Health Promotion and Chronic Disease Prevention in Canada

Research, Policy and Practice

Volume 38 · Number 12 · December 2018

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ISSN 2368-738X
Pub. 170295
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*

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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.38.12.01

Original quantitative research

Obesity and healthy aging: social, functional and mental well-being among older Canadians

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Abstract

Introduction: Canadians are living longer than before, and a large proportion of them are living with obesity. The present study sought to describe how older participants in the Canadian Longitudinal Study on Aging (CLSA) who are living with obesity are aging, through an examination of measures of social, functional and mental well-being.

Methods: We used data from the first wave of the CLSA for people aged 55 to 85 years in this study. We used descriptive statistics to describe characteristics of this population and adjusted generalized logistic models to assess measures of social, functional and mental well-being among obese participants (body mass index ≥ 30 kg/m^2) relative to non-obese participants. Findings are presented separately for females and males.

Results: More than half of the participants reported living with a low personal income (less than $50 000); females were particularly affected. Less than half of the participants were obese; those who were had higher odds of multimorbidity than those who were not living with obesity (among those aged 55–64 years: odds ratio [OR] 2.7, 95% CI: 2.0–3.5 males; OR 2.8, 95% CI: 2.2–2.5 females). Low social participation was associated with obesity among older female participants, but not males. Physical functioning issues and impairments in activities of daily living were strongly associated with obesity for both females and males. While happiness and life satisfaction were not associated with obesity status, older females living with obesity reported negative impressions of whether their aging was healthy.

Conclusion: The odds of multimorbidity were higher among participants who were obese, relative to those who were not. Obese female participants tended to have a negative perception of whether they were aging healthily and had lower odds of involvement in social activities, while both sexes reported impairments in functional health. The associations we observed, independent of multimorbidity in older age, highlight areas where healthy aging initiatives may be merited.

Keywords: *obesity, healthy aging, mental health, social participation, multimorbidity, happiness*

Highlights

- Participants of the Canadian Longitudinal Study on Aging reported high levels of involvement in social activities, happiness, life satisfaction and perceived healthy aging.
- The odds of multimorbidity were higher among participants who were obese relative to those who were not.
- Involvement in social activities was reduced among older female participants living with obesity.
- Impairments in functional health were reported more often by participants of both sexes living with obesity.
- Older female participants living with obesity had lower odds of reporting healthy aging than older females who were not living with obesity.

Introduction

Canadians are living longer than in previous generations: the proportion of Canadians aged 65 years and older is expected to be 1 in 5 by 2024.[1] Healthy aging constitutes more than just longevity, however; an individual's quality of life (QOL) has a bearing on the years spent living in good health. So, while average Canadians may live longer, they might not necessarily be living well.[2] The majority of seniors in Canada are overweight or obese,[3] the latter being a known risk factor for a number of chronic conditions[4,5] and a factor that can exacerbate age-related declines in physical function and frailty.[6] Furthermore, even though perceived weight does not always agree with actual weight, the former has been associated with measures of self-rated health and life satisfaction that vary based on sex.[7] Therefore, understanding the role that obesity may play in successful aging among older Canadians is important.

There is, however, an obesity paradox among the elderly: high body mass index (BMI) appears to provide a survival advantage and have a lower association with mortality, while low BMI is often associated with higher mortality relative to normal weight.[8] The risks of excess weight among the elderly are complex and there are added considerations such as fat redistribution with age, competing mortalities, and risks associated with weight

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change that all contribute to the unique perspective on obesity treatment and prevention for this age group.[9] The clinical definition of obesity is based on BMI, but there are other metrics of excess weight that may be more applicable to this age group. Metrics that better reflect fat distribution, such as waist circumference, may be able to provide an indication of health risk where BMI cannot.[10] In regard to healthy aging, weight management in the elderly is geared towards improving physical function (minimizing muscle and bone loss) and health-related QOL.[6]

While there is no uniform definition for successful aging, it can be interpreted as maintaining physical, social and mental well-being with age.[11] QOL in older individuals is largely determined by these factors,[12] and by the ability to maintain autonomy and independence.[12] Fewer chronic conditions, strong social supports, high independent functioning and life satisfaction are among the many indicators of successful aging.[11,13-15] Within this holistic understanding, social, functional and mental well-being, in combination with fewer chronic conditions and lower levels of mental illness, can be examined together to provide an objective indication of successful aging.

Recent estimates suggest that roughly 15% of Canadians aged 20 years and older are living with two or more chronic diseases (multimorbidity),[16] and that these rates increase with age.[17] Accordingly, there is growing interest in research on attitudes in later life that contribute to living well.[18] Current trends also suggest that obesity and its related illnesses will persist as the "baby boomer" population approaches retirement.[19,20] Given this trend, it is prudent to better understand the role obesity may play in successful aging in Canada. Consequently, this study aimed to profile indicators of social, functional and mental health among older Canadians living with obesity, in spite of their multiple chronic conditions.

Methods

Data source

This study was conducted using cross-sectional data from the first wave of the Tracking Component of the Canadian Longitudinal Study on Aging (CLSA). Participants (n = 21 241) were recruited (1) from Statistics Canada's Canadian Community Health Survey (CCHS)—Healthy Aging focus survey (n = 3923); (2) the provincial health care registration databases (n = 3810); and (3) through random digit dialling (n = 13 508). All participants were asked survey questions using the computer-assisted telephone interviewing (CATI) technique between 2010 and 2014. The sampling frames excluded residents of the three Canadian territories, persons living on federal First Nations Reserves, full-time members of the Canadian Armed Forces, individuals living in long-term care institutions, and individuals unable to communicate in English or French. A detailed background and methodology on CLSA are available elsewhere.[21] The study population was restricted to individuals between the ages of 55 and 85 years (N = 15 345).

Variables

Socioeconomic characteristics

We ascertained annual individual income levels based on self-reported total personal income from all sources and recoded them as a binary variable (< $50 000 vs. ≥ $50 000). We derived home residence status, which was used as a subjective measure of financial well-being, from a combination of the dwelling within which the individual resided, and their ownership status. Individuals who lived in seniors' housing, old-age facilities and hotels were identified as not residing in their own home, and individuals who lived in other independent venues (house or apartment) but who also indicated that they did not own their residence were also considered not to live in their own home. Individuals who responded that they lived in a house or apartment and that they owned their home were identified as living in their own home.

Behavioural characteristics

Current smoking status was identified based on self-report (current smoker vs. current nonsmoker [former smoker or never smoker]), as was level of usual alcohol consumption (≥ 4 alcoholic beverages per week vs. < 4).

Health characteristics

We derived BMI from self-reported height and weight and calculated it as weight (kg) divided by height squared (m^2). Obesity was identified as BMI ≥ 30 kg/m^2, and non-obesity (including normal weight and overweight) was identified as BMI < 30 kg/m^2.[22]

We derived multimorbidity from self-reported diagnosis with two or more of the following conditions[23,24]: arthritis, respiratory conditions (asthma or chronic obstructive pulmonary disease), diabetes, heart disease (including angina, heart attack, and peripheral vascular disease), stroke (including cerebrovascular event and transient ischemic attack), neurological conditions (Alzheimer's or Parkinson's disease), cancer, or mental health disorders (mood or anxiety). Respondents were identified with these conditions if they responded yes to the respective question of whether they had ever been told by a doctor that they had the condition.

Social health

Participants were asked how often in the past 12 months (at least once a day, at least once a week, at least once a month, at least once a year, never) they participated in eight different activities: (1) family- or friendship-based activities outside the household; (2) church or religious activities; (3) sports or physical activities that you do with other people; (4) educational and cultural activities involving other people; (5) service club or fraternal organization activities; (6) neighbourhood, community or professional association activities; (7) volunteer or charity work; or (8) other recreational activities involving other people. Based on their responses, participation in community and social activities was recoded as participating in community or social activities at least once a week versus less frequently. Questions were taken from the Medical Outcomes Study Social Support Survey for these measures, which have been shown to be valid and reliable in older females.[25]

Functional health

We determined physical functioning based on responses to 14 questions. For each of the 14 scenarios asked, such as whether an individual experienced physical difficulty extending an arm above their head, we coded individuals as having functional limitations if they experienced limitations with 3 or more of the proposed scenarios. Impairments to activities of daily living were recoded based on responses using the Older Americans Resources and Services Multidimensional Assessment scale,[26] which has been validated previously.[27] Ordinal response options were recoded as either "no impairment" or "mild to total impairment."

Mental health and well-being

We determined mental health status based on self-report of a mood or anxiety disorder diagnosed by a physician. Various measures were used for mental well-being. We identified happiness as feeling happy 3 or more days per week versus fewer. While this measure is not a substitute for specific mental health assessment, it has been validated as a useful one to measure general mental health.[28] Self-reported measures of happiness have been shown to associate with lower mortality, which may be mediated by physical activity and comorbidity, in the elderly.[29] Life satisfaction was derived from reports of feeling slightly satisfied or better with life versus neutral or dissatisfied. These measures (self-rated mental health and self-rated healthy aging) were each coded as binary variables based on self-report responses of "fair" or "poor" versus "good," "very good" or "excellent," respectively.

Analysis

We used descriptive analyses to examine socioeconomic, behavioural and health characteristics among older Canadian participants (restricted to those aged 55 to 85 years). We used chi-square analyses to compare characteristics across age-groups, and by sex. Logistic regression models were constructed to examine the association between obesity (compared to non-obesity) and multimorbidity, functional health, social health, mental health and mental well-being. We tested potential confounders individually for inclusion in a logistic regression model assessing the odds of multimorbidity based on obesity status, and the level of significance was set at p-value $< .20$. Accordingly, we used the following confounding variables: income level, alcohol consumption and current smoking behaviour. Education level and marital status were also tested but were not found to be significant. We included multimorbidity in the models to control for its association with obesity. Odds ratios (ORs) and 95% CIs are presented. The overall response rate was 10% for the CLSA–Tracking Component sample, and although trimmed sampling weights were used to account for the complex and multiple sampling frames in the CLSA, results are described for the CLSA sample and not generalizable to the Canadian population.[30]

Results

With each successive age group, the number of individuals represented through weighting techniques diminished by a factor of two (weighted $N_{55\text{-}64y}$ = 4 090 454; weighted $N_{65\text{-}74y}$ = 2 599 404; and weighted $N_{75\text{-}85y}$ = 1 664 872). The prevalence and distribution of socioeconomic, behavioural and health characteristics are described in Table 1. Roughly half of male participants aged 55 to 64 years had a personal income of greater than $50 000, with this value decreasing significantly in older age groups. Less than a third of female participants aged 55 to 64 years had a personal income greater than $50 000, significantly fewer than the proportion of males. We observed significant decreases in older age groups. We observed significant differences in residence ownership between the sexes, as well as across age groups, with proportions showing that many older participants lived in their own home.

With respect to health, the proportion of current smokers was lower in older age groups for each sex. While smoking behaviours were not significantly different between the sexes at age 55 to 64 years, more females than males aged 75 to 85 years reported smoking ($p < .01$). The consumption of 4 or more alcoholic beverages per week differed significantly between the sexes, and also decreased significantly with increasing age groups. Obesity was significantly higher among males and decreased with age, until age 75 to 85, where more females lived with obesity than males, despite their own age-related decreases. Finally, significantly more females than males reported having multimorbidity at ages 55 to 64, with differences disappearing by ages 75 to 85 years (Table 1). Across all age groups, and for both sexes, multimorbidity was strongly associated with obesity (Table 2). We observed differences between the sexes in younger age groups ($p < .01$), but not among those aged 75 to 85 years ($p = .8$).

Reduced social participation among male participants was not associated with obesity. However, among female participants aged 55 to 64 and 75 to 85, it was (OR 0.5, 95% CI: 0.4–0.7, and OR 0.5, 95% CI: 0.3–0.8, respectively; Table 3). While social participation among individuals living with obesity did not vary significantly between the sexes, there were significant differences across age groups for females ($p < .01$). Reduced physical functioning was strongly associated with obesity for both males and females, with differences between the sexes being significant only among those aged 65 to 74 years old. The strength of this association between reduced physical functioning and obesity increased with age for both sexes. Similarly, impairments in activities of daily life were significantly associated with obesity for both sexes, with the strength of association increasing with age. The difference between sexes was significant across all age group, with females living with obesity reporting more impairments than males living with obesity.

The odds of having a mood or anxiety disorder among those who were obese, relative to those who were not, was significant among females aged 65 to 74 years (OR 0.6, 95% CI: 0.4–0.9); differences between the sexes and across ages were significant as well ($p < .01$) (Table 4). Measures of happiness and life satisfaction were not significantly associated with obesity status for either sex or for any age group. Self-reported good mental health, however, was significantly lower among females in the 55 to 64 age group who were living with obesity, but this association of mental health with obesity disappeared in older age groups. Self-reported healthy aging was significantly associated with obesity among older Canadian participants—females in all age groups reported strong negative impressions of their aging. Among males, however, this finding was only observed among those aged 55 to 64 years (OR 0.4, 95% CI: 0.2–0.5).

Discussion

Canadians are enjoying a longer life span than ever before, with recent population estimates showing that the number of Canadians aged 65 years and older outnumber those 14 years and below.[1] More than half of older Canadians are living with a low personal income, and females are disproportionately affected.[31] While studies have suggested that poor financial health is linked with disease,[32] we observed that CLSA participants had strong subjective financial well-being. We also found that many drank 4 or more drinks per week in their older age, although the prevalence of current smokers decreased with increasing age. The former finding is not necessarily troubling, since regular alcohol consumption has been associated with increasing QOL and mood,[33] although it is still linked to chronic diseases such as cancer.[34]

The burden of multimorbidity in seniors is well recognized[17,35,36] and is a combination

TABLE 1
Socioeconomic, behavioural and health characteristics of older respondents to the Canadian Longitudinal Study on Aging, 2014

	Ages 55–64 years					Ages 65–74 years					Ages 75–85 years				
	Males		Females		χ^2	Males		Females		χ^2	Males		Females		χ^2
	Percent (%)	95% CI	Percent (%)	95% CI	*p*-value[a]	Percent (%)	95% CI	Percent (%)	95% CI	*p*-value[a]	Percent (%)	95% CI	Percent (%)	95% CI	*p*-value[a]
Socioeconomic characteristics															
Personal income ≥ $50 000	56.0	53.8–58.1	29.7	27.7–31.7	< .01	41.1	38.6–43.7	17.6	15.6–19.6	< .01	42.8	40.0–45.6	17.7	15.5–19.9	< .01
Live in their own home	89.6	88.3–90.9	87.3	85.9–88.7	< .01	89.4	87.9–91.0	84.2	82.4–86.1	< .01	84.2	82.2–86.3	76.1	73.8–78.4	< .01
Behavioural characteristics															
Current smoker	13.2	11.7–14.7	11.4	10.1–12.7	.23	6.7	5.5–7.9	8.3	7.0–9.7	.20	3.7	2.7–4.7	5.5	4.3–6.7	< .01
Consume ≥ 4 alcoholic beverages/wk.	28.9	26.9–31.0	19.3	17.6–21.1	< .01	36.4	33.9–38.9	23.3	21.0–25.5	< .01	36.9	34.2–39.6	21.7	19.3–24.0	< .01
Health characteristics															
Obese	45.5	42.5–48.5	39.4	36.9–41.9	< .01	41.3	38.0–44.7	40.1	37.0–43.1	.20	26.1	22.8–29.5	29.7	26.7–32.8	.20
Multimorbid (≥2 chronic conditions)	29.7	27.8–31.7	37.8	35.7–39.8	< .01	39.8	37.3–42.3	43.6	41.1–46.1	.01	53.0	50.3–55.7	50.6	47.9–53.3	.50
Healthy aging characteristics															
Social health															
Involvement in social activities at least once a week	76.7	74.8–78.6	83.7	82.2–85.3	< .01	82.3	80.4–84.3	86.6	84.9–88.4	< .01	82.2	80.1–84.3	85.1	83.1–87.1	< .01
Functional health															
Physical functioning issues	13.6	12.1–15.0	17.5	15.9–19.1	< .01	14.3	12.6–16.1	20.4	18.4–22.4	< .01	19.8	17.6–22.0	26.7	24.3–29.1	< .01
Impairment(s) in Activities of Daily Living	5.2	4.3–6.1	11.5	10.2–12.8	< .01	7.2	5.9–8.4	15.2	13.4–17.0	< .01	12.9	11.1–14.7	30.9	28.5–33.4	< .01
Mental health															
Mood or anxiety disorder	15.9	14.3–17.5	26.2	24.4–28.1	< .01	11.7	10.1–13.3	19.3	17.3–21.2	< .01	7.0	5.7–8.4	14.2	12.4–16.0	< .01
Mental well-being															
Happiness[b]	89.8	88.6–91.1	88.5	87.2–89.9	.32	90.9	89.4–92.3	89.3	87.7–90.9	.40	90.6	89.0–92.2	87.7	85.9–89.6	.13
Life satisfaction	85.2	83.7–86.8	85.7	84.3–87.2	1.0	90.8	89.4–92.3	88.1	86.5–89.7	< .01	91.8	90.4–93.2	88.5	86.8–90.3	.04
Mental health	95.3	94.4–96.2	93.8	92.8–94.8	.01	97.0	96.1–97.8	96.7	95.8–97.5	.27	96.5	95.5–97.4	96.5	95.5–97.4	.84
Healthy aging[c]	89.5	88.2–90.8	90.2	89.0–91.4	.28	92.1	90.8–93.4	90.9	89.4–92.4	.85	90.0	88.4–91.6	90.8	89.2–92.3	.07

Data source: Canadian Longitudinal Study on Aging, 2014.

Abbreviations: CI, confidence interval; wk., week.

Note: For all variables examined, $\chi 2$ *p*-value across age groups for each sex were $p < .01$, with the exceptions in notes b and c, below.

[a] χ^2 *p*-values comparing characteristics across sexes for each age group.

[b] Happiness: $p = .14$ across ages for males, and $p = .35$ across ages for females.

[c] Healthy aging: $p = .01$ across ages for females.

TABLE 2
Odds ratio of multimorbidity among older obese respondents to the Canadian Longitudinal Study on Aging, 2014, by age group and sex

	Males		Females		χ^2 *p*-value[a]
	OR	95% CI	OR	95% CI	
Age groups					
55–64 years	2.7*	2–3.5	2.8*	2.2–3.5	< .01
65–74 years	2.5*	1.9–3.4	2.7*	2.1–3.6	< .01
75–85 years	2.0*	1.4–2.9	2.1*	1.5–2.9	.80
χ^2 *p*-value[b]	< .01		< .01		

Data source: Canadian Longitudinal Study on Aging, 2014.

Abbreviations: CI, confidence interval; OR, odds ratio.

Notes: Models are controlled for income level, alcohol consumption and current smoking behaviour. Analyses use nonobese Canadians as the referent category.

[a] χ^2 *p*-value between sexes among obese individuals.

[b] χ^2 *p*-value across age groups among obese individuals.

* $p < .01$.

of physical and mental health that impacts QOL[37,38] and often results in greater self-care needs.[38] Assessing the impact of obesity on older Canadians would require accounting for the significant prevalence of multimorbidity among older individuals. Although declines in obesity were observed with increasing age in our study, this may reflect mortality patterns. It may also reflect frailty in the aging population, which is a syndrome linked with declines in health and function that include unintentional weight loss, muscle loss or weakness and fatigue.[39] So, while BMI may be treated as an independent state, it can also be both a symptom and risk factor associated with disease.

Given these complex associations, our study describes how older participants of the CLSA study were aging in spite of their chronic conditions, lifestyle behaviours or socioeconomic circumstances. Subjective well-being consisted of three different aspects: evaluative (life satisfaction), hedonic (feelings, including happiness) and eudemonic (sense of purpose) well-being. These measures are thought to capture what matters to individuals and have been shown to be relevant to health and QOL as people age.[40,41] We observed that social participation, which is a eudemonic construct, is diminished among older female participants living with obesity, but not males. The decreasing trend of social participation with increasing age among female participants living with obesity was significant. A previous study found that social participation was not associated with BMI, but unlike this study, they controlled for depression and self-esteem.[42] Given the strong ties of self-esteem to social participation, it is possible that our findings reflect feelings of lowered self-esteem among older females living with obesity. Social participation and support are important to good physical health, more so than positive health behaviours, even into late adulthood (90 to 97 years).[43] Obesity has been associated with lowered physical functioning,[6] although women living with obesity experience fewer such impairments than men. The strong positive associations of physical limitations with obesity in this study align with previous research suggesting that obesity and low physical activity predicts the onset of mobility limitations in older adults.[44] While we were unable to control for levels of physical activity in our analyses, our finding of an association between obesity and physical function might still be influenced by physical activity. One study has found that those older adults who were moderately to vigorously physically active had reduced risks of mobility limitation relative to those who were not active, and that individuals who maintained or took up physical activity also saw mobility benefits when compared to those who did not.[45] Similarly, the finding that impairments of daily living increased with age, and were stronger among females,

TABLE 3
Odds ratios for indicators of social and functional health among older obese respondents to the Canadian Longitudinal Study on Aging, 2014, by age group and sex

	Ages 55–64 years					Ages 65–74 years					Ages 75–85 years					χ^2	
	Males		Females		χ^2 *p*-value[a]	Males		Females		χ^2 *p*-value[a]	Males		Females		χ^2 *p*-value[a]	Males *p*-value[b]	Females *p*-value[b]
	OR	95% CI	OR	95% CI		OR	95% CI	OR	95% CI		OR	95% CI	OR	95% CI			
Social health																	
Involvement in social activities at least once a week	0.8	0.6–1.1	0.5*	0.4–0.7	.10	1.0	0.7–1.4	0.7	0.5–1.1	.08	0.8	0.5–1.3	0.5**	0.3–0.8	.10	.09	.01
Functional health																	
Physical functioning issues	2.2*	1.5–3.1	2.0*	1.5–2.8	.06	1.5	1.0–2.3	3.0*	2.1–4.3	< .01	2.8*	1.8–4.3	1.5**	1.0–2.2	.30	.01	< .01
Impairment(s) in Activities of Daily Living	1.8**	1.1–3.0	2.0*	1.4–2.9	< .01	1.1	0.7–1.9	2.7*	1.8–4.1	< .01	2.1*	1.3–3.3	2.2*	1.6–3.1	< .01	< .01	< .01

Data source: Canadian Longitudinal Study on Aging, 2014.

Abbreviations: CI, confidence interval; OR, odds ratio.

Notes: Models are controlled for income level, multimorbidity, alcohol consumption and current smoking behaviour. Analyses use nonobese Canadians as the referent category.

[a] χ^2 *p*-value between sexes among obese individuals.

[b] χ^2 *p*-value across age groups among obese individuals.

* $p < .01$.

** $p < .05$.

TABLE 4
Odds ratios for indicators of mental health and well-being among older obese respondents to the Canadian Longitudinal Study on Aging, 2014, by age group and sex

	Ages 55–64 years					Ages 65–74 years					Ages 75–85 years					χ^2	
	Males		Females		χ^2	Males		Females		χ^2	Males		Females		χ^2	Males	Females
	OR	95% CI	OR	95% CI	*p*-value[a]	OR	95% CI	OR	95% CI	*p*-value[a]	OR	95% CI	OR	95% CI	*p*-value[a]	*p*-value[b]	*p*-value[b]
Mental health																	
Mood or anxiety disorder	1.3	0.9–1.9	0.8	0.6–1.1	< .01	0.8	0.5–1.3	0.6*	0.4–0.9	< .01	1.0	0.5–1.9	0.7	0.5–1.2	< .01	< .01	< .01
Mental well-being																	
Happiness	1.0	0.6–1.5	1.4	1.0–2.0	.40	1.3	0.8–2.2	1.0	0.6–1.6	.30	1.0	0.5–1.8	1.3	0.8–2.1	.40	.50	.70
Life satisfaction	0.8	0.6–1.2	0.8	0.6–1.1	.40	0.8	0.5–1.4	0.8	0.5–1.2	.05	1.2	0.7–2.3	0.9	0.6–1.6	.60	< .01	.08
Good mental health	0.7	0.4–1.2	0.5*	0.3–0.8	.40	1.2	0.5–2.7	1.2	0.6–2.2	.20	0.7	0.3–1.6	0.5	0.2–1.2	.20	.02	< .01
Healthy aging	0.4*	0.2–0.5	0.3*	0.2–0.4	.60	0.8	0.5–1.3	0.4*	0.2–0.6	.40	0.6	0.4–1.0	0.4*	0.2–0.2	.07	.03	.03

Data source: Canadian Longitudinal Study on Aging, 2014.

Abbreviations: CI, confidence interval; OR, odds ratio.

Notes: Models are controlled for income level, multimorbidity, alcohol consumption, and current smoking behaviour. Analyses use nonobese Canadians as the referent category.

[a] χ^2 *p*-value between sexes among obese individuals.

[b] χ^2 *p*-value across age groups among obese individuals.

* $p < .01$.

highlights an at-risk demographic that may benefit from healthy aging programs.

Measures of mental health and well-being can vary by age and sex.[45,46] Anxiety in older age has been shown to have a bidirectional relationship with cognition and with decreases in executive functioning.[47] Measures of mental well-being included those that were evaluative and hedonic. We observed no significant associations of these constructs with obesity in older age, although when we examined these attributes across age groups, chi-square estimates suggested that age is related to life satisfaction among males. Life satisfaction has been previously shown to associate with mortality among men, but not women[48]. Furthermore, these associations were suggested to be partially mediated through adverse health behaviours.[48] So, while adjusting for covariates may have dissipated associations of obesity with life satisfaction, as observed with ORs, the chi-square trends suggest an opportunity to study this evaluative construct among older males. The low perception of good mental health among older females is noteworthy, although this improves with age. Finally, in the context of how retaining a positive outlook can support living well into old age,[18] we found that older participants living with obesity self-identified as not aging with good health. This finding was significant for females in all the age groups examined, and for males in the group aged 55 to 64 years. A negative association of obesity on life satisfaction has been described previously as well, and although this finding was significant among both sexes, Wadsworth et al. found the association to be stronger among females than among males.[49]

Strengths and limitations

The use of a large national survey to examine detailed characteristics of aging is one of the main strengths of this study. However, some limitations must be considered in interpreting our findings. First, BMI was derived based on self-reported measures of height and weight, which may be subject to respondent bias, with some data indicating that misreporting is greatest in the oldest age group.[50] Because of these possible biases, it is difficult to gauge their impact in the context of the multivariable models discussed. Second, given the current literature regarding frailty in older age, it is unclear whether BMI is the most appropriate measurement of obesity or excess body fat for older individuals. Third, the analysis conducted in this study is limited by the information available in the survey. Thus, there may be other important factors that were not included, such as physical activity, nutrition and other environmental factors. The lack of information on physical activity, sedentary time and general time use constrains the interpretation of the obesity–health relationship, particularly given the known associations of physical activity with measures of health in old age.[45] Fourth, although sample weights are generally applied so as to permit an estimation of statistics representative to the Canadian population, the first wave of the CLSA had a low response rate. Therefore, while we have applied sampling weights in our analyses, we describe our results in relation to CLSA participants, and these might not be generalizable to the Canadian population. Finally, we are aware that not all self-reported measures used in this analysis have been validated, such as happiness and healthy aging; therefore, interpretations should be made with caution.

Conclusion

This study provides a baseline analysis of healthy aging among older Canadian CLSA participants living with obesity that may be continued with successive cycles of the CLSA. The finding that these older Canadians' social and functional health profiles were associated with their obesity, even though other measures of well-being mostly were not, is also concerning as we transition to an era in which healthy aging is becoming a growing concern. These profiles should help to assist efforts geared toward promoting healthy aging for all by providing a picture of how social, functional and mental well-being is impacted by obesity in this age demographic.

Conflicts of interest

None of the authors have conflicts of interest to declare.

Authors' contributions and statement

All authors were involved in the conceptualization of this study, the interpretation of findings, and in the approval of the final manuscript. PP and DR analyzed the data and drafted 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.

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https://doi.org/10.24095/hpcdp.38.12.02

Original quantitative research

Screening, prevention and management of osteoporosis among Canadian adults

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This article has been peer reviewed.

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Abstract

Introduction: This study provides a benchmark for the nationwide use of osteoporosis screening, prevention and management strategies among Canadians aged 40 years and older (40+) using data collected one year prior to the release of Osteoporosis Canada's latest (2010) clinical practice guidelines.

Methods: Data are from the 2009 Canadian Community Health Survey—Osteoporosis Rapid Response Component. The study sample (n = 5704) was divided into four risk subgroups: (1) osteoporosis diagnosis and major fracture; (2) osteoporosis diagnosis only; (3) major fracture only; or (4) neither osteoporosis diagnosis nor major fracture. We calculated descriptive statistics and performed multinomial multivariate logistic regression analyses to examine factors independently associated with osteoporosis screening, prevention and management strategies. Estimates were weighted to represent the Canadian household population (40+) living in the 10 provinces.

Results: Approximately 10.1% of the population or 1.5 million Canadians 40+ reported having been diagnosed with osteoporosis. The majority related taking vitamin D or calcium supplements and having been prescribed osteoporosis medication(s), while less than 40% reported regular physical activity. Among those without a reported osteoporosis diagnosis, an estimated 6.7% or 1 million reported having had a major fracture, of which one-third reported having had a bone density test and less than half reported taking vitamin D supplements, calcium supplements or engaging in regular physical activity. Major fracture history was not associated with bone density testing or osteoporosis medication use.

Conclusions: A large proportion of Canadians at risk for osteoporosis—those with a major fracture history—are not undergoing bone density testing nor are they engaging in lifestyle approaches known to help maintain healthy bones. This study provides the historical information required to evaluate whether the latest clinical practice guidelines have had an impact on osteoporosis care in Canada.

Keywords: *osteoporosis, screening, prevention, disease management, health surveys, population surveillance*

Highlights

Q: Who is more likely to receive bone mineral density tests?

A: Older women (aged 65 years and older) with other physical chronic conditions.

Q: Who is more likely to use nutritional supplements known to facilitate healthy bone development?

A: Older women *with* osteoporosis, with postsecondary education (calcium only) and higher income (vitamin D only) who are not obese, have had a major fracture after age 40 (vitamin D only) and have other physical chronic conditions.

Q: Who is more likely to engage in regular physical activity?

A: Men and women of all ages *without* osteoporosis, with postsecondary education and higher income, who are not obese, and who are without other physical chronic conditions.

Introduction

Osteoporosis is a common skeletal disorder characterized by low bone density and an elevated risk of fracture. It is more prevalent among older individuals and among women. Its prevalence is projected to rise markedly over the next few decades, as the number of older individuals is expected to increase.[1] The fractures associated with osteoporosis, especially fractures of the spine and hip, are a significant cause of disability, mortality and health care use. Despite available evidence-based interventions that can substantially reduce the risk of these fractures,[2] extensive data suggest that most individuals with fracture do not undergo appropriate assessment or treatment.[3-7]

Clinical practice guidelines outline several clinical factors that help to identify people who have a high risk of fracture. These factors include advanced age, previous fragility fracture, parental hip fracture, cigarette smoking, heavy alcohol consumption, low body weight, prolonged use of glucocorticoids and other bone-depleting medications, certain disease states and

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genetic disorders associated with bone loss. Furthermore, they provide recommendations regarding lifestyle approaches such as calcium and vitamin D intake and physical activity, in addition to the appropriate and selective use of medications for the prevention and management of osteoporosis.[2]

The Public Health Agency of Canada developed and funded the 2009 Canadian Community Health Survey (CCHS)—Osteoporosis Rapid Response (ORR) Component to provide information on the prevalence, screening, prevention and management of osteoporosis in a nationally representative sample of Canadians 40 years of age or older living in the community. Using data from this questionnaire, the objectives of our study were: 1) to provide prevalence estimates of diagnosed osteoporosis and/or major fracture history (i.e. self-reported fracture after age 40 of the wrist, upper arm, spine or hip); 2) to describe the sociodemographics, behavioural risk and protective factors, health characteristics, and use of osteoporosis screening, prevention and management strategies according to four risk subgroups based on osteoporosis diagnosis and major fracture history; and 3) to determine the factors associated with the use of these osteoporosis management strategies.

The findings from this study represent the most recent data of their kind and serve as a benchmark for the nationwide use of osteoporosis screening, prevention and management strategies. Furthermore, the findings are based on data from an ideal moment in time—that is, one year prior to release of the latest (2010) clinical practice guidelines for the diagnosis and management of osteoporosis in Canada—and therefore provide the necessary historical information to evaluate whether these guidelines have had a positive impact on osteoporosis care in Canada.

Methods

Data source and study sample

The 2009 CCHS is a cross-sectional, population-based health survey designed to provide reliable estimates at the health region level.[8] The target population included Canadians 12 years of age and older living in private dwellings in the 10 provinces and three territories. Persons living on Indian reserves or Crown lands, those residing in institutions, full-time members of the Canadian Forces and residents of certain remote regions were excluded (approximately 2% of the target population). The 2009 CCHS used three sampling frames in order to select the sample of households: 49% of the sampled households from an area frame, 50% from a list frame of telephone numbers and the remaining 1% from a random digit dialling telephone number frame. The selection of a household member was made at the time of contact for data collection. All members of the household were listed, and a person aged 12 years or over was selected using various selection probabilities based on age and household composition. The survey was administered by trained personnel via either computer-assisted telephone interview or computer-assisted personnel interview (English or French).

The questions within the ORR Component appeared in the 2009 CCHS for a single collection period (i.e. during the months of March and April) and took approximately two minutes of interview time. The target population included all Canadians 40 years of age and older living in private dwellings in the 10 provinces. It was designed to produce reliable estimates at the national level, by sex and by the following age groups: 40 to 64 and 65 to 79 years. A total of 7461 survey respondents aged 40 years and older participated. Of these respondents, 5849 consented to share their data with the Public Health Agency of Canada, Health Canada and provincial and territorial ministries of health, with an overall response rate of 78.4%. After excluding 145 respondents with missing responses to the diagnosed osteoporosis or major fracture questions, the final study sample contained 5704 individuals. More detailed information regarding the 2009 CCHS is available online: http://www23.statcan.gc.ca/imdb/p2SV.pl?Function=getSurvey&Id=67251

Ethics

This study did not require a research ethics board review as it relied exclusively on secondary use of anonymous information as per Article 2.4 of the *Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans*.* Furthermore, participation in the 2009 CCHS-ORR was completely voluntary. Respondents were informed of the voluntary nature of the survey through a notice prior to the start of the data collection. Interviewers were also instructed to permit respondents to refuse to answer any question or to terminate an interview at any time. Share partners, including the Public Health Agency of Canada, have access to the data under the terms of the data sharing agreements.[8] These data files contain only information on respondents who agreed (as part of the survey) to share their information with Statistics Canada's partners. Personal identifiers are removed from the share files to respect respondent confidentiality. Users of these files must first certify that they will not disclose, at any time, any information that might identify a survey respondent.

Measures

Four risk subgroups based on osteoporosis diagnosis status and major fracture history

Respondents were classified into one of four mutually exclusive osteoporosis risk subgroups based on their responses to questions regarding their osteoporosis diagnosis status ("Has a doctor ever told you that you had osteoporosis, sometimes called thin or brittle bones?"; response options: "yes", "no"); and their major fracture history ("Since turning 40 years old, have you broken or fractured your [lower arm/wrist, upper arm, spine, or hip]?"†; response options: "yes", "no"). Based on responses to these questions, respondents were categorized as having (1) *both* osteoporosis diagnosis *and* major fracture; (2) osteoporosis diagnosis *only* (and no major fracture); (3) major fracture *only* (and no osteoporosis diagnosis); or (4) *no* osteoporosis diagnosis and *no* major fracture. Figure 1 illustrates how respondents were categorized among the aforementioned risk subgroups.

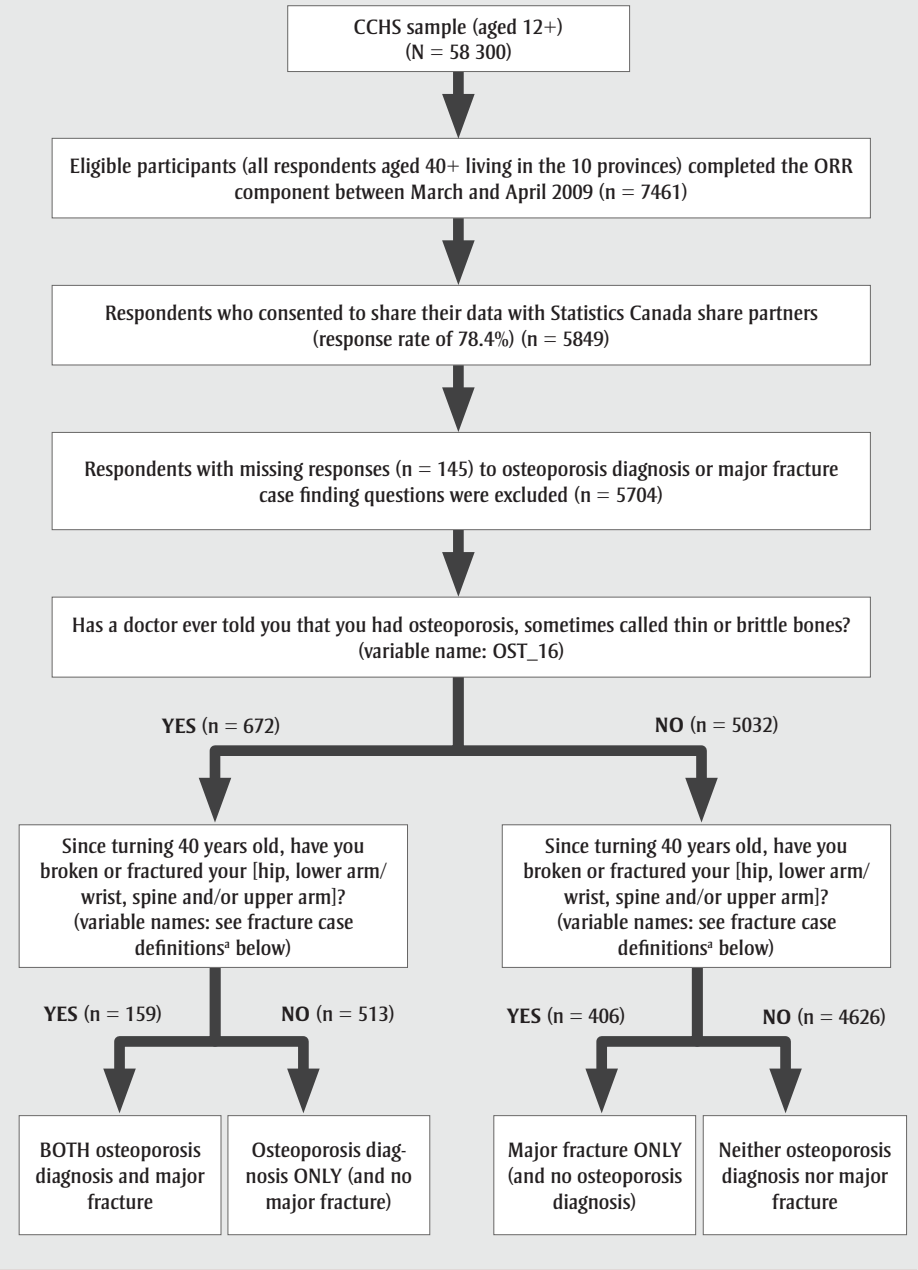
Sociodemographic characteristics

The sociodemographic characteristics included were age (mean age and age

* This 2014 policy statement ("TCPS2 [2014]") is a joint policy of Canada's three federal research agencies—the Canadian Institutes of Health Research, the Natural Sciences and Engineering Research Council of Canada and the Social Sciences and Humanities Research Council of Canada. Available from: http://www.pre.ethics.gc.ca/eng/policy-politique/initiatives/tcps2-eptc2/chapter2-chapitre2/#toc02-intro

† Major fracture history did not take into account the mechanism of injury.

FIGURE 1
Flowchart for identification of the final study sample (n = 5704), 2009 CCHS-ORR



Abbreviations: CCHS-ORR, Canadian Community Health Survey—Osteoporosis Rapid Response; n, unweighted number.

Note: The 2009 CCHS questionnaire is available online: http://www23.statcan.gc.ca/imdb/p2SV.pl?Function=getSurvey&Id=67251

[a] **Fracture case definitions:**

Lower arm/wrist fracture: if OST_Q05='yes' or (INJ_Q05='broken or fractured bones' and INJ_Q06='elbow or lower arm' and OST_Q04='lower arm') or (INJ_Q05='broken or fractured bones' and INJ_Q06='wrist')

Upper arm fracture: if OST_Q12='yes' or (INJ_Q05='broken or fractured bones' and INJ_Q06='shoulder/upper arm' and OST_Q11='upper arm')

Spine fracture: if OST_Q08='yes' or (INJ_Q05='broken or fractured bones' and INJ_Q06='upper back and spine (excluding neck) or lower back or spine')

Hip fracture: If OST_Q01='yes' or (INJ_Q05='broken or fractured bones' and INJ_Q06='hip')

groups 40–64 and 65+ years); sex (female, male); cultural/racial background (White, non-White); respondent's highest level of education (less than postsecondary education and postsecondary graduation); and adjusted household income adequacy quintiles based on deciles, derived by Statistics Canada,[‡] transformed into quintiles (first/second quintile [low], third quintile [middle] and fourth/fifth quintile [high]).

Risk and protective factors

The risk and protective factors included body mass index (BMI), smoking status and alcohol consumption.

BMI

We used BMI to quantify the prevalence of underweight, normal weight, overweight and obesity. Based on self-reported height and weight, BMI was calculated by dividing weight in kilograms (kg) by height in metres squared (m^2).

We applied correction factors[9] to adjust for known biases in self-reported BMI (i.e. people overreport their height and underreport their weight).[10] These correction factors were as follows:

Corrected BMI for males = −1.08 + 1.08 (self-reported BMI); and

Corrected BMI for females = −0.12 + 1.05 (self-reported BMI).

Using cut-points according to the World Health Organization (WHO) Consultation on obesity,[11] respondents were classified into one of the following four categories based on their corrected BMI (kg/m^2): underweight (less than 18.5), normal (18.5–24.9), overweight (25.0–29.9) and obese (30.0 or more).

Smoking status

Respondents were classified as a daily smoker based on their response to the following question: "At the present time, do you smoke cigarettes daily, occasionally or not at all?" (response options: "daily", "occasionally", "not at all").

Alcohol consumption

Respondents were asked about the frequency with which they drank alcohol in

[‡] This derived variable is a distribution of respondents in deciles (10 categories including approximately the same percentage of residents for each province) based on the adjusted ratio of their total household income to the low-income cut-off corresponding to their household and community size. It provides, for each respondent, a relative measure of their household income to the household incomes of all other respondents.

the past 12 months, i.e. "During the past 12 months, how often did you drink alcoholic beverages?" (response options: "less than once a month", "once a month", "2 to 3 times a month", "once a week", "2 to 3 times a week", "every day", "not applicable") and classified as daily drinkers if they responded that they drank "every day."

Health status

For health status, we included the number of nonosteoporosis physical chronic conditions based on responses to questions regarding specific health conditions that were expected to last or had already lasted six months or more, and had been diagnosed by a health professional. The conditions included were arthritis, asthma, chronic obstructive pulmonary disease, diabetes, heart disease, cancer, stroke, bowel disorder and Alzheimer disease/other dementia. A summary measure was computed by summing the number of conditions and then categorizing as follows: none, 1–2 and 3 + .

Osteoporosis screening, prevention and management strategies

The osteoporosis screening, prevention and management strategies included receipt of a bone density test, use of vitamin D and calcium supplements, regular physical activity and having been prescribed osteoporosis medication(s).

Bone density test

Respondents were asked if they had had a bone density test of the spine (lower back) or hip (response options: "yes", "no"). A bone density test for osteoporosis was described as a test using a special x-ray device called dual-energy X-ray absorptiometry (DXA).

Supplements

Respondents were asked if they took calcium supplements ("yes", "no") and/or vitamin D supplements ("yes", "no").

Physical activity

Respondent's level of physical activity was based on the Leisure Time Physical Activity Index, which categorizes a respondent as being "active", "moderately active", or "inactive" in their leisure time according to their total daily energy expenditure (EE) value (kcal/kg/day).[8] The respondent's total daily EE is calculated by determining their average daily EE for each leisure time physical activity in the previous three months using their self-reported frequency and duration of a variety of leisure time activities,[§] as well as the metabolic energy cost of each activity. The respondent's total daily EE is the sum of their average daily EE of all leisure time activities. Respondents that were categorized as being "active" had a total daily EE value of ≥ 3 kcal/kg/day; "moderately active" 1.5 to 2.9 kcal/kg/day; and "inactive" < 1.5 kcal/kg/day.

Osteoporosis medications

Respondents that answered "yes", "don't know" or refused to answer the question "Has a doctor ever told you that you had osteoporosis, sometimes called thin or brittle bones?" were asked if they were prescribed medication for osteoporosis ("yes", "no").

Statistical analysis

We carried out descriptive analyses to determine the prevalence estimates of self-reported diagnosed osteoporosis and major fracture history. We conducted cross-tabulation analyses to describe the sociodemographic, behavioural risk/protective factors, health characteristics and use of osteoporosis screening, prevention and management strategies according to four mutually exclusive risk subgroups based on osteoporosis diagnosis status and major fracture history. We used chi-square tests to explore the relationship between the four subgroups and respondents' characteristics (categorical variables only) as well as respondents' uptake of the described osteoporosis strategies. Finally, we conducted multivariate logistic regression analyses to examine factors independently associated with the use of the aforementioned osteoporosis strategies. Approximately 16% of the original data in the models were missing. Analyses were performed using respondents with complete data only. Statistical significance was determined at the p-value < .05 level.

We used SAS Enterprise Guide, version 5.1 (SAS Institute Inc., Cary, NC, USA) for all data analyses. All estimates are based on weighted data. Sample weights were created by Statistics Canada so that the data would be representative of the Canadian household population aged 40 years and older living in the 10 provinces in 2009 and were adjusted to compensate for nonresponse to the 2009 CCHS-ORR.[8] Estimates were age-standardized using the 2011 Canadian population in order to minimize the effects of differences in age composition when comparing estimates of the four risk subgroups.[12] Variance estimates and 95% confidence intervals (CIs) were calculated using bootstrap weights provided with the data and using the bootstrap technique to account for the complex survey design.[8,13] In accordance with Statistics Canada's release guidelines, only results with a coefficient of variation less than 33.3% are reported. If high sampling variability (i.e. coefficient of variation between 16.6% and 33.3%) is associated with any of the estimates reported in Tables 1 and 2, a superscript "a" is used to indicate that the estimate must be interpreted with caution. Note that weighted estimates based on sample sizes of less than 10 observations are not reportable regardless of the value of the coefficient of variation.[8]

Results

Prevalence of diagnosed osteoporosis and major fracture history

In 2009, 10.1% of Canadians aged 40 years and older (an estimated 1.5 million people) reported having been diagnosed with osteoporosis (Table 1). Of these individuals, 80.9% were female, and 21.7% reported having had a major fracture. Additionally, 6.7% of Canadians aged 40 years and older (an estimated 1.0 million people) reported having had a major fracture but not having been diagnosed with osteoporosis; of these, 55.4% were female.

Sociodemographics, behavioural risk/protective factors, health characteristics, and use of osteoporosis screening, prevention and management strategies

We found important differences in the individuals' characteristics between the four risk subgroups (Table 1). Increasing age, being female, decreasing levels of education and household income, lower BMI and increasing number of nonosteoporosis physical chronic conditions were

[§] Including walking for exercise, gardening/yard work, swimming, bicycling, popular/social dance, home exercises, ice hockey, ice skating, inline skating/rollerblading, jogging/running, golfing, exercise class/aerobics, downhill skiing, bowling, baseball/softball, tennis, weight training, fishing, volleyball, basketball and up to three other categories.

TABLE 1
Sociodemographic, risk and protective factors and health characteristics overall and according to osteoporosis diagnosis and major fracture history, household population aged 40 or older, Canada excluding territories, 2009

Sociodemographic, risk and protective factors and health characteristics	Overall (100%)	BOTH osteoporosis diagnosis and major fracture (2.2%)	Osteoporosis diagnosis ONLY (and no major fracture) (7.9%)	Major fracture ONLY (and no osteoporosis diagnosis) (6.7%)	NEITHER osteoporosis diagnosis nor major fracture (83.2%)	χ^2 *p*-value
	% (95% CI)	% (95% CI)	% (95% CI)	% (95% CI)	% (95% CI)	
Age (years)						
Mean age	57.5 (57.3–57.7)	70.0 (67.3–72.7)	64.1 (62.4–65.7)	63.8 (61.4–66.1)	56.1 (55.8–56.3)	n/a
Age group						
40–64	72.9 (72.5–73.3)	33.7 (22.6–44.8)[a]	55.9 (48.4–63.4)	52.1 (43.7–60.4)	77.2 (76.3–78.1)	< .001
65+	27.1 (26.7–27.5)	66.3 (55.2–77.4)	44.1 (36.6–51.6)	47.9 (39.6–56.3)	22.8 (21.9–23.7)	
Sex (females)	51.6 (51.2–52.0)	91.1 (85.3–96.9)	78.1 (70.6–85.7)	55.4 (47.6–63.2)	47.7 (46.7–48.7)	< .001
Cultural/racial background (White)	86.4 (84.5–88.3)	93.0 (87.0–99.1)	87.2 (79.6–94.8)	88.3 (81.1–95.5)	86.0 (84.0–88.0)	.658
Highest level of education (postsecondary graduation)	58.3 (56.2–60.3)	45.1 (31.9–58.2)	49.3 (41.9–56.6)	53.5 (45.5–61.6)	59.8 (57.6–62.1)	.004
Household income adequacy quintile						
Low (Q1–Q2)	38.1 (35.8–40.3)	53.8 (38.2–69.4)	54.4 (45.8–63.1)	47.5 (39.1–56.0)	35.5 (33.1–37.9)	
Middle (Q3)	19.5 (17.7–21.4)	16.0 (6.3–25.7)[a]	19.1 (12.5–25.8)[a]	19.4 (14.4–24.3)	19.7 (17.7–21.7)	< .001
High (Q4–Q5)	42.4 (40.1–44.7)	30.2 (13.1–47.3)[a]	26.4 (18.8–34.0)	33.1 (25.1–41.1)	44.8 (42.3–47.3)	
BMI (kg/m^2)						
Underweight (< 18.5)	0.8 (0.4–1.2)	NR[b]	NR[b]	NR[b]	0.8 (0.3–1.3)[a]	
Normal weight (18.5–24.9)	29.0 (27.0–31.0)	37.4 (25.5–49.2)	39.3 (31.2–47.3)	32.9 (24.0–41.8)	27.5 (25.4–29.6)	.004
Overweight (25.0–29.9)	43.4 (41.2–45.6)	45.1 (31.6–58.6)	32.1 (24.8–39.3)	41.6 (33.7–49.6)	44.5 (42.2–46.9)	
Obese (≥ 30.0)	26.8 (24.9–28.7)	16.8 (8.7–24.8)[a]	27.6 (20.0–35.2)	24.8 (18.1–31.5)	27.2 (25.1–29.2)	
Smoking status (daily)	15.4 (13.9–16.8)	10.6 (4.4–16.9)[a]	13.3 (9.1–17.4)	13.0 (8.0–17.9)[a]	15.9 (14.2–17.5)	.300
Alcohol consumption (daily)	11.7 (10.3–13.0)	NR[b]	8.7 (4.6–12.8)[a]	13.3 (7.6–19.0)[a]	11.9 (10.3–13.4)	.528
Number of nonosteoporosis physical chronic conditions:						
None	59.1 (57.2–61.0)	21.6 (11.9–31.2)[a]	32.0 (25.1–38.8)	41.4 (33.5–49.3)	64.1 (62.2–65.9)	
1–2	35.7 (33.7–37.6)	62.7 (50.7–74.6)	56.8 (49.1–64.6)	49.8 (42.0–57.5)	31.8 (29.9–33.7)	< .001
3+	5.2 (4.4–6.0)	15.8 (6.8–24.7)[a]	11.2 (6.5–15.9)[a]	8.8 (4.6–13.0)[a]	4.1 (3.4–4.8)	

Data source: 2009 Canadian Community Health Survey—Osteoporosis Rapid Response.
Abbreviations: BMI, body mass index; CI, confidence interval; NR, nonreportable; Q, quintile.
Notes: Percentages (%), means and 95% CIs are based on weighted data.
[a] High sampling variability (coefficient of variation between 16.6% and 33.3%).
[b] Coefficient of variation > 33.3%.

associated with having an osteoporosis diagnosis and major fracture history.

Furthermore, we found differences in bone density testing, calcium, vitamin D and physical activity between the four risk subgroups (Table 2). Overall, bone density testing was reported by a minority (27.8%) of Canadians aged 40 years and older, but by an overwhelming majority (over 85%) of those with an osteoporosis diagnosis. Canadians with diagnosed osteoporosis with and without prior major fracture also had high self-reported use of vitamin D supplements (89.2% and 68.5%, respectively) or calcium supplements (90.7% and 81.7%, respectively). In contrast, less than 40% reported regular physical activity. In addition, the majority of respondents diagnosed with osteoporosis reported having been prescribed osteoporosis medication(s) (59.3% overall) and this was slightly higher for those with (as opposed to without) prior major fracture (69.5% and 56.5%, respectively). Among respondents who had not been diagnosed with osteoporosis but reported having had a major fracture at one of the common osteoporotic sites, one-third (33.4%) reported having had a bone density test, fewer than half reported taking vitamin D supplements (45.2%) or calcium supplements (40.7%), or regular physical activity (44.6%). Sex-stratified results demonstrated that all screening, prevention and management strategies were more common among women than men, with the exception of physical activity.

Age-standardized estimates related to screening, prevention and management strategies were consistently lower than the

TABLE 2
Screening, prevention and management strategies overall and according to osteoporosis diagnosis and major fracture history, household population aged 40 or older, Canada excluding territories, 2009

Screening, prevention and management strategies	Overall		BOTH osteoporosis diagnosis and major fracture		Osteoporosis diagnosis ONLY (and no major fracture)		Major fracture ONLY (and no osteoporosis diagnosis)		NEITHER osteoporosis diagnosis nor major fracture		χ^2	
	Both sexes % (95% CI)		Both sexes % (95% CI)		Both sexes % (95% CI)		Both sexes % (95% CI)		Both sexes % (95% CI)		Both sexes *p*-value	
	Females % (95% CI)	Males % (95% CI)	Females % (95% CI)	Males % (95% CI)	Females % (95% CI)	Males % (95% CI)	Females % (95% CI)	Males % (95% CI)	Females % (95% CI)	Males % (95% CI)	Females *p*-value	Males *p*-value
Bone density test	27.8 (26.3–29.2)		89.1 (82.5–95.7)		85.9 (81.2–90.6)		33.4 (26.6–40.2)		20.2 (18.5–21.8)		< .001	
	44.6 (42.3–46.6)	9.9 (7.9–11.8)	88.5 (81.3–95.7)	94.9 (85.7–100)	91.5 (88.6–94.3)	66.0 (48.1–83.9)	47.8 (36.6–59.1)	15.5 (9.0–22.1)[a]	34.6 (32.0–37.3)	6.9 (5.2–8.5)	< .001	< .001
Vitamin D supplements	41.5 (39.5–43.5)		89.2 (83.3–95.0)		68.5 (60.0–77.0)		45.2 (37.3–53.0)		37.5 (35.3–39.6)		< .001	
	53.1 (50.3–56.0)	29.1 (26.4–31.9)	90.2 (84.4–96.1)	78.6 (51.0–100)[a]	72.8 (64.7–80.9)	53.0 (31.4–74.7)[a]	59.7 (48.1–71.2)	27.2 (18.3–36.1)[a]	47.7 (44.4–50.9)	28.1 (25.2–30.9)	< .001	.001
Calcium supplements	39.4 (37.5–41.3)		90.7 (85.1–96.4)		81.7 (76.5–86.9)		40.7 (32.9–48.5)		34.0 (32.0–36.0)		< .001	
	54.9 (52.0–57.7)	22.9 (20.4–25.5)	92.8 (87.9–97.7)	69.6 (38.2–100)[a]	87.8 (83.7–91.8)	60.2 (40.8–79.6)	55.7 (44.0–67.4)	21.9 (13.6–30.3)[a]	47.8 (44.6–51.1)	21.3 (18.8–23.8)	< .001	< .001
Regular physical activity[c]	42.0 (39.8–44.2)		37.0 (23.1–51.0)[a]		29.4 (23.2–35.7)		44.6 (36.3–52.9)		43.1 (40.7–45.5)		.003	
	40.7 (37.7–43.7)	43.3 (40.2–46.5)	35.5 (20.4–50.6)[a]	NR[b]	31.2 (24.3–38.2)	23.0 (8.8–37.3)[a]	43.9 (31.8–56.1)	45.5 (35.2–55.9)	42.2 (38.8–45.6)	43.9 (40.6–47.3)	.089	.031
Osteoporosis medication	59.3 (53.0–65.7)		69.5 (58.7–80.4)		56.5 (49.1–63.9)		n/a		n/a		.059	
	64.8 (58.9–70.8)	36.2 (18.5–54.0)	69.0 (57.1–80.8)	NR[b]	63.5 (56.3–70.6)	31.8 (12.4–51.1)[a]	n/a	n/a	n/a	n/a	n/a	n/a

Data source: 2009 Canadian Community Health Survey—Osteoporosis Rapid Response.
Abbreviations: CI, confidence interval; n/a, not applicable; NR, nonreportable.
Notes: Percentages (%) and 95% CIs are based on weighted data.
[a] High sampling variability (coefficient of variation between 16.6% and 33.3%).
[b] Coefficient of variation > 33.3%.
[c] Defined as moderately active or active.

crude for all the risk subgroups with the exception of those with neither an osteoporosis diagnosis nor a prior major fracture (available from the author upon request).

Factors independently associated with use of screening, prevention and management strategies

After adjusting for all sociodemographic factors, risk and protective factors and health characteristics,[**] results demonstrated that factors independently associated with the use of osteoporosis prevention and management strategies varied by type of strategy (Table 3). Older age was positively associated with having received a bone density test and use of vitamin D and calcium supplements. Being male was negatively associated with all strategies except for regular physical activity, which was not associated with osteoporosis strategies for either sex. Having a lower level of education and lower household income were negatively associated with use of calcium and vitamin D supplements, and both were negatively associated with regular physical activity. Being obese (vs. normal weight) and a daily smoker were negatively associated with use of vitamin D supplements, calcium supplements and regular physical activity. The number of nonosteoporosis physical chronic conditions was positively associated with all strategies with the exception of regular physical activity. Major fracture history, despite being an important risk factor for future fractures, was not associated with any strategy with the exception of vitamin D supplements.

Discussion

Osteoporosis and its complications are common. In 2009, approximately 10% of Canadian adults aged 40 years and older (an estimated 1.5 million people) reported having been diagnosed with osteoporosis, of which one in five also reported a major fracture history. More concerning is the large proportion of the one million Canadians aged 40 years and older at risk of osteoporosis—those with a major fracture history—that had not undergone bone density testing (approximately two-thirds) and were not engaging in lifestyle approaches recommended to maintain healthy bones (about half). Many of the factors found to be independently associated with the osteoporosis screening, prevention and management strategies studied

[**] Age, sex, cultural/racial background, respondent's level of education, adjusted household income adequacy quintile, body mass index, smoking status, alcohol consumption, major fracture after the age of 40 and number of nonosteoporosis physical chronic conditions.

TABLE 3
Factors independently associated with use of osteoporosis screening, prevention and management strategies, household population aged 40 or older, Canada excluding territories, 2009

	Bone density test	Vitamin D supplements	Calcium supplements	Regular physical activity[a]	Osteoporosis medication
	Adjusted OR[b] (95% CI), *p*-value				
Age group (years)					
65+	3.0 (2.3–4.0), < .001[c]	1.7 (1.4–2.1), < .001[c]	1.6 (1.2–2.0), ≤ .001[c]	1.0 (0.8–1.2)	1.6 (0.8–3.0)
40–64	Referent	Referent	Referent	Referent	Referent
Sex					
Male	0.1 (0.1–0.2), < .001[c]	0.4 (0.3–0.5), < .001[c]	0.2 (0.2–0.3), < .001[c]	1.1 (0.9–1.3)	0.3 (0.1–0.7), .003[c]
Female	Referent	Referent	Referent	Referent	Referent
Cultural/racial background					
Non-White	1.4 (0.8–2.4)	0.9 (0.6–1.3)	1.2 (0.9–1.8)	0.7 (0.5–1.1)	3.9 (0.6–23.5)
White	Referent	Referent	Referent	Referent	Referent
Highest level of education					
Less than postsecondary	0.8 (0.6–1.0)	0.8 (0.7–1.0)	0.8 (0.6–1.0), .030[c]	0.7 (0.6–0.9), .001[c]	1.1 (0.6–2.2)
Postsecondary	Referent	Referent	Referent	Referent	Referent
Household income adequacy quintile					
Low (Q1–Q2)	1.0 (0.7–1.4)	0.7 (0.6–0.9), .004[c]	1.0 (0.8–1.3)	0.7 (0.5–0.9), .003[c]	0.9 (0.4–1.9)
Middle (Q3)	0.9 (0.7–1.3)	0.6 (0.5–0.9), .003[c]	0.9 (0.6–1.2)	0.8 (0.6–1.1)	0.6 (0.2–1.4)
High (Q4–Q5)	Referent	Referent	Referent	Referent	Referent
BMI (kg/m^2)					
Underweight (< 18.5)	0.9 (0.2–3.6)	1.8 (0.4–8.1)	0.7 (0.2–2.4)	1.2 (0.3–5.7)	1.0 (0.5–2.0)
Overweight (25.0–29.9)	0.9 (0.7–1.2)	0.8 (0.6–1.0)	0.9 (0.7–1.1)	0.9 (0.7–1.1)	1.0 (0.5–2.0)
Obese (> 30.0)	0.9 (0.7–1.3)	0.6 (0.5–0.8), .001[c]	0.6 (0.5–0.8), ≤ .001[c]	0.5 (0.4–0.6), < .001[c]	0.9 (0.4–2.1)
Normal weight (18.5–24.9)	Referent	Referent	Referent	Referent	Referent
Daily smoker					
Yes	0.9 (0.6–1.3)	0.5 (0.4–0.7), < .001[c]	0.6 (0.4–0.8), .001[c]	0.5 (0.4–0.7), < .001[c]	1.0 (0.5–2.0)
No	Referent	Referent	Referent	Referent	Referent
Daily drinker					
Yes	1.1 (0.8–1.6)	1.2 (0.9–1.6)	1.2 (0.9–1.7)	1.4 (1.0–1.9), .040[c]	1.0 (0.5–2.0)
No	Referent	Referent	Referent	Referent	Referent
Major fracture after the age of 40					
Yes	1.4 (0.9–2.1)	1.4 (1.0–1.9), .035[c]	1.2 (0.8–1.7)	1.0 (0.7–1.4)	1.0 (0.5–2.0)
No	Referent	Referent	Referent	Referent	Referent
Number of nonosteoporosis physical chronic conditions					
3+	2.9 (1.7–5.0), < .001[c]	1.2 (0.8–1.9)	1.7 (1.1–2.7), .018[c]	0.4 (0.3–0.6), .001[c]	1.0 (0.5–2.0)
1–2	2.3 (1.7–3.0), < .001[c]	1.4 (1.1–1.7), .001[c]	1.8 (1.4–2.2), < .001	0.8 (0.6–1.0), .031[c]	1.0 (0.5–2.0)
None	Referent	Referent	Referent	Referent	Referent

Data source: 2009 Canadian Community Health Survey—Osteoporosis Rapid Response.

Abbreviations: BMI, body mass index; CI, confidence interval; OR, odds ratio; Q, quintile.

Note: OR and 95% CIs are based on weighted data.

[a] Defined as moderately active or active.

[b] Adjusted for all variables in the model including age, sex, cultural/racial background, respondent's level of education, household income adequacy quintile, BMI, smoking status, alcohol consumption, major fracture after the age of 40 and number of nonosteoporosis physical chronic conditions.

[c] Significantly different from the referent (*p*-value < .05).

are in keeping with what we know about those at greatest risk and those most likely to receive osteoporosis care.[2] However, the negligible effect that a prior major fracture had on any of the strategies studied (particularly bone density testing) is of great concern given that individuals with a prior osteoporosis-related fracture are known to be at greatest risk of a future fracture.[14] Prevalence estimates based on Canadian administrative health data generally corroborate the findings from this study, with approximately 11% of Canadian adults aged 40 years and older having been diagnosed with osteoporosis in 2009/10.[15]

Between the release of the 2002 clinical practice guidelines and the latest update in 2010,[16] there was a fundamental shift in osteoporosis care from treating low bone mineral density to preventing fractures, given the readily identifiable clinical factors that increase the risk of fracture independent of bone mineral density. As a result, the 2010 guidelines outline a more integrated approach to identify people who should be assessed for osteoporosis and recommended for treatment based on high absolute fracture risk, which incorporates clinical risk factors beyond bone mineral density.[2] Also, in order to address the well documented osteoporosis care gap among high-risk individuals,[3-7] the 2010 clinical practice guidelines concentrate on the assessment and management of women and men over age 50 who are at high risk of fragility fractures, and the integration of new tools for assessing the 10-year risk of fracture into overall management.

Indications for measuring bone density in the 2010 guidelines include advanced age, previous fragility fracture, parental hip fracture, cigarette smoking, heavy alcohol consumption, body weight under 60 kg (132 lbs), prolonged use of glucocorticoids and other bone-depleting medications, certain disease states and genetic disorders associated with bone loss.[2] Furthermore, the 2010 clinical guidelines provide recommendations regarding lifestyle approaches such as calcium and vitamin D intake and physical activity, in addition to the use of medications for the prevention and management of osteoporosis.

Future work is essential to determine if there has been a positive change in osteoporosis care in Canada as a result of implementing the latest evidence-based clinical practice guidelines and respective knowledge translation strategies.[17,18]

Repeating similar questions in a future CCHS would assist in a re-evaluation of the osteoporosis care gap on a national level; alternately, the use of administrative data via the Public Health Agency of Canada's Canadian Chronic Disease Surveillance System has the potential to achieve this on an ongoing basis.

Strengths and limitations

This study has a number of strengths, including the large, population-based sample and the administration of the survey by trained personnel using a structured format. Furthermore, it makes use of data from the only national survey to have collected information on the screening, prevention and management of osteoporosis including health determinants, lifestyle behaviours and comorbidities among Canadian adults.

However, findings should be interpreted in light of some important limitations. First, as with most population-based health surveys, the 2009 CCHS-ORR relies on self-reporting of health-related events with no third-party corroboration or verification of these self-reports. While this is the most practical method of assessing disease status in large population studies, self-reporting of health events and related information is susceptible to misclassification of the outcome or explanatory variables due to social desirability bias, recall bias and conscious nonreporting. Nevertheless, validation studies have demonstrated that the prevalence of self-reported diagnosis of osteoporosis and major osteoporotic fractures is reasonably accurate.[19,20]

Second, associations between different factors can be explored; however, causal inferences cannot be drawn from the results due to the survey's cross-sectional design.[21] For example, while the use of vitamin D and calcium supplements are associated with osteoporosis and fracture risk, we do not know whether receiving an osteoporosis diagnosis or having had a major fracture preceded the use of these prevention strategies or vice versa.

Third, while the 2009 CCHS-ORR was designed to be nationally representative, the generalizability of the findings to the entire Canadian population 40 years and older is limited due to the exclusion of the territories and some subpopulations known to be at an elevated risk of osteoporosis, including Indigenous populations living on Indian reserves or Crown lands[22] and institutionalized patients.[23]

Fourth, while the majority (58.6%) of those having had at least one major fracture after the age of 40 reported it occurred as a result of a fall from a standing height or less, 23.1% reported it occurred as a result of a hard fall and 19.5% reported it was the result of other severe trauma.[††] We elected to include all fractures, irrespective of the mechanism of injury, given that it is uncertain whether such trauma classifications are useful for determining whether a fracture is related to low bone density or indicates an increased risk of future fracture,[24] and given the recent shift in thinking that all fractures in older adults warrant careful evaluation in an effort to reduce the risk of future fractures.[25]

Finally, we encountered analytical limitations due to available sample size when disaggregating data by specific characteristics of interest. For example, it was not possible to provide a statistical description of the population by racial/ethnic group, as the estimates for the different categories had high coefficients of variation (CV), indicating high sampling variability and estimates of unacceptable quality; therefore, we were limited to collapsing respondents into "White" or "non-White" response categories only.

Conclusion

Osteoporosis is common among Canadians 40 years of age and older, but more concerning is the large proportion at risk for osteoporosis—those with a major fracture history—who have not received a bone density test, nor engaged in lifestyle approaches recommended to help maintain healthy bones. The latest clinical practice guidelines released by Osteoporosis Canada in 2010 focus on preventing fragility fractures, as opposed to treating low bone mineral density, which represents a fundamental shift in the prevention and treatment of osteoporosis and related

[††] Percentages do not add up to 100% because an individual can report more than one fracture of the major fracture sites with different mechanisms of injury.

fractures since the release of the 2002 clinical practice guidelines. The results from this study represent the most recent data of their kind and serve as a benchmark for the nationwide use of osteoporosis screening, prevention and management strategies among Canadians aged 40 years and older. Based on 2009 CCHS-ORR data captured one year prior to the release of the 2010 clinical practice guidelines, the findings within provide the necessary historical information to evaluate whether the release of these guidelines has had a positive impact on osteoporosis care in Canada.

Acknowledgements

Osteoporosis Surveillance Expert Working Group: Jacques Brown, David Hanley, Susan Jaglal, Sonia Jean, Famida Jiwa, Stephanie Kaiser, David Kendler, William Leslie, Louise McRae, Suzanne Morin, Siobhan O'Donnell, Jay Onysko, Alexandra Papaioannou and Kerry Siminoski.

Kate Zhang, from the Alberta & Northwest Territory Region of the Public Health Agency of Canada, provided analytic support in the initial stages of this project.

This research received no specific grant from any funding agency or commercial or not-for-profit organization.

Conflicts of interest

None.

Authors' contributions and statement

SO contributed to the study design, conducted the statistical analysis, assisted with the interpretation of the data and drafted and revised the manuscript. Members of the Osteoporosis Surveillance Expert Working Group contributed to the study design, assisted with the interpretation of data, reviewed and revised the manuscript and approved its submission.

The conclusions in this manuscript reflect the opinions of individual experts and not their affiliated organizations.

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Erratum

This erratum is being published to correct a number of errors, including inaccurate references, on pages 380 and 383 of the following article:

Simpson A, Furlong A, Jetha N. At-a-glance – Bringing equity into the fold: a review of interventions to improve mental health. Health Promot Chronic Dis Prev Can. 2018;38(10):380-4. doi: 10.24095/hpcdp.38.10.04.

Before correction

According to the Canadian chronic disease surveillance statistics, more than one in ten individuals are affected by a mood or anxiety disorder in Canada, representing nearly three-quarters of the population that uses health services for a mental illness annually.[9] Of the 4000 deaths by suicide each year in Canada, more than 90 percent of individuals were experiencing a mental illness or mental health problem.[10] Suicide is the second leading cause of death in children, youth and young adults aged 10-29 years.[10] Boys account for 65% of suicides among 15-19 year olds, while girls account for over 80% of self-harm hospitalizations in that same age group.[11,12] Perhaps less known, girls aged 10-14 years account for 59% of suicides in that age cohort.[11]

with the following references:

9. Public Health Agency of Canada. Report from the Canadian Chronic Disease Surveillance System: Mental Illness in Canada, 2015. Ottawa (ON): Public Health Agency of Canada; 2015. 34 p. Cat. No.: HP35-56/2015E-PDF.

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11. Statistics Canada. Leading causes of death, total population, by age group. Table 13-10-0394-01 (formerly CANSIM 102-0561). Ottawa (ON): Statistics Canada; 2017. Available from: https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=1310039401

12. Canadian Institute for Health Information. Intentional self-harm among youth in Canada. Canadian Institute for Health Information; 2014. Available from: https://www.cihi.ca/sites/default/files/info_child_harm_en.pdf

After correction

According to estimates from the Canadian Chronic Disease Surveillance System, close to one in ten individuals in Canada used health services for mood and anxiety disorders in 2009/10, which represents about three-quarters of Canadians who used health services for a mental illness.[9] Of the approximately 4000 deaths by suicide each year in Canada, research suggests that almost 90 percent of individuals may have been living with a mental illness or mental health problem.[10] According to 2016 data, suicide is the second leading cause of death in youth and young adults aged 15-29 years.[11] Boys account for 64% of suicides among 15-19 year olds[11] while girls account for approximately 83% (excludes Quebec data) of self-harm hospitalizations in that same age group.[12] Perhaps less known, girls aged 10-14 years account for 66% of suicides in that age cohort.[11]

with the following references:

9. Public Health Agency of Canada. Report from the Canadian Chronic Disease Surveillance System: Mood and Anxiety Disorders in Canada, 2016. Ottawa (ON): Public Health Agency of Canada; 2016. 44 p. Cat. No.: HP35-70/2016E-PDF.

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12. Canadian Institute for Health Information. Discharge Abstract Database (DAD): 2016 data. Ottawa (ON): Canadian Institute for Health Information; 2018 [cited 2018 Oct 29].

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 2018:

Brooks JI, Bell CA, Rotondo J, Gilbert NL, Tunis M, Ward BJ, **Desai S**. Low levels of detectable pertussis antibody among a large cohort of pregnant women in Canada. Vaccine. 2018;36(41):6138-6143. doi: 10.1016/j.vaccine.2018.08.066.

Ellis VL, Milliken OV. Integrating economics into the rationale for multisectoral action on obesity. Pan Am J Public Health. 2018;42:e58. doi: 10.26633/RPSP.2018.58.

England G, Casey R, Ferro M, MacMillan H, **Tonmyr L**, Gonzalez A. Child maltreatment and adult multimorbidity: results from the Canadian Community Health Survey. Can Journal Public Health. 2018;109(4):561-572. doi: 10.17269/s41997-018-0069-y.

Gonzalez A, Catherine N, Boyle M, […] **Tonmyr L**, et al. Healthy Foundations Study: a randomised controlled trial to evaluate biological embedding of early-life experiences. BMJ Open. 2018;8(1):e018915. doi: 10.1136/bmjopen-2017-018915.

Govia RNM, **Birse KD**, Sepehri S, Khafipour E, Menticoglou SM, **Burgener AD**, et al. Amniotic fluid proteomic signatures of cervical insufficiency and their association with length of latency. Am J Reprod Immunol. 2018. doi: 10.1111/aji.13030.

Lix LM, Ayles J, **Bartholomew S**, Cooke CA, **Ellison J**, […] **O'Donnell S**, […] **Pelletier C**, […] **Robitaille C**, […] **Pelletier L**. The Canadian Chronic Disease Surveillance System: a model for collaborative surveillance. International Journal of Population Data Science. 2018;3(3). doi: 10.23889/ijpds.v3i3.433.

Milliken OV, Ellis VL. Development of an investment case for obesity prevention and control: perspectives on methodological advancement and evidence. Pan Am J Public Health. 2018;42:e62. doi: 10.26633/RPSP.2018.62.

Rhodes AE, Sinyor M, Boyle M, [...] **Tonmyr L**, **Skinner R**. Emergency department presentations and youth suicide: a case-control study. Can J Psychiatry. 2018:1-10. doi: 10.1177/0706743718802799.

Tonmyr L, Mathews B, **Shields ME, Hovdestad WE**, Afifi TO. Does mandatory reporting legislation increase contact with child protection? – a legal doctrinal review and an analytical examination. BMC Public Health. 2018;18(1):1021. doi: 10.1186/s12889-018-5864-0.