Health Promotion and Chronic Disease Prevention in Canada
Research, Policy and Practice

Volume 40 · Number 1 · January 2020

Inside this issue

To promote and protect the health of Canadians through leadership, partnership, innovation and action in public health.
— Public Health Agency of Canada

Published by authority of the Minister of Health.

ISSN 2368-738X
Pub. 190450
PHAC.HPCDP.journal-revue.PSPMC.ASPC@canada.ca

Également disponible en français sous le titre : *Promotion de la santé et prévention des maladies chroniques au Canada : Recherche, politiques et pratiques*

Submission guidelines and information on article types are available at:
https://www.canada.ca/en/public-health/services/reports-publications/health-promotion-chronic-disease-prevention-canada-research-policy-practice/information-authors.html

Indexed in Index Medicus/MEDLINE, DOAJ, SciSearch® and Journal Citation Reports/Science Edition

Public Health Agency of Canada · Agence de la santé publique du Canada

Canada

https://doi.org/10.24095/hpcdp.40.1.01

Original multimethod research

Beyond BMI: a feasibility study implementing NutriSTEP in primary care practices using electronic medical records (EMRs)

Lesley Andrade, RD, MHSc (1,2); Kathy Moran, MHSc (3); Susan J. Snelling, PhD (4); Darshaka Malaviarachchi, MSc (2); Joanne Beyers, RD, MA (2); Kelsie Near, MPH (5); Janis Randall Simpson, RD, PhD (6)

This article has been peer reviewed.

Tweet this article

Abstract

Introduction: Primary care providers have a role to play in supporting the development of healthy eating habits, particularly in a child's early years. This study examined the feasibility of implementing the NutriSTEP® screen—a 17-item nutrition risk screening tool validated for use with both toddler and preschooler populations—integrated with an electronic medical record (EMR) in primary care practices in Ontario, Canada, to inform primary care decision-making and public health surveillance.

Methods: Five primary care practices implemented the NutriSTEP screen as a standardized form into their EMRs. To understand practitioners' experiences with delivery and assess factors associated with successful implementation, we conducted semi-structured qualitative interviews with primary care providers who were most knowledgeable about NutriSTEP implementation at their site. We assessed the quality of the extracted patient EMR data by determining the number of fully completed NutriSTEP screens and documented growth measurements of children.

Results: Primary care practices implemented the NutriSTEP screen as part of a variety of routine clinical contacts; specific data collection processes varied by site. Valid NutriSTEP screen data were captured in the EMRs of 80% of primary care practices. Approximately 90% of records had valid NutriSTEP screen completions and 70% of records had both valid NutriSTEP screen completions and valid growth measurements.

Conclusion: Integration of NutriSTEP as a standardized EMR form is feasible in primary care practices, although implementation varied in our study. The application of EMR-integrated NutriSTEP screening as part of a comprehensive childhood healthy weights surveillance system warrants further exploration.

Keywords: *child, obesity, electronic medical records, protective factors, NutriSTEP, surveillance system, feasibility, intervention research*

Highlights

- Primary care practices present an opportunity to identify nutrition risk in children using the NutriSTEP screening tool.
- Successful implementation of an EMR-integrated NutriSTEP screen varied by primary care practice site.
- Extraction of NutriSTEP data from EMRs is feasible; extracted data were of good quality.
- Implementation of an EMR-integrated NutriSTEP screen presents an opportunity to improve the care and management of children and their families, as well as support population health outcomes and health system quality improvement.

Introduction

Roughly one-third of Canadian children and adolescents aged 5 to 17 years are living with excess weight or obesity.[1,2] Because weight-related behaviours established in early childhood persist into adolescence and beyond,[3] and consequences associated with overweight and obesity start early in life,[4,5] it is important to intervene early.[3] Given the complexity of childhood obesity, effective public health interventions require an approach that considers multiple factors that influence a child's weight, including family, peer and environmental influences;[3] these factors often lie outside the mandate of the health sector.[6] Recognizing the important role nutrition plays in weight and well-being, Ontario's Food and Nutrition Strategy[7] recommends that children be screened using the NutriSTEP® screening tool. NutriSTEP is also recommended as a tool for primary care providers' use in the routine assessment of children's healthy eating behaviours as noted in the Primary Prevention of Childhood Obesity clinical practice guidelines.[8] The NutriSTEP questionnaire is a validated screening tool used to identify nutritional risk and protective factors in both toddler (18–35 months) and preschooler (3–5 years) populations,[9,10] and parent completion of NutriSTEP has been shown to increase parental knowledge of healthy eating.[11] In addition to the

Author references:

1. School of Public Health and Health Systems, University of Waterloo, Waterloo, Ontario, Canada
2. Public Health Sudbury & Districts, Sudbury, Ontario, Canada
3. Durham Region Health Department, Whitby, Ontario, Canada
4. Social Research Consulting, Inc., Kagawong, Ontario, Canada
5. Toronto Public Health, Toronto, Ontario, Canada
6. Department of Family Relations and Applied Nutrition, University of Guelph, Guelph, Ontario, Canada

Correspondence: Lesley Andrade, School of Public Health and Health Systems, University of Waterloo, 200 University Avenue West, Waterloo, ON N2L 3G1; Email: landrade@uwaterloo.ca

screening tool, NutriSTEP implementation involves the provision of parent resource materials and community referrals for services to support parents of children identified as being at risk.[12]

Although it is traditionally implemented in community and public health settings by a variety of health and non-health practitioners, one Canadian study found that parents were interested in completing the NutriSTEP screen in health care settings.[13] Implementation in this manner would facilitate early intervention through the early identification of toddlers and preschoolers identified as being at risk. Collaborations between public health and primary care are becoming increasingly common and contribute to strengthened programs and services.[14] Previous research evaluating the implementation of the paper-based NutriSTEP screen in a variety of primary care settings demonstrated use by primary care providers, primarily during their enhanced well-baby visits.[15] This research also identified an interest on the part of participating primary care practices to have the NutriSTEP screen integrated into their EMRs to facilitate patient care and management and a willingness to centralize patient data to support a comprehensive childhood healthy weights surveillance system.[15]

The establishment of a comprehensive surveillance system has been identified as an essential component to primary prevention[8] and evidence of an effective public health system.[16,17] Enhanced collaborations and partnerships have the potential to inform primary prevention efforts of the public health system through sharing of relevant primary health care data. However, there is limited alignment between current public health surveillance systems' objectives and corresponding data collected. For example, due to lack of data, the estimation of rates of overweight and obesity in children aged 5 years and younger is a critical information gap for public health in Canada.[16,18,19] Public health professionals could potentially overcome this obstacle by accessing EMR data, such as measured height and weight data, collected during routine primary health care visits.

There is limited literature about the use of an EMR-integrated NutriSTEP screen in primary care practices and the necessary supports and processes for successful implementation. In an effort to address this gap, our study aimed to understand the experiences of primary care providers implementing an EMR-integrated NutriSTEP screen; identify factors associated with successful implementation; and assess data completeness. This study builds upon previous research[20] that investigated the feasibility of accessing EMR data transmitted to a provincial registry[21] and examined the implementation of the paper-based NutriSTEP screen in 10 primary care practices in Ontario.[15]

Methods

This feasibility study used both qualitative and quantitative methods.

Participants and settings

We recruited a convenience sample of family health teams and nurse practitioner practices through family health team, dietitian and professional networks through the promotion of a one-page advertisement shared using a variety of communication channels. Primary care practices were eligible for inclusion if they were current users of the Accuro® digital EMR software (QHR Technologies, Kelowna, BC, Canada) and were willing to implement the EMR-integrated version of the NutriSTEP screen.

Implementation of the EMR-integrated NutriSTEP screening tool

The development of a standardized NutriSTEP form was led by staff at QHR Technologies, in consultation with the leads for the NutriSTEP screening tool. Functional elements of the standardized NutriSTEP form included automatic scoring of individual questions and overall total score, which was tested by members of the research team. A flag function was built into the standardized form as an option to remind primary care practices of children eligible for a NutriSTEP screen based on their age at the time of their visit. A purpose-built query function was also created for the extraction of discrete data elements of the patient EMR and was determined in collaboration with the research team. As a result of a licensing agreement between QHR Technologies and the University of Guelph, owner of the NutriSTEP screen, the EMR-integrated NutriSTEP screen was made available to all primary care practices using the Accuro EMR.

Research team members provided a 1-hour NutriSTEP training session to interested staff at participating primary care practices via webinar. The research team also developed a key message primer booklet for primary care providers, outlining detailed recommendations and follow-up responses corresponding to each of the 17 NutriSTEP questions. In addition, a variety of educational resources were provided for primary care providers to distribute (at their discretion) to parents based on their child's NutriSTEP score and risk profile. Participating sites implemented the EMR-integrated NutriSTEP screen in a manner that best fit their practice. For primary care practices new to NutriSTEP, implementation began at a time that was convenient for them, once their training was completed.

Data collection and analysis

To understand the experiences of primary care providers implementing the EMR-integrated NutriSTEP screen, we conducted semi-structured interviews with key individuals identified (by their employer) as the person most knowledgeable about NutriSTEP implementation at their site. The implementation science framework developed by Durlak and DuPre,[22] which was used as a theoretical basis for this research, informed the development of the interview guide. One author conducted a one-on-one, audio-recorded telephone interview with the person most knowledgeable about the current use of NutriSTEP at each site. An experienced transcriber transcribed all interviews verbatim. One author then checked the transcript of one interview against the audio recording for verification, and the remaining transcripts were considered accurate. Transcripts were analyzed thematically by one author with support of NVivo 10 qualitative software version 10 (QSR International Pty Ltd. 2012), with the coding structure established a priori based on a modified Durlak and DuPre[22] framework and the research questions. This same author then analyzed each transcript according to the established coding structure. An iterative process was used to develop codes, whereby initial analyses informed the development of additional new codes; all transcripts were analyzed a second time using the newly revised coding structure.

Using the purpose-built query, discrete EMR data were extracted from the EMRs of the participating primary care practices between 20 June, 2016, and 7 July, 2017, by primary care practice staff and transferred to the agency of one member of the research team using a secure file transfer site. Descriptive statistics were generated using SAS version 9.3 (SAS Institute Inc., Cary, NC, USA). The NutriSTEP screen is a 17-item questionnaire that covers four attributes of nutritional status, including food and fluid intake, physical activity and sedentary behaviour, physical growth and development and factors affecting dietary intake and eating behaviours;[12] variables of interest included individual NutriSTEP question score and overall total NutriSTEP score. Each NutriSTEP question has between two and five response options, and each response option is coded with a value ranging between zero and four.[12] The sum of all individual NutriSTEP questions provides an indication of nutritional risk for the child, with a score of 20 or less indicating low risk, a score of 21 to 25 indicating moderate risk and a score of 26 or greater indicating high nutritional risk.[12] The research team considered NutriSTEP data to be valid if primary care providers completed the appropriate screen for the child's age (i.e. providers used a toddler screen for children aged 18–35 months and a preschooler screen for children aged 3–5 years). Furthermore, in this study, we allowed for a one-month buffer, whereby NutriSTEP data were considered valid if the respective screen for a child's age group was within one month of the designated age range (i.e. 17–36 months for the toddler screen and 35–72 months for the preschooler screen).

Other variables of interest extracted from the EMRs included primary care practice site where the screen was completed; child's date of birth; gender; postal code; date (of both NutriSTEP screen completion and height/length and weight measurements); and measured height/length and weight. We established weight-for-age, weight-for-length and BMI-for-age z-scores for children up to 60 months using the World Health Organization's (WHO) Child Growth Standards.[23] We defined weight-for-age and BMI-for-age z-scores using the WHO's Growth Reference Data for 5–19 Years[24] for children 61 to 72 months of age. Growth status was determined using the Dietitians of Canada and Canadian Paediatric Society guidelines.[25] Growth status was determined to be invalid if height/length or weight variables were missing; height/length or weight measurements were deemed implausible; or measurement of height/length or weight was not timely. (After consultation with experts from the field, we decided that growth status calculations would be considered valid from records that collected a child's height/length and weight measurements no more than 30 days apart).

Ethics approval process

Participating public health units with research ethics committees received their respective research ethics approval for this study. Further details of the research ethics process can be found in a report published on Public Health Ontario's website.[26]

Results

Five primary care practices were recruited to implement the EMR-integrated NutriSTEP screen. Two of the sites had prior experience implementing the paper-based screen in their practices and declined to participate in the training webinar provided by the research team. Implementation of NutriSTEP varied by practice site (Table 1). The most common context for administration of the NutriSTEP screen was the 18-month enhanced well-baby visit (n = 3), though some practices also administered it at the 36-month visit (n = 2) and at the 4-year immunization appointment (n = 1); one primary care site administered the NutriSTEP screen only when nutritional risk was suspected (n = 1). Two practices completed the NutriSTEP screen directly into the EMR during their appointments, two practices had an EMR flag prompt front office administrative staff to provide parents with a paper-based NutriSTEP screen for their completion in the waiting room before their appointment, and one practice had parents complete the paper-based NutriSTEP screen during their appointment (when risk was suspected) and responses were entered into the EMR after the visit. Of the two practices that routinely requested that parents complete the paper-based screen before their appointment, one had the registered nurse review the screen with parents during their appointment and enter the NutriSTEP responses into the EMR after the visit, while the other had front office staff enter the NutriSTEP responses into the EMR, with a follow-up phone consult by their registered dietitian to discuss results. In our study, the NutriSTEP screen was administered or reviewed by a registered nurse (n = 3), a nurse practitioner (n = 1) or a registered dietitian (n = 1).

TABLE 1
Characteristics of participating primary care practice sites implementing the EMR-integrated NutriSTEP screen, Ontario, Canada, 2016–2017

Practice site	Tool(s) implemented	Context of use	Administering practitioner	Administration
A	Toddler	18-month EWBV	Registered nurse (RN)	Screen completed during the appointment. Both parent(s) and practitioner look at the monitor and complete together.
B	Toddler, Preschooler	18-month EWBV and 36-month checkup	Registered nurse (RN)	Parent completes screen on paper in waiting room. RN reviews paper version with parent. RN enters data into EMR after the visit.
C	Toddler, Preschooler	18-month EWBV and 36-month checkup	Registered dietitian (RD)	EMR prompts appropriate screen to complete based on age. Parent completes screen on paper in the waiting room. Front office staff enter data into EMR after the visit. RD follows up by phone after appointment and will schedule an appointment if child screens high risk.
D	Preschooler	4-year routine immunizations	Registered nurse (RN)	Screen completed during the appointment. Both parent(s) and practitioner look at the monitor and complete together.
E	Limited number of either screen completed	As needed, if concerns raised during appointment	Nurse practitioner (NP)	Limited number of screens completed.

Abbreviations: EMR, electronic medical record; EWBV, enhanced well-baby visit.

Experiences of primary care practices implementing the EMR-integrated NutriSTEP screen

Using the modified Durlak and DuPre[22] framework (Table 2), we identified critical factors for successful implementation of the EMR-integrated NutriSTEP screen in participating primary care practices; they are described below.

Provider characteristics

According to Durlak and DuPre,[22] provider characteristics include perceptions of a need for the innovation, perceived benefits or drawbacks of the innovation, self-efficacy and skill proficiency to implement the innovation as intended, and are important factors associated with successful implementation of a health promotion innovation. Overall, providers valued the NutriSTEP screen and felt it enhanced the traditional patient visit. This sentiment is described below by one participant.

> I think it's a huge value. I'm a big EMR user, [using] pathways and reminders. I think the Rourke and the well-baby visits are good, but they're very generalized. We don't look at how people eat, you know, we look at what they eat sometimes, but not how they eat, and promoting healthy habits. We have lots of obese children here, so I think it's a good tool to actually get the conversation started about better nutrition and healthy eating habits. It's nice to have. I like objective data…. it's nice to have the scores, and say oh, hey, maybe this patient should go to a pediatrician, or whatever.

Having a staff member advocating for NutriSTEP use and incorporating the screen into appointments were identified as important factors by some practitioners. However, widespread implementation of NutriSTEP screening by all primary care providers did not always occur. As one respondent described, "For the other two physicians [who complete the well-baby visits but did not implement NutriSTEP], they have a nurse to assist, so they go through the Rourke, and the Nipissing, and all of those sort of things, and they didn't really push or promote the NutriSTEP portion of it." Some practitioners noted the voluntary nature of NutriSTEP as an influence on their decision not to administer the screen, instead choosing to use other, required screens, despite their limited nutritional scope.

TABLE 2
Factors associated with the implementation of the NutriSTEP screen in participating primary care practice sites, Ontario, Canada, 2016–2017

I. Provider characteristics
A. Perceived need [or lack of need] for NutriSTEP
Need for nutrition information
NutriSTEP scores
B. Perceived benefits [and drawbacks] of NutriSTEP
Validated and reliable tool
Starts the conversation
Targeting programming
Time commitment
C. Self-efficacy
Personal comfort with nutrition discussions
D. Skill proficiency
II. Characteristics of the innovation
A. Compatibility
Easy to use
Accessible literacy level
Validity and social desirability
B. Adaptability
III. Organizational capacity to implement NutriSTEP
A. General organizational factors
Organizational strategy
Internal committee decision making
Supports within the practice
Value for innovation and leadership
B. Specific practices and processes
Incorporation of NutriSTEP into existing well-baby or well-child visits
Integration of reminders into EMRs
Referral capacity and systems
Prioritizing and making time to implement
C. Specific staffing considerations
Administrative staff roles
Registered dietitian roles
IV. Systems to support NutriSTEP implementation
A. Training and technical assistance

Source: Based on the framework presented in Durlak and DuPre.[22]

Practitioners' responses varied when a concern or a higher level of risk was identified, and included the provision of educational resources for parents, providing advice and detailing current guidelines and recommendations, referring families to a registered dietitian on staff for follow-up, or to another service provider in the community. In addition, primary care providers indicated that parents appreciated the opportunity to discuss nutrition-related issues with practitioners at their scheduled appointments, regardless of their child's nutritional risk score. The additional time required to complete the NutriSTEP screen in an existing visit was a challenge for some practices; while some practitioners were able to extend the visit time, others opted to have parents complete the screen on paper in the waiting room before their visit.

Characteristics of the EMR-integrated NutriSTEP screen

Durlak and DuPre[22] highlight compatibility and adaptability of a health promotion innovation as important features associated with successful implementation. The

NutriSTEP screen was easily adapted and integrated into the current EMR; however, we did not consistently see the adaptation of the EMR-integrated NutriSTEP screen into existing workflows of primary care providers throughout all participating sites. Though having NutriSTEP in the patient EMR facilitated efficient storing and extraction of data, it was not important for all participating sites to have the screen completed electronically: two primary care practices chose to complete the NutriSTEP screen in paper format and later transfer the responses into the patient EMR. One of the practices found the direct completion of the screen in the EMR to be helpful, as illustrated below.

> It's easy to use. It even does the math for you, which I love, it's kind of cool, it's already in there, so nobody had to scan it and make text boxes, which might not sound like a big deal, but when the medical secretaries have to load a PDF that way, they hate it, and put 400 little text boxes, so it really, it made it easy to put it into play. The metrics were already set up, which is also equally as awesome, we didn't have to figure out how to do that, again, it took some of that workload off everybody here.

Some providers noted the compatibility of the NutriSTEP screen to their health care appointments and found the screen facilitated the provider–patient conversations about healthy eating and healthy weights and provided an opportunity to discuss recommendations. As noted by one respondent, "I think that the NutriSTEP, in how it has been developed in the conversation style that you have it set as, is an easy approach for parents, and it's a neutral approach. You're getting them to just rate on average what they think from a day-to-day, and it opens up that conversation."

Organizational capacity and community-level supports

Durlak and DuPre[22] describe organizational capacity to support delivery and community-level supports such as administrative and referral supports as important considerations for successful implementation. Participants in this study identified administrative support as a critical factor for the implementation of the EMR-integrated NutriSTEP screen. Though administration varied across the five participating sites (Table 1), participants noted the value of the NutriSTEP screen in the clinical care and management of patients, as noted below by one participant.

> The good part of it was it addressed some of the feeding issues that some people have, and so then I was able to refer to a dietitian with that. The dietitian loved getting NutriSTEP. They really like it, because otherwise they just get a script with your few notes, right…so [with NutriSTEP] they have something to go by.

For one participating site already implementing the NutriSTEP screen, interviewees identified a pre-existing partnership with public health unit staff and their ongoing support as an important factor for their implementation of this new innovation.

Systems supports for implementing the EMR-integrated NutriSTEP screen

Durlak and DuPre[22] also describe systems supports, including training and technical support, as important factors for successful implementation of a health promotion innovation. In our findings, participants appreciated the training and educational resources provided by the research team; specifically, the educational resources and the key message primer booklet for primary care providers were well received and helpful in building provider confidence with nutrition-related conversations. As noted by one respondent, "I have some of your resources that I always carry with me. …I like that little book too, that's a really nice little booklet that has each question, I really like that. I read that cover to cover, so I knew what I was doing, I thought I did, but making sure I knew everything."

The EMR itself was also identified as an important factor for the implementation of the EMR-integrated NutriSTEP screen. Participating sites identified various functional aspects of the EMR that enhanced the clinical care and management of patients, including the use of flags and reminders in the patient EMR.

Quality of NutriSTEP data extracted from the EMR-integrated screen

In total, 282 patient records were successfully extracted from the EMRs of the five participating primary care practices; two records were identified as duplicates and excluded, resulting in 280 unique patient records available for analysis. The majority of records (74%, n = 206) were generated from one primary care practice, and one participating primary care practice did not yield any valid NutriSTEP completions (Table 3).

Figure 1 illustrates the data processing flow of data extracted via the purpose-built data query. Overall, 92% (n = 258) of records had valid NutriSTEP completions. Reasons for invalid NutriSTEP screens included age not within range at time of completion (n = 3), errors in using the appropriate NutriSTEP screen (i.e. incorrect screen for child's age) (n = 5), missing date of birth (n = 1), and incorrect totalling of individual question scores (n = 13). Growth status was determined for approximately 81% of records (n = 228). Reasons for not being able to calculate growth status included missing height/length or weight measurements (n = 5), invalid date of birth (n = 1), unbelievability of recorded height/length (n = 1), and the lack of recency or timeliness of height/length and weight measurements (i.e. taken more than 30 days apart) (n = 45). Approximately 70% of records (n = 197) had both valid NutriSTEP completions and valid growth measurements. Additional details regarding data extraction findings are listed in Table 4. The dates for

TABLE 3
Number of valid NutriSTEP screen and growth measurement records produced by five participating primary care practice sites, Ontario, Canada, 2016–2017

Practice site	# Unique records	# Valid NutriSTEP completions	Valid NutriSTEP and child growth measurements
A	21	15	13
B	206	200	146
C	31	28	25
D	19	15	13
E	3	0	0
Total	**280**	**258**	**197**

FIGURE 1
Flow chart showing the processing of NutriSTEP implementation feasibility study data collected through EMRs of participating primary care practice sites, Ontario, Canada, 2016–2017

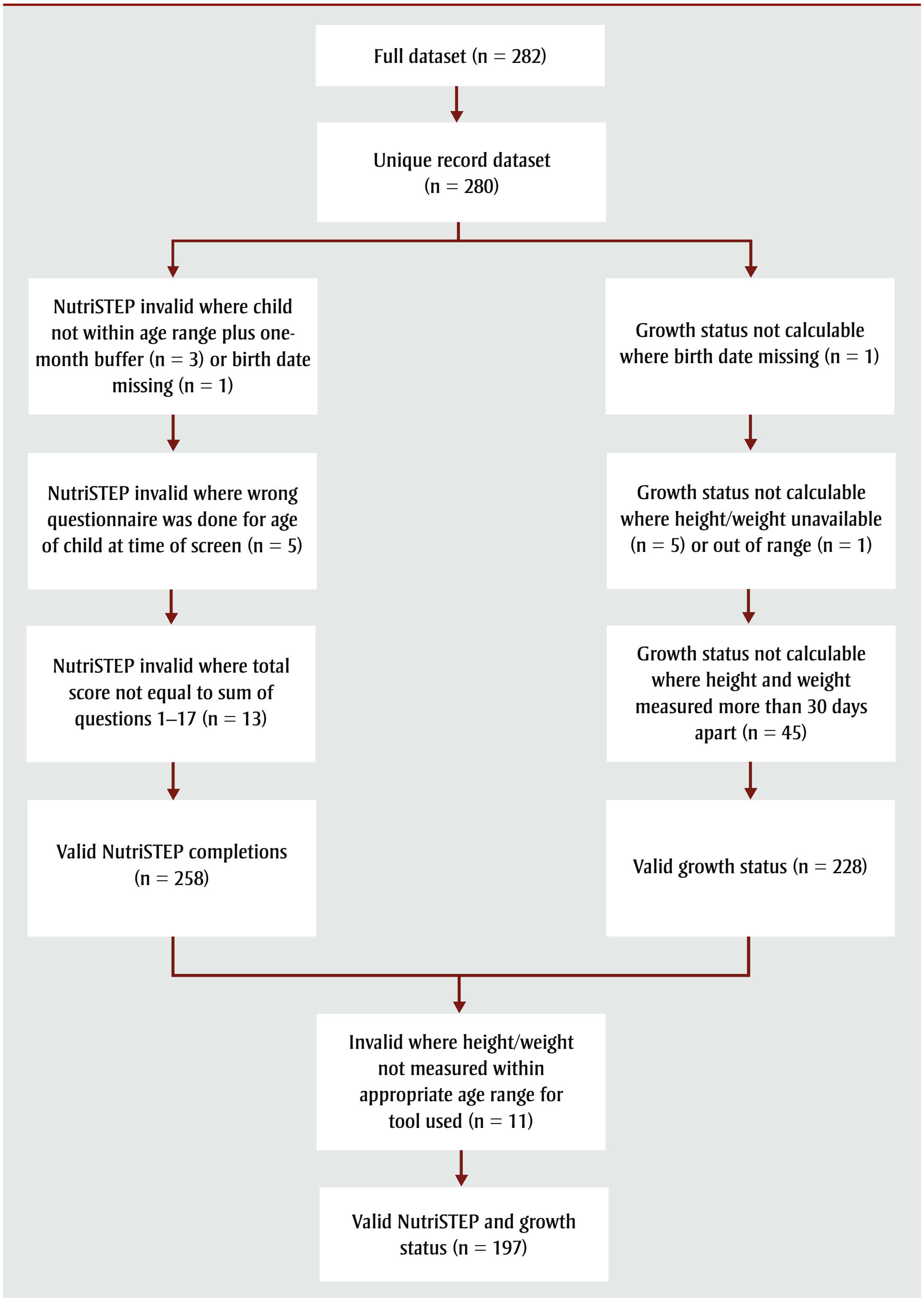

TABLE 4
Data extraction findings from the EMR-integrated NutriSTEP screen in five participating primary care practice sites, Ontario, Canada, 2016–2017

Unique records	n (%)
	280 (100)
Age	
< 17 months	3 (1)
17–23 months	177 (63)
24–35 months	10 (4)
36–47 months	67 (24)
48–59 months	17 (6)
60–72 months	5 (2)
Missing	1 (0.4)
Sex	
Male	131 (47)
Female	149 (53)
Screens used	
Toddler (18–35 months)	190 (68)
Preschooler (36–60 months)	90 (32)
NutriSTEP risk score classification	
Low risk (≤ 20)	245 (88)
Moderate risk (21–25)	9 (3)
High risk (≥ 26)	4 (1)
Indeterminate	22 (8)
Growth status classification	
Underweight/healthy weight	143 (51)
Risk of overweight	49 (18)
Overweight/obese/severely obese	36 (13)
Missing	52 (19)

NutriSTEP screening, height/length measurement and weight measurement did not always coincide. It was later identified that the purpose-built query extracted records with a completed NutriSTEP screen and the most recent height/length and weight for the patient. The date for the most recent height/length and weight collected was not always the same date as the NutriSTEP screen completion date (Table 5); fewer than 50% of records had the same date for height/length, weight and NutriSTEP screen. Due to the small number of records, the research team did not examine the association between nutritional risk and growth status.

Discussion

Overall, primary care providers valued the NutriSTEP screen and felt it positively contributed to the health care visit experience. Though the EMR proved useful for storing and extracting NutriSTEP data, additional work with the purpose-built query function is required to ensure extraction of appropriate data, particularly if EMR data are used to inform a child healthy weight surveillance system.

Implementation varied across participating sites. Having the NutriSTEP screen integrated into the EMR was not essential for its completion, as evidenced by some practices requiring parents to complete the screen in paper format prior to their visit, followed by manual entry by staff into the patient EMR afterwards. Previous research documented similar practices[15,27] and found that additional provider time was required to scan paper-based screening results into patient EMRs. In the study conducted by Saviñon et al.,[27] authors recommended the development of a software program to eliminate the administrative screening step and allow for linking discrete risk and protective factor data to other weight-related variables for a more comprehensive health assessment. Findings from our study demonstrated the feasibility of integrating such a tool as a standardized form and the ability to link NutriSTEP data with measured height/length and weight data. In addition to facilitating appropriate referrals and care, integrating the NutriSTEP screen as an EMR form has the potential to streamline workflow and contribute to possible health care savings.[28]

NutriSTEP screening at one site was only conducted when a nutritional concern was identified or suspected. This non-routine implementation likely contributed to the limited number of screens completed. Given the low prevalence of nutrition risk in young children,[9,10] it is not surprising to see so few screen completions when NutriSTEP is implemented in this manner. Furthermore, none of the three completed screens at this site were valid because the wrong screen was used for the patients' age. The greatest number of valid screens was completed when NutriSTEP was routinely integrated into existing visits such as the 18-month enhanced well-baby visits. In our study, approximately 70% of screens were completed during this visit. Yet, time constraints remained an important consideration because participating practitioners faced challenges completing multiple tasks during this busy appointment. For two sites, this challenge was mitigated by asking parents to complete

TABLE 5
Difference in dates of EMR-collected height and weight and NutriSTEP screen among participating primary care practice sites, Ontario, Canada, 2016–2017

	n (%)
Dates of height and weight measurement and screening are all the same	135 (48)
Weight and height measurements collected on the same date; screening date is different	87 (31)
Screening and collection of height measurement taken on the same date; date of weight measurement is different	29 (10)
Screening and collection of weight measurement taken on the same date; date of height measurement is different	7 (3)
Dates of height and weight measurement collection and screening are all different	22 (8)

NutriSTEP in paper format in the waiting room before their appointment, resulting in the greatest number of screens completed. For one site, this manner of implementation proved very successful, contributing approximately three-quarters of all screen completions.

The low number of screens completed by the other participating practices could be due, in part, to the limited number of primary care providers integrating NutriSTEP into routine visits. While all sites had an individual who advocated for NutriSTEP implementation, other practitioners did not always use the screen, sometimes due to its voluntary nature. Currently, in Ontario, completion of the NutriSTEP screen as part of routine child health visits is not required; yet there remains the opportunity for NutriSTEP implementation during the enhanced 18-month well-baby visit. Province-level support and direction requiring the completion of a comprehensive nutritional risk screen, such as NutriSTEP, would aid in greater uptake and use by primary care providers. Such support would present an opportunity to leverage existing province-level infrastructure and processes[16] that would enhance access to relevant and timely surveillance data. Access to such data would improve the quality of care and management in primary care practices as well as population health assessment and surveillance efforts.

While our study did assess the quality of individual data variables captured through primary care practices' EMRs, a data quality assessment of EMR data collected between sites, as recommended by Kahn et al.,[29] was not conducted. Future research examining the use of EMR data for surveillance purposes should ensure the collection of consistent, accurate and reliable data across multiple sites and EMR platforms.[29] Future research might also consider the use of other frameworks to guide the assessment of widespread adoption and use. The Human–Organization–Technology (HOT–fit) framework proposed by Yusof et al.,[30] for example, considers multiple factors that influence implementation categorized into four domains (i.e. Human, Organization, Technology and net benefits). This framework shares many common elements with the Durlak and DuPre[22] framework; however, the HOT–fit framework[30] provides additional detail for evaluating the technological aspects of an innovation. While our study demonstrated the ability to extract both NutriSTEP and height/length and weight data elements from the EMRs, the query extracted the most recent measured height/length and weight, which were not always measured on the same date of NutriSTEP completion, thereby limiting the ability to link NutriSTEP data with the child's growth status. When considering the development of a provincial or national surveillance system informed by EMR data, technological aspects such as data quality are critical; therefore, it would be ideal if the query extracted these data based on the same visit date.

Strengths and limitations

This small-scale study provides an important contribution to the literature by providing insight into the varying implementation styles of an EMR-integrated NutriSTEP screen in primary care practices and potential factors that influence these workflows. Because this was a feasibility study, we used a convenience sampling method. As a result, our samples were small and nonrepresentative, and though in line with evidence of feasibility studies,[31] the findings cannot be assumed to be generalizable to all primary care practices. In addition, the majority of quantitative data extracted were from one site, further limiting generalizability. Some participating primary care practices were current users of the (paper-based) NutriSTEP screening tool and therefore it is possible that their interest and willingness to implement the EMR-integrated NutriSTEP screen into their practices was different from those practices that were not current users. In addition, participating primary care practices implementing the EMR-integrated NutriSTEP screen were users of one EMR in particular and the experiences, barriers and enablers of participating sites may be different from those of sites using a different EMR.

Conclusion

Many interconnections exist between nutrition behaviour and growth status of children, and consideration of risk and protective factor data by primary care practitioners provides an opportunity for early identification, management and referral for individual support. There are still many challenges to consistent and accurate EMR use in primary care that must be addressed. Critical to population health intervention research is an understanding of factors that may influence outcomes.[6] Our study identified several factors associated with the implementation of an EMR-integrated NutriSTEP screen in the primary care setting. While findings should be interpreted in the context of a small-scale study, they can inform further efforts to broaden its implementation to other primary care practices. Taken together, findings from our research suggest that it is feasible to integrate a validated nutrition screening tool into primary care EMRs, store the resulting data as discrete data elements for later extraction, and link them with other weight-related measures, allowing for comprehensive child health and weight assessments.

EMRs also present an opportunity to address the current gap in childhood healthy weights surveillance data for use in public health. This study highlighted the value of key partnerships with stakeholders such as EMR vendors, local public health units and primary care practices as important factors in such a screening program. Such collaborations should be considered if EMR data are to be used to inform a surveillance system that moves beyond BMI to improve population health.[32] EMRs provide an opportunity for enhanced integration of preventive public health action and primary care provision, and bi-directional sharing of information[30] through the development of a centralized surveillance system. The benefits of this system would extend beyond supporting clinical decision-making to include monitoring of population health outcomes and support quality improvement for an evidence-informed health system; however, additional work is required to determine if the widespread collection of data from EMRs would result in accurate and representative estimates.[33]

Acknowledgements

The findings outlined in this manuscript come from a multi-phased Beyond BMI research project, which was funded by a Public Health Ontario (PHO) Locally Driven Collaborative Projects (LDCP) grant; no funding was provided for the development of this manuscript. The preliminary study occurred in 2014/15, followed by the EMR-integration study, which occurred in 2016/17. Findings from the larger Beyond BMI LDCP project are found in final reports provided to PHO as part of the LDCP Transfer Payment Agreements. These reports are publicly available on the

PHO website (and cited in the current manuscript).

Conflicts of interest

The authors declare they have no competing interest. The University of Guelph holds the rights from Public Health Sudbury & Districts, Dr. Janis Randall Simpson, Dr. Heather Keller and Ms. Lee Rysdale to license the NutriSTEP screening tool, the Toddler NutriSTEP screening tool and related documentation, translations, trademarks, trade names or logos. Dr. Randall Simpson is one of the originators of NutriSTEP and receives royalties with respect to the licensing of questionnaires.

Authors' contributions and statement

LA, KM, DM and JB designed the study. SJS, KM, KN, DM, LA, JRS and JB developed the data collection and analysis protocols. SJS and KN led data analysis with contributions from all other authors. LA took the lead in drafting and revising the manuscript, with critical feedback and input from KM, SJS, JRS and JB. All authors have read and provided final approval of this manuscript for publication.

The content and views expressed in this article are those of the authors and do not necessarily reflect those of the Government of Canada.

References

1. Roberts KC, Shields M, de Groh M, et al. Overweight and obesity in children and adolescents: results from the 2009 to 2011 Canadian Health Measures Survey. Health Rep. 2012;23(3):37-41.

2. Rao DP, Kropac E, Do MT, et al. Childhood overweight and obesity trends in Canada. Health Promot Chronic Dis Prev Can. 2016;36(9): 194-8.

3. Ontario Agency for Health Protection and Promotion (Public Health Ontario). Addressing obesity in children and youth: evidence to guide action for Ontario. Toronto (ON): Queen's Printer for Ontario; 2013. 288 p.

4. Ogden CL, Carroll MD, Kit BK, et al. Prevalence of childhood and adult obesity in the United States, 2011–2012. J Am Med Assoc. 2014;311(8):806-14.

5. Wheeler JJ. Risk of obesity at 4 to 6 years of age among overweight or obese 18-month-olds: community-based cohort study. Can Fam Physician. 2013; 59(4):e202-e208.

6. Hawe P, Potvin L. What is population health intervention research? Can J Public Health. 2009;100(1): Suppl I8-I14.

7. Ontario Food and Nutrition Strategy Group. Ontario Food and Nutrition Strategy: a comprehensive evidence-informed plan for healthy food and food systems in Ontario. Toronto (ON): Ontario Food and Nutrition Strategy Group; 2017. 112 p.

8. Registered Nurses' Association of Ontario. Primary prevention of childhood obesity. 2nd ed. Toronto (ON): Registered Nurses' Association of Ontario; 2014. 144 p.

9. Randall Simpson J, Keller H, Rysdale L, et al. Nutrition Screening Tool for Every Preschooler (NutriSTEP): validation and test-retest reliability of a parent-administered questionnaire assessing nutrition risk of preschoolers. Eur J Clin Nutr. 2008;62:770-80.

10. Randall Simpson J, Gumbley J, Whyte K, et al. Development, reliability, and validity testing of Toddler NutriSTEP: a nutrition risk screening questionnaire for children 18–35 months of age. Appl Physiol Nutr Metab. 2015; 40(9):877-86.

11. Randall Simpson J, Boere M, Dwyer J, et al. Efficacy of nutrition risk screening with NutriSTEP among toddlers and preschoolers. Poster session presented at: Canadian Nutrition Society. Scientific Abstracts from the 8th Annual Scientific Meeting; 2017 May 25-27; Montréal, Quebec.

12. NutriSTEP Implementation Toolkit. Toronto (ON): Nutrition Resource Centre and Janis Randall Simpson. 2008 [updated 2015]. 39 p.

13. Watson-Jarvis K, McNeil D, Fenton TR, et al. Implementing the Nutrition Screening Tool for Every Preschooler (NutriSTEP) in community health centres. Can J Diet Pract Res. 2011;72(2):96-8.

14. Valaitis R. Strengthening primary health care through primary care and public health collaboration: final report for CFHI. Hamilton (ON): Canadian Foundation for Healthcare Improvement; 2012. 45 p.

15. Snelling SJ, Andrade L, Malaviarachchi D, et al. Beyond BMI (Phase 2): risk and protective factors for child healthy weights assessed using NutriSTEP in primary health care. In: Beyond BMI Research Team. Beyond BMI: investigating the feasibility of using NutriSTEP and electronic medical records as a surveillance system for healthy weights including risk and protective factors in children. Toronto (ON): Locally Driven Collaborative Projects; 2015; 32-80.

16. Healthy Kids Panel. No time to wait: the healthy kids strategy. Toronto (ON): Ministry of Health and Long-Term Care; 2013. 66 p.

17. Groseclose SL, Buckeridge DL. Public health surveillance systems: recent advances in their use and evaluation. Annu Rev Public Health. 2017;38: 57-79.

18. Ontario Agency for Health Protection and Promotion (Public Health Ontario). Measuring the health of infants, children and youth for public health in Ontario: indicators, gaps and recommendations for moving forward. Toronto (ON): Queen's Printer for Ontario; 2013. 58 p.

19. Brauer P, Royall D, Dwyer J, et al. Obesity services planning framework for interprofessional primary care organizations. Prim Heal Care Res Dev. 2017;18(2):135-47.

20. Beyond BMI Research Team. Beyond BMI: investigating the feasibility of using NutriSTEP and electronic medical records as a surveillance system for healthy weights including risk and protective factors in children. Toronto (ON): Locally Driven Collaborative Projects; 2015. 95 p.

21. Jamal S, Moran K, Biro S, et al. Data quality assessment of child healthy weights from electronic medical records. In: Beyond BMI Research Team. Beyond BMI: investigating the feasibility of using NutriSTEP and electronic medical records as a surveillance system for healthy weights including risk and protective factors in children. Toronto (ON): Locally Driven Collaborative Projects; 2015:1-31.

22. Durlak JA, DuPre EP. Implementation matters: a review of research on the influence of implementation on program outcomes and the factors affecting implementation. Am J Community Psychol. 2008;41(3–4): 327-50.

23. World Health Organization (WHO). The WHO child growth standards [Internet]. Geneva (CH): WHO; 2010 [updated 2014; cited 2017 Sep 1]. Available from: https://www.who.int/childgrowth/standards/en/

24. World Health Organization (WHO). The WHO growth reference data for 5-19 years [Internet]. Geneva (CH): WHO; 2007 [cited 2017 Sept 1]. Available from: http://www.who.int/growthref/en/

25. Dietitians of Canada and Canadian Paediatric Society. A health professional's guide for using the WHO growth charts for Canada. 2014. 14 p.

26. Beyond BMI Research Team. Beyond BMI: building an EMR-based childhood healthy weights surveillance system to include nutritional risk and protective factors through the collection and EMR integration of NutriSTEP: final report (Phase 3). Toronto (ON): Locally Driven Collaborative Projects; 2017. 33 p.

27. Saviñon C, Taylor JS, Canty-Mitchell J, et al. Childhood obesity: can electronic medical records customized with clinical practice guidelines improve screening and diagnosis? J Am Acad Nurse Pract. 2012;24(8):463-71.

28. Hillestad R, Bigelow J, Bower A, et al. Can electronic medical record systems transform health care? Potential health benefits, savings, and costs. Health Aff. 2005;24(5):1103-17.

29. Kahn MG, Raebel MA, Glanz JM, et al. A pragmatic framework for single-site and multisite data quality assessment in electronic health record-based clinical research. Med Care. 2012;50(7 Suppl 1):S21-S29.

30. Yusof MM, Kuljis J, Papazafeiropoulou A, et al. An evaluation framework for health information systems: human, organization and technology-fit factors (HOT-fit). Int J Med Inform. 2008; 77(6):386-98.

31. Bowen DJ, Kreuter M, Spring B, et al. How we design feasibility studies. Am J Prev Med. 2009;36(5):452-7.

32. IOM (Institute of Medicine). Primary care and public health: exploring integration to improve population health. Washington (DC): The National Academies Press; 2012. 212 p.

33. Birkhead GS, Klompas M, Shah NR. Uses of electronic health records for public health surveillance to advance public health. Annu Rev Public Health. 2015;36(1):345-59.

https://doi.org/10.24095/hpcdp.40.1.02

Original quantitative research

Adoption of municipal bylaw legislating mandatory helmet use for cyclists under the age of 18: impact on cycling and helmet use

Aurélie Maurice, FRCPC (1); Michel Lavoie, MD (2); Denis Hamel, MSc (3); Mylène Riva, PhD (4)

This article has been peer reviewed.

Tweet this article

Abstract

Introduction: Bicycle helmet use is recognized as an effective way to prevent head injuries in cyclists. A number of countries have introduced legislation to make helmets mandatory, but many object to this type of measure for fear that it could discourage people, particularly teenagers, from cycling. In 2011, the City of Sherbrooke adopted a bylaw requiring minors to wear a bicycle helmet. The objective of this study was to assess the impact of this bylaw on cycling and bicycle helmet use.

Methods: The impact of the bylaw was measured by comparing the evolution of bicycle helmet use among youth aged 12 to 17 years in the Sherbrooke area (n = 248) and in three control regions (n = 767), through the use of logistic regression analyses.

Results: Cycling rates remained stable in the Sherbrooke area (going from 49.9% to 53.8%) but decreased in the control regions (going from 59.1% to 46.3%). This difference in evolution shows that cycling rates increased in the Sherbrooke area after the adoption of the bylaw, compared to the control regions (odds ratio [OR] of the interaction term: 2.32; 95% confidence interval [CI]: 1.01–5.35). With respect to helmet use, a non–statistically significant upward trend was observed in the Sherbrooke area (going from 43.5% to 60.6%). This figure remained stable in the control regions (going from 41.5% to 41.9%). No significant difference was observed in the evolution of helmet use between the two groups (OR of the interaction term of 2.70; 95% CI: 0.67–10.83).

Conclusion: After the bylaw was adopted, bicycle use among youth aged 12 to 17 years in the Sherbrooke area remained stable and helmet used increased, though not significantly.

Keywords: *legislation, helmet use, cycling, youth*

Highlights

- A municipal bylaw requiring cyclists under the age of 18 years to wear a bicycle helmet has not been associated with a decrease in cycling among youth aged 12 to 17 years.
- These results are not necessarily generalizable to a province or country because it is not certain that the promotional activities that accompanied the bylaw can be carried out with the same intensity in those regions as at the municipal level.

Introduction

Cycling is encouraged for its health benefits.[1] However, cycling is also associated with a risk of serious injury, in particular to the head.[2-4] Bicycle helmets are known to be effective in preventing head injuries, especially among young people, both in the event of a fall and in the event of a collision with a motor vehicle.[5-7] In Quebec, in 2014, just 34.5% of cyclists over the age of 12 reported having always worn a bicycle helmet in the previous 12 months.[8]

A few countries, including Australia and New Zealand, some American states and several Canadian provinces have made bicycle helmets mandatory in order to increase helmet use. In Canada, bicycle helmets are mandatory in eight provinces, either for all cyclists (Nova Scotia, New Brunswick, Prince Edward Island, Newfoundland and Labrador and British Columbia) or for minors only (Ontario, Manitoba and Alberta).[9] In Quebec, the use of bicycle helmets is voluntary, except in the City of Sherbrooke, where a municipal bylaw has required cyclists under the age of 18 to wear helmets since March 2011. Three parliamentary committees in Quebec had heated debates on whether bicycle helmets should be mandatory throughout Quebec (in 1996, 2000 and 2010) but this measure was rejected each time. The main argument used by opponents was that this measure could have an overall negative health impact, by reducing cycling rates.[10,11]

Around 10 studies have been carried out in Australia,[11-14] New Zealand,[15] the United States[16] and Canada[9,17-19] to assess the impact of mandatory bicycle helmet measures on cycling rates. The results observed in the majority of these studies show that this type of measure is associated with

Author references:

1. Direction de santé publique, Centre intégré universitaire de santé et de services sociaux de la Capitale-Nationale, Québec City, Quebec, Canada
2. Direction du développement des individus et des communautés, Institut national de santé publique du Québec, Québec City, Quebec, Canada
3. Bureau d'évaluation et d'études en santé des populations, Institut national de santé publique du Québec, Québec City, Quebec, Canada
4. Institute for Health and Social Policy and Department of Geography, McGill University, Montréal, Quebec, Canada

Correspondence: Aurélie Maurice, Direction de santé publique, Centre intégré universitaire de santé et de services sociaux de la Capitale-Nationale, 2400 avenue D'Estimauville, Québec City, QC G1E 7G9; Tel: 418-666-7000; Email: aurelie.maurice.ciussscn@ssss.gouv.qc.ca

reduced cycling rates, particularly among youth.[11-14,16] However, most of these studies have significant methodological limitations (e.g. lack of a control group; a single measure before or after the law; or failure to control the effect of confounding variables, such as weather or changes in cycling infrastructure), which make it more difficult to interpret the observed results. Although it is not certain that legislation requiring cyclists to wear helmets would reduce cycling rates, this risk remains a public health concern, particularly for youth. In addition, a lack of helmet use is worrisome, considering that helmets can prevent between 50% and 69% of head injuries among cyclists.[6]

The objective of this study was to assess how a City of Sherbrooke bylaw legislating mandatory helmet use for cyclists under the age of 18 has affected cycling rates and bicycle helmet use. This article is based on the results of a Master of Public Health degree thesis on this topic.[20]

Methods

Intervention description

The City of Sherbrooke, with a population of around 140 000,[21] adopted a bylaw requiring cyclists under the age of 18 to wear a bicycle helmet. This bylaw has been in effect since March 1, 2011. Violations come with a $30 fine, but a non-punitive approach has been the preferred choice. Instead of issuing the fine, patrol officers inform cyclists who are not wearing a helmet that it is important to wear a helmet. Officers may even provide a helmet to cyclists who do not have one. Other types of activities were carried out in the community, particularly in schools, businesses and the health sector, before and after this bylaw came into force, to promote cycling and helmet use among youth (e.g. helmet donations, low-cost bicycles, expansion of cycling network, media campaign).

Study specifications and parameters

This study compared the evolution of cycling and helmet use (after the implementation of the bylaw vs. before) among young people subject to this bylaw, compared to a control group of young people who were not subject to this bylaw.

Data source

Data on cycling and helmet use are from the Canadian Community Health Survey (CCHS), a cross-sectional survey administered by Statistics Canada and conducted on an ongoing basis. Data for this survey are collected using surveys administered in person or by telephone to a representative sample of the Canadian population aged 12 years and over. This sample varies from one cycle to the next.[22] The use of random sample selection and survey weights allows the sample results to be inferred from regional populations. The data on cycling come from four survey cycles: two cycles before (2007–08 and 2009–10) and two cycles after (2011–12 and 2013–14) the adoption of the bylaws. For helmet use, only one survey cycle was used before (2009–10) and one after (2013–14) the adoption of these bylaws, since the data were not available prior to 2009–10 and were collected only every other cycle.

Exposed group

The exposed group consisted of the 248 youth aged 12 to 17 years who participated in one of the four CCHS cycles conducted in the Sherbrooke Census Metropolitan Area (CMA). The age limit of 12 years was determined based on the minimum age of the CCHS participants, and the age limit of 17 years was determined based on the maximum age of the persons covered by the bylaw. The Sherbrooke CMA encompasses a number of census subdivisions, and 77% of youth aged 12 to 17 residing in the CMA live in the City of Sherbrooke.

Unexposed group

The unexposed group consisted of the 767 youth aged 12 to 17 years who participated in one of the four CCHS cycles conducted in the Gatineau (n = 335), Trois-Rivières (n = 192) and Saguenay (n = 240) CMAs between 2009 and 2014. These three CMAs were selected because of their similarities to the Sherbrooke CMA in terms of the main factors influencing cycling, namely, the size of the population,[23] the topography of the land,[24] the climate and the size of the cycling network.[25]

Cycling

Cycling rates were measured using CCHS data on recreational and utility cycling. In this survey, recreational cycling was measured by the question, "In the past three months…have you done any of the following activities [including cycling]?" Utility cycling was measured by the question, "In the past three months…[did you bicycle] to and from work or school?" Anyone who answered yes to at least one of these two questions was considered to be a cyclist, and anyone who answered no to these questions was considered a non-cyclist. We chose to use a dichotomous variable to maintain statistical power and to reduce the risk of recall bias, which is more likely with a frequency variable.

Helmet use

Helmet use was measured based on data collected from CCHS participants who reported riding a recreational or utility bicycle at least once in the previous three months. In this survey, helmet use was measured by the question, "When riding a bicycle, how often do you wear a helmet?" Respondents who reported wearing a helmet most of the time or always were considered helmet users, and those who reported wearing a helmet rarely or never were considered non-users.

Adjustment variables

The following variables were considered as adjustment variables in the statistical models: age, gender, season, level of material deprivation (proportion of people with less than high school graduation, employment/population ratio and average personal income) and level of social deprivation (proportion of people who are separated, divorced or widowed; proportion of people living alone; and proportion of single-parent families).[26] The "season" variable was created to ensure that the regions were balanced with respect to the seasons. The season was determined based on the month of the study, considering the fact that the respondent was providing answers corresponding to the three months prior to the study. Respondents who answered the survey from August to October were assigned the summer variable, fall was assigned to November to January, winter was assigned to February to April and spring was assigned to May to July.

Statistical analyses

The 1015 participants in the study were divided based on the survey cycles conducted before and after the bylaw came into force and compared for each of the adjustment variables using a Chi-square test at a 5% significance level. Analyses were then conducted to calculate the prevalence of cycling and helmet use in the

Sherbrooke CMA and the control CMAs, before and after the adoption of the bylaw, with 95% confidence intervals (CI). The prevalence of cycling was calculated by adjusting for the season. Logistic regression analyses were conducted to compare the evolution of cycling and helmet use before and after the adoption of the regulation in the Sherbrooke CMA and the control CMAs by transforming the results obtained into an odds ratio (OR). The impact of the bylaw on cycling and helmet use in the Sherbrooke CMA was measured by adding to the regression model a term of interaction between the Time variable (before vs. after the bylaw) and the CMA variable (Sherbrooke CMA vs. control CMAs). The presence of interaction signifies that the change observed before versus after the implementation of the bylaw differs in the two groups of CMAs, which shows the impact of the bylaw. The regression analyses were all done by controlling for the effect of potentially confounding variables present in the databases.

Table 1 shows the OR calculation of the dependent variable before and after the adoption of the bylaw in the Sherbrooke CMA and in the other CMAs, the gap observed between these two periods in the Sherbrooke CMA and the other CMAs ("difference"), and the gap observed between these two groups ("difference in the difference"). The OR is calculated by taking the exponential of β calculated by the regression model (e.g. $e^{\beta 1}$ = OR of the dependent variable in the Sherbrooke CMA before the adoption of the bylaw). The reference group corresponds to the other CMAs before the bylaw, which is why the OR equals 1 ($e^0 = 1$) for this group in the regression model. The other ORs refer to this value. The value of an OR may be equal to 1 (probability unchanged), less than 1 (decreased probability) or greater than 1 (increased probability). We calculated a 95% CI for the ORs and set the statistical significance threshold at .05 (*p*-value of β coefficients). The OR is therefore statistically significant when the CI does not include the value 1 for a significance threshold at .05.

In addition, in order to ensure that the results of the analyses are representative of the population of each CMA and not of the sample used in this study, a weighting factor adapted to the scale of the CMAs was included in the statistical analyses.[22] Lastly, in accordance with Statistics Canada recommendations,[22] bootstrapping was used to estimate the variance of the model parameters. The statistical analyses were performed using SAS 9.4 (SAS Institute Inc., Cary, NC, USA) and SPSS 22.0 (IBM, Chicago, IL, USA).

Results

The results presented in Table 2 show that the sample is equally distributed before and after the coming into force of the bylaw for gender, season, material deprivation and social deprivation. However, the sample distribution differs for the CMAs, likely due to the decrease in the number of participants in the Trois-Rivières CMA after the coming into force of the regulation compared to before. A difference was observed for the age distribution of the sample, but this result is not statistically significant.

Cycling

Before the bylaw came into force, the prevalence of cycling among youth aged 12 to 17 years was 49.9% (95% CI: 40.7–59.1) in the Sherbrooke CMA and 59.1% (95% CI: 53.9–64.3) in the control CMAs (Table 3). After the adoption of the bylaw, the prevalence of cycling increased to 53.8% in the Sherbrooke CMA, but this increase was not statistically significant (OR: 1.25; 95% CI: 0.58–2.59). Conversely, there was a marked decrease to 46.3% in the prevalence of cycling in the control CMAs (OR: 0.54; 95% CI: 0.36–0.80). The value of the OR associated with the CMA*Time interaction term shows that the decline in cycling observed in the control CMAs was not observed in the Sherbrooke CMA, despite the adoption of the bylaw (OR interaction: 2.32; 95% CI: 1.01–5.35).

Helmet use

Before the bylaw came into force, the prevalence of bicycle helmet use among youth aged 12 to 17 years was 43.5% (95% CI: 24.6–64.0) in the Sherbrooke CMA and 41.5 % (95% CI: 32.8–50.2) in the control CMAs (Table 3). After the bylaw came into force, helmet use increased to 60.6% in the Sherbrooke CMA, but the impact measured by the OR was not statistically significant (OR: 2.61; 95% CI: 0.75–9.04). In the control CMAs, helmet use remained stable at 41.9% (OR: 0.97; 95% CI: 0.52–1.80). Analysis of the interaction results suggests an increase in helmet use in the Sherbrooke CMA compared to the control CMAs after the adoption of the bylaw versus before (OR interaction: 2.70; 95% CI: 0.67–10.83). The CI is high because of a lack of statistical power.

Discussion

Cycling

Cycling among youth aged 12 to 17 years remained stable in the Sherbrooke CMA in the period before and after the coming into force of the City of Sherbrooke bylaw, while cycling decreased in the control CMAs. This decrease is consistent with the results observed in Quebec as a whole as well as in the Estrie region, which includes the Sherbrooke CMA, for both youth aged 12 to 17 and adults aged 18 to 24.[20] As a result of this different evolution, cycling rates among youth aged 12 to 17 were higher in the Sherbrooke CMA than in the control CMAs after the coming into force of the bylaw compared to before.

This different evolution could be the result of two factors likely to have had a positive

TABLE 1
Probability of occurrence of the dependent variable (OR) before and after the coming into force of the mandatory helmet-use bylaw, based on place of residence

	Before	After	Difference	Difference in the difference[a]
Sherbrooke CMA	$e^{\beta 1}$	$e^{\beta 1 + \beta 2 + \beta 3}$	$e^{\beta 2 + \beta 3}$	$e^{\beta 3}$
Other CMAs	1	$e^{\beta 2}$	$e^{\beta 2}$	

Abbreviations: CMA, census metropolitan area; OR, odds ratio.

Note: e^{β} = OR.

[a] The difference in the difference corresponds to the net impact of the bylaw or to the term CMA*Time of the regression model.

TABLE 2
Sample distribution (n = 1015) before and after the bylaw came into force for the adjustment variables studied

Variables	Before		After		
	Percentage (%)	Respondents (n)	Percentage (%)	Respondents (n)	*p*-value[a]
Gender					.660
Boy	50.9	278	49.6	232	
Girl	49.1	268	50.5	237	
Age (years)					**.052**
12–14	50.0	272	43.9	205	
15–17	50.0	274	56.1	264	
Seasons					.606
Summer	27.8	152	27.2	127	
Fall	27.7	151	24.5	115	
Winter	21.9	119	24.4	114	
Spring	22.6	124	23.9	113	
Material deprivation					.379
Very privileged	27.5	150	31.5	147	
Privileged	25.1	137	21.0	98	
Neither privileged nor underprivileged	20.4	111	20.1	94	
Underprivileged[b]	27.1	148	27.4	130	
Social deprivation					.175
Very privileged	20.1	109	20.5	96	
Privileged	23.3	132	18.7	88	
Neither privileged nor underprivileged	24.8	135	23.2	109	
Underprivileged[b]	31.9	170	37.6	176	
CMA					**< .001**
Sherbrooke	23.6	129	25.4	119	
Trois-Rivières	23.3	127	13.9	65	
Gatineau	33.0	180	33.1	155	
Saguenay	20.2	110	27.7	130	

Abbreviation: CMA, census metropolitan area.

Note: Bolded values are statistically significant.

[a] The *p*-value is that of the likelihood ratio test of the Chi-square test.

[b] The "Underprivileged" category is a grouping of quintiles 4 and 5 of disadvantage.

TABLE 3
Prevalence (%) and odds ratios (OR) for cycling and helmet use among youth aged 12 to 17 years before and after the bylaw came into force, by place of residence

	Prevalence (%) Before the bylaw (95% CI)	Prevalence (%) After the bylaw (95% CI)	Adjusted OR (95% CI)[b]	OR interaction (95% CI)[c]
Cycling[a]				**2.32 (1.01–5.35)**
Sherbrooke CMA	49.9 (40.7–59.1)	53.8 (43.4–64.2)	1.25 (0.58–2.59)	
Other CMAs	59.1 (53.9–64.3)	46.3 (40.1–52.6)	**0.54 (0.36–0.80)**	
Helmet use				2.70 (0.67–10.83)
Sherbrooke CMA	43.5 (24.6–64.0)	60.6 (37.5–80.7)	2.61 (0.75–9.04)	
Other CMAs	41.5 (32.8–50.2)	41.9 (30.2–53.6)	0.97 (0.52–1.80)	

Abbreviations: CI, confidence interval; CMA, census metropolitan area; OR, odds ratio.

Note: Bolded values are statistically significant.

[a] The prevalence of cycling is adjusted for the season.

[b] This value corresponds to the difference in the measurement of the dependent variable (cycling or helmet use) after compared to before the coming into force of the bylaw. These ORs are adjusted for potentially confounding variables: age, sex, season and level of material and social deprivation.

[c] The interaction term (CMA*Time) is the net impact of bylaw. The latter corresponds to the difference in the difference in the measurement of the dependent variable (cycling or helmet use) after the bylaw came into force compared to before, in the Sherbrooke CMA versus the other CMAs.

influence on cycling in Sherbrooke. Information from key informants showed that, on the one hand, there was more, and more varied, promotion of cycling and helmet use before and after the adoption of the bylaw in the Sherbrooke CMA than in the control CMAs. On the other hand, the non-punitive approach used by City of Sherbrooke police officers to enforce the bylaw (e.g. giving a bicycle helmet to cyclists who did not have one instead of issuing a fine) had a positive impact. Analysis of the weather data shows that, during the period studied, the number of days with low temperatures (below 15°C) or high temperatures (above 28°C) and the number of days of rain (1 mm or more) were comparable in the three control CMAs and in the Sherbrooke CMA.[27]

The results of studies conducted in Australia,[11-14] New Zealand[15] and the United States[16] show that cycling rates decreased after bicycle helmets were made mandatory, in particular among young people. However, the results of the studies conducted in Australia and New Zealand should be interpreted with caution, given the presence of significant methodological limitations (lack of a control group; a single measure before or after the law; or failure to control the effect of confounding variables, such as weather or changes in cycling infrastructure). On the other hand, the results of the study conducted in the United States are of concern since it was much more methodologically rigorous than those conducted in Australia and New Zealand. The results observed in the three studies conducted in Canada are contradictory. The Karkaneh study[17,18] observed a reduction in cycling rates among youth in Alberta after the law, while those conducted by Macpherson et al.[19] in Ontario and by Dennis et al.[9] in Alberta and Prince Edward Island show no change in cycling. All of these studies were conducted at the territorial level of country or province, which may have masked the smaller-scale changes, for example, at the regional level. Moreover, none of the studies allow the results observed to be interpreted in the context of the implementation and enforcement of the law, due to the lack of information on the nature and type of activities carried out to strengthen bylaw enforcement or to promote cycling and helmet use.

Helmet use

The results of our study suggest that bicycle helmet use increased among youth aged 12 to 17 years in the Sherbrooke CMA after the bylaw came into effect, while it remained stable in the control CMAs. Although helmet use increased from 43.5% to 60.6% among young cyclists aged 12 to 17 in Sherbrooke after the bylaw came into effect, this increase is not significant, likely as a result of the small sample sizes available for the two cycles of the CCHS in question (50 and 39 respondents, respectively). The sample was small because just one measure was available both before and after the coming into force of the bylaw, and also because this measure applied only to those who reported having cycled in the previous three months. In our study, an OR of 2.6 can be detected with a statistical power of just 30%. For an OR of 2.6 to have been detected with a statistical power of 80%, the regression model would have to have been adjusted based on a sample of at least 280 respondents in total over the two cycles (before and after), which was not possible. That said, assuming that this increase in helmet use was real, this type of before-and-after change would be of clinical importance, given that helmet use is an effective way to prevent head injuries.[5-7] Furthermore, the measurement of bicycle helmet use may be overestimated in the Sherbrooke CMA, as it is possible that young Sherbrooke residents were more reluctant to report not always wearing a bike helmet, knowing that the use of this equipment was then mandatory in their municipality. However, the fact that the CCHS ensures the anonymity of respondents likely reduced the extent of this bias. Finally, we cannot exclude the possibility that helmet use increased independently of the regulations, as a result of the numerous promotional activities that were carried out.

The results of this study are consistent with those observed in the study by Cyr and Ouedrago,[28] which showed a significant increase in bike helmet use among young Sherbrooke residents after the bylaw came into force. According to this observational study, the extensive bicycle-safety awareness campaign (including the coming into force of the bylaw) helped increase helmet use. The results of this study showed that helmet use increased from 38% in 2006 to 92.9% in 2011 in cyclists aged 10 to 15, and from 12% to 57% for cyclists aged 16 to 18. A number of studies observed an increase in helmet use after it was made mandatory.[29-35] However, some authors attribute the proportional increase in helmet use to the decrease in the number of cyclists who do not use helmets (which leads to an artificial increase of the proportion of helmet users) instead of an increase in the number of helmet users (which involves a real increase in the proportion of helmet use).[36,37] In this study, the increase in the use of bicycle helmets cannot be attributed to a decrease in the number of cyclists not wearing a helmet, since cycling remained stable after the bylaw came into force in the Sherbrooke CMA.

Strengths and limitations

This study has several methodological characteristics that ensure the internal validity of the observed results: a before-and-after research design with an exposed group and a control group; the availability of two measures of cycling before and after the coming into force of the bylaw; documentation on the type of activities carried out to implement the bylaw; knowledge of the type of activities carried out in Sherbrooke and the three control CMAs to promote cycling and helmet use during this period; and knowledge of weather data in the regions concerned.

However, the research design of this study has some limitations. Our study does not make it possible to separate the specific impact that the bylaw had on cycling and helmet use from the impact of the awareness campaigns. To do so, it would have been necessary to have a control group from a region that had the same awareness campaigns as in Sherbrooke, which did not exist in Quebec. Also, in order to obtain sufficient statistical power, all youth in the Sherbrooke CMA were included in the exposed group, even though the bylaw applied only to the territory of the City of Sherbrooke. We obtained high ORs, but these figures remained insignificant. A larger sample size would have allowed us to verify the trends observed, especially for bicycle helmet use. Furthermore, we did not use the more sensitive variable of cycling frequency, but by using a dichotomous variable we observed an increase in cycling rates in the Sherbrooke CMA compared to the control CMAs (Table 3; interaction OR: 2.32; 95% CI: 1.01–5.35). Lastly, the results of this study are valid in an area in which a non-punitive approach was taken to enforce the bylaw.

Conclusion

The results of this study suggest that a municipal bylaw legislating mandatory helmet use for cyclists under the age of 18 can be implemented without being associated with a decrease in cycling rates among youth aged 12 to 17, if the bylaw is implemented in a non-punitive manner and if cycling and helmet use are promoted. However, the study specifications and parameters do not exclude the possibility that such a bylaw could have reduced the impact of cycling promotional activities. Furthermore, these results cannot necessarily be applied at a provincial or national level because there is no guarantee that the awareness campaigns for the bylaw can be carried out to the same degree as at the municipal level.

Acknowledgements

We would like to thank the members of comité Communauté sécuritaire de l'organisme Sherbrooke Ville en santé, who graciously agreed to collaborate on this project by providing enlightening information on the specific context of cycling in Sherbrooke. We would also like to thank Dr. Pierre Maurice and Mathieu Gagné of the Institut national de santé publique du Québec for their help in revising the manuscript.

Conflict of interest

The authors have no conflicts of interest to declare.

Authors' contributions and statement

All authors contributed to the preparation of the study specifications and parameters. DH provided expertise in statistical analysis. AM wrote the first version of the manuscript. All authors assisted in manuscript revision and have approved the final version.

The content and views expressed in this article are those of the authors and do not necessarily reflect those of the Government of Canada.

Ethics approval

This research project obtained the exemption of the Comités d'éthique de la recherche avec des êtres humains de l'Université Laval (CÉRUL) since it involved secondary analyses of individual CCHS data. Access to this data was granted following the evaluation of an analytical protocol submitted to the Social Sciences and Humanities Research Council of Canada (SSHRC). The analyses were conducted at the Centre interuniversitaire québécois de statistiques sociales (CIQSS) at Université Laval, which had secure access.

References

1. Vélo Québec. Cycling in Québec in 2015. Montréal (QC): Vélo Québec; 2015. 24 p.
2. Société de l'assurance automobile du Québec (SAAQ). Le traumatisme craniocérébral. Québec (QC): SAAQ; 2003. 65 p. Available from: http://publications.msss.gouv.qc.ca/msss/fichiers/2016/Traumatisme_FR.pdf
3. Meehan WP III, Lee LK, Fischer CM, Mannix RC. Bicycle helmet laws are associated with a lower fatality rate from bicycle-motor vehicle collisions. J Pediatr. 2013;163(3):726-9.
4. Sosin D, Sacks J, Webb K. Pediatric head injuries and deaths from bicycling in the United States. Pediatrics. 1996;98(5):868-70.
5. Attewell R, Glase K, McFadden M. Bicycle helmet efficacy: a meta-analysis. Accid Anal Prev. 2001;33(3):345-52.
6. Thompson D, Rivara F, Thompson R. Helmets for preventing head and facial injuries in bicyclists. Cochrane Database Syst Rev. 2000;(2):CD001855. doi:10.1002/14651858.CD001855.
7. Elvik R. Publication bias and time-trend bias in meta-analysis of bicycle helmet efficacy: a re-analysis of Attewell, Glase and McFadden, 2001. Accid Anal Prev. 2011;43(3):1245-51.
8. Statistics Canada. Cycling in Canada [Internet]. Table 2: Percentage who always wore helmet when cycling, by sex and selected characteristics, household population aged 12 or older who reported cycling in past 12 months, Canada, 2013/2014. Ottawa (ON): Statistics Canada; 2017. Available from: https://www150.statcan.gc.ca/n1/pub/82-003-x/2017004/article/14788/tbl/tbl02-eng.htm
9. Dennis J, Potter B, Ramsay T, Zarychanski R. The effects of provincial bicycle helmet legislation on helmet use and bicycle ridership in Canada. Inj Prev. 2010;16(4):219-24.
10. Robinson DL. Safety in numbers in Australia: more walkers and bicyclists, safer walking and bicycling. Health Promot J Austr. 2005;16(1):47-51.
11. Cameron MH, Vulcan AP, Finch CF, Newstead SV. Mandatory bicycle helmet use following a decade of helmet promotion in Victoria, Australia–an evaluation. Accid Anal Prev. 1994;26(3):325-37.
12. Finch C, Heiman L, Neiger D. Bicycle use and helmet wearing rates in Melbourne, 1987 to 1992: the influence of the helmet wearing law. Clayton (AU): Monash University Accident Research Centre; 1993. 86 p. Available from: http://www.monash.edu.au/miri/research/reports/muarc045.pdf
13. Walker MB. Law compliance and helmet use among cyclists in New South Wales. Sydney (AU): Road Safety Bureau Consultants CR 6/90, for the Roads and Traffic Authority, NSW; 1990. 59 p.
14. Smith N, Milthorpe F. An observational survey of law compliance and helmet wearing by bicyclists in New South Wales. Sydney (AU): Institute of Transport Studies, University of Sydney; 1993. 51 p.
15. Clarke CF. Evaluation of New Zealand's bicycle helmet law. N Z Med J. 2012;125(1349):60-69.
16. Carpenter CS, Stehr M. Intended and unintended consequences of youth bicycle helmet laws. J Law Econ. 2011;54(2):305-24. Available from: https://www.jstor.org/stable/10.1086/652902?seq=1-%20page_scan_tab_contents#page_scan_tab_contents
17. Karkhaneh M, Rowe B, Saunders L, et al. The association between bicycle helmet legislation and the rate of cycling in Alberta, Canada [abstract]. Can J Emerg Med. 2010;12(3):266.
18. Karkhaneh M, Rowe BH, Saunders LD, et al. Bicycle helmet use four years after the introduction of helmet legislation in Alberta, Canada. Accid Anal Prev. 2011;43(3):788-96.
19. Macpherson A, Parkin P, To T. Mandatory helmet legislation and children's exposure to cycling. Inj Prev. 2001;7(3):228-230.

20. Maurice A. Influence du règlement adopté à Sherbrooke pour obliger les moins de 18 ans à porter un casque à vélo sur la pratique du vélo et le port du casque [master's thesis]. Montréal (QC): Université Laval; 2017. 91 p. Available from: https://corpus.ulaval.ca/jspui/bitstream/20.500.11794/28258/1/33855.pdf

21. Statistics Canada. Census profile, 2016 census: Sherbrooke [Internet]. Ottawa (ON): Statistics Canada; 2017. [Catalogue no. 98-316-X2016001]. Available from: https://www12.statcan.gc.ca/census-recensement/2016/dp-pd/prof/details/page.cfm?Lang=E&Geo1=POPC&Code1=0758&Geo2=PR&Code2=24&Data=Count&SearchText=Sherbrooke&SearchType=Begins&SearchPR=01&B1=All&TABID=1

22. Statistics Canada. Canadian Community Health Survey – Annual Component (CCHS) 2015. Ottawa (ON): Statistics Canada; 2015. Available from: http://www23.statcan.gc.ca/imdb/p2SV.pl?Function=getSurvey&Id=238854

23. Institut de la statistique du Québec (ISQ). Estimations de la population des régions métropolitaines de recensement (RMR), 1er juillet 2006 à 2019 [Internet]. Québec City (QC): ISQ; 2019 [updated 2019 May 28]. Available from: https://www.stat.gouv.qc.ca/statistiques/population-demographie/structure/rmr-totaux.htm

24. Natural Resources Canada. The Atlas of Canada – Toporama. 2015 [Internet]. Ottawa (ON): Natural Resources Canada; 2015. Available from: http://atlas.nrcan.gc.ca/toporama/en/index.html

25. Transportation Association of Canada. Urban transportation indicators, fourth survey. Ottawa (ON): Transportation Association of Canada; 2010. 125 p. Available from: http://tac-atc.ca/sites/tac-atc.ca/files/site/doc/resources/report-uti-survey4.pdf

26. Pampalon R, Hamel D, Gamache P, Raymond G. A deprivation index for health planning in Canada. Chronic Dis Can. 2009;29(4):178-91.

27. Government of Canada. Historical climate data [Internet]. Ottawa (ON): Government of Canada; 2019. Available from: http://climat.meteo.gc.ca/index_e.html

28. Cyr C, Ouedraogo N. A safe community-based campaign to promote the use of bicycle helmets in children 2013. Paper presented at: American Academy of Pediatrics; 2013 Oct 26-29; Orlando, USA. Available from: https://aap.confex.com/aap/2013/webprogram/Paper20527.html

29. National Highway Traffic Safety Administration (NHTSA). Bicycle helmet use laws: lessons learned from selected sites. Washington (DC): NHTSA; 2005. 219 p.

30. Hagel BE, Rizkallah JW, Lamy A, et al. Bicycle helmet prevalence two years after the introduction of mandatory use legislation for under 18 year olds in Alberta, Canada. Inj Prev. 2006;12(4):262-5.

31. Karkhaneh M, Rowe BH, Duncan Saunders L, Voaklander D, Hagel B. Bicycle helmet use after the introduction of all ages helmet legislation in an urban community in Alberta, Canada. Can J Pub Health. 2011;102(2):134-8.

32. Macpherson A, Spinks A. Bicycle helmet legislation for the uptake of helmet use and prevention of head injuries. Cochrane Database Syst Rev. 2008;Jul 16(3):CD005401. doi: 10.1002/14651858.CD005401.pub3.

33. Karkhaneh M, Kalenga J, Hagel BE, Rowe BH. Effectiveness of bicycle helmet legislation to increase helmet use: a systematic review. Inj Prev. 2006;12(2):76-82.

34. Lindsay H, Brussoni M. Injuries and helmet use related to non-motorized wheeled activities among pediatric patients. Chronic Dis Inj Can. 2014;34(2-3):74-81.

35. Liller K, Nearns J, Cabrera M, Joly B, Noland V, McDermott R. Children's bicycle helmet use and injuries in Hillsborough County, Florida before and after helmet legislation. Inj Prev. 2003;9(2):177-9.

36. Markowitz S, Chatterji P. Effects of bicycle helmet laws on children's injuries. Health Econ. 2015;24(1):26-40.

37. Robinson DL. Head injuries and bicycle helmet laws. Accid Anal Prev. 1996;28(4):463-75.

https://doi.org/10.24095/hpcdp.40.1.03

At-a-glance

Living arrangements and health status of seniors in the 2018 Canadian Community Health Survey

Sebastian A. Srugo, BHSc; Ying Jiang, MD, MSc; Margaret de Groh, PhD

Tweet this article

Abstract

Currently, 1 in 3 Canadian seniors meet the criteria for successful aging, which include low probability of disease and disability, high cognitive and physical ability and active engagement in life. The sociodemographic characteristic of living alone can identify high-risk seniors, due to its association with lower social support and interactions, thus increasing susceptibility to negative health outcomes in older age. However, limited data exists on the living arrangements of Canadian seniors. In this analysis, we present sociodemographic characteristics and measures of health and social well-being of seniors by living arrangement. This information should be used to identify and support vulnerable seniors and increase the prevalence of healthy aging among Canadians.

Keywords: *living arrangements, seniors, healthy aging*

Highlights

- An understanding of living arrangements may help those who develop intervention programs better target seniors at higher risk for negative health outcomes in older age.
- We found that seniors who were female, older, lower-income, divorced or separated, living in a population centre, renters and less educated were most likely to live alone.
- Seniors who were living alone were also more likely to report poor perceived health and social well-being.
- These results may be useful in targeting policies and programs aimed to improve health outcomes among seniors.

Introduction

Due to increasing life expectancy[1] and decreasing fertility rates,[2] the proportion of seniors in Canada is growing faster than ever. In 2011, this trend began to accelerate as the first baby boomers turned 65 years old. Seniors now total over 6 million (1 in 6) persons in Canada,[3] and outnumber children aged 0 to 14 years for the first time.[4] Moreover, current trends suggest that this age group will continue to grow, with the proportion of seniors set to rise to 1 in 5 by 2024 and 1 in 4 by 2055.[3] Implementing policies and programs to promote health in older age will be of increasing importance, as only about 1 in 3 seniors currently meet the criteria for successful aging,[5] defined by Rowe and Kahn[6] as low probability of disease and disability, high cognitive and physical capacity and active engagement in life.

Recent international studies have shown that living arrangements of seniors are an important determinant of healthy aging, as they predict social support and interactions. Seniors living with a spouse or partner were more likely to have lower incidence rates of dementia,[7] better mental health, and fewer limitations due to multimorbidity on their involvement in all aspects of life (including social life, housework and leisure-time activities)[8]; those living with family demonstrated lower rates of chronic and acute diseases[9]; and those living with others reported better mental health, social support and engagement in more physical activities, compared to those living alone.[10] However, there are only a few studies that have assessed the living arrangements of Canadian seniors,[11-14] and none aimed to identify the subpopulations of seniors who are more likely to live alone, putting them at higher risk for negative health outcomes in older age. As well, half of those studies focussed on Asian-Canadian seniors alone.[13,14] Recent and complete data on this topic are necessary to identify and address gaps in the promotion of healthy aging among seniors.

The purpose of this brief analysis was to examine the living arrangements of Canadian seniors in the most recent (2018) Canadian Community Health Survey (CCHS) by sociodemographics and health and social well-being, stratified by sex.

Methods

The CCHS is an annual, cross-sectional survey that collects representative data on the health status and determinants of the noninstitutionalized Canadian population in all provinces.[15] Those living in the territories were excluded from the annual component due to small samples and non-representativeness.[15] We employed data from the 2018 CCHS cycle on individuals aged 65 and over living in private dwellings who responded to the living arrangement question. Information on living arrangements, sociodemographics (age group, race, health region–level household income ratio [quintiles], marital group, region of residence, classification of region

Author reference:

Public Health Agency of Canada, Ottawa, Ontario, Canada

Correspondence: Margaret de Groh, Centre for Surveillance and Applied Research, Health Promotion and Chronic Disease Prevention Branch, Public Health Agency of Canada, 785 Carling Avenue, Ottawa, ON K1S 5H4; Tel: 613-614-2045; Email: Margaret.degroh@canada.ca

[population centre vs. rural area], dwelling ownership, participant education and household size) and self-reported well-being (perceived health, perceived mental health, life satisfaction and sense of community belonging) were used for this analysis. The household income ratio measures a participant's household income relative to other residents in their health region, adjusting for household and community size.[15] A population centre is defined as an area with a population of at least 1000 and a density of at least 400 persons per km^2; all other areas are considered rural.[15] Descriptive statistics were stratified by sex and weighted using bootstrap methods to produce data representative of the Canadian senior population living in the provinces. Please note that in 2016, the CCHS asked respondents whether they were male or female; we recognize that perceptions and behaviours are influenced by a person's gender and should be taken into consideration when interpreting our results. Data are shown as row percent with bootstrapped 95% confidence intervals (95% CI) and compared using the Rao-Scott χ^2 test. All analyses were run on SAS Enterprise Guide version 5.1 (SAS Institute Inc., Cary, NC, USA).

Results

In total, 8261 female and 6532 male seniors in the 2018 CCHS were included in the analyses. Data on the living arrangements of females and males were weighted and stratified by selected characteristics in Table 1 and Table 2, respectively. Females were almost twice as likely to live alone (35.7% vs. 19.1%) and 1.5-fold less likely to live with a partner (48.9% vs. 71.3%) compared to males. Among both sexes, the prevalence of living alone was highest for participants who were older, lower-income, divorced or separated, living in a population centre, renters, and less educated. The opposite set of characteristics were associated with living with a partner (younger, higher-income, married or common-law, living in a rural area, owners and more educated). Asians were most likely to live with children, relatives or nonrelatives and least likely to live alone (for both sexes). For seniors of both sexes, living arrangement did not differ by region. However, some sex differences were noted. Among females, White participants were more likely to live with a partner than Asians and those of "other" ethnicity (e.g. Black, Latin American and Arab), though no racial differences were found

TABLE 1
Living arrangements of 8261 female seniors in the 2018 CCHS, weighted and stratified by selected characteristics

Characteristics	Living alone (n = 4313)	Living with partner[a] (n = 3214)	Other[b] (n = 734)	*p*-value
Weighted N (%)	1 170 194 (35.7)	1 604 305 (48.9)	507 312 (15.5)	
Age group				< .001
65–74	28.4 (26.3–30.4)	57.1 (54.8–59.5)	14.5 (12.3–16.7)	
75–84	42.6 (39.5–45.7)	43.0 (39.7–46.3)	14.5 (11.5–17.4)	
85 or over	58.4 (53.1–63.6)	18.3 (13.7–22.9)	23.3 (18.3–28.4)	
Race				< .001
White	36.8 (35.0–38.6)	50.9 (49.1–52.7)	12.3 (10.8–13.9)	
Indigenous	34.1 (25.6–42.6)	51.3 (41.0–61.7)	14.6 (7.6–21.6)	
Asian[c]	16.0 (10.6–21.4)	38.7 (30.1–47.2)	45.3 (35.9–54.8)	
Other[d]	38.6 (28.2–49.0)	34.3 (24.3–44.3)	27.1 (16.3–37.8)	
Health region–level household income ratio (quintiles)[e]				< .001
1	54.2 (50.9–57.5)	32.1 (29.0–35.2)	13.7 (11.0–16.4)	
2	35.7 (32.5–38.9)	48.0 (44.6–51.4)	16.3 (13.1–19.4)	
3	29.1 (25.8–32.5)	55.9 (51.9–60.0)	14.9 (10.9–18.9)	
4	22.6 (19.3–26.0)	58.9 (53.7–64.1)	18.5 (13.1–23.9)	
5	20.6 (16.8–24.5)	64.9 (59.8–70.1)	14.4 (10.6–18.3)	
Marital group				N/A[f]
Married or common-law	1.6 (1.2–1.9)	92.6 (91.2–94.0)	5.8 (4.4–7.2)	
Widowed	73.7 (70.3–77.2)	0	26.3 (22.8–29.7)	
Divorced or separated	76.9 (71.1–82.8)	0	23.1 (17.2–28.9)	
Single	66.9 (58.2–75.6)	0	33.1 (24.4–41.8)	
Region of residence[g]				0.2
Atlantic	34.4 (31.0–37.9)	53.3 (49.6–57.0)	12.3 (9.5–15.1)	
Central	35.8 (33.5–38.0)	48.0 (45.5–50.5)	16.2 (14.0–18.5)	
Prairies	37.6 (33.9–41.3)	49.5 (45.7–53.2)	12.9 (9.0–16.8)	
West	33.8 (30.3–37.3)	50.0 (45.5–54.5)	16.2 (12.5–19.9)	
Classification of region[h]				< .001
Population centre	37.7 (35.7–39.7)	46.2 (44.0–48.4)	16.1 (14.1–18.1)	
Rural area	26.7 (24.5–28.8)	60.6 (57.8–63.3)	12.7 (10.4–15.0)	
Dwelling ownership				< .001
Owned	26.9 (25.3–28.6)	56.7 (54.7–58.7)	16.4 (14.5–18.2)	
Rented	62.4 (58.4–66.4)	25.0 (21.7–28.3)	12.6 (9.1–16.2)	
Personal education				< .001
Less than HS	41.0 (37.5–44.4)	38.6 (35.1–42.1)	20.4 (16.9–23.9)	
HS grad	35.3 (32.0–38.5)	52.7 (49.0–56.4)	12.0 (9.4–14.6)	
Postsecondary grad	33.3 (30.9–35.7)	52.5 (49.7–55.2)	14.2 (11.5–16.9)	

Abbreviations: CCHS, Canadian Community Health Survey; CI, confidence interval; HS, high school.
Note: Data are row % (95% CI), unless otherwise stated.
[a] Includes living with or without children.
[b] Includes living with children, relatives and nonrelatives.
[c] Includes South Asian, West Asian, Southeast Asian, Chinese, Korean, Japanese and Filipino.
[d] Includes Black, Latin American, Arab, other racial background and multiple ethnicities.
[e] Distribution of participants in each health region based on the adjusted ratio of total household income over the low-income cut-off corresponding to household and community size.
[f] No tests can be computed for the table since at least one cell has 0 frequency.
[g] Atlantic includes Prince Edward Island, New Brunswick, Nova Scotia and Newfoundland and Labrador; Central includes Quebec and Ontario; Prairies includes Alberta, Manitoba and Saskatchewan; and West includes British Columbia.
[h] A population centre is defined as an area with a population of at least 1000 and a density of at least 400 persons per km^2; all other areas are considered rural.

TABLE 2
Living arrangements of 6532 male seniors in the 2018 CCHS, weighted and stratified by selected characteristics

	Living alone (n = 2105)	Living with partner[a] (n = 4065)	Other[b] (n = 362)	*p*-value
Weighted N (%)	540 770 (19.1)	2 022 160 (71.3)	273 833 (9.7)	
Age group				< .001
65–74	17.5 (15.9–19.0)	73.4 (71.2–75.6)	9.1 (7.3–10.9)	
75–84	20.0 (17.6–22.4)	71.1 (68.1–74.1)	8.9 (6.6–11.1)	
85 or over	28.3 (23.3–33.4)	54.5 (48.0–61.0)	17.1 (10.9–23.4)	
Race				< .001
White	20.6 (19.1–22.0)	72.0 (70.3–73.8)	7.4 (6.1–8.7)	
Indigenous	20.0 (11.4–28.6)	63.8 (52.8–74.8)	16.2 (7.0–25.4)	
Asian[c]	8.5 (3.8–13.2)	67.8 (58.7–76.9)	23.7 (15.2–32.2)	
Other[d]	13.7 (7.4–20.1)	69.6 (60.0–79.2)	16.7 (8.6–24.8)	
Health region–level household income ratio (quintiles)[e]				< .001
1	30.7 (27.4–34.0)	57.8 (54.0–61.7)	11.5 (8.6–14.3)	
2	18.0 (15.5–20.4)	71.0 (67.5–74.6)	11.0 (7.8–14.2)	
3	15.8 (13.6–18.0)	74.4 (70.8–77.9)	9.9 (6.5–13.2)	
4	12.5 (10.0–15.0)	80.9 (77.6–84.3)	6.6 (4.1–9.1)	
5	14.6 (11.6–17.5)	78.2 (74.2–82.1)	7.3 (4.4–10.2)	
Marital group				N/A[f]
Married or common-law	1.3 (0.9–1.6)	92.1 (90.7–93.5)	6.6 (5.2–8.0)	
Widowed	78.4 (73.7–83.2)	0	21.6 (16.8–26.3)	
Divorced or separated	83.0 (77.3–88.6)	0	17.0 (11.4–22.7)	
Single	78.0 (69.7–86.2)	0	22.0 (13.8–30.3)	
Region of residence[g]				.07
Atlantic	18.5 (15.5–21.6)	75.1 (71.8–78.5)	6.3 (4.2–8.4)	
Central	19.6 (17.9–21.3)	71.2 (68.9–73.5)	9.2 (7.3–11.1)	
Prairies	16.1 (13.6–18.5)	73.2 (69.5–76.9)	10.7 (7.3–14.0)	
West	20.0 (16.7–23.2)	67.8 (63.3–72.3)	12.2 (8.3–16.2)	
Classification of region[h]				.02
Population centre	19.6 (18.0–21.2)	70.2 (68.1–72.2)	10.2 (8.5–11.9)	
Rural area	17.2 (15.3–19.0)	75.1 (72.6–77.6)	7.7 (5.7–9.8)	
Dwelling ownership				< .001
Owned	13.6 (12.4–14.7)	76.3 (74.6–78.1)	10.1 (8.5–11.7)	
Rented	45.5 (40.8–50.1)	47.9 (42.9–52.9)	6.7 (4.0–9.3)	
Personal education				< .001
Less than HS	23.2 (20.5–25.9)	64.9 (61.2–68.5)	12.0 (8.8–15.1)	
HS grad	22.8 (19.2–26.3)	69.2 (65.2–73.1)	8.1 (5.3–10.8)	
Postsecondary grad	17.0 (15.3–18.6)	74.1 (71.8–76.3)	9.0 (7.1–10.8)	

Abbreviations: CCHS, Canadian Community Health Survey; CI, confidence interval; HS, high school.
Note: Data are row % (95% CI), unless otherwise stated.
[a] Includes living with or without children.
[b] Includes living with children, relatives and nonrelatives.
[c] Includes South Asian, West Asian, Southeast Asian, Chinese, Korean, Japanese and Filipino.
[d] Includes Black, Latin American, Arab, other racial background and multiple ethnicities.
[e] Distribution of participants in each health region based on the adjusted ratio of total household income over the low-income cut-off corresponding to household and community size.
[f] No tests can be computed for the table since at least one cell has 0 frequency.
[g] Atlantic includes Prince Edward Island, New Brunswick, Nova Scotia and Newfoundland and Labrador; Central includes Quebec and Ontario; Prairies includes Alberta, Manitoba and Saskatchewan; and West includes British Columbia.
[h] A population centre is defined as an area with a population of at least 1000 and a density of at least 400 persons per km^2; all other areas are considered rural.

among males living with a partner. Female renters were much more likely to live alone than with a partner (62.4% vs. 25.0%), though no such tendency was displayed among male renters (45.5% vs. 47.9%). Finally, the prevalence of living with a partner increased with higher education for both sexes, though the largest increase was between females with less than a high school education and females who graduated from high school (females: 38.6% vs. 52.7; males: 64.9% vs. 74.1%).

Measures of perceived health and social well-being were also stratified by sex and living arrangement (Table 3). Across all four measures, seniors living with a partner were less likely to report poor health and social well-being. Compared to those living with a partner, females living alone or living with children, relatives or nonrelatives reported poorer general health and mental health; further, females living alone reported lower life satisfaction, while those living with children, relatives or nonrelatives had a weaker sense of community belonging. Among males, those living alone reported poorer mental health, life satisfaction and sense of community belonging compared to those living with a partner. Perceived general health did not differ between males in the three living arrangements. Further, males living with children, relatives or nonrelatives were no more likely than those living with partners to report poor health and social well-being across the four measures.

Discussion

Using the 2018 Canadian Community Health Survey data, we found that nearly half of seniors were living with a partner (49.2% in total). Other studies have identified that living with others may be especially beneficial for healthy aging, and living alone may be detrimental.[7–10] Still, the prevalence of living alone may be rising among this age group. In an analysis of the 2011 census, other researchers found that 31.5% of females and 16.0% of males aged 65 or over lived alone[11]; those numbers increased to 33.0% and 17.4% in the 2016 census,[12] further rising to 35.7% and 19.1% in our 2018 analysis of the CCHS.

Seniors who were female, older, lower-income, divorced or separated, living in a population centre, renters, and less educated were most likely to live alone. Similar results have been demonstrated elsewhere. Female seniors have consistently

TABLE 3
Measures of perceived health and social well-being among participants of the 2018 CCHS, weighted and stratified by sex and living arrangement

	Perceived general health		Perceived mental health		Life satisfaction		Sense of community belonging	
	Less than very good	Very good or excellent	Less than very good	Very good or excellent	Less than satisfied	Satisfied or very satisfied	Somewhat or very weak	Somewhat or very strong
Females	$p < .001$		$p = .001$		$p < .001$		$p < .001$	
Living arrangement								
Living alone	53.4 (51.1–55.7)	46.6 (44.3–48.9)	31.2 (28.9–33.6)	68.8 (66.4–71.1)	11.9 (10.3–13.6)	88.1 (86.4–89.7)	24.8 (22.7–26.9)	75.2 (73.1–77.3)
Living with partner[a]	46.9 (44.3–49.6)	53.1 (50.4–55.7)	25.9 (23.6–28.1)	74.1 (71.9–76.4)	7.1 (5.7–8.4)	92.9 (91.6–94.3)	21.7 (19.4–24.1)	78.3 (75.9–80.6)
Other[b]	61.7 (55.2–68.3)	38.3 (31.7–44.8)	35.2 (28.8–41.7)	64.8 (58.3–71.2)	11.7 (8.1–15.2)	88.3 (84.8–91.9)	35.7 (29.1–42.2)	64.3 (57.8–70.8)
Males	$p = .01$		$p = .007$		$p < .001$		$p = .003$	
Living arrangement								
Living alone	56.5 (53.2–59.8)	43.5 (40.2–46.8)	31.7 (28.9–34.6)	68.3 (65.4–71.1)	13.0 (11.1–15.0)	87.0 (85.0–88.9)	29.7 (26.7–32.7)	70.3 (67.3–73.3)
Living with partner[a]	51.6 (49.2–54.0)	48.4 (46.0–50.8)	25.0 (22.8–27.2)	75.0 (72.8–77.2)	6.2 (4.9–7.4)	93.8 (92.6–95.1)	22.0 (19.9–24.1)	78.0 (75.9–80.1)
Other[b]	61.1 (53.1–69.1)	38.9 (30.9–46.9)	30.2 (22.3–38.1)	69.8 (61.9–77.7)	8.7 (4.9–12.5)	91.3 (87.5–95.1)	27.6 (19.1–36.1)	72.4 (63.9–80.9)

Abbreviations: CCHS, Canadian Community Health Survey; CI, confidence interval.
Note: Data are row % (95% CI), unless otherwise stated.
[a] Includes living with or without children.
[b] Includes living with children, relatives and nonrelatives.

been found to have a greater likelihood of living alone, both in Canada[11,12] and in other countries,[16,17] in part because of their greater life expectancy compared to opposite-sex partners.[11] Seniors with low income[17,18] or low education[16] have been reported in other studies to be more likely to live alone, which may be a consequence of their inability to afford the high cost of assisted living facilities.[19] Moreover, seniors living in urban areas were more likely to live alone, which may be due to the disparity in supports and services available to seniors in rural areas[20]; in fact, the most-used services for seniors are senior centres, homemaker services and transportation services,[21] all of which are more likely to be available in urban areas. Finally, we replicated the result that living alone was associated with poorer perceived health and social well-being among seniors, though the temporality of this association and the others mentioned cannot be determined from this cross-sectional analysis. Still, identifying this vulnerable senior subpopulation will help us more effectively develop policies and programs to promote healthy aging. Of course, other factors, such as desire to live alone, loneliness (vs. solitude) and social capital, should all be taken into consideration to focus more specifically on those at highest risk.

Strengths and limitations

This analysis is based on cross-sectional questionnaire data, making causal inferences problematic. Moreover, data on seniors residing in the territories or in institutions were not included, meaning that these data cannot be used to infer living arrangements of seniors in those areas or circumstances. Nevertheless, the sample size used is large and has been weighted in an attempt to be representative of the Canadian, provincial, noninstitutionalized population. Further, this analysis uses the most recent data available on seniors in Canada.

Conclusion

Our analysis found that seniors who were female, older, lower-income, divorced or separated, living in a population centre, renters, less educated and who demonstrated poor perceived health and social well-being were most likely to live alone and potentially most vulnerable to negative health outcomes in aging. This information could help programs and policies identify and target older adults at higher risk of negative health outcomes due to their living arrangements, with the aim of increasing the prevalence of healthy aging among Canadian seniors. As an example, health policy makers could promote the development of community programs that increase the social participation and inclusion of older females who live alone, for the purpose of increasing their sense of community belonging.

Acknowledgements

We would like to acknowledge the contributions of Kerry Anderson, Patti Gorr and Rachel Milliken from the Aging and Seniors Unit of the Centre for Health Promotion at PHAC. Their thorough understanding of the issues facing seniors in Canada helped guide the analysis and the interpretation of the findings. As well, we would like to acknowledge Dr. Howard Morrison for his professional advice.

Conflicts of interest

The authors have no conflicts of interest to disclose. This research did not receive any funding.

Authors' contributions and statement

All authors conceived and designed the methods. SAS conducted the analyses and wrote the initial draft. All authors interpreted the results and critically reviewed the paper. All authors read and approved the final version of the manuscript.

The content and views expressed in this article are those of the authors and do not necessarily reflect those of the Government of Canada.

References

1. Shumanty R. Report on the demographic situation in Canada. Mortality: overview, 2014 to 2016. Ottawa (ON): Statistics Canada [Catalogue No.: 91-209-X]; 2018. 14 p.

2. Provencher C, Milan A, Hallman S, et al. Report on the demographic situation in Canada. Fertility: overview, 2012 to 2016. Ottawa (ON): Statistics Canada [Catalogue No.: 91-209-X]; 2018. 19 p.

3. Statistics Canada. Annual demographic estimates: Canada, provinces and territories, 2018. Analysis: population by age and sex [Internet]. Ottawa (ON): Statistics Canada; 2018 [cited 2019 May 29]. Available from: https://www150.statcan.gc.ca/n1/pub/91-215-x/2018002/sec2-eng.htm

4. Statistics Canada. The Daily—Canada's population estimates: age and sex, July 1, 2018 [Internet]. Ottawa (ON): Statistics Canada; 2019 Jan 25 [cited 2019 May 29]. Available from: https://www150.statcan.gc.ca/n1/daily-quotidien/190125/dq190125a-eng.htm

5. Meng X, D'Arcy C. Successful aging in Canada: prevalence and predictors from a population-based sample of older adults. Gerontology. 2014;60(1):65-72.

6. Rowe JW, Kahn RL. Successful aging. Gerontologist. 1997;37(4):433-40.

7. Arai A, Katsumata Y, Konno K, et al. Sociodemographic factors associated with incidence of dementia among senior citizens of a small town in Japan. Care Manag J. 2004;5(3):159-65.

8. Müller F, Hagedoorn M, Tuinman MA. Chronic multimorbidity impairs role functioning in middle-aged and older individuals mostly when non-partnered or living alone. PLOS ONE [Internet]. 2017 [cited 2019 May 29];12(2):e0170525. Available from: https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0170525

9. Agrawal S. Effect of living arrangement on the health status of elderly in India: findings from a national cross sectional survey. Asian Popul Stud. 2012;8(1):87-101.

10. Yu C-Y, Hou S-I, Miller J. Health for older adults: the role of social capital and leisure-time physical activity by living arrangements. J Phys Act Health. 2018;15(2):150-8.

11. Statistics Canada. Living arrangements of seniors [Internet]. Ottawa (ON): Government of Canada; 2012 [cited 2019 May 21]. Available from: https://www12.statcan.gc.ca/census-recensement/2011/as-sa/98-312-x/98-312-x2011003_4-eng.cfm

12. Tang J, Galbraith N, Truong J. Living alone in Canada. Ottawa (ON): Statistics Canada [Catalogue No.: 75-006-X]; 2019.

13. Gee EM. Living arrangements and quality of life among Chinese Canadian elders. Soc Indic Res. 2000;51(3):309-29.

14. Ng CF, Northcott HC, Abu-Laban SM. Housing and living arrangements of South Asian Immigrant Seniors in Edmonton, Alberta. Can J Aging. 2007;26(3):185-94.

15. Statistics Canada. Canadian Community Health Survey (CCHS) – Annual Component user guide. 2018 Microdata File. Ottawa (ON): Government of Canada; 2018.

16. You KS, Lee H. The physical, mental, and emotional health of older people who are living alone or with relatives. Arch Psychiatr Nurs. 2006;20(4):193-201.

17. Beckett MK, Elliott MN, Haviland AM, Burkhart Q, Gaillot S, Montfort D, et al. Living alone and patient care experiences: the role of gender in a national sample of Medicare beneficiaries. J Gerontol A. 2015;70(10):1242-7.

18. Administration on Aging. A profile of older Americans: 2011. Washington (DC): US Department of Health and Human Services; 2011. Available from: https://acl.gov/sites/default/files/Aging%20and%20Disability%20in%20America/2011profile.pdf

19. White G, Singh T, Caine K, Connelly K. Limited but satisfied: low SES older adults' experiences of aging in place. In: Proceedings of the 9th International Conference on Pervasive Computing Technologies for Healthcare. 2015 May 20-23; Istanbul, Turkey: 121-8.

20. Siconolfi D, Shih RA, Friedman EM, et al. Rural-urban disparities in access to home- and community-based services and supports: stakeholder perspectives from 14 states. J Am Med Dir Assoc. 2019;20(4):503-508.e1.

21. Ewen HH, Washington TR, Emerson KG, et al. Variation in older adult characteristics by residence type and use of home- and community-based services. Int J Environ Res Public Health [Internet]. 2017 [cited 2019 May 28];14(3):330. Available from: https://www.mdpi.com/1660-4601/14/3/330

Other PHAC publications

Researchers from the Public Health Agency of Canada also contribute to work published in other journals. Look for the following articles published in 2019:

Doggett A, Qian W, **Godin K**, **de Groh M**, et al. Examining the association between exposure to various screen time sedentary behaviours and cannabis use among youth in the COMPASS study. SSM Popul Health. 2019;9:100487. doi:10.1016/j.ssmph.2019.100487.

Fitzmaurice C, Abate D, [...] **Badawi A**, et al. Global, regional, and national cancer incidence, mortality, years of life lost, years lived with disability, and disability-adjusted life-years for 29 cancer groups, 1990 to 2017: a systematic analysis for the Global Burden of Disease Study. JAMA Oncol. 2019. doi:10.1001/jamaoncol.2019.2996.

Huston P, **Edge VL**, **Bernier E**. Reaping the benefits of Open Data in public health. Can Commun Dis Rep. 2019;45(10):252-6. doi: 10.14745/ccdr.v45i10a01.

Liu S, Pan Y, Auger N, et al. Small head circumference at birth: an 8-year retrospective cohort study in China. BMJ Paediatr Open. 2019;3(1):e000470. doi:10.1136/bmjpo-2019-000470.

Zakaria D, **Shaw A**, **Xie L**. Risk of a second cancer in Canadians diagnosed with a first cancer in childhood or adolescence. EClinicalMedicine. 2019. doi:10.1016/j.eclinm.2019.10.002.