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Prevalence of age-specific and sex-specific overweight and obesity in Ontario and Quebec, Canada: a cross-sectional study using direct measures of height and weight

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ABSTRACT

Objective To evaluate whether combining three cycles of the Canadian Health Measures Survey (CHMS) produces provincially representative and valid estimates of overweight and obesity in Ontario and Quebec.

Setting An ongoing, nationally representative health survey in Canada, with data released every 2 years. Objective measures of height and weight were taken at mobile examination centres located within 100 km of participants' residences. To increase sample size, we combined three cycles completed during 2007–2013.

Participants 5740 Ontario residents and 3980 Quebec residents aged 6–79, with birth dates and directly measured height and weight recorded in the CHMS. Pregnant females were excluded. Sociodemographic characteristics of the Ontario and Quebec portions of the CHMS appeared similar to characteristics from the 2006 Canada Census.

Primary outcome measures Objectively measured overweight and obesity prevalence overall and among males and females in the following age groups: 6–11, 12–19, 20–39, 40–59 and 60–79. We compared these with provincially representative and objectively measured estimates from the 2015 Canadian Community Health Survey (CCHS)-Nutrition.

Results 57.1% (95% CI 52.8% to 61.4%) of Ontarians were classified overweight or obese and 24.0% (95% CI 20.3% to 27.6%) obese, while Quebec's corresponding percentages were 56.2% (95% CI 51.3% to 61.1%) and 24.4% (95% CI 20.6% to 28.3%). Generally, overweight and obesity combined was higher in older age groups and males. Comparisons with the CCHS-Nutrition did not yield unexplainable differences between surveys.

Conclusions Combining three CHMS cycles can produce estimates of overweight and obesity in populations representative of Ontario and Quebec. As new CHMS data are collected, these estimates can be updated and used to evaluate trends.

Strengths and limitations of this study

► In the Canadian provinces of Ontario and Quebec, this is the first study to estimate overweight and obesity prevalence using objective measures that will be updated regularly.
► This study assesses important attributes of the data to verify the validity of the estimates of overweight and obesity.
► The proportion of true cases of overweight and obesity that are identified by this study is difficult to assess due to the absence of gold-standard data on overweight and obesity.
► This study examines people aged 6–79, so is not able to estimate overweight and obesity among small children or the elderly.

cardiovascular disease, diabetes and premature mortality.[1] Globally, the prevalence of elevated BMI has increased rapidly since 1980, with a particularly high rate of increase among children.[1] Ongoing monitoring of overweight and obesity is needed to identify trends and search for causes, as well as to assess the effectiveness of programmes targeting BMI reduction. In Canada, however, there are no ongoing monitoring systems that capture provincially representative BMI data using objective measures.[2 3] We, therefore, assessed whether existing data sources can be used for BMI monitoring.

Data sources can be assessed using the Centers for Disease Control and Prevention's (CDC) attributes of effective surveillance systems: simplicity, stability, flexibility, timeliness, acceptability, representativeness, data quality, sensitivity and predictive value positive.[4] Electronic medical records (EMRs) often capture patients' heights and weights during medical system encounters. However, EMR systems and measurement practices are

INTRODUCTION

Overweight and obesity or high body mass index (BMI) are widespread conditions that can lead to serious health issues such as

not standardised, reducing data quality.[5] Representativeness is also problematic, as not all medical practices use EMRs and some people rarely use medical services.[5] Another option is the Canadian Community Health Survey (CCHS), an ongoing survey that asks for respondents' heights and weights.[6 7] Data quality is reduced by the biases observed in self-reported heights and weights.[8] Additionally, the CCHS does not assess children under 12, decreasing its representativeness.[6 7] The CCHS-Nutrition is a specialised CCHS version that covers people aged 1 and older and measures height and weight objectively; however, it is not regularly updated, so stability is problematic for regular monitoring.[9]

A promising option is the Canadian Health Measures Survey (CHMS), an ongoing survey of Canadians aged 3–79 that objectively measures height and weight, which are used to calculate BMI.[10–12] It was designed to be nationally representative; however, provincial-level estimates can be obtained for Ontario and Québec by combining multiple survey cycles.[13] Simplicity, stability, flexibility and timeliness are surveillance system attributes that can be evaluated without accessing CHMS microdata. Data can be acquired with relative simplicity, as data are collected and managed by a single organisation, Statistics Canada. Stability depends on continued funding of the CHMS. As of 2017, future cycle content was planned until at least 2023.[14] This content plan also provides an appropriate level of flexibility, as overweight and obesity are non-communicable conditions with stable definitions that change relatively slowly.[15 16] Timeliness is also acceptable, with data released in 2 year cycles, typically within a year after data collection.[10–12] Assessing the remaining CDC surveillance attributes requires analysis of the CHMS microdata. This study, therefore, has two objectives: (1) To assess the acceptability, representativeness, data quality, sensitivity and predictive value positive of the CHMS for monitoring overweight and obesity and (2) To estimate the prevalence of age-specific and sex-specific overweight and obesity in Ontario and Québec using the CHMS.

METHODS
Statistics Canada granted access to the CHMS through its Research Data Centre network.

Study design
The CHMS is an ongoing cross-sectional survey, run by Statistics Canada, that uses three-stage stratified sampling to obtain a sample representative of 96% of Canadians.[10–12] The target population excludes people in institutions, full-time members of the Canadian Armed Forces, the three Canadian territories and people living on reserves, other Aboriginal settlements or certain remote areas. We combined the first three cycles, completed between 2007 and 2013, to increase our sample size and obtain statistically stable estimates for Ontario and Québec.[13] As a result of combining cycles, estimates represent the average prevalence of overweight and obesity for the 2007–2013 timespan, rather than a specific year's prevalence.

Setting
Respondents completed questionnaires delivered in person in their homes using computer-assisted interviewing.[10–12] Participants then visited a mobile examination centre where direct measures were taken.

Population
Statistics Canada created bootstrap survey weights for the combined cycles to account for the complex sampling strategy and ensure that estimates can be considered nationally representative. We excluded respondents who were pregnant or were missing date of birth or directly measured height or weight. We also excluded respondents aged 3–5 because sampling variability in this age group was unacceptably high. Although females and males were combined in this age group, variability was high enough that estimates of overweight and obesity had to be interpreted with caution in both provinces, while estimates of obesity had to be interpreted with caution in Ontario and were unreportable in Québec.

Main measurements
Participants' heights were measured using a stadiometer if they could stand unassisted; otherwise, they were excluded from our analysis.[10] Weights were measured using a digital scale. We reported separate weighted estimates for the age and sex strata used in the CHMS sample allocation scheme: females and males separately aged 6–11, 12–19, 20–39, 40–59 and 60–79. We used bootstrapped survey weights to estimate the variance of the estimates.

Analysis
We assessed acceptability using the CHMS response rate, as this indicates the percentage of the population willing to have researchers measure their heights and weights. To evaluate representativeness of the CHMS populations in Ontario and Québec, we compared age, sex, ethnicity, education, immigrant status and household income with the results of the 2006 Canada Census.[17] We identified CHMS estimates with 95% CIs that did not include the census value, then calculated percentage point differences by subtracting CHMS point estimates from their corresponding census values. We examined data quality based on the two dimensions described by the CDC, completeness and validity.[4] Data were considered incomplete if respondents were missing birth dates or objectively measured height or weight. Birth dates were needed to calculate BMI z-scores using WHO SAS macro, a tool for calculating standardised BMI scores.[18] We examined validity using two indicators: whether BMI data were self-reported or directly measured by researchers and sampling variability of the estimates as measured by coefficient of variation (CV). Sensitivity is defined as the proportion of true health events identified by the system.[4] Predictive value positive is a related concept, calculated as

Table 1 Demographic characteristics of CHMS sample compared with 2006 census for Ontario, Québec and all of Canada

Variable	Canada			Ontario			Québec		
	Census	CHMS	Differ	Census	CHMS	Differ	Census	CHMS	Differ
Age									
Age 6–19 in CHMS, 5–19 in Census	21.0	**18.2 (18.1–18.3)**	2.8	21.5	**18.8 (18.7–19.0)**	2.7	19.6	**17.2 (16.7–17.6)**	2.4
Age 20–39	28.8	**30.4 (30.1–30.8)**	−1.6	27.5	**30.5 (30.2–30.7)**	−3.0	26.6	**29.4 (27.9–30.9)**	−2.8
Age 40–59	33.6	**33.2 (33.0–33.5)**	0.4	31.3	**33.2 (33.0–33.4)**	−1.9	32.7	33.6 (32.5–34.8)	−0.9
Age 60–79	16.5	**18.1 (17.8–18.4)**	−1.6	15.3	**17.5 (17.4–17.6)**	−2.2	17.0	**19.8 (18.1–21.4)**	−2.8
Sex									
Females	51.0	**49.8 (49.6–50.0)**	1.2	51.2	**50.1 (49.9–50.3)**	1.1	51.1	**49.7 (48.7–50.8)**	1.4
Males	49.0	**50.2 (50.0–50.4)**	−1.2	48.8	**49.9 (49.7–50.1)**	−1.1	48.9	**50.3 (49.2–51.3)**	−1.4
Ethnicity*									
Visible minority	16.2	20.6 (14.8–26.3)	−4.4	22.8	26.0 (14.5–37.5)†	−3.2	8.8	12.4 (4.0–20.8)†	−3.6
Not visible minority	83.8	**79.4 (73.6–85.1)**	4.4	77.2	73.9 (62.4–85.4)	3.3	91.2	87.6 (79.2–95.9)	3.6
Immigration‡									
Immigrant	20.0	23.6 (19.0–28.3)	−3.6	28.5	29.8 (21.1–38.4)	−1.3	11.5	15.3 (5.8–24.8)†	−3.8
Not immigrant	80.0	76.2 (71.5–80.9)	3.8	71.5	70.0 (61.1–78.8)	1.5	88.5	84.7 (75.2–94.2)	3.8
Education‡									
No certificate/diploma/degree	23.8	**25.4 (24.1–26.8)**	−1.6	22.2	**24.5 (23.0–26.1)**	−2.3	25.0	**28.8 (25.2–32.4)**	−3.8
High school certificate/diploma	25.5	**16.6 (15.0–18.1)**	8.9	26.8	**17.8 (15.1–20.6)**	9.0	22.3	**14.8 (13.3–16.3)**	7.5
Non-degree postsecondary	32.6	**34.8 (32.7–37.0)**	−2.2	30.5	32.4 (29.6–35.3)	−1.9	36.2	39.1 (34.0–44.3)	−2.9
Bachelor's degree or higher	18.1	21.6 (18.1–25.1)	−3.5	20.5	23.7 (18.4–29.0)	−3.2	16.5	15.3 (10.3–20.3)	1.2
Median household income	53 634	69 207	−15 573	60 455	74 009	−13 554	46 419	55 585	−9166

Census, 2006 Canada Census. Differ=absolute difference in percentage points between census estimate and CHMS point estimate. CHMS estimates in bold if census value not within 95% CI.
**'Not visible minority' includes people who identified as white or aboriginal, while 'visible minority' includes people who identified as other ethnicities (ie, non-white, non-aboriginal).
†Interpret with caution due to CV between 16.6% and 33.3%.
‡CHMS values may not add up to 100% due to missing values.
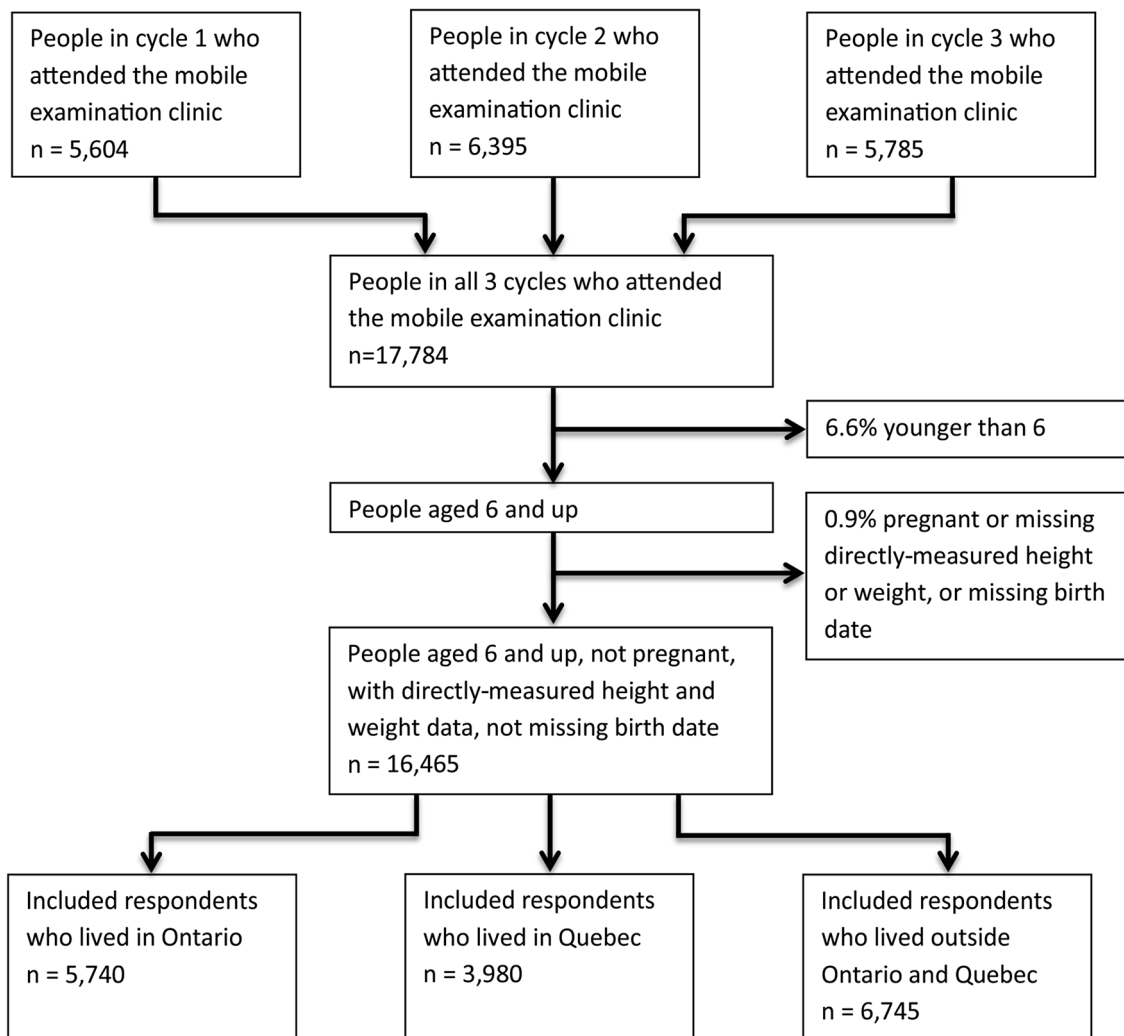CHMS, Canadian Health Measures Survey; CV, coefficient of variation.

Figure 1 Flow diagram of study sample inclusion.

the proportion of health events identified by the system that are truly classified as overweight and obese.[4] There was no gold-standard dataset to use as a reference when evaluating sensitivity and predictive value positive. The best available option was the 2015 CCHS-Nutrition, which used direct measures and was designed to be representative at the provincial level.[9] We used the publicly available CCHS-Nutrition data from Statistics Canada's website, which reported on age groups that did not perfectly align with CHMS age strata. We were, therefore, unable to compare age-specific estimates quantitatively and assessed the differences qualitatively instead. Additionally, the publicly available CCHS-Nutrition data did not include estimates of overweight and obesity combined, so comparisons are limited to estimates of obesity only.

We calculated BMI as weight (in kilograms) divided by squared height (in metres) for adults aged 19 and older, then classified respondents with BMIs over 25 as overweight or obese and those with BMIs over 30 as obese. For respondents aged 6–18, we used a tool from WHO that calculates BMI z-score,[18] then classified respondents with BMIs at least 1 SD above the mean as overweight or obese and those with BMIs at least 2 SDs above the mean as

obese. We then calculated the proportion overweight and obese and the proportion obese for all respondents and for the following subgroups: males; females; all respondents aged 6–12, 13–19, 20–39, 40–59, 60–79; and males and females separately in the aforementioned age groups. We did not report our calculation for respondents aged 3–5 due to high sampling variability in this age group.

Patient and public involvement

This study is a secondary data analysis of a health survey conducted by Statistics Canada. Respondents' data were de-identified, so it was not possible to involve them in development of the research question, design and conduct of the study or dissemination of the results.

RESULTS
Acceptability

All respondents who completed the household questionnaire were asked to visit the mobile examination centre to have direct measures taken. The combined response rates for people who completed the household questionnaire and visited the mobile examination centres were

Table 2 Obesity estimates from CHMS (n=16 465) and CCHS-Nutrition (n~24 000)

	CHMS 2007–2013			CCHS-Nutrition 2015	
Ontario females	Age 6–11	9.6 (6.1–13.1)*		Age 5–11	NR
	Age 12–19	14.5 (9.3–19.8)*		Age 12–17	8.9 (5.2–14.9)*
	Age 20–39	22.0 (14.7–29.3)		Age 18–34	15.0 (9.3–23.5)*
	Age 40–59	27.4 (19.4–35.3)		Age 35–44	21.1 (12.6–33.2)*
	Age 60–79	30.8 (25.0–36.5)		Age 45–64	31.2 (24.0–39.3)
				Age 65+	20.0 (14.6–26.9)
Ontario males	Age 6–11	13.8 (10.4–17.1)		Age 5–11	13.4 (7.9–21.9)*
	Age 12–19	16.4 (9.9–22.9)*		Age 12–17	21.2 (13.8–31.1)*
	Age 20–39	19.1 (13.3–24.8)		Age 18–34	NR
	Age 40–59	31.9 (26.2–37.6)		Age 35–44	34.6 (22.2–49.5)*
	Age 60–79	29.1 (20.7–37.5)		Age 45–64	29.1 (21.9–37.6)
				Age 65+	34.6 (26.5–43.7)
Québec females	Age 6–11	10.5 (5.2–15.7)*		Age 5–11	NR
	Age 12–19	7.1 (4.0–10.2)*		Age 12–17	NR
	Age 20–39	22.6 (10.7–34.6)*		Age 18–34	24.7 (13.4–41.0)*
	Age 40–59	29.6 (20.5–38.6)		Age 35–44	30.2 (16.4–49.0)*
	Age 60–79	34.2 (28.5–39.9)		Age 45–64	18.3 (12.2–26.7)*
				Age 65+	26.4 (19.4–34.9)
Québec males	Age 6–11	15.2 (11.7–18.7)		Age 5–11	7.7 (4.4–13.3)*
	Age 12–19	NR		Age 12–17	14.4 (8.5–23.4)*
	Age 20–39	18.1 (11.9–24.3)		Age 18–34	9.5 (5.0–17.3)*
	Age 40–59	26.8 (19.3–34.2)		Age 35–44	18.7 (10.2–31.9)*
	Age 60–79	36.0 (30.5–41.4)		Age 45–64	27.7 (20.8–35.9)
				Age 65+	34.4 (25.1–45.1)

NR, not reported due to CV greater than 33.3%.
*Interpret with caution due to CV between 16.6% and 33.3%.
CCHS, Canadian Community Health Survey; CHMS, Canadian Health Measures Survey; CV, coefficient of variation.

51.7%, 55.5% and 51.7%, for CHMS cycles 1, 2 and 3, respectively.[10 19 20] The response rate for all three cycles combined was 52.9%.[13]

Representativeness

Table 1 compares sociodemographic characteristics of the Ontario and Québec portions of the CHMS sample, as well as the Canada-wide sample, with the corresponding regions from the 2006 Canada Census. The Canada-wide CHMS sample was designed to represent Canada's population characteristics, so the Canada-wide comparisons are a benchmark for the Ontario and Québec comparisons. Differences between the Ontario and Québec CHMS samples and the census were similar across the two provinces and to those in the nationally representative Canada-wide sample, pointing to systematic differences between the CHMS and census, rather than random differences. The largest percentage point differences were in highest education achieved. Median household income, the only continuous variable compared, was higher in the CHMS sample in all three regions.

Data quality

Few (<1%) of the included respondents were missing data on birth date or objectively measured height or weight (see figure 1). Regarding validity, the objective measures of height and weight captured in the CHMS provide more valid estimates of BMI than self-reported measures.[16] However, the CVs for some estimates were high, indicating that repeated samples from the same population might produce substantially different estimates. Among 3–5 years, the CVs for all of the estimates were above 16.6% and one was above 33.3%. Respectively, these are Statistics Canada's thresholds for 'interpret with caution' and 'not reportable', so we excluded this age group entirely. In the remaining age groups, none of the estimates of overweight and obesity combined had CVs above 16.6%. In both Ontario and Québec, three of the estimates of obesity had CVs from 16.6% to 33.3% and must be interpreted with caution (see table 2). Additionally, the estimate of obesity among Québec males aged 12–19 had a CV above 33.3%, so we did not report this estimate.
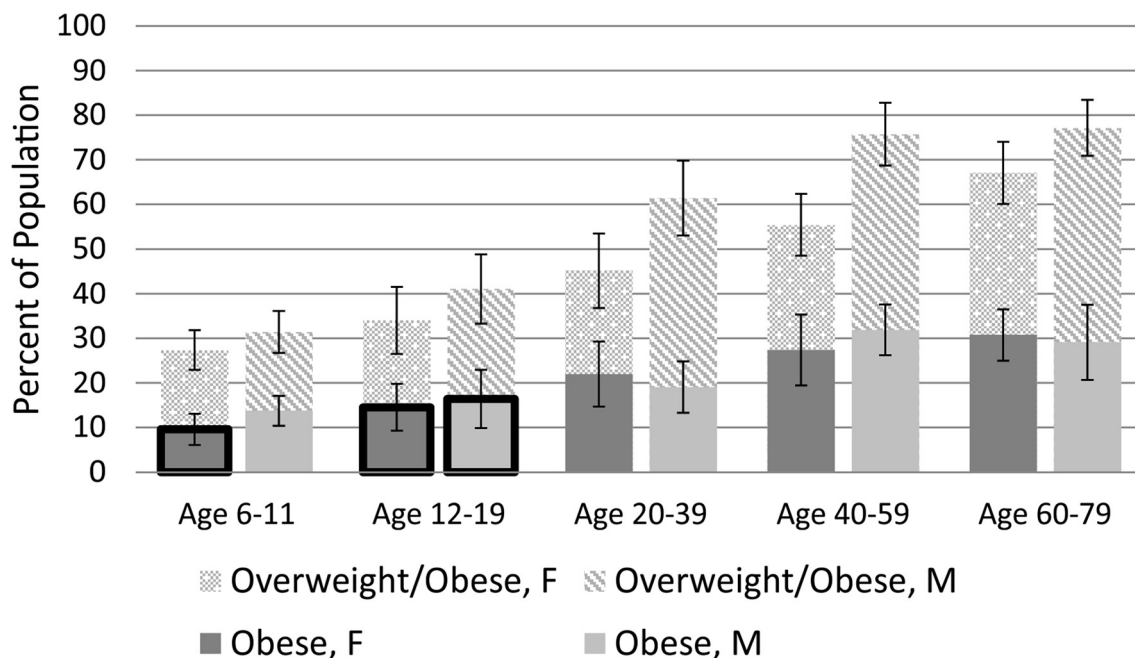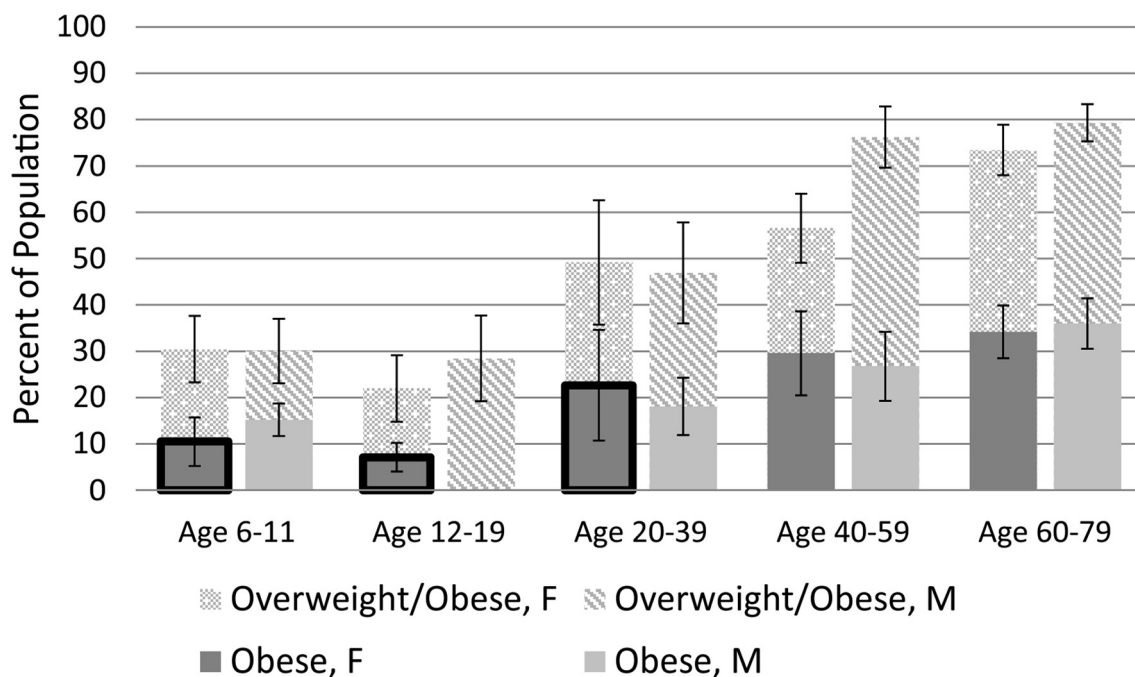
Figure 2 Prevalence of overweight and obesity and prevalence of obesity by age and sex in Ontario, from 2007 to 2013 cycles of the Canadian Health Measures Survey. Error bars represent 95% CI around each estimate. Black border indicates an estimate that must be interpreted with caution due to a coefficient of variation over 16.6%. F, female; M, male.

Sensitivity and predictive value positive

Table 2 shows estimates of obesity prevalence in various age–sex groups from the CHMS and the CCHS-Nutrition. While the age categories do not perfectly align, we expect older age categories to have successively higher levels of obesity, with the exception of people over 65.[21] Estimates for two CCHS-Nutrition subgroups were lower than expected: Québec females aged 45–64 and Québec males aged 18–34.

Prevalence of overweight and obesity and prevalence of obesity

In Ontario, 57.1% (95% CI 52.8% to 61.4%) of all CHMS respondents, 50.1% (95% CI 45.4% to 54.7%) of females

Figure 3 Prevalence of overweight and obesity and prevalence of obesity by age and sex in Québec, from 2007 to 2013 cycles of the Canadian Health Measures Survey. Error bars represent 95% CI around each estimate. Black borders indicate an estimate that must be interpreted with caution due to a coefficient of variation over 16.6%. Data not shown if coefficient of variation over 33.3%. F, female; M, male.

and 64.1% (95% CI 59.2% to 68.9%) of males were classified as overweight or obese; 24.0% (95% CI 20.3% to 27.6%) of all Ontarians, 23.7% (95% CI 18.6% to 28.7%) of females and 24.3% (95% CI 20.6% to 28.0%) of males were classified as obese. In Québec, 56.2% (95% CI 51.3% to 61.1%) of all respondents, 52.7% (95% CI 46.2% to 59.2%) of females and 59.6% (95% CI 54.1% to 65.2%) of males were classified as overweight or obese; 24.4% (95% CI 20.6% to 28.3%) of all Québecers, 25.0% (95% CI 19.6% to 30.5%) of females and 23.9% (95% CI 20.1% to 27.7%) of males were classified as obese. Figure 2 shows the prevalence of overweight and obesity combined and the prevalence of obesity for females and males in five age groups in Ontario, as estimated by the CHMS. Figure 3 shows the same information for Québec.

DISCUSSION

Averaged over 2007–2013, over half of the populations of Ontario and Québec aged 6–79 were affected by overweight or obesity, with almost a quarter affected by obesity. While levels tended to be higher in older age groups and among males, overweight and obesity were high across all age–sex groups. These results are similar to other Canadian prevalence estimates based on different data sources.[21 22] Acceptability, based on the combined CHMS response rate of 53%, is in line with similar surveys of directly measured height and weight in the USA and several European countries, which have ranged from 45% to 69% in recent years.[23 24] Additionally, the CHMS appears to be representative of the populations of Ontario and Québec based on comparisons with the census. While the proportion of respondents with 'high school diploma' as their highest education level was higher in the census, this was likely due to two reasons. First, the census excluded people younger than 15 from its education question, most of whom would have yet to complete high school. Second, census respondents with some postsecondary education who did not complete a degree/certificate/diploma were categorised as 'high school only', while similar respondents in the CHMS were categorised as 'some postsecondary'. Median incomes were also higher in the CHMS; however, differences may be due to the time difference between the 2006 census and the 2007–2013 CHMS sample, as median incomes in Canada rose during this period.[25]

Sensitivity and predictive value positive were difficult to assess, as there was no provincially representative gold standard of overweight and obesity prevalence. The best available option was the CCHS-Nutrition. Qualitative comparisons yielded two notable differences in obesity prevalence, which can both be attributed to high sampling variability in the CCHS-Nutrition. Lastly, data quality is acceptable, as indicated by the high degree of completeness and the objective height and weight measures, which are more accurate than self-reported measures.[16] Correction factors have been developed to account for biased self-reported BMI values; however, residual bias remains after applying these because the biases vary by geography, time, age, sex and socioeconomic status.[16] The high variability among some obesity estimates reduced data quality. Several age-specific and sex-specific estimates of obesity in both Ontario and Québec need to be interpreted with caution and one obesity estimate in Québec was not reportable. However, none of the estimates of overweight and obesity combined in the CHMS had to be interpreted with caution.

Limitations

There are some limitations to our analysis that should be considered. For one, the time period of the CHMS was 2007–2013, which did not overlap with the 2006 Census or the 2015 CCHS-Nutrition. However, we do not expect significant changes in sociodemographic characteristics or overweight and obesity to occur over time differences of this length. Representativeness of later CHMS cycles can be examined using the 2016 Canada Census.[26] Additionally, the publicly accessible data from the CCHS-Nutrition was not available in categories that exactly aligned with the CHMS sampling strata, which limited our assessment of sensitivity and predictive value positive to qualitative comparisons. Another limitation was that the usable CHMS data excluded respondents younger than 6 and older than 79 at the time of the household interview, so results are only representative within this age range. There are also limitations with the BMI metric, which does not measure the percentage or distribution of body fat and may be less accurate for certain populations, such as very muscular people.[27] Nonetheless, BMI is a useful metric due to its correlation with disease outcomes, ease of collection and widespread use.[15 27]

CONCLUSION

Combining three CHMS cycles appears to be, at present, the best available option for ongoing monitoring of objectively measured overweight and obesity prevalence in Ontario and Québec. Six-year rolling averages, from combining three 2-year cycles, can be produced every 2 years as new cycles become available. Policy-makers and researchers can use CHMS data to evaluate whether interventions are effective at reducing the high prevalence of overweight and obesity in Ontario and Québec. The CHMS directly measures many other health indicators, such as indicators of diagnosed and undiagnosed diabetes.[14 28] Future analyses should examine whether valid Ontario and Quebec-level estimates can be obtained for other measures that are not available in routinely collected provincial data sources.

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