BMJ Open

BMJ Open is committed to open peer review. As part of this commitment we make the peer review history of every article we publish publicly available.

When an article is published we post the peer reviewers' comments and the authors' responses online. We also post the versions of the paper that were used during peer review. These are the versions that the peer review comments apply to.

The versions of the paper that follow are the versions that were submitted during the peer review process. They are not the versions of record or the final published versions. They should not be cited or distributed as the published version of this manuscript.

BMJ Open is an open access journal and the full, final, typeset and author-corrected version of record of the manuscript is available on our site with no access controls, subscription charges or pay-per-view fees (http://bmjopen.bmj.com).

If you have any questions on BMJ Open's open peer review process please email info.bmjopen@bmj.com

BMJ Open: first published as 10.1136/bmjopen-2018-022029 on 5 September 2018. Downloaded from http://bmjopen.bmj.com/ on April 23, 2024 by guest. Protected by copyright.

BMJ Open

Measuring the obesity epidemic: Combining cycles of a cross-sectional national health survey for sub-national monitoring of overweight and obesity

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2018-022029
Article Type:	Research
Date Submitted by the Author:	02-Feb-2018
Complete List of Authors:	Thielman, Justin; Public Health Ontario, Health Promotion, Chronic Disease & Injury Prevention Harrington, Daniel; Public Health Ontario, Health Promotion, Chronic Disease and Injury Prevention Rosella, Laura; University of Toronto, Manson, Heather; Public Health Ontario, Health Promotion, Chronic Disease and Injury Prevention
Keywords:	EPIDEMIOLOGY, PREVENTIVE MEDICINE, PUBLIC HEALTH, STATISTICS & RESEARCH METHODS

SCHOLARONE™
Manuscripts

For peer review only

BMJ Open: first published as 10.1136/bmjopen-2018-022029 on 5 September 2018. Downloaded from http://bmjopen.bmj.com/ on April 23, 2024 by guest. Protected by copyright.

TITLE PAGE

Title:

Measuring the obesity epidemic: Combining cycles of a cross-sectional national health survey for sub-national monitoring of overweight and obesity.

Corresponding author:
Justin Thielman
480 University Avenue, Suite 300
Toronto, Ontario, Canada, M5G 1V2
e: justin.thielman@oahpp.ca
t: 647-260-7525

Authors and affiliations:
Thielman, Justin,[1] Harrington, Daniel,[1,2] Rosella, Laura,[1,3] Manson, Heather.[1,2,3]

1. Department of Health Promotion, Chronic Disease & Injury Prevention
   Public Health Ontario
   Toronto, Canada
2. School of Public Health and Health Systems
   University of Waterloo
   Waterloo, Canada
3. Dalla Lana School of Public Health
   University of Toronto
   Toronto, Canada

Word count: 2,474

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

BMJ Open: first published as 10.1136/bmjopen-2018-022029 on 5 September 2018. Downloaded from http://bmjopen.bmj.com/ on April 23, 2024 by guest. Protected by copyright.

For peer review only

BMJ Open: first published as 10.1136/bmjopen-2018-022029 on 5 September 2018. Downloaded from http://bmjopen.bmj.com/ on April 23, 2024 by guest. Protected by copyright.

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 two 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: 5,740 Ontario residents and 3,980 Quebec residents aged 6-79, with birth dates and directly-measured height and weight recorded in the CHMS. Pregnant females were excluded. Socio-demographic 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, 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% confidence interval (CI): 52.8-61.4] of Ontarians were classified overweight or obese and 24.0% [95% CI: 20.3-27.6] obese, while Quebec's corresponding percentages were 56.2% [95% CI: 51.3-61.1] and 24.4% [95% CI: 20.6-28.3]. Generally, overweight and obesity 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.

Keywords: Epidemiology; Preventive Medicine; Obesity; Public Health; Surveillance; Statistics & Research Methods

Article summary – strengths and limitations of this study:

- This is the first study to produce provincial-level estimates of overweight and obesity using objectively-measured data from a regularly updated survey
- This study assesses whether data collected for national-level estimates can be used to produce sub-national estimates of overweight and obesity

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

- 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
- This study examines people aged 6-79, so is not able to estimate overweight and obesity among small children or the elderly

What is already known on this subject:

Monitoring the prevalence of overweight and obesity at sub-national levels is necessary to evaluate programs that target this health issue. However, Canadian data sources for provincial-level monitoring are limited; some sources do not include children younger than 12 and rely on self-reported data, others are not updated regularly. One data source, the Canadian Health Measures Survey, measures overweight and obesity objectively for Canadians aged 3-79 and is updated regularly, but is not designed to be provincially representative.

What this study adds:

In a novel approach to provincial-level monitoring, we combined multiple cycles of the Canadian Health Measures Survey to obtain provincial-level estimates of overweight and obesity for Ontario and Quebec. Our analyses showed that over half of the population in each province was affected by overweight or obesity. Socio-demographic characteristics of the survey respondents in both provinces were representative of their respective populations and the quality of the data on overweight and obesity was acceptable. This approach appears to be the best available option for ongoing monitoring of overweight and obesity in Ontario and Quebec.

For peer review only

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

BMJ Open: first published as 10.1136/bmjopen-2018-022029 on 5 September 2018. Downloaded from http://bmjopen.bmj.com/ on April 23, 2024 by guest. Protected by copyright.

BMJ Open: first published as 10.1136/bmjopen-2018-022029 on 5 September 2018. Downloaded from http://bmjopen.bmj.com/ on April 23, 2024 by guest. Protected by copyright.

INTRODUCTION

Overweight and obesity, or high body mass index (BMI), are widespread conditions that can lead to serious health issues.(1) Ongoing monitoring of overweight and obesity is needed to identify trends and search for causes, as well as to assess the effectiveness of programs targeting BMI reduction. In Canada, 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 not standardized, 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 specialized CCHS version that covers people aged one 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 organization, 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 two-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- and sex-specific overweight and obesity in Ontario and Québec using the CHMS.

METHODS

Ethics approval

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

The Ethics Review Board at Public Health Ontario approved this study after reviewing the protocol. Statistics Canada granted access to the CHMS through its Research Data Centre network.

Study design

The CHMS is an ongoing cross-sectional survey that uses three-stage stratified sampling to obtain a sample representative of 96% of Canadians.(10–12) It 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% confidence intervals (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 was considered incomplete if respondents were missing birth

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

BMJ Open: first published as 10.1136/bmjopen-2018-022029 on 5 September 2018. Downloaded from http://bmjopen.bmj.com/ on April 23, 2024 by guest. Protected by copyright.

dates or objectively-measured height or weight. Birth dates were needed to calculate BMI z-scores using the WHO SAS macro, a tool for calculating standardized 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 coefficients 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 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 the World Health Organization that calculates BMI z-score,(18) then classified respondents with BMIs at least one standard deviation above the mean as overweight or obese and those with BMIs at least two standard deviations 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.

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 rate for people who completed the household questionnaire and visited the mobile examination centre was 52.9% for CHMS cycles 1-3 combined.(13)

Representativeness

Table 1 compares socio-demographic 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

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

BMJ Open: first published as 10.1136/bmjopen-2018-022029 on 5 September 2018. Downloaded from http://bmjopen.bmj.com/ on April 23, 2024 by guest. Protected by copyright.

differences were in highest education achieved. Median household income, the only continuous variable compared, was higher in the CHMS sample in all three regions.

For peer review only

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

BMJ Open: first published as 10.1136/bmjopen-2018-022029 on 5 September 2018. Downloaded from http://bmjopen.bmj.com/ on April 23, 2024 by guest. Protected by copyright.

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

	Canada			Ontario			Québec		
Variable	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 post-secondary	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	-9,166

Census = 2006 Canada Census. CHMS = Canadian Health Measures Survey. Differ = absolute difference in percentage points between census estimate and CHMS point estimate. CHMS estimates in bold if census value not within 95% confidence interval. *CHMS values may not add up to 100% due to missing values. †Interpret with caution due to CV between 16.6% and 33.3%.

For peer review only

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

BMJ Open: first published as 10.1136/bmjopen-2018-022029 on 5 September 2018. Downloaded from http://bmjopen.bmj.com/ on April 23, 2024 by guest. Protected by copyright.

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, among 3-5 year olds, 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%-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.

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%.

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

BMJ Open: first published as 10.1136/bmjopen-2018-022029 on 5 September 2018. Downloaded from http://bmjopen.bmj.com/ on April 23, 2024 by guest. Protected by copyright.

BMJ Open: first published as 10.1136/bmjopen-2018-022029 on 5 September 2018. Downloaded from http://bmjopen.bmj.com/ on April 23, 2024 by guest. Protected by copyright.

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.(19) 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: 52.8-61.4] of all CHMS respondents, 50.1% [95% CI: 45.4-54.7] of females, and 64.1% [95% CI: 59.2-68.9] of males were classified as overweight or obese; 24.0% [95% CI: 20.3-27.6] of all Ontarians, 23.7% [95% CI: 18.6-28.7] of females, and 24.3% [95% CI: 20.6-28.0] of males were classified as obese. In Québec, 56.2% [95% CI: 51.3-61.1] of all respondents, 52.7% [95% CI: 46.2-59.2] of females, and 59.6% [95% CI: 54.1-65.2] of males were classified as overweight or obese; 24.4% [95% CI: 20.6-28.3] of all Québecers, 25.0% [95% CI: 19.6-30.5] of females, and 23.9% [95% CI: 20.1-27.7] 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. On average, older respondents and males tended to have higher BMIs.

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.(19,20) Acceptability, based on the combined CHMS response rate of 53%, is in line with similar surveys of directly-measured height and weight in the United States and several European countries, which have ranged from 45% to 69% in recent years.(21,22) 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 post-secondary education who did not complete a degree/certificate/diploma were categorized as 'high school only', while similar respondents in the CHMS were categorized as 'some post-secondary'. 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.(23)

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

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-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 socio-demographic 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.(24) 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.(25) Nonetheless, BMI is useful metric due to its correlation with disease outcomes, ease of collection, and widespread use.(15,25)

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 two-year cycles, can be produced every two years as new cycles become available. Policymakers 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.(14,26) 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.

Contributorship statement:

JT, DH, LR, and HM contributed to conceptualizing and designing the study, planning analytical methods, and analyzing and interpreting statistical output. JT conducted the literature review, statistical analysis, and drafted the manuscript. JT, DH, LR, and HM reviewed the manuscript for intellectual content, made

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

BMJ Open: first published as 10.1136/bmjopen-2018-022029 on 5 September 2018. Downloaded from http://bmjopen.bmj.com/ on April 23, 2024 by guest. Protected by copyright.

revisions as needed, and approved the final version for publication. JT, DH, LR, and HM agree to be accountable for this work and to ensure that questions relating to the work are investigated and resolved.

Acknowledgements

Statistics Canada's Research Data Centre Program made the Canadian Health Measures Survey data available and provided support for working with these data.

Competing interests

The authors have no competing interests to declare.

Funding

Financial support for this study was provided to all authors by Public Health. The opinions, results and conclusions reported in this paper are those of the authors and are independent from the funding source. The study sponsor had no role in the study design; collection, analysis, or interpretation of data; report writing or review; approval of the manuscript; or the decision to submit for publication.

Data sharing statement

No additional data are available.

Figure legends

Figure 1: Flow diagram of study sample inclusion

Figure 2: Prevalence of overweight and obesity and prevalence of obesity by age and sex in Ontario.
F = Female. M = Male. Error bars represent 95% confidence interval around each estimate. Black border indicates an estimate that must be interpreted with caution due to a coefficient of variation over 16.6%.

Figure 3: Prevalence of overweight and obesity and prevalence of obesity by age and sex in Québec.
F = Female. M = Male. Error bars represent 95% confidence interval 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%.

REFERENCES

1. The GBD 2015 Obesity Collaborators. Health Effects of Overweight and Obesity in 195 Countries over 25 Years. *N Engl J Med*. 2017;377(1):13–27.
2. Public Health Ontario. Addressing Obesity in Children and Youth: Evidence to Guide Action for Ontario [Internet]. 2013 [accessed 2017 Dec 21]. p. 1–288. Available from: https://www.publichealthontario.ca/en/eRepository/Addressing_Obesity_Children_Youth_Sept2013.pdf
3. Healthy Kids Panel. No time to wait: the healthy kids strategy [Internet]. 2013 [accessed 2017 Dec 21]. p. 63. Available from: http://www.health.gov.on.ca/en/common/ministry/publications/reports/healthy_kids/healthy_kids.pdf

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

BMJ Open: first published as 10.1136/bmjopen-2018-022029 on 5 September 2018. Downloaded from http://bmjopen.bmj.com/ on April 23, 2024 by guest. Protected by copyright.

4. Centers for Disease Control and Prevention. Updated guidelines for evaluating public health surveillance systems [Internet]. 2001 [accessed 2017 Dec 21]. Available from: https://www.cdc.gov/mmwr/preview/mmwrhtml/rr5013a1.htm
5. Birken CS, Tu K, Oud W, et al. Determining rates of overweight and obese status in children using electronic medical records. *Can Fam Physician*. 2017;63:e114–22.
6. Statistics Canada. Canadian Community Health Survey (CCHS) Annual component. User guide 2010 and 2009-2010 Microdata files [Internet]. 2011 [accessed 2017 Dec 21]. Available from: http://www23.statcan.gc.ca/imdb-bmdi/pub/document/3226_D7_T9_V8-eng.pdf
7. Canada S. Canadian Community Health Survey (CCHS) Annual component. User guide 2007-2008 Microdata files [Internet]. 2009 [accessed 2017 Dec 21]. Available from: http://www23.statcan.gc.ca/imdb-bmdi/pub/document/3226_D7_T9_V6-eng.pdf
8. Yun S, Zhu B-P, Black W, et al. A comparison of national estimates of obesity prevalence from the behavioral risk factor surveillance system and the national health and nutrition examination survey. *Int J Obes*. 2006;30:164–70.
9. Statistics Canada. Canadian Community Health Survey - Nutrition (CCHS) [Internet]. 2017 [accessed 2017 Dec 21]. Available from: http://www23.statcan.gc.ca/imdb/p2SV.pl?Function=getSurvey&SDDS=5049
10. Statistics Canada. Canadian Health Measures Survey (CHMS) Data User Guide: Cycle 1 [Internet]. 2011 [accessed 2017 Dec 21]. Available from: http://www23.statcan.gc.ca/imdb-bmdi/document/5071_D2_T1_V1-eng.htm#a5_3_2_2
11. Statistics Canada. Canadian Health Measures Survey (CHMS). Detailed information for August 2009 to November 2011 (Cycle 2) [Internet]. 2012 [accessed 2017 Dec 21]. Available from: http://www23.statcan.gc.ca/imdb/p2SV.pl?Function=getSurvey&Id=62444#a4
12. Statistics Canada. Canadian Health Measures Survey (CHMS). Detailed information for January 2012 to December 2013 (Cycle 3) [Internet]. 2014 [accessed 2017 Dec 21]. Available from: http://www23.statcan.gc.ca/imdb/p2SV.pl?Function=getSurvey&Id=136652
13. Statistics Canada. Instructions for Combining Multiple Cycles of Canadian Health Measures Survey (CHMS) Data. 2015.
14. Canadian Health Measures Survey (CHMS) Content summary for cycles 1 to 8. 2015.
15. Kuczmarski RJ, Flegal KM. Criteria for definition of overweight in transition: Background and recommendations for the United States. *Am J Clin Nutr*. 2000;72(5):1074–81.
16. NCD Risk Factor Collaboration. Trends in adult body-mass index in 200 countries from 1975 to 2014: a pooled analysis of 1698 population-based measurement studies with 19·2 million participants. *Lancet*. 2016 Apr 2;387(10026):1377–96.
17. Statistics Canada. 2006 Census Dictionary [Internet]. 2008 [accessed 2017 Dec 21]. Available from: http://www12.statcan.gc.ca/census-recensement/2006/ref/dict/index-eng.cfm
18. World Health Organization. Growth reference 5-19 years [Internet]. 2015 [accessed 2017 Dec 21]. Available from: http://www.who.int/growthref/tools/en/
19. Statistics Canada. Overweight and obese adults (self-reported), 2014 [Internet]. Health Fact Sheets. 2015 [accessed 2017 Dec 21]. Available from: https://www.statcan.gc.ca/pub/82-625-x/2015001/article/14185-eng.htm
20. Shields M, Tremblay MS. Canadian childhood obesity estimates based on WHO, IOTF and CDC cut-points. *Int J Pediatr Obes*. 2010;5(3):265–73.
21. Mindell JS, Giampaoli S, Goesswald A, et al. Sample selection, recruitment and participation rates in health examination surveys in Europe--experience from seven national surveys. *BMC Med Res Methodol*. 2015;15:78.
22. Centers for Disease Control and Prevention. National Health and Nutrition Examination Survey: Questionnaires, Datasets, and Related Documentation [Internet]. 2016 [accessed 2017 Dec 21].

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

BMJ Open: first published as 10.1136/bmjopen-2018-022029 on 5 September 2018. Downloaded from http://bmjopen.bmj.com/ on April 23, 2024 by guest. Protected by copyright.

Available from: https://www.cdc.gov/nchs/nhanes/nhanes_questionnaires.htm

23. Statistics Canada. Income of Canadians, 2000 to 2013 [Internet]. 2015 [accessed 2017 Dec 21]. p. 1–6. Available from: http://www.statcan.gc.ca/daily-quotidien/151217/dq151217c-eng.htm
24. Statistics Canada. Data Products, 2016 Census [Internet]. 2017 [accessed 2017 Dec 21]. Available from: http://www12.statcan.gc.ca/census-recensement/2016/dp-pd/index-eng.cfm
25. Health Canada. Canadian Guidelines Guidelines for Weight Classification Classification in Adults [Internet]. 2003 [accessed 2017 Dec 21]. Available from: https://www.canada.ca/en/health-canada/services/food-nutrition/healthy-eating/healthy-weights/canadian-guidelines-body-weight-classification-adults.html
26. Mardon R, Marker D, Nooney J, et al. Novel Methods and Data Sources for Surveillance of State-Level Diabetes and Prediabetes Prevalence. *Prev Chronic Dis*. 2017;14:e106.

For peer review only

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

BMJ Open: first published as 10.1136/bmjopen-2018-022029 on 5 September 2018. Downloaded from http://bmjopen.bmj.com/ on April 23, 2024 by guest. Protected by copyright.

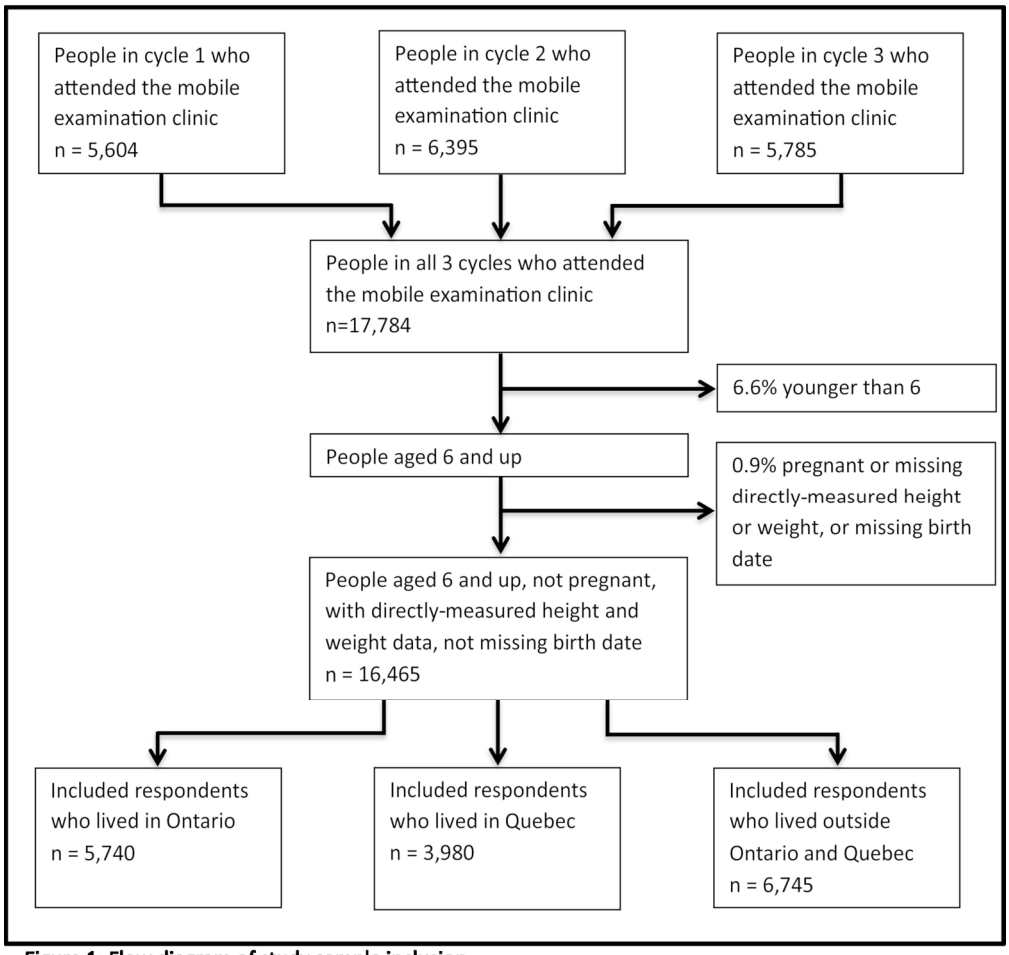

Figure 1: Flow diagram of study sample inclusion

Flow diagram of study sample inclusion

172x171mm (300 x 300 DPI)

BMJ Open: first published as 10.1136/bmjopen-2018-022029 on 5 September 2018. Downloaded from http://bmjopen.bmj.com/ on April 23, 2024 by guest. Protected by copyright.

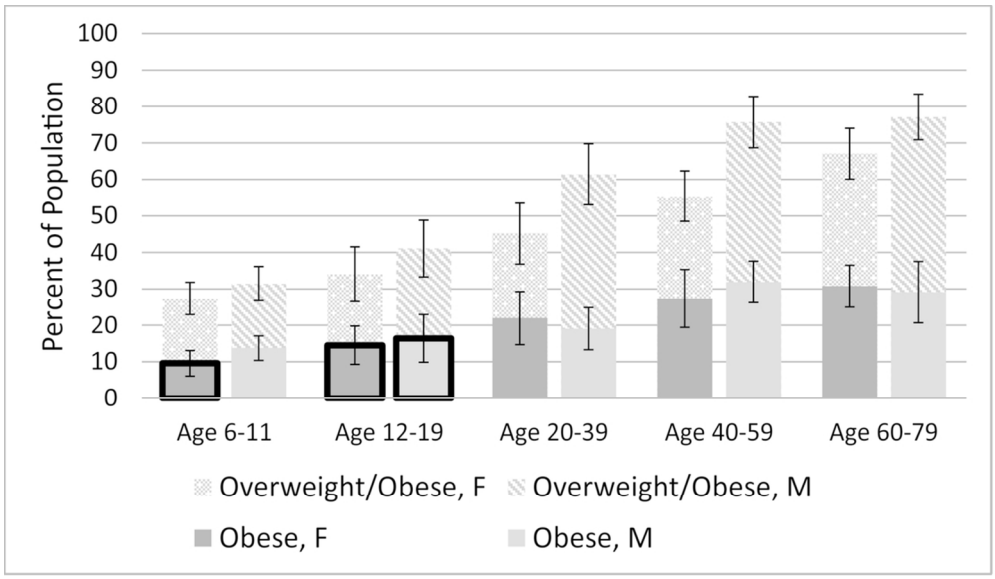

Figure 2: Prevalence of overweight and obesity and prevalence of obesity by age and sex in Ontario.
F = Female. M = Male. Error bars represent 95% confidence interval around each estimate. Black border indicates an estimate that must be interpreted with caution due to a coefficient of variation over 16.6%.

Prevalence of overweight and obesity and prevalence of obesity by age and sex in Ontario.
F = Female. M = Male. Error bars represent 95% confidence interval around each estimate. Black border indicates an estimate that must be interpreted with caution due to a coefficient of variation over 16.6%.

109x74mm (300 x 300 DPI)

ew only

BMJ Open: first published as 10.1136/bmjopen-2018-022029 on 5 September 2018. Downloaded from http://bmjopen.bmj.com/ on April 23, 2024 by guest. Protected by copyright.

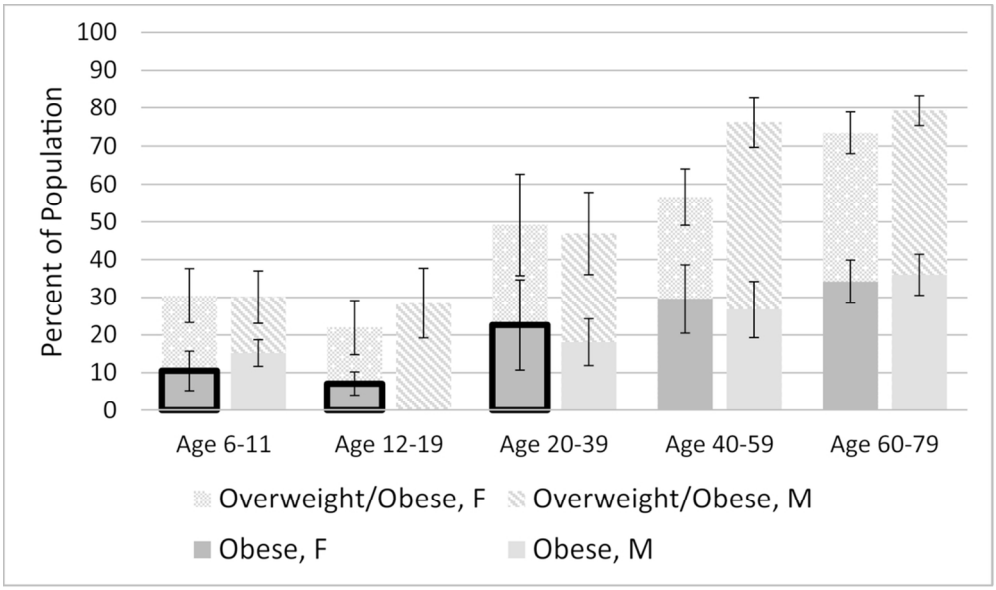

Figure 3: Prevalence of overweight and obesity and prevalence of obesity by age and sex in Québec.
F = Female. M = Male. Error bars represent 95% confidence interval around each estimate. Black borders indicate an estimate that must be interpreted with caution due to a coefficient of variation over 16.6%. Data not shown if coefficient of variation over 33.3%.

Prevalence of overweight and obesity and prevalence of obesity by age and sex in Québec.
F = Female. M = Male. Error bars represent 95% confidence interval 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%.

110x76mm (300 x 300 DPI)

w only

BMJ Open: first published as 10.1136/bmjopen-2018-022029 on 5 September 2018. Downloaded from http://bmjopen.bmj.com/ on April 23, 2024 by guest. Protected by copyright.

STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation	Y/N, page
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	Y, p.1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	Y, p.2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	Y, p.4
Objectives	3	State specific objectives, including any prespecified hypotheses	Y, p.4
Methods			
Study design	4	Present key elements of study design early in the paper	Y, p.5-6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	Y, p.5
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	Y, p.5
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	Y, p.5-6
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	Y, p.5-6
Bias	9	Describe any efforts to address potential sources of bias	Y, p.5-6
Study size	10	Explain how the study size was arrived at	Y, p.5
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	Y, p.5-6
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	Y, p.5-6
		(*b*) Describe any methods used to examine subgroups and interactions	Y, p.5
		(*c*) Explain how missing data were addressed	Y, p.5
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	Y, p.5
		(*e*) Describe any sensitivity analyses	N/A
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	Y, fig.1
		(b) Give reasons for non-participation at each stage	Y, fig.1
		(c) Consider use of a flow diagram	Y, fig.1
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Y, p.8
		(b) Indicate number of participants with missing data for each variable of interest	Y, fig.1
Outcome data	15*	Report numbers of outcome events or summary measures	Y, p.9
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	Y, p.9

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

BMJ Open: first published as 10.1136/bmjopen-2018-022029 on 5 September 2018. Downloaded from http://bmjopen.bmj.com/ on April 23, 2024 by guest. Protected by copyright.

		(*b*) Report category boundaries when continuous variables were categorized	Y, p.8-9
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	Y, p.9
Discussion			
Key results	18	Summarise key results with reference to study objectives	Y, p.10
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	Y, p.11
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	Y, p.11
Generalisability	21	Discuss the generalisability (external validity) of the study results	Y, p.10
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	Y, p.12

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

For peer review only

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

BMJ Open: first published as 10.1136/bmjopen-2018-022029 on 5 September 2018. Downloaded from http://bmjopen.bmj.com/ on April 23, 2024 by guest. Protected by copyright.

BMJ Open

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

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2018-022029.R1
Article Type:	Research
Date Submitted by the Author:	22-Jun-2018
Complete List of Authors:	Thielman, Justin; Public Health Ontario, Health Promotion, Chronic Disease & Injury Prevention Harrington, Daniel; Public Health Ontario, Health Promotion, Chronic Disease and Injury Prevention Rosella, Laura; University of Toronto, Manson, Heather; Public Health Ontario, Health Promotion, Chronic Disease and Injury Prevention
Primary Subject Heading:	Epidemiology
Secondary Subject Heading:	Public health, Research methods, Nutrition and metabolism
Keywords:	EPIDEMIOLOGY, PREVENTIVE MEDICINE, PUBLIC HEALTH, STATISTICS & RESEARCH METHODS

SCHOLARONE™
Manuscripts

BMJ Open: first published as 10.1136/bmjopen-2018-022029 on 5 September 2018. Downloaded from http://bmjopen.bmj.com/ on April 23, 2024 by guest. Protected by copyright.

TITLE PAGE

Title:

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

Corresponding author:
Justin Thielman
480 University Avenue, Suite 300
Toronto, Ontario, Canada, M5G 1V2
e: justin.thielman@oahpp.ca
t: 647-260-7525

Authors and affiliations:
Thielman, Justin,[1] Harrington, Daniel,[1,2] Rosella, Laura,[1,3] Manson, Heather.[1,2,3]

1. Department of Health Promotion, Chronic Disease & Injury Prevention
   Public Health Ontario
   Toronto, Canada
2. School of Public Health and Health Systems
   University of Waterloo
   Waterloo, Canada
3. Dalla Lana School of Public Health
   University of Toronto
   Toronto, Canada

Word count: 2,529

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

BMJ Open: first published as 10.1136/bmjopen-2018-022029 on 5 September 2018. Downloaded from http://bmjopen.bmj.com/ on April 23, 2024 by guest. Protected by copyright.

For peer review only

BMJ Open: first published as 10.1136/bmjopen-2018-022029 on 5 September 2018. Downloaded from http://bmjopen.bmj.com/ on April 23, 2024 by guest. Protected by copyright.

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 two 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: 5,740 Ontario residents and 3,980 Quebec residents aged 6-79, with birth dates and directly-measured height and weight recorded in the CHMS. Pregnant females were excluded. Socio-demographic 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, 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% confidence interval (CI): 52.8-61.4] of Ontarians were classified overweight or obese and 24.0% [95% CI: 20.3-27.6] obese, while Quebec's corresponding percentages were 56.2% [95% CI: 51.3-61.1] and 24.4% [95% CI: 20.6-28.3]. Generally, overweight and obesity 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.

Keywords: Epidemiology; Preventive Medicine; Obesity; Public Health; Surveillance; Statistics & Research Methods

Article summary – 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

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

- 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

For peer review only

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

BMJ Open: first published as 10.1136/bmjopen-2018-022029 on 5 September 2018. Downloaded from http://bmjopen.bmj.com/ on April 23, 2024 by guest. Protected by copyright.

BMJ Open: first published as 10.1136/bmjopen-2018-022029 on 5 September 2018. Downloaded from http://bmjopen.bmj.com/ on April 23, 2024 by guest. Protected by copyright.

INTRODUCTION

Overweight and obesity, or high body mass index (BMI), are widespread conditions that can lead to serious health issues such as 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 programs 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 not standardized, 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 specialized CCHS version that covers people aged one 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 organization, 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 two-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- and sex-specific overweight and obesity in Ontario and Québec using the CHMS.

METHODS

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

BMJ Open: first published as 10.1136/bmjopen-2018-022029 on 5 September 2018. Downloaded from http://bmjopen.bmj.com/ on April 23, 2024 by guest. Protected by copyright.

Ethics approval

The Ethics Review Board at Public Health Ontario approved this study after reviewing the protocol. 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% confidence intervals (CIs) that did not include the census value,

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

BMJ Open: first published as 10.1136/bmjopen-2018-022029 on 5 September 2018. Downloaded from http://bmjopen.bmj.com/ on April 23, 2024 by guest. Protected by copyright.

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 was considered incomplete if respondents were missing birth dates or objectively-measured height or weight. Birth dates were needed to calculate BMI z-scores using the WHO SAS macro, a tool for calculating standardized 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 coefficients 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 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 the World Health Organization that calculates BMI z-score,(18) then classified respondents with BMIs at least one standard deviation above the mean as overweight or obese and those with BMIs at least two standard deviations 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 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)

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

Representativeness

Table 1 compares socio-demographic 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.

For peer review only

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

BMJ Open: first published as 10.1136/bmjopen-2018-022029 on 5 September 2018. Downloaded from http://bmjopen.bmj.com/ on April 23, 2024 by guest. Protected by copyright.

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

	Canada			Ontario			Québec		
Variable	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 post-secondary	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	-9,166

Census = 2006 Canada Census. CHMS = Canadian Health Measures Survey. Differ = absolute difference in percentage points between census estimate and CHMS point estimate. CHMS estimates in bold if census value not within 95% confidence interval. *'Not visible minority' includes people who identified as White or Aboriginal, while 'visible minority' includes people who identified as other ethnicities (i.e., 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.

For peer review only

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

BMJ Open: first published as 10.1136/bmjopen-2018-022029 on 5 September 2018. Downloaded from http://bmjopen.bmj.com/ on April 23, 2024 by guest. Protected by copyright.

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 year olds, 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%-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.

For peer review only

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

BMJ Open: first published as 10.1136/bmjopen-2018-022029 on 5 September 2018. Downloaded from http://bmjopen.bmj.com/ on April 23, 2024 by guest. Protected by copyright.

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%.

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

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

BMJ Open: first published as 10.1136/bmjopen-2018-022029 on 5 September 2018. Downloaded from http://bmjopen.bmj.com/ on April 23, 2024 by guest. Protected by copyright.

In Ontario, 57.1% [95% CI: 52.8-61.4] of all CHMS respondents, 50.1% [95% CI: 45.4-54.7] of females, and 64.1% [95% CI: 59.2-68.9] of males were classified as overweight or obese; 24.0% [95% CI: 20.3-27.6] of all Ontarians, 23.7% [95% CI: 18.6-28.7] of females, and 24.3% [95% CI: 20.6-28.0] of males were classified as obese. In Québec, 56.2% [95% CI: 51.3-61.1] of all respondents, 52.7% [95% CI: 46.2-59.2] of females, and 59.6% [95% CI: 54.1-65.2] of males were classified as overweight or obese; 24.4% [95% CI: 20.6-28.3] of all Québecers, 25.0% [95% CI: 19.6-30.5] of females, and 23.9% [95% CI: 20.1-27.7] 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 United States 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 post-secondary education who did not complete a degree/certificate/diploma were categorized as 'high school only', while similar respondents in the CHMS were categorized as 'some post-secondary'. 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-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.

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

BMJ Open: first published as 10.1136/bmjopen-2018-022029 on 5 September 2018. Downloaded from http://bmjopen.bmj.com/ on April 23, 2024 by guest. Protected by copyright.

BMJ Open: first published as 10.1136/bmjopen-2018-022029 on 5 September 2018. Downloaded from http://bmjopen.bmj.com/ on April 23, 2024 by guest. Protected by copyright.

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 socio-demographic 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 two-year cycles, can be produced every two years as new cycles become available. Policymakers 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.

Contributorship statement:

JT, DH, LR, and HM contributed to conceptualizing and designing the study, planning analytical methods, and analyzing and interpreting statistical output. JT conducted the literature review, statistical analysis, and drafted the manuscript. JT, DH, LR, and HM reviewed the manuscript for intellectual content, made revisions as needed, and approved the final version for publication. JT, DH, LR, and HM agree to be accountable for this work and to ensure that questions relating to the work are investigated and resolved.

Acknowledgements

Statistics Canada's Research Data Centre Program made the Canadian Health Measures Survey data available and provided support for working with these data.

Competing interests

The authors have no competing interests to declare.

Funding

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

Financial support for this study was provided to all authors by Public Health Ontario. The opinions, results and conclusions reported in this paper are those of the authors and are independent from the funding source. The study sponsor had no role in the study design; collection, analysis, or interpretation of data; report writing or review; approval of the manuscript; or the decision to submit for publication.

Data sharing statement

No additional data are available.

Figure legends

Figure 1: Flow diagram of study sample inclusion

Figure 2: Prevalence of overweight and obesity and prevalence of obesity by age and sex in Ontario, from the 2007-2013 cycles of the Canadian Health Measures Survey.

F = Female. M = Male. Error bars represent 95% confidence interval around each estimate. Black border indicates an estimate that must be interpreted with caution due to a coefficient of variation over 16.6%.

Figure 3: Prevalence of overweight and obesity and prevalence of obesity by age and sex in Québec, from the 2007-2013 cycles of the Canadian Health Measures Survey.

F = Female. M = Male. Error bars represent 95% confidence interval 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%.

REFERENCES

1. The GBD 2015 Obesity Collaborators. Health Effects of Overweight and Obesity in 195 Countries over 25 Years. N Engl J Med. 2017;377(1):13–27.
2. Public Health Ontario. Addressing Obesity in Children and Youth: Evidence to Guide Action for Ontario [Internet]. 2013 [cited 2017 Dec 21]. p. 1–288. Available from: https://www.publichealthontario.ca/en/eRepository/Addressing_Obesity_Children_Youth_Sept2013.pdf
3. Healthy Kids Panel. No time to wait: the healthy kids strategy [Internet]. 2013 [cited 2017 Dec 21]. p. 63. Available from: http://www.health.gov.on.ca/en/common/ministry/publications/reports/healthy_kids/healthy_kids.pdf
4. Centers for Disease Control and Prevention. Updated guidelines for evaluating public health surveillance systems [Internet]. 2001 [cited 2017 Dec 21]. Available from: https://www.cdc.gov/mmwr/preview/mmwrhtml/rr5013a1.htm
5. Birken CS, Tu K, Oud W, Carsley S, Hanna M, Lebovic G, et al. Determining rates of overweight and obese status in children using electronic medical records. Can Fam Physician. 2017;63:e114–22.
6. Statistics Canada. Canadian Community Health Survey (CCHS) Annual component. User guide 2010 and 2009-2010 Microdata files [Internet]. 2011 [cited 2017 Dec 21]. Available from: http://www23.statcan.gc.ca/imdb-bmdi/pub/document/3226_D7_T9_V8-eng.pdf
7. Canada S. Canadian Community Health Survey (CCHS) Annual component. User guide 2007-2008 Microdata files [Internet]. 2009 [cited 2017 Dec 21]. Available from:

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

BMJ Open: first published as 10.1136/bmjopen-2018-022029 on 5 September 2018. Downloaded from http://bmjopen.bmj.com/ on April 23, 2024 by guest. Protected by copyright.

http://www23.statcan.gc.ca/imdb-bmdi/pub/document/3226_D7_T9_V6-eng.pdf

8. Yun S, Zhu B-P, Black W, Brownson R. A comparison of national estimates of obesity prevalence from the behavioral risk factor surveillance system and the national health and nutrition examination survey. Int J Obes. 2006;30:164–70.
9. Statistics Canada. Canadian Community Health Survey - Nutrition (CCHS) [Internet]. 2017 [cited 2017 Dec 21]. Available from: http://www23.statcan.gc.ca/imdb/p2SV.pl?Function=getSurvey&SDDS=5049
10. Statistics Canada. Canadian Health Measures Survey (CHMS) Data User Guide: Cycle 1 [Internet]. 2011 [cited 2017 Dec 21]. Available from: http://www23.statcan.gc.ca/imdb-bmdi/document/5071_D2_T1_V1-eng.htm#a5_3_2_2
11. Statistics Canada. Canadian Health Measures Survey (CHMS). Detailed information for August 2009 to November 2011 (Cycle 2) [Internet]. 2012 [cited 2017 Dec 21]. Available from: http://www23.statcan.gc.ca/imdb/p2SV.pl?Function=getSurvey&Id=62444#a4
12. Statistics Canada. Canadian Health Measures Survey (CHMS). Detailed information for January 2012 to December 2013 (Cycle 3) [Internet]. 2014 [cited 2017 Dec 21]. Available from: http://www23.statcan.gc.ca/imdb/p2SV.pl?Function=getSurvey&Id=136652
13. Statistics Canada. Instructions for Combining Multiple Cycles of Canadian Health Measures Survey (CHMS) Data. 2015.
14. Canadian Health Measures Survey (CHMS) Content summary for cycles 1 to 8. 2015;
15. Kuczmarski RJ, Flegal KM. Criteria for definition of overweight in transition: Background and recommendations for the United States. Am J Clin Nutr. 2000;72(5):1074–81.
16. NCD Risk Factor Collaboration. Trends in adult body-mass index in 200 countries from 1975 to 2014: a pooled analysis of 1698 population-based measurement studies with 19·2 million participants. Lancet. 2016 Apr 2;387(10026):1377–96.
17. Statistics Canada. 2006 Census Dictionary [Internet]. 2008 [cited 2017 Dec 21]. Available from: http://www12.statcan.gc.ca/census-recensement/2006/ref/dict/index-eng.cfm
18. World Health Organization. Growth reference 5-19 years [Internet]. 2015 [cited 2017 Dec 21]. Available from: http://www.who.int/growthref/tools/en/
19. Statistics Canada. Canadian Health Measures Survey (CHMS) Data User Guide: Cycle 2. 2012.
20. Statistics Canada. Canadian Health Measures Survey (CHMS) Data User Guide: Cycle 3. 2015.
21. Statistics Canada. Overweight and obese adults (self-reported), 2014 [Internet]. Health Fact Sheets. 2015 [cited 2017 Dec 21]. Available from: https://www.statcan.gc.ca/pub/82-625-x/2015001/article/14185-eng.htm
22. Shields M, Tremblay MS. Canadian childhood obesity estimates based on WHO, IOTF and CDC cut-points. Int J Pediatr Obes. 2010;5(3):265–73.
23. Mindell JS, Giampaoli S, Goesswald A, Kamtsiuris P, Mann C, Männistö S, et al. Sample selection, recruitment and participation rates in health examination surveys in Europe--experience from seven national surveys. BMC Med Res Methodol. 2015;15:78.
24. Centers for Disease Control and Prevention. National Health and Nutrition Examination Survey: Questionnaires, Datasets, and Related Documentation [Internet]. 2016 [cited 2017 Dec 21]. Available from: https://www.cdc.gov/nchs/nhanes/nhanes_questionnaires.htm
25. Statistics Canada. Income of Canadians, 2000 to 2013 [Internet]. 2015 [cited 2017 Dec 21]. p. 1–6. Available from: http://www.statcan.gc.ca/daily-quotidien/151217/dq151217c-eng.htm
26. Statistics Canada. Data Products, 2016 Census [Internet]. 2017 [cited 2017 Dec 21]. Available from: http://www12.statcan.gc.ca/census-recensement/2016/dp-pd/index-eng.cfm
27. Health Canada. Canadian Guidelines Guidelines for Weight Classification Classification in Adults [Internet]. 2003 [cited 2017 Dec 21]. Available from: https://www.canada.ca/en/health-canada/services/food-nutrition/healthy-eating/healthy-weights/canadian-guidelines-body-

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

BMJ Open: first published as 10.1136/bmjopen-2018-022029 on 5 September 2018. Downloaded from http://bmjopen.bmj.com/ on April 23, 2024 by guest. Protected by copyright.

weight-classification-adults.html
28. Mardon R, Marker D, Nooney J, Campione J, Jenkins F, Johnson M, et al. Novel Methods and Data Sources for Surveillance of State-Level Diabetes and Prediabetes Prevalence. Prev Chronic Dis. 2017;14:e106.

For peer review only

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

BMJ Open: first published as 10.1136/bmjopen-2018-022029 on 5 September 2018. Downloaded from http://bmjopen.bmj.com/ on April 23, 2024 by guest. Protected by copyright.

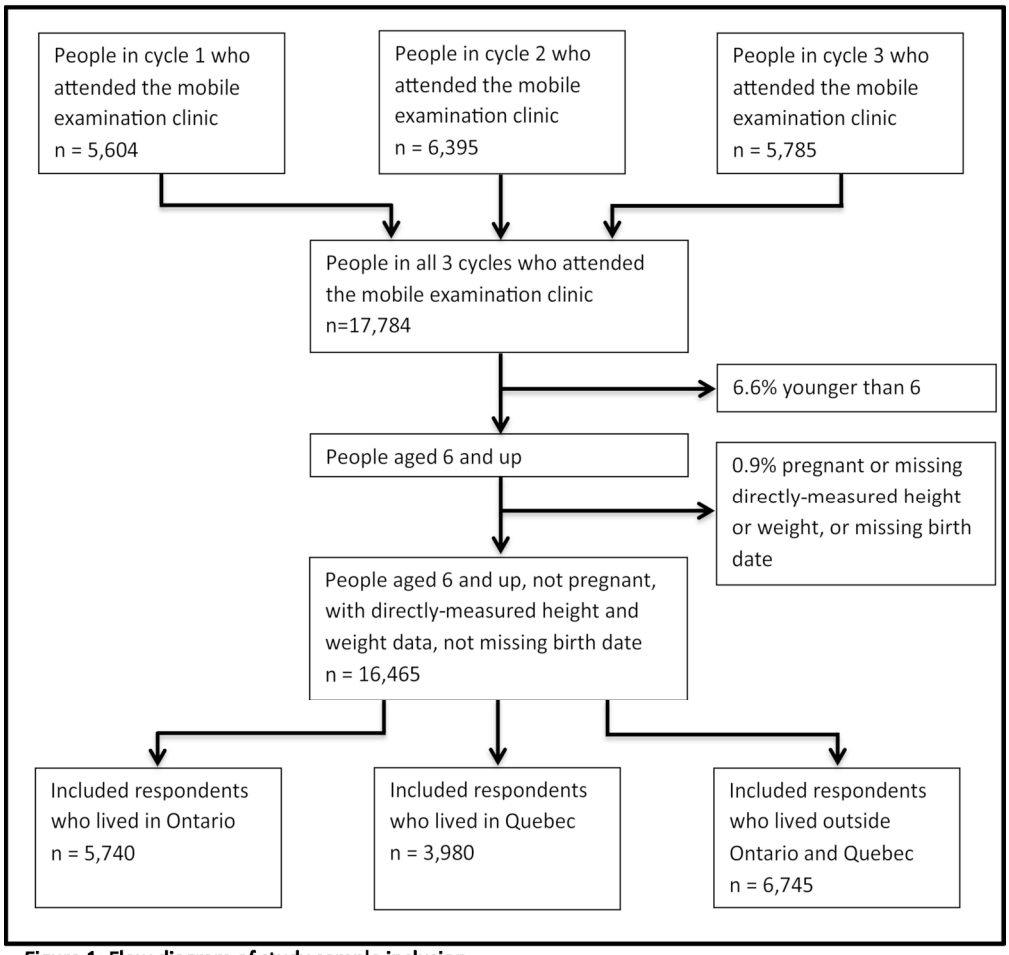

Figure 1: Flow diagram of study sample inclusion

Flow diagram of study sample inclusion

172x171mm (300 x 300 DPI)

BMJ Open: first published as 10.1136/bmjopen-2018-022029 on 5 September 2018. Downloaded from http://bmjopen.bmj.com/ on April 23, 2024 by guest. Protected by copyright.

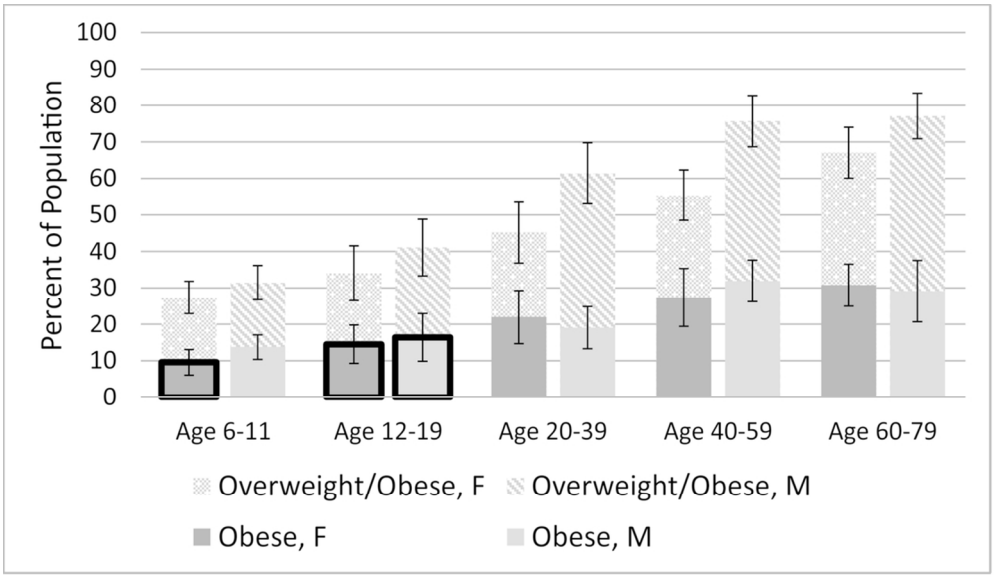

Figure 2: Prevalence of overweight and obesity and prevalence of obesity by age and sex in Ontario.
F = Female. M = Male. Error bars represent 95% confidence interval around each estimate. Black border indicates an estimate that must be interpreted with caution due to a coefficient of variation over 16.6%.

Prevalence of overweight and obesity and prevalence of obesity by age and sex in Ontario.
F = Female. M = Male. Error bars represent 95% confidence interval around each estimate. Black border indicates an estimate that must be interpreted with caution due to a coefficient of variation over 16.6%.

109x74mm (300 x 300 DPI)

For peer review only

BMJ Open: first published as 10.1136/bmjopen-2018-022029 on 5 September 2018. Downloaded from http://bmjopen.bmj.com/ on April 23, 2024 by guest. Protected by copyright.

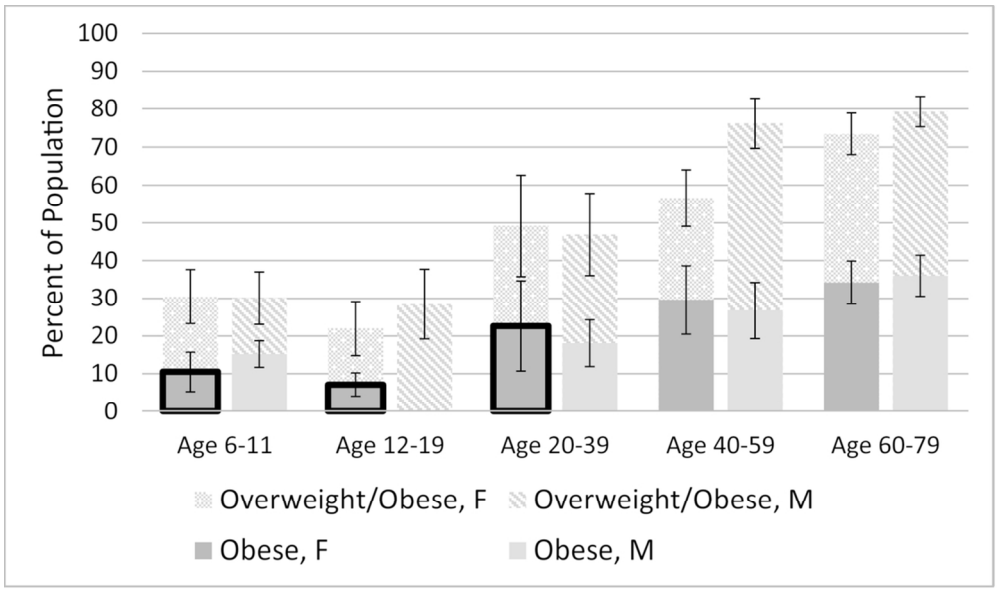

Figure 3: Prevalence of overweight and obesity and prevalence of obesity by age and sex in Québec.

F = Female. M = Male. Error bars represent 95% confidence interval 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%.

Prevalence of overweight and obesity and prevalence of obesity by age and sex in Québec.
F = Female. M = Male. Error bars represent 95% confidence interval 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%.

110x76mm (300 x 300 DPI)

w only

BMJ Open: first published as 10.1136/bmjopen-2018-022029 on 5 September 2018. Downloaded from http://bmjopen.bmj.com/ on April 23, 2024 by guest. Protected by copyright.

STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation	Y/N, page
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	Y, p.1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	Y, p.2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	Y, p.4
Objectives	3	State specific objectives, including any prespecified hypotheses	Y, p.4
Methods			
Study design	4	Present key elements of study design early in the paper	Y, p.5-6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	Y, p.5
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	Y, p.5
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	Y, p.5-6
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	Y, p.5-6
Bias	9	Describe any efforts to address potential sources of bias	Y, p.5-6
Study size	10	Explain how the study size was arrived at	Y, p.5
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	Y, p.5-6
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	Y, p.5-6
		(*b*) Describe any methods used to examine subgroups and interactions	Y, p.5
		(*c*) Explain how missing data were addressed	Y, p.5
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	Y, p.5
		(*e*) Describe any sensitivity analyses	N/A
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	Y, fig.1
		(b) Give reasons for non-participation at each stage	Y, fig.1
		(c) Consider use of a flow diagram	Y, fig.1
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Y, p.8
		(b) Indicate number of participants with missing data for each variable of interest	Y, fig.1
Outcome data	15*	Report numbers of outcome events or summary measures	Y, p.9
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	Y, p.9

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

BMJ Open: first published as 10.1136/bmjopen-2018-022029 on 5 September 2018. Downloaded from http://bmjopen.bmj.com/ on April 23, 2024 by guest. Protected by copyright.

		(*b*) Report category boundaries when continuous variables were categorized	Y, p.8-9
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	Y, p.9
Discussion			
Key results	18	Summarise key results with reference to study objectives	Y, p.10
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	Y, p.11
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	Y, p.11
Generalisability	21	Discuss the generalisability (external validity) of the study results	Y, p.10
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	Y, p.12

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

For peer review only

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

BMJ Open: first published as 10.1136/bmjopen-2018-022029 on 5 September 2018. Downloaded from http://bmjopen.bmj.com/ on April 23, 2024 by guest. Protected by copyright.