STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of cross-sectional studies

An observational study of the prevalence of toddler, child and adolescent overweight and obesity derived from primary care electronic medical records (Manuscript no. CMAJOpen-2015-0108)

Section/ Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract	Title includes "observational study"
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	Abstract section
Introduction			
Background/ rationale	2	Explain the scientific background and rationale for the investigation being reported	Reported on page 1, lines 5 through 44.
Objectives	3	State specific objectives, including any prespecified hypotheses	Reported on page 1, lines 46 through 53.
Methods			
Study design	4	Present key elements of study design early in the paper	Reported on page 2, line 44-48.
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	Reported on page 2, lines 18 through 25.
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants	Reported on page 2, lines 37 through 48; page 3, lines 8 through 13.
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	Reported on page 3, lines 17 through 56; page 4, lines 3-6.
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	Reported on page 2, lines 18 through 25.
Bias	9	Describe any efforts to address potential sources of bias	Reported on page 2, line 53-56; page 3,

			lines 3-6.
Study size	10	Explain how the study size was arrived at	Page 2, lines 39 through 44.
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	Reported on page 4, lines 10 through 25.
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	Reported on page 4, lines 10 through 25.
		(b) Describe any methods used to examine subgroups and interactions	Reported on page 4, lines 10 through 25.
		(c) Explain how missing data were addressed	Reported on page 2, lines 39-44.
		(d) If applicable, describe analytical methods taking account of sampling strategy	n/a
		(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	Reported on page 5, lines 10 through 32 plus addition of figure 1: flow diagram
		(b) Give reasons for non-participation at each stage	Exclusions are reported on page 5, lines 10 through 32 plus addition of figure 1: flow diagram
		(c) Consider use of a flow diagram	Inserted
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Reported on page 5, lines 46 through 56, and page 6, lines 3-6, plus additional tables 1, 2 & 3.

		(b) Indicate number of participants with missing data for each variable of interest	Have not included
Outcome data	15*	Report numbers of outcome events or summary measures	Reported on page 5, lines 46 through 56, and page 6, lines 3-6, plus additional tables 1, 2 & 3.
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	Tables 1, 2, & 3.
		(b) Report category boundaries when continuous variables were categorized	Tables 1, 2, & 3.
		(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	Page 7, lines 8 through 23 and Tables 1, 2, & 3.
Discussion			
Key results	18	Summarise key results with reference to study objectives	Page 7, lines 44 through 56, and page 8, line 3.
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	Page 9, lines 10 through 56; page 10 lines 3 through 20.
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	Page 9, lines 10 through 56; page 10 lines 3 through 20.
Generalisability	21	Discuss the generalisability (external validity) of the study results	Page 9, lines 22-30.
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	This is provided in the conflict of interest section and the acknowledgements section.

* Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

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.

INTRODUCTION

One third of Canadian children and adolescents, aged 5 to 17 years are overweight or obese (1). Children with obesity have higher risk for both short$term health consequences (2–5) and long term persistence of obesity into adulthood (6–8). Evidence demonstrates that early childhood is a critical time for obesity prevention strategies and that early markers of obesity could be targeted for universal and individual intervention strategies to show positive, long term, health benefits (9–11). In Canada, child and adolescent population health monitoring is limited. There are a few national surveys, such as the Canadian Community Health Survey (CCHS) (ages 12+), the Health Behaviour in School$Aged Children Survey (ages 11$15) and the National Longitudinal Study of Children and Youth that provide population level surveillance data (12–14). In 2004 and 2005 the CCHS included representative subsamples in which height and weight were measured. Measured heights and weights are also obtained as part of the Canadian Health Measures Survey (CHMS) (aged 3 to 79 years)(15). However, data on 3 to 5 year olds represents approximately 500 children from across Canada. The absence of data under 3 years is a critical gap given that early life trajectories in growth and development are of great significance in determining lifelong health and well$being. Also, the lack of objectively measured data at regional levels severely limits design and evaluation efforts of a "whole system" public health approach to the prevention of childhood obesity (16).

We conducted this study to determine the prevalence of overweight and obesity, using measured heights and weights for toddlers, children and adolescents under 20 years, derived from a sample of primary care electronic medical records from the Canadian Primary Care Sentinel Surveillance Network (CPCSSN) chronic disease database (17,18). In particular, to fill

the known data gap, we examined height and weight data for toddlers under age 2 years and assessed it in relation to a known well$child visit, the enhanced 18$month well baby visit.

Methods

Setting and Sources of Data

The Canadian Primary Care Sentinel Surveillance Network (CPCSSN) database contains standardized, de$identified electronic medical record (EMR) data from multiple EMR platforms, from ten primary care practice$based research networks across Canada. For this study, data was extracted from EMRs on all patients from three Ontario networks of the CPCSSN (the Eastern Ontario Network, the University of Toronto Practice Based Research Network and London's Deliver Primary Healthcare Information Project). Extracted data from EMRs included all patients who had an encounter with a CPCSSN primary care provider prior to March 31st, 2014. Duplicate patient records were removed and remaining EMR data was standardized using established CPCSSN algorithmic coding processes. For example, each height and weight value is cleaned and converted into standard units (kilograms, centimeters). Following standardization, the EMR data was uploaded into the CPCSSN database. For this study, additional eligible patients were excluded if key measurement variables were missing: height (length), weight, date of height taken, date of weight taken, year of birth, and month of birth. Data for this observational study included all height and weight records for children under 20 years of age, between 2004 and December 31st, 2013 to produce a sample for cross$sectional research. Data from 2013 was selected to report growth status indicators as this year provided the largest sample set. In addition, we obtained the encounter date (clinic visit date), the child's month and year of birth, and sex. The A002 and A002A fee codes corresponding to the enhanced 18$month well baby visit were also extracted (19). Because a toddler's primary care clinic encounter could be

associated with either a wellness or illness visit, the fee code was used to assess weight classification against a known "well toddler" visit. To provide a larger data set for this comparison, toddler visits with length and height measurements collected on the same date were taken from January 1st, 2008 to December 31st, 2013. If a toddler had weight-for-length values available, the latest one was used.

Measures

The World Health Organization (WHO) Growth Standards (birth to five years) and Reference (5 to 19 years) were used to assign growth status indicators (20,21). Body mass index (BMI) (weight in kilograms/height in metres^2) was calculated from height and weight measurements that were collected on the same date for children and adolescents 5 to 19 years of age. If a child or adolescent had multiple BMI values available in 2013, the latest one was used. BMI-for-age was used as the growth status indicator, classified into four categories: "wasting", "normal weight", "overweight" and "obesity". The BMI-for-age cut-off point for "overweight" was >85th percentile and the cut-off point for "obesity" was >97th percentile for these age groups.

As per recommendations outlined in the Canadian collaborative statement: using the new WHO growth charts, weight-for-length was used as the growth status indicator for children birth to 2 years of age (toddlers) (21). Weight-for-length was calculated from length and weight measurements that were collected on the same date. If a toddler had multiple weight-for-length values available between 2008 to 2013, the latest one was used. Similarly, for preschool aged children (2-5 years), BMI-for-age was used as the growth status indicator. Toddler and preschool aged children were classified into five growth status indicator categories as "wasting", "normal weight", "risk of overweight", "overweight" and "obesity". The cut-off point for these age groups differ from older children and adolescents: the cut-off point for "risk of overweight" was

>85th percentile; the cut$off point for "overweight" was > 97th percentile; and the cut$off point for "obesity" was >99th percentile.

Statistical Analysis

We calculated prevalence estimates for growth indicator variables and expressed the results in terms of percentage and corresponding 95% confidence interval values by sex and age (as of the date for height/length and weight measurement). In addition, we compared the proportion of toddlers with the 18$month enhanced well baby visit fee code to those without a fee code. Significant differences between prevalence estimates within variable categories were assessed using chi square tests. Alpha was set a priori at 0.05. Variable classifications and all statistical analyses were performed in 2015 using SAS, version 9.3.

This study was approved by the Health Sciences Research Ethics Board at Queen's University.

Results

In total, 349 613 patients were extracted from source EMRs. Duplicate records (5915) were identified and removed and the remaining 343 698 patient records were uploaded to the CPCSSN database. Patient records with a missing month of birth (118 139), a missing or invalid height or weight measurement, or weight measurement without a height measurement taken on the same date (100 986) were excluded. Patients 20 years and older were removed from the dataset (97 070). A further 4651 weight and height records in the remaining dataset were removed as the measurements were taken outside the study period. The final child and adolescent sample of children with weight and height records (with the same measurement date) taken between January 1, 2008 and December 31, 2013, was 22 852. See Figure 1 for a flow diagram of the study sample inclusion process.

In 2013, there was a total of 5310 school aged children, 5 to 19 years of age, with BMIforage calculated from height and weight measurements that were collected on the same date. There was a total of 1842 preschool aged children, 2$5 years of age with BMI$for$age and a total of 1127 toddlers (0$2 years of age) with a weight$for length calculated from length and weight measurements that were collected on the same date in 2013. This represents a total of 8279 children, birth to 19 years of age, with a growth status indicator derived from objectively measured height (length) and weights.

BMIforage for school aged children, 5$19 years old, derived from the last height and weight measurements taken from encounters in 2013 are presented in Table 1. The prevalence of overweight and obesity, overall was28.4%. Boys and girls were equally represented (48.1% and 51.8% respectively). Significantly more boys, 12$19 years of age, were categorized as overweight and obese compared with girls in the same age group. For boys 5 to 11 years of age, there were significantly more categorised as obese compared with girls in the same age group. It follows that girls were significantly more likely to be categorised as normal weight compared with boys. There were no significant differences across age groups within BMIforage categories for children and adolescents 5$19 years of age. .

The percentage distribution of toddler (0$2 years of age) and preschool children (2$5 years of age) by growth status indicator, weightforlength and BMIforage, respectively, are presented in Table 2. Overall, 6% of toddler$and preschool$aged children were classified as overweight or obese in 2013; 18.1% were classified as having risk of overweight. Recognising different growth indicators for these two age groups may prohibit comparison of growth between age groups, there appeared to be significantly more toddlers classified as wasting, 6.8%, compared with preschool aged children,2.7%, (and consequently, preschool aged children were

more likely to be classified as having normal weight). Both toddler and preschool aged girls were significantly more likely to be classified as normal weight compared with boys in the same age groups.

Between 2008 and 2013, toddlers who had physician encounters without an 18$month enhanced well baby visit fee code assigned, were significantly more likely to be classified as wasting compared to toddlers with well baby visits, 9.1 % versus 3.3% respectively (Table 3). Significantly more boys, 10.9%, in the wasting category visited their physician for reasons other than a well baby visit, compared with girls, 7.1%. The overall percentage of toddlers who were classified as overweight and obese between 2008 and 2013 was 6.7 %; 17.5% were classified as having risk of overweight.

Interpretation

This study represents the first population assessment report on the prevalence of overweight and obesity among toddlers under age 2 years in Canada based on objectively measured heights and weights. Our results indicate that 6.7% of toddlers, less than 2 years of age, are already overweight or obese and that 18% are at risk of overweight. For school aged children and adolescents , 5$19 years, population estimates of overweight and obesity in our study are slightly lower than estimates derived from the CHMS (2009 to 2011) for children 5$17 years (22), 28.4%% versus 31.5% respectively. Likely, this lower estimate is due to more "unwell" child visits with primary care providers in our study population compared with a general population. Similarities across weightforlength categorizations for normal, risk of overweight, overweight and obesity for toddlers under 2 years with and without a "well child visit" code, indicate that weightforlength measures derived from primary care EMRs can provide good proxy population

risk of overweight, overweight and obesity estimates for this younger age group. The discrepancy between groups for the wasting category supports the inherent population bias in our study: likely children with poor weight gain in infancy or who are unwell at a younger age are more often visiting primary care providers.

Our study includes height (length) and weight measurements for a large number of children and adolescents below 20 years of age, and for the first time, population assessment measures for toddlers and preschool aged children below 3 years. Our study included 8,279 toddlers, children and adolescents and their corresponding growth indicators, a sample close to four times larger than the national survey sample from the second cycle of the CHMS (22). Moreover, indicator variables were derived from objectively measured length, height and weight records in a clinical setting. Parents' reported measures of child heights and weights are consistently underestimated (23). It is commonly agreed that the best place for measuring length, height and weight is primary health care settings during routine wellness visits; this setting minimises concerns about unintended negative consequences related to growth monitoring in other settings (e.g. schools) such as stigmatization; ensures appropriate equipment is used; provides ongoing staff training ; and follows measurement protocols (24–26).

There are limitations of this study. First, our results depend on the quality of data that we were able to extract. The recording of primary care EMR data continues to suffer entry error and can be absent or unavailable for use (27–29). Missing measurements for length, heights and weights and data standardization is variable across clinics and EMRs and also within the same EMR (30,31). Second, our study population was limited to patients who visit their primary care providers. In a study investigating the representativeness of patients in CPCSSN, network patients were reasonably representative of patients in Canadian primary care practices and only

somewhat representative of the Canadian general population (32). Ontario had the highest proportion of patients in CPCSSN; provincial level comparison was reasonable (32). Third, our data was derived from physicians who participate as sentinels with the CPPSSN, limiting data extraction to include only providers who use electronic medical records. Though the number of primary care physicians using EMRs in Canada(77.6%) has more than doubled since 2006, there may be practice differences between providers who use or don't use EMRs (33,34). Since our study population was comprised of toddlers, children and adolescents who visit their primary care provider, the children may represent a population with shifting growth indicator measures due to medical reasons, biasing our prevalence estimates (35). Fourth, for toddlers less than 2 years of age, length is most often measured laying down as opposed to standing. There are inherent practical challenges to provide accurate measurement of length for infants and toddlers, despite standardized techniques and equipment (21). For example, it is difficult for toddlers to lie still and to capture a measurement with full extension of the legs. Similarly, height measurements for older children may be biased by measurement variability. Despite measures taken by trained care providers in primary care settings, it is possible growth indicator classifications may not be accurately derived given the measurement difficulty. Finally, it is important to note that weight$for length and BMI$for age growth indicators represent only one of many risk factors (9,11,36), and that any prevention or treatment strategy, whether targeted or universal, must clearly account for the complexity of factors that influence healthy growth and development.

These findings have important implications. Evidence clearly indicates the need to assess weight status in children and adolescents and particularly for toddlers and preschoolers less than 3 years of age (25). Our study demonstrates that EMR data is a valuable source for this

information. These results provide a foundation upon which to build an ongoing, regionally specific, longitudinal monitoring system for population healthy weight status of Canadian toddlers, children and adolescents, especially toddlers, against which prevention measures may be designed, implemented and evaluated. Though primary health care could become an improved source for healthy weight surveillance, a whole system population health approach to prevention is necessary (16,37,38). Our study demonstrates the first steps toward improving our knowledge so that collectively, clinical and community partners know how, when and where to focus and scale successful health promotion programming and policies.

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Table 1: Percentage distribution of school aged children and adolescents, by BMI-for-age category in 2013

		Percentage (95% confidence interval)			
Age group (years)	Number of children	Wasting	Normal weight	Overweight*	Obesity**
All children and adolescents					
5-11	2649	2.6 (1.9-3.2)	69.5 (67.7-71.2)	18.1 (16.6-19.6)	9.9 (8.7-11.0)
12 – 19	2661	1.5 (1.1-2.0)	69.6 (67.8-71.4)	18.0 (16.5-19.5)	10.9 (9.7-12.1)
5 – 19	5310	2.1 (1.7-2.4)	69.5 (68.3-70.8)	18.0 (17.0-19.1)	10.4 (9.5-11.2)
Boys					
5 - 11	1356	3.3 (2.3-4.3)	65.7 (63.1-68.3)	19.4 (17.3-21.5)	11.6 (9.8-13.3)
12 – 19	1201	1.8 (1.0-2.6)	64.2 (61.4-66.9)	20.8 (18.5-23.2)	13.2 (11.2-15.1)
5– 19	2557	2.6 (2.0-3.3)	65.0 (63.1-66.9)	20.1 (18.5-21.6)	12.3 (11.0-13.6)
Girls					
5 - 11	1293	1.8 (1.0-2.5)	73.4† (70.9-75.8)	16.7 (14.6-18.8)	8.1† (6.6-9.6)
12 – 19	1460	1.3 (0.7-1.9)	74.0† (71.8-76.3)	15.7† (13.8-17.6)	9.0† (7.5-10.5)
5 – 19	2753	1.5 (1.0-2.0)	73.7† (72.1-75.4)	16.2† (14.8-17.6)	8.6† (7.5-9.6)

*The cut-off point for overweight is >85th percentile.
**The cut-off point for obesity is >97th percentile.
† significantly different from boys within the same age group ($p<0.05$)
BMI, Body Mass Index

Table 2: Percentage distribution of toddler and preschool aged children, by growth status indicator ǂ category in 2013

		Percentage (95% confidence interval)				
Age group (years)	Number of children	Wasting	Normal weight	Risk of overweight*	Overweight**	Obesity***
All children						
0 - 2	1127	6.8 (5.3-8.3)	68.5 (65.7-71.3)	18.0 (15.7-20.3)	5.5 (4.1-6.9)	1.2 (0.5-1.8)
2 - 5	1842	2.7£ (1.9-3.4)	73.5£ (71.4-75.5)	18.2 (16.4-20.0)	4.0 (3.0-4.9)	1.7 (1.1-2.4)
0 - 5	2969	4.2 (3.5-5.0)	71.6 (69.9-73.2)	18.1 (16.7-19.5)	4.5 (3.8-5.3)	1.5 (1.1-2.0)
Boys						
0 - 2	566`	8.1 (5.8-10.5)	63.8 (59.7-67.8)	20.1 (16.7-23.5)	6.7 (4.6-8.9)	1.2 (0.2-2.2)
2 - 5	918	3.7 (2.4-5.0)	70.2 (67.1-73.2)	19.5 (16.9-22.1)	4.4 (3.0-5.7)	2.3 (1.3-3.3)
0 - 5	1484	5.4 (4.2-6.6)	67.7 (65.3-70.1)	19.7 (17.7-21.8)	5.3 (4.1-6.4)	1.9 (1.2-2.6)
Girls						
0 - 2	561	5.5 (3.5-7.5)	73.3† (69.5-77.0)	15.9 (12.8-19.0)	4.3 (2.5-6.0)	1.1 (0.1-2.0)
2 - 5	924	1.6 (0.8-2.5)	76.7† (74.0-79.5)	16.9 (14.4-19.4)	3.6 (2.3-4.8)	1.2 (0.4-1.9)
0 - 5	1485	3.1† (2.2-4.0)	75.4† (73.2-77.6)	16.5 (14.6-18.4)	3.8 (2.8-4.8)	1.1 (0.6-1.7)

ǂ For children birth to 2 years, weight-for-length was used as the growth status indicator and for children 2 to 5 years, BMI-for-age was used as the growth status indicator. Cut-off points are the same for each indicator.

*The cut-off point for risk of overweight is >85th percentile.
**The cut-off point for overweight is >97th percentile.
***The cut-off point for obesity is >99.9th percentile.
£ significantly different from toddlers ($p<0.05$)
† significantly different from boys within the same age group ($p<0.05$)

Table 3: Percentage distribution of toddlers less than 2 years, by weight-for-length category, with and without the 18-month enhanced well baby visit fee code 2008 to 2013

		Percentage (95% confidence interval)				
Age group (years)	Number of children	Wasting	Normal weight	Risk of overweight*	Overweight**	Obesity***
All toddlers						
18-month fee code	1154	3.3 (2.2-4.4)	70.6 (68.0-73.3)	19.2 (16.9-21.6)	6.1 (4.6-7.5)	0.8 (0.2-1.3)
WITHOUT fee code	2000	9.1£ (7.8-10.3)	68.1 (66.0-70.2)	16.5 (14.8-18.2)	5.3 (4.3-6.3)	1.1 (0.6-1.5)
All Children < 2	3154	6.9 (6.0-7.8)	69.0 (67.4-70.7)	17.5 (16.2-18.8)	5.6 (4.8-6.4)	1.0 (0.6-1.3)
Boys						
18-month fee code	560	3.8 (2.1-5.4)	68.2 (64.3-72.2)	20.9 (17.4-24.3)	6.1 (4.0-8.1)	1.1 (0.1-2.0)
WITHOUT fee code	1032	10.9 (8.9-12.8)	65.9 (63.0-68.8)	16.7 (14.3-19.0)	5.7 (4.3-7.2)	0.9 (0.3-1.5)
All Boys < 2	1592	8.4 (7.0-9.7)	66.7 (64.4-69.1)	18.2 (16.2-20.1)	5.8 (4.7-7.0)	0.9 (0.4-1.4)
Girls						
18-month fee code	594	2.9 (1.4-4.3)	72.9 (69.2-76.6)	17.7 (14.5-20.8)	6.1 (4.1-8.1)	0.5 (-0.1-1.2)
WITHOUT fee code	968	7.1† (5.5-8.8)	70.5 (67.5-73.4)	16.3 (13.9-18.7)	4.9 (3.4-6.3)	1.2 (0.5-2.0)
All Girls < 2	1562	5.5 (4.3-6.7)	71.4 (69.1-73.7)	16.8 (14.9-18.7)	5.3 (4.2-6.5)	1.0 (0.4-1.5)

*The cut-off point for risk of overweight is >85th percentile.
**The cut-off point for overweight is >97th percentile.
***The cut-point for obesity is >99.9th percentile.
£ significantly different from toddlers with the 18-month enhanced well baby visit code ($p<0.05$)
† significantly different from boys within the same fee code category ($p<0.05$)