 years, reaching the highest level of 27.2% in 2017/18 ( $p < 0.001$ ), and showing a gradually rising temporal pattern (Table 2, Figure 2, Figure 3, Figure 4).

In 2005, the prevalence of obesity among males was substantially higher than among females (24.0% v. 20.4%,  $p < 0.001$ ). Over the subsequent 14 years, the prevalence increased in both sexes, with larger increases among females. By 2017/18, the prevalence of obesity among males continued to be significantly higher than among females (28.9% v. 25.4%,  $p < 0.001$ ) (Table 2, Figure 2).

Adults aged 50–59 and 60–69 years had the highest prevalence of obesity in 2005, followed by adults aged 40–49 years (28.0%, 27.8% and 23.8%, respectively). Over the next

**Table 1: Demographic characteristics of survey respondents by cycle of the Canadian Community Health Survey**

Characteristic	No. (%) of survey respondents						
	2005 <i>n</i> = 115 787	2007/08 <i>n</i> = 113 322	2009/10 <i>n</i> = 106 950	2011/12 <i>n</i> = 107 691	2013/14 <i>n</i> = 110 349	2015/16 <i>n</i> = 94 316	2017/18 <i>n</i> = 97 993
<b>Sex</b>							
Female	61 970 (49.7)	61 492 (50.0)	57 993 (49.7)	59 078 (49.9)	60 648 (49.8)	50 158 (49.7)	52 243 (49.8)
Male	53 817 (50.3)	51 830 (50.0)	48 957 (50.3)	48 613 (50.1)	49 701 (50.2)	44 158 (50.3)	45 750 (50.2)
<b>Age category, yr</b>							
18–19	3840 (3.3)	3223 (3.2)	3319 (3.2)	3084 (3.0)	2973 (3.0)	1976 (3.1)	1756 (3.0)
20–29	15 961 (17.4)	13 851 (17.4)	13 934 (17.4)	13 653 (17.5)	12 703 (17.1)	10 818 (16.1)	11 174 (16.1)
30–39	19 321 (17.4)	17 856 (17.5)	15 438 (16.6)	14 304 (16.6)	13 752 (16.7)	14 235 (17.5)	14 802 (17.9)
40–49	19 756 (21.8)	18 688 (20.8)	15 680 (20.2)	14 539 (18.4)	13 116 (17.6)	13 739 (17.4)	13 757 (16.6)
50–59	20 487 (17.4)	21 638 (18.5)	20 124 (18.9)	20 309 (19.1)	20 835 (19.5)	17 388 (18.8)	17 250 (18.0)
60–69	16 788 (11.5)	18 227 (12.0)	18 927 (13.0)	21 186 (14.3)	23 596 (14.7)	18 579 (15.5)	19 877 (15.8)
70–79	12 758 (7.6)	12 879 (7.4)	12 521 (7.2)	13 079 (7.4)	15 186 (8.0)	11 829 (8.3)	13 069 (9.0)
≥ 80	6876 (3.5)	6960 (3.2)	7007 (3.4)	7537 (3.6)	8188 (3.6)	5752 (3.3)	6308 (3.6)
<b>Province or territory</b>							
Alberta	10 151 (9.7)	10 215 (10.3)	9924 (10.5)	9760 (10.9)	10 434 (11.3)	11 381 (11.6)	11 732 (11.5)
British Columbia	13 570 (13.3)	13 718 (13.3)	12 995 (13.4)	13 418 (13.5)	13 387 (13.3)	12 419 (13.2)	13 338 (13.2)
Manitoba	6353 (3.4)	6433 (3.3)	5837 (3.3)	5905 (3.4)	6337 (3.3)	4631 (3.3)	4719 (3.4)
New Brunswick	4512 (2.4)	4746 (2.3)	4215 (2.2)	4207 (2.2)	4279 (2.1)	2841 (2.1)	3182 (2.1)
Newfoundland and Labrador	3587 (1.7)	3481 (1.6)	3243 (1.5)	3074 (1.5)	3410 (1.5)	2729 (1.5)	2804 (1.5)
Nova Scotia	4442 (2.9)	4486 (2.9)	4048 (2.8)	4011 (2.8)	4548 (2.7)	4105 (2.7)	4174 (2.6)
Ontario	36 578 (38.8)	38 137 (39.0)	36 418 (38.9)	36 640 (38.7)	36 566 (38.4)	28 024 (38.3)	28 585 (38.5)
Prince Edward Island	1751 (0.4)	2029 (0.4)	1612 (0.4)	1513 (0.4)	1695 (0.4)	1511 (0.4)	1653 (0.4)
Quebec	25 980 (24.2)	20 742 (23.9)	19 862 (23.7)	20 495 (23.6)	20 675 (23.7)	20 487 (23.8)	21 447 (23.5)
Saskatchewan	6706 (2.9)	6633 (2.8)	6328 (2.8)	6132 (2.8)	6338 (2.9)	3970 (2.9)	4172 (2.9)
Yukon, Northwest Territories or Nunavut	2157 (0.3)	2702 (0.3)	2468 (0.3)	2536 (0.3)	2680 (0.3)	2218 (0.3)	2187 (0.3)

**Table 2 (part 1 of 2): Temporal dynamics in prevalence of obesity across Canada and by province or territory by cycle of the Canadian Community Health Survey**

Parameter	Prevalence, % (95% CI)*							p value	
	2005	2007/08	2009/10	2011/12	2013/14	2015/16	2017/18	Pearson $\chi^2$ test†	Cochran-Armitage test of trend
Canada, all sexes and ages	22.2 (22.2–22.2)	23.4 (23.4–23.4)	24.0 (24.0–24.0)	25.0 (25.0–25.1)	26.3 (26.3–26.4)	26.6 (26.5–26.6)	27.2 (27.1–27.2)	< 0.001	< 0.001
Sex-specific estimates									
Females	20.4 (20.4–20.4)	21.7 (21.7–27.8)	22.0 (21.9–22.0)	23.2 (23.2–23.2)	23.9 (23.9–23.9)	24.3 (24.3–24.3)	25.4 (25.4–25.5)	< 0.001	< 0.001
Males	24.0 (23.9–24.0)	25.0 (25.0–25.1)	26.0 (25.9–26.0)	26.9 (26.8–26.9)	28.8 (28.8–28.8)	28.8 (28.8–28.8)	28.9 (28.8–28.9)	< 0.001	< 0.001
Age-specific estimates, yr									
18–19	8.3 (8.3–8.4)	9.2 (9.1–9.2)	10.7 (10.6–10.7)	8.7 (8.6–8.7)	9.8 (9.8–9.9)	9.9 <sup>a</sup> (9.9–10.0)	9.9 <sup>a</sup> (9.9–10.0)	< 0.001	< 0.001
20–29	14.7 (14.7–14.7)	15.8 (15.7–15.8)	16.2 (16.2–16.2)	16.3 (16.3–16.3)	17.8 (17.8–17.8)	16.9 (16.9–17.0)	17.5 (17.5–17.6)	< 0.001	< 0.001
30–39	22.0 (21.9–22.0)	22.9 (22.9–23.0)	22.5 (22.4–22.5)	23.8 (23.8–23.9)	26.7 (26.6–26.7)	26.0 (26.0–26.0)	26.8 (26.8–26.9)	< 0.001	< 0.001
40–49	23.8 (23.7–23.8)	24.2 (24.2–24.3)	25.8 (25.8–25.8)	28.2 <sup>b</sup> (28.1–28.2)	28.2 <sup>b</sup> (28.1–28.2)	30.2 (30.2–30.3)	30.9 (30.8–30.9)	< 0.001	< 0.001
50–59	27.8 (27.7–27.8)	28.6 (28.6–28.7)	29.3 (29.2–29.3)	30.3 (30.2–30.3)	31.2 (31.2–31.3)	31.5 (31.5–31.6)	31.4 (31.4–31.4)	< 0.001	< 0.001
60–69	28.0 (28.0–28.1)	30.3 (30.3–30.4)	30.2 (30.1–30.2)	30.9 (30.8–30.9)	31.8 (31.7–31.8)	31.2 (31.2–31.3)	32.3 (32.3–32.3)	< 0.001	< 0.001
70–79	22.9 (22.8–22.9)	24.8 (24.8–24.9)	25.4 (25.3–25.4)	26.7 (26.7–26.8)	27.2 (27.2–27.3)	28.1 (28.1–28.2)	29.4 (29.4–29.5)	< 0.001	< 0.001
≥ 80	15.5 (15.4–15.5)	16.7 (16.6–16.7)	17.0 (16.9–17.1)	16.2 (16.1–16.3)	19.5 <sup>c</sup> (19.4–19.6)	18.4 (18.3–18.5)	19.5 <sup>c</sup> (19.4–19.6)	< 0.001	< 0.001
Province-specific estimates									
Newfoundland and Labrador	33.5 (33.4–33.7)	32.5 (32.3–32.6)	36.6 (36.5–36.8)	35.7 (35.5–35.8)	38.9 (38.8–39.1)	41.0 (40.8–41.2)	39.4 (39.2–39.5)	< 0.001	< 0.001
Prince Edward Island	30.1 <sup>d</sup> (29.9–30.4)	29.9 <sup>d</sup> (29.6–30.2)	27.7 (27.4–27.9)	32.7 <sup>e</sup> (32.4–33.0)	32.9 <sup>e</sup> (32.6–33.2)	30.9 (30.6–31.2)	34.2 (34.0–34.5)	< 0.001	< 0.001
Nova Scotia	28.0 (27.9–28.1)	31.1 (31.0–31.2)	31.5 (31.4–31.7)	33.0 (32.9–33.1)	34.6 <sup>f</sup> (34.5–34.7)	34.2 (34.1–34.4)	34.7 <sup>i</sup> (34.6–34.8)	< 0.001	< 0.001
New Brunswick	30.9 <sup>g</sup> (30.8–31.1)	31.1 <sup>g</sup> (31.0–31.2)	36.2 (36.1–36.3)	33.8 (33.7–34.0)	34.6 (34.4–34.7)	38.7 (38.6–38.9)	36.7 (36.5–36.8)	< 0.001	< 0.001
Quebec	20.1 (20.1–20.2)	21.3 (21.3–21.4)	22.1 (22.0–22.1)	23.1 (23.1–23.1)	24.9 (24.9–24.9)	24.8 (24.7–24.8)	26.0 (26.0–26.1)	< 0.001	< 0.001

**Table 2 (part 2 of 2): Temporal dynamics in prevalence of obesity across Canada and by province or territory by cycle of the Canadian Community Health Survey**

Parameter	Prevalence, % (95% CI)*							p value	
	2005	2007/08	2009/10	2011/12	2013/14	2015/16	2017/18	Pearson $\chi^2$ test†	Cochran–Armitage test of trend
Ontario	21.9 (21.9–22.0)	23.6 (23.5–23.6)	24.1 (24.1–24.1)	25.1 (25.1–25.1)	26.1 <sup>h</sup> (26.1–26.12)	26.3 (26.3–26.3)	26.2 <sup>h</sup> (26.2–26.2)	< 0.001	< 0.001
Manitoba	25.4 (25.3–25.5)	26.9 (26.8–27.0)	30.1 (30.0–30.2)	28.0 (27.9–28.1)	32.5 (32.4–32.6)	30.8 (30.7–30.9)	30.0 (29.9–30.1)	< 0.001	< 0.001
Saskatchewan	29.0 (28.9–29.1)	31.1 (31.0–31.3)	28.7 (28.6–28.8)	31.7 (31.6–31.8)	32.9 (32.8–33.0)	31.5 (31.4–31.6)	35.4 (35.3–35.5)	< 0.001	< 0.001
Alberta	22.9 (22.9–23.0)	25.3 (25.2–25.3)	24.7 (24.6–24.7)	26.1 (26.0–26.1)	27.2 (27.2–27.3)	28.1 (28.0–28.1)	29.2 (29.2–29.3)	< 0.001	< 0.001
British Columbia	19.2 (19.1–19.2)	18.2 (18.1–18.2)	18.8 (18.7–18.8)	20.6 (20.6–20.7)	21.1 (21.0–21.1)	21.6 (21.6–21.7)	22.8 (22.8–22.9)	< 0.001	< 0.001
Yukon, Northwest Territories or Nunavut	29.3 <sup>i</sup> (28.9–29.6)	30.0 (29.6–30.4)	29.5 <sup>i</sup> (29.1–29.8)	31.9 (31.5–32.2)	34.1 (33.8–34.5)	35.9 (35.6–36.3)	36.9 (36.6–37.2)	< 0.001	< 0.001

Note: CCHS = Canadian Community Health Survey, CI = confidence interval.

\*Data are based on adjusted and weighted estimates.

†Proportions compared across CCHS cycles using a 2-tailed Pearson  $\chi^2$  test, with subsequent cycle-to-cycle pairwise comparisons using a 2-tailed Pearson  $\chi^2$  test with *p*-value adjustment for multiple testing, according to the Bonferroni method. All pairwise comparisons between CCHS cycles show a statistically significant difference in proportions (*p* < 0.05), except for those cycles indicated by paired tags with superscript letters (a, b, c, etc.).

14 years, the prevalence increased significantly in all age groups, with the largest increase among people aged 40–49 years (*p* < 0.001). By 2017/18, the prevalence of obesity among adults aged 60–69, 50–59 and 40–49 years was 32.3%, 31.4% and 30.9%, respectively (Table 2, Figure 3).

In 2005, British Columbia and Quebec had the lowest prevalence of obesity (19.2% and 20.1%, respectively), while Newfoundland and Labrador, New Brunswick and Prince Edward Island had the highest prevalence (33.5%, 30.9% and 30.1%, respectively). All provinces and territories had increases in obesity prevalence from 2005 to 2017/18 (*p* < 0.001), with the highest prevalence remaining in Newfoundland and Labrador at 39.4% and the lowest prevalence in BC at 22.8%. Over the 14-year study period, Quebec and Alberta had the largest relative increases in obesity prevalence (Table 2, Figure 4, Figure 5).

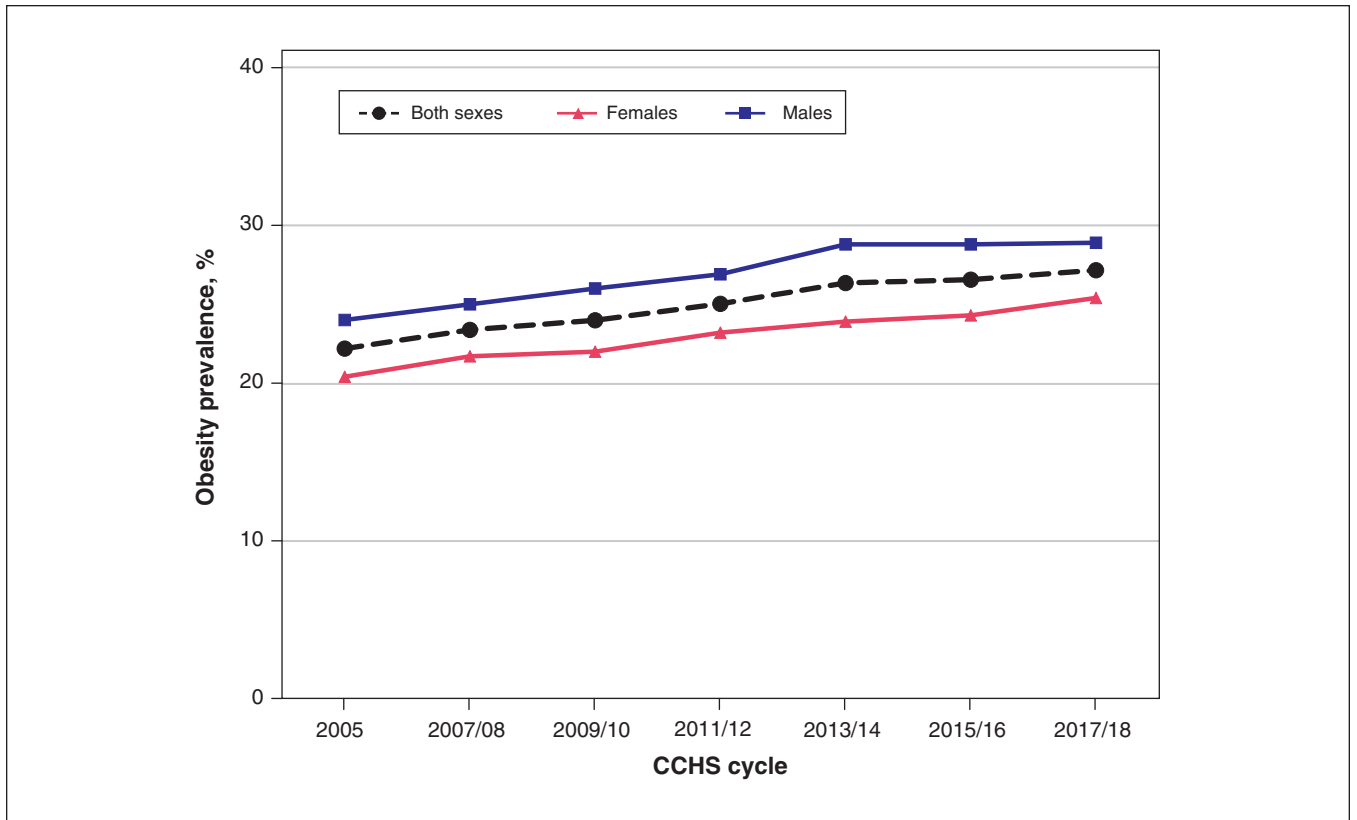
There were statistically significant differences in obesity prevalence across CCHS cycles for both sexes, all age categories, and at the national and provincial or territorial levels (*p* < 0.001). Findings of pairwise comparisons were consistent, with a significant increase in obesity prevalence across Canada with each subsequent CCHS cycle (*p* < 0.001). In 2017/18, sex-specific, age-specific, national and provincial or territorial prevalences were significantly higher than those in 2005 (*p* < 0.001). Furthermore, from 2005 through 2017/18, there was a statistically significant increasing linear trend in obesity prevalence in both sexes, and across all age groups, across Canada and in all

provinces or territories (Cochran–Armitage test of trend, *p* < 0.001) (Table 2, Figure 2, Figure 3, Figure 4).

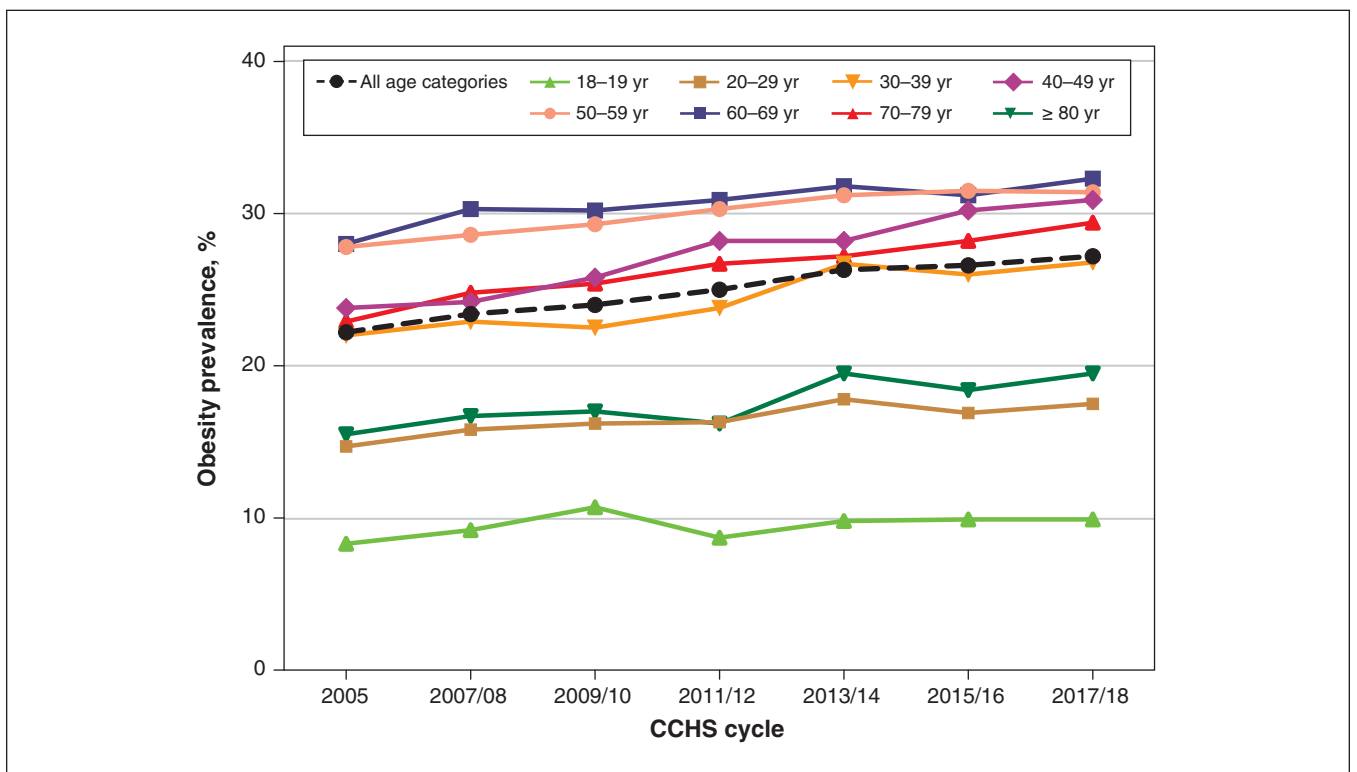
### Interpretation

Our study findings show that the prevalence of obesity among adults in Canada increased from 22.2% in 2005 to 27.2% in 2017/18. We observed this trend across sexes, in all studied age categories and in all provinces and territories. In 2017/18, the prevalence of obesity among males was substantially higher than among females; this pattern remained unchanged over the 14-year study period. Adults aged 40–69 years had the highest obesity prevalence, exceeding 30%; those aged 40–49 years had the largest increase. Almost 4 out of 10 residents of Newfoundland and Labrador lived with obesity in 2017/18; BC had the lowest prevalence of obesity in Canada, but nevertheless, at least every fifth person was affected in that province. Quebec and Alberta exhibited the largest relative increases in obesity prevalence from 2005 to 2017/18.

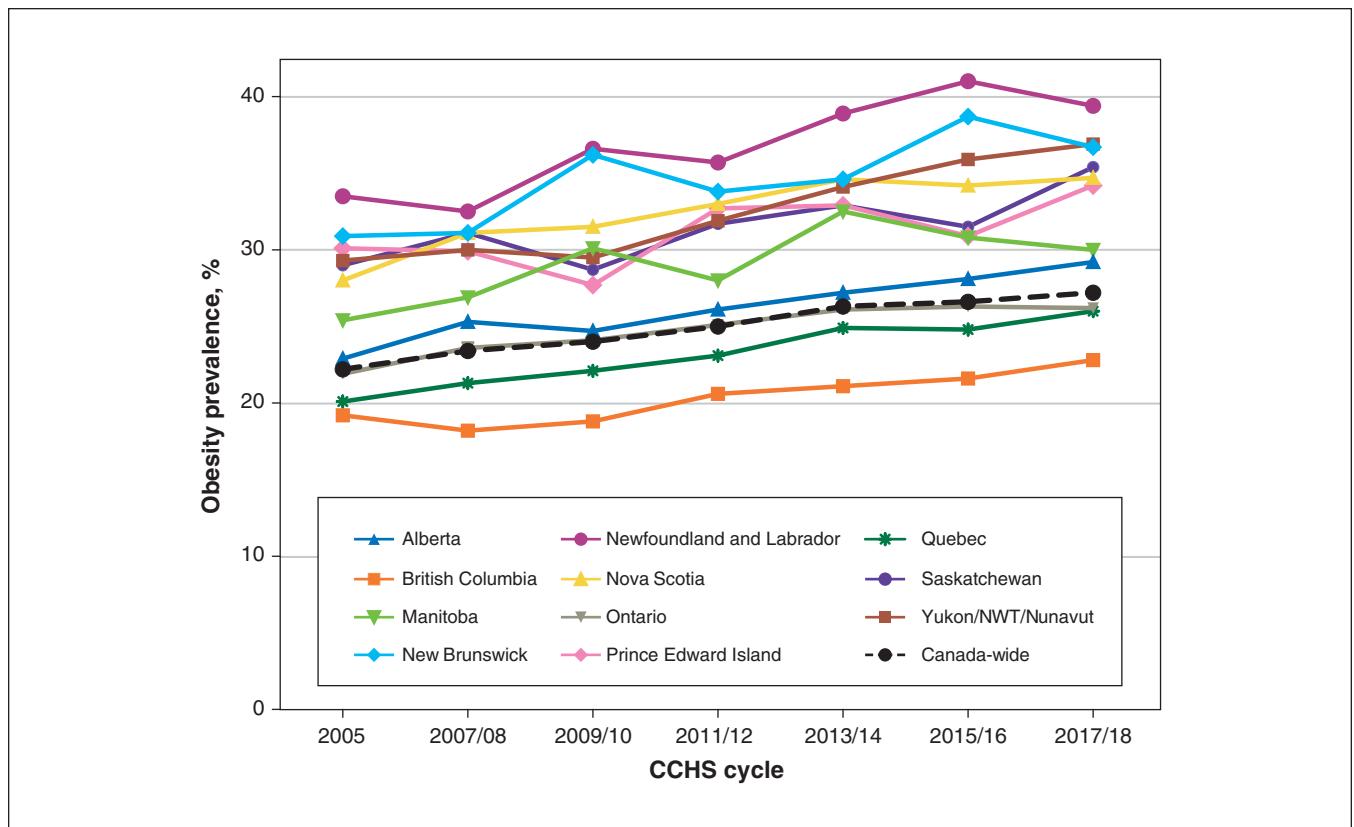
We analyzed data from 7 consecutive CCHS cycles, with large sample sizes and complete data that allowed for comprehensive trend analyses. In addition, we applied well-defined and robust methodological processes as we defined explicit inclusion and exclusion criteria, included the 18–19 year age category and excluded the underweight category from analyses, rederived weight categories based on 2-decimal point



**Figure 2:** Trends in obesity prevalence among adults in Canada, by sex, from 2005 through 2017/18. All groups showed a significantly increasing trend ( $p < 0.001$ ).



**Figure 3:** Trends in obesity prevalence among adults in Canada, by age category, from 2005 through 2017/18. All groups showed a significantly increasing trend ( $p < 0.001$ ).



**Figure 4:** Trends in obesity prevalence among adults in Canada, by province or territory, from 2005 through 2017/18. All groups showed a significantly increasing trend ( $p < 0.001$ ).

BMI values to improve precision and used correction equations. A previous study comparing obesity prevalence between nonconsecutive CCHS cycles was based on data up to 2013.<sup>20</sup> Therefore, it is challenging to compare our findings with those of other studies directly.

Based on data from the WHO Global Health Observatory data repository, the prevalence of obesity in Canada was 23.3% in 2005 and increased to 29.4% by 2016, higher than the prevalence reported in our study.<sup>38</sup> Other high-income, English-speaking countries had similar increases, including Australia (from 22.9% to 29.0%), Ireland (from 18.7% to 25.3%), New Zealand (from 24.4% to 30.8%), the United Kingdom (from 21.4% to 27.8%) and the United States (from 29.0% to 36.2%). Global relative increases for obesity were even higher (from 9.9% to 13.1%).<sup>38</sup> Overall, the trends identified in our study are comparable with global data, reflecting the consistently increasing prevalence of obesity worldwide.<sup>39–41</sup>

In multiple studies across the world, obesity has been identified as a major risk factor for cardiovascular diseases, different types of cancer and type 2 diabetes, along with their sequelae.<sup>3,4,8</sup> Over the last 20 years, cardiovascular diseases and cancers have been the leading causes of death in Canada, and type 2 diabetes carries the heaviest health care cost burden.<sup>42–44</sup> In addition, high BMI and adiposity-associated conditions, such as hypertension, hyperglycemia and hypercholesterolemia, are responsible for 27.1% of all-cause

disability-adjusted life years in Canada, and high BMI is the top risk factor contributing to years lived with disability.<sup>45</sup> The economic burden of cardiovascular diseases, cancer and type 2 diabetes combined exceeds \$23 billion in direct health care costs.<sup>46</sup>

Recent meta-analyses suggest that obesity is a key risk factor for SARS-CoV-2 infection and a strong predictor of its adverse outcomes. Obesity was associated with up to a 2.1-fold higher risk for severe COVID-19, a 2.4-fold higher risk for hospital admission, a 5.3-fold higher risk for ICU admission, a 7.4-fold higher risk for invasive mechanical ventilation support and a 2.7-fold higher risk for death.<sup>47–56</sup>

The trajectory of obesity trends in Canada and across provinces and territories is increasing alarmingly and poses a substantial concern that cannot be disregarded. To understand the Canadian subpopulations most affected, it would be essential to evaluate temporal obesity patterns by sociodemographic and behavioural factors, and trends in severe obesity. Addressing obesity and its associated comorbidities will require joint efforts from many sectors, including physicians (in primary care, those specializing in obesity medicine and specialists treating comorbidities) and other health care providers; public health professionals; various stakeholders at the municipal, provincial and federal levels (including policymakers, urban planners and developers shaping community environments); community organizations; the pharmaceutical industry; employers; academia; and those living with obesity.

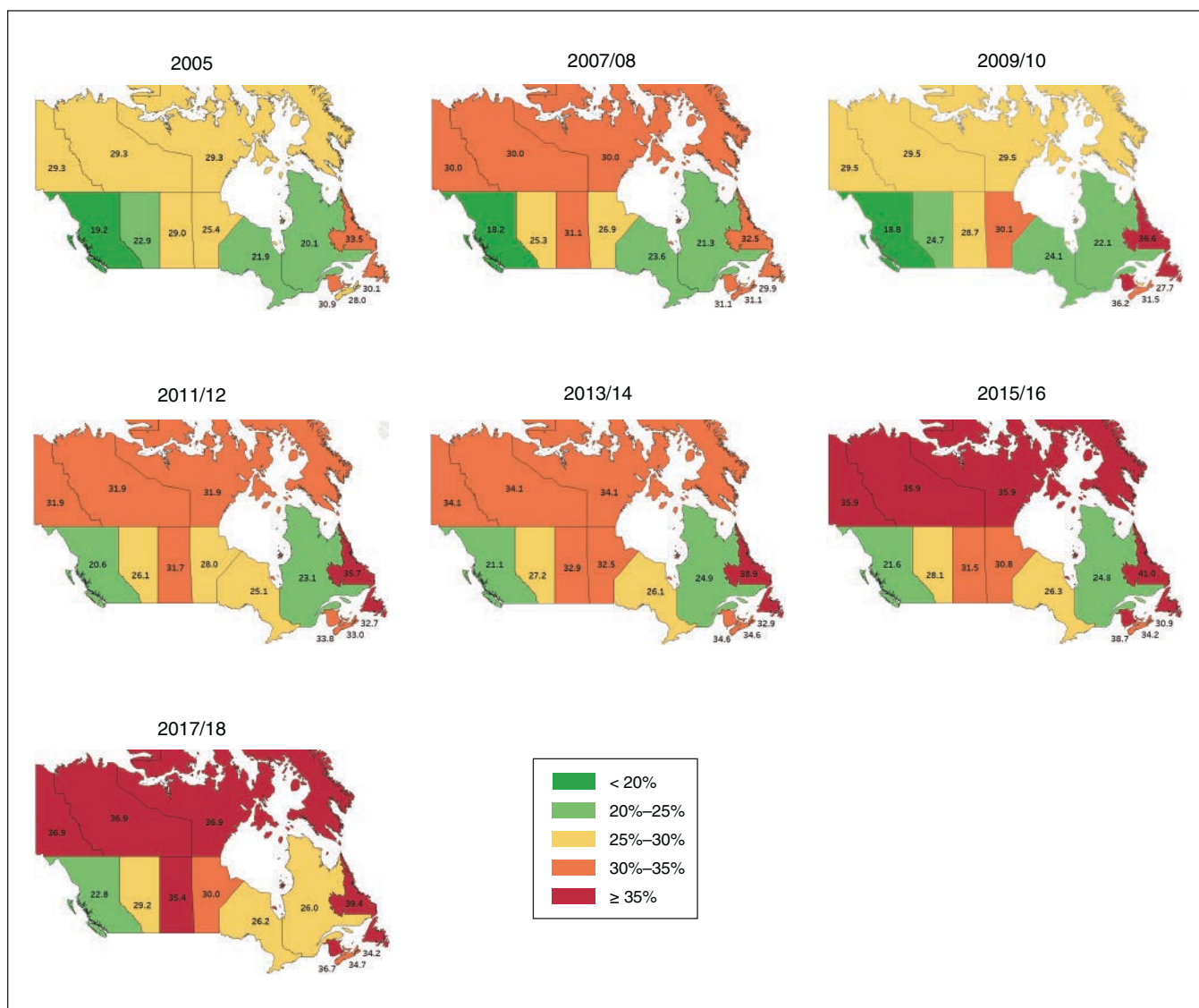


Figure 5: Prevalence of obesity among adults in Canada, from 2005 through 2017/18.

More recently, newly introduced medications for obesity and bariatric surgery are changing the overall approach to obesity management at an individual level.<sup>57</sup> At the population and community levels, many interventions aimed at behavioural modification and large-scale changes in policies, in built or human-made environments, and in social support systems in various settings show evidence of meaningful weight reduction and improvement in dietary patterns and physical activity levels.<sup>58</sup>

In 2017, the Chief Public Health Officer of Canada released the *Designing Healthy Living* report in a call to action to improve our community environments in support of healthy living.<sup>59</sup> Implementing and evaluating innovative interventions that have already shown reversals in longstanding obesity trends and increasing life expectancies from improvement in comorbidities at a population level should be a priority for all Canadian provinces and territories.<sup>59–74</sup> For example, policy and environmental approaches that successfully

reversed childhood obesity trends and increased life expectancies from chronic diseases in New York in 2002–2013 are being developed and evaluated in Canada through the *Housing for Health* initiative, funded by the Public Health Agency of Canada.<sup>75–77</sup> Learning from the US experience, the University of Alberta’s Public Health and Preventive Medicine Residency Program and patient care partners are also developing and piloting an adult Obesity Medicine Fellowship Program in Canada for approval by the Obesity Medicine Fellowship Council.<sup>78</sup>

### Limitations

Analyzing a series of cross-sectional studies does not assess for a definitive trend over time, given the lack of a clear longitudinal component. Recall, observer and social acceptability biases could also not be ruled out. Individuals living on reserves and other Indigenous settlements are excluded from CCHS coverage and, therefore, were excluded from our



study; however, Indigenous populations living off reserve were included in the study population. A higher prevalence of obesity among Indigenous people in Canada living on reserve, reaching 51% in some Indigenous populations, may have contributed to the underestimation of obesity prevalence.<sup>79</sup>

Use of BMI as a proxy of weight status does not take into consideration ethnicity, sex and body composition and can be an inaccurate marker of adiposity, with high specificity but low-to-moderate sensitivity.<sup>80,81</sup> Nevertheless, BMI has been shown to be a reliable standardized weight status measure at the population level.<sup>80–85</sup> The robustness of relationships between BMI, obesity-related comorbidities and mortality also reflects its high utility and reliability.<sup>86</sup> Tendency to under-report weight and over-report height, especially among people living with obesity, youth and females, can lead to underestimation of obesity prevalence but helps to avoid overestimation.<sup>29,87–90</sup> However, unless the tendency to under-report and over-report varies over time, this should not affect temporal trends. Self-reported anthropometric measurements correlate strongly with objective measures and can be used in epidemiological studies.<sup>91–93</sup> To overcome potential divergence, we applied correction equations developed and used by Statistics Canada to self-reported BMI estimates to produce adjusted BMI estimates that are maximally in line with measured ones.<sup>31–33</sup>

## Conclusion

Our study findings suggest that more than 1 in 4 adults in Canada lived with obesity in 2017/18. From 2005 to 2017/18, the prevalence of obesity increased substantially across sexes and age groups, and in all Canadian provinces and territories. We cannot afford to ignore the increasing prevalence of obesity and obesity-related comorbidities and their negative impact on health and well-being of the current Canadian population and our future generations. Our findings highlight the urgent need to identify, develop, implement and evaluate solutions for obesity prevention and management in Canada as well as funding for such efforts.

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**Data sharing:** The public use microdata files of the Canadian Community Health Survey are produced by Statistics Canada and are publicly accessible via the Data Liberation Initiative.

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