Health Promotion and Chronic Disease Prevention in Canada

Research, Policy and Practice

Volume 36 • Number 4 • April 2016

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. 150134
Journal_HPCDP-Revue_PSPMC@phac-aspc.gc.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: http://www.phac-aspc.gc.ca/publicat/hpcdp-pspmc/authinfo-eng.php

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

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

Interactive social media interventions to promote health equity: an overview of reviews

V. Welch, PhD (1); J. Petkovic, MSc (2); J. Pardo Pardo, BSc (2); T. Rader, MLIS (3); P. Tugwell, MD (1, 3, 4)

This article is part of our Health Equity Series.
This article has been peer reviewed.

Tweet this article

Abstract

Introduction: Social media use has been increasing in public health and health promotion because it can remove geographic and physical access barriers. However, these interventions also have the potential to increase health inequities for people who do not have access to or do not use social media. In this paper, we aim to assess the effects of interactive social media interventions on health outcomes, behaviour change and health equity.

Methods: We conducted a rapid response overview of systematic reviews. We used a sensitive search strategy to identify systematic reviews and included those that focussed on interventions allowing two-way interaction such as discussion forums, social networks (e.g. Facebook and Twitter), blogging, applications linked to online communities and media sharing.

Results: Eleven systematic reviews met our inclusion criteria. Most interventions addressed by the reviews included online discussion boards or similar strategies, either as stand-alone interventions or in combination with other interventions. Seven reviews reported mixed effects on health outcomes and healthy behaviours. We did not find disaggregated analyses across characteristics associated with disadvantage, such as lower socioeconomic status or age. However, some targeted studies reported that social media interventions were effective in specific populations in terms of age, socioeconomic status, ethnicities and place of residence. Four reviews reported qualitative benefits such as satisfaction, finding information and improved social support.

Conclusion: Social media interventions were effective in certain populations at risk for disadvantage (youth, older adults, low socioeconomic status, rural), which indicates that these interventions may be effective for promoting health equity. However, confirmation of effectiveness would require further study. Several reviews raised the issue of acceptability of social media interventions. Only four studies reported on the level of intervention use and all of these reported low use. More research on established social media platforms with existing social networks is needed, particularly in populations at risk for disadvantage, to assess effects on health outcomes and health equity.

Keywords: *social media, disadvantaged populations, public health, health promotion, health equity*

Highlights

- The use of social media interventions has been increasing in the field of public health as they can cross geographical and physical access barriers.
- Eleven systematic reviews found mixed effects of social media interventions on improving health outcomes and healthy behaviours.
- Some of the reviewed studies found benefits from social media interventions while others found no change or found that outcomes were worse than those from non–social media interventions.
- We know little about how the design and implementation features and the intensity and duration of interventions could improve health or whether they could increase negative behaviours, stigmatization or exacerbation of health inequities.
- Many of the studies used social media platforms that were developed by the researchers. The effects of using existing social networks with commercial platforms, such as Facebook and Twitter, as part of social media health interventions are unknown.

Introduction

Social media is increasingly used for public health and health promotion: 60% of state departments in the United States use one or more social media applications;[1] the Public Health Agency of Canada has a presenceon social media sites including Twitter (2300 tweets, over 52 000 followers as of January 14, 2015)[2] and Facebook (over 13 000 ''likes'' as of January 14, 2016)[3]; and 34 out of the 36 public health units in Ontario[4] are using social media. Social media holds promise for public health interventions reaching a wide number of people as over 60% of adults and 90% of youth with Internet access in Canada are active on one or more forms of social media.[5,6]

Author references:

1. Bruyère Research Institute, University of Ottawa, Ottawa, Ontario, Canada
2. Centre for Global Health, University of Ottawa, Ottawa, Ontario, Canada
3. Ottawa Hospital Research Institute, University of Ottawa, Ottawa, Ontario, Canada
4. Department of Medicine, Faculty of Medicine, University of Ottawa, Ontario, Ottawa, Canada

Correspondence: Vivian Welch, 43 Bruyère Street, Annex E room 304, Ottawa, ON K1N 5C8; Tel: 613-562-6262 ext. 2904; Fax: 613-569-6734; Email: Vivian.Welch@uottawa.ca

Various social media can be defined by the extent to which they focus on seven functional building blocks to do with the degree of interaction and communication among users: 1) identity: the extent to which users reveal themselves; 2) conversations: the extent to which users communicate with each other; 3) sharing: the extent to which users exchange, distribute and receive content; 4) presence: the extent to which users know if others are available; 5) relationships: the extent to which users relate to each other; 6) reputation: the extent to which users know the social standing of others and content; and 7) groups: the extent to which users form communities.[7]

Evidence from systematic reviews suggests social media that facilitates interaction with other users by way of bulletin boards, chatrooms or available networking sites (e.g. Twitter and Facebook) effectively improves knowledge. However, effects on health behaviours (e.g. smoking, eating, physical activity) and health outcomes (such as weight loss and mental health) have been found to be both positive and negative.[8-12] While the social media interventions in these reviews were mostly assessed in well-educated, higher-income populations, some studies have shown benefits for low-income populations, older adults, youth and different ethnocultural groups.

However, mass media strategies for public health also have the potential to increase health inequities, defined as differences in health outcomes that are avoidable and unfair.[13,14] Differences in access to technology and cultural differences and preferences might affect uptake and use of social media interventions and may also result in health inequities.

In this paper, we aim to assess the effects of interactive social media interventions for health communication on health outcomes, behaviour change and health equity by overviewing systematic reviews.

Methods

Approach

We defined the review question using the population, intervention, comparator, outcome (PICO) approach.[15]

Population

We included systematic reviews of any population exposed to a social media intervention.

Intervention

We defined social media as "activities among people gathered online who share information using conversational media that make it easy to create and share content in the form of words, pictures, videos, and audios."[16] As mentioned previously, different types of social media can be defined by the extent to which they focus on seven functional building blocks.[7] Social media includes activities such as discussion forums, social networks (e.g. Facebook and Twitter), blogging and microblogging, bookmarking and media sharing.[17] To distinguish from other web-delivered programs and to qualify as social media for the purposes of this review, an intervention needed to have an interactive component with two-way communication between peers or between the website and users.

We excluded mass media and any unidirectional forms of health communication (e.g. where the Internet or text messages are used to broadcast messages with no interactive component). We also excluded e-health interventions that involved using technology to deliver health care (e.g. using remote consultation between a patient and a provider through the Telestroke network).[18,19] We excluded smartphone applications if they lacked an interactive component with other users (e.g. feedback or tracking of weight on a smartphone for personal use only with no sharing or feedback from other users/peers).

Comparator

We included comparators of usual care, no intervention, or another intervention method that may have had a social media component. Usual care could include any type of health care or health promotion activity. We kept the comparator broad so we could compare this to any other method of delivering health promotion or health care for the same condition.

Outcomes

We included systematic reviews that reported on at least one of the following primary outcomes: physical outcomes (e.g. weight change, functional status), psychosocial health outcomes (e.g. quality of life and self-efficacy), satisfaction, behaviour change and adverse effects (e.g. addiction, depression). We collected and reported data on secondary outcomes of attitudes and knowledge. We documented process measures such as quality of communication, knowledge, reach, engagement and fidelity of the intervention (whether the intervention was implemented as planned).[20]

To assess the outcome of health equity, we determined whether results were presented separately across characteristics associated with privilege/disadvantage. We also assessed whether the intervention was aimed at a disadvantaged population, which could potentially improve health equity. We used the acronym PROGRESS-Plus to identify these characteristics, defined as Place of residence, Race/ethnicity/culture/language, Occupation, Gender/sex, Religion, Education, Socioeconomic status, Social capital or other factors associated with privilege/disadvantage such as age (e.g. children or elderly), sexual orientation, and disease status.[21]

Study design

We conducted a rapid response overview of systematic reviews approach. A rapid response provides an overview of the available evidence, usually from guidelines or systematic reviews, in response to a need or priority identified by a knowledge user in a short timeframe.[22,23] An a priori protocol was developed and submitted to the Public Health Agency of Canada as a Statement of Work (available from the authors on request). We defined a systematic review as a systematic and transparent synthesis of eligible studies, with transparent methods and an explicit search strategy. We included reviews of randomized controlled trials, non-randomized studies and qualitative studies.

Search methods for identification of studies

We designed a sensitive search strategy to retrieve systematic reviews from electronic bibliographic databases. Our knowledge user advised us to avoid a grey literature search because of time constraints. To retrieve systematic reviews, we used the Montori filter, a validated systematic review

study design filter.[24] No date limitations or language restrictions were applied.

We identified 4580 items from the following databases on 27 February 2014:

- MEDLINE via OVID (1946* to 27 February 2014);
- PsycINFO via OVID (PsycINFO 1806 to February Week 3 2014);
- Cochrane Library via Wiley (Issue 2 of 12, 2014) including the Cochrane Database of Abstracts of Reviews of Effects (DARE), Cochrane Database of Systematic Reviews (CDSR), Health Technology Assessment (HTA) and Economic Evaluations Database (EED) to scan the reference lists of relevant systematic reviews;
- PUBMED via National Library of Medicine ''Related Articles'' search in PUBMED using 4 relevant systematic reviews as seed papers, 27 February 2014; and
- Campbell Library (hand searched all issues, 2004–present).

The search strategy was devised in OVID MEDLINE by a librarian scientist (TR) and peer reviewed by another member of the team (JPP) following PRESS (Peer Review of Electronic Search Strategies) guidelines.[25] The strategy was then adapted for the other databases. The complete search strategies are available upon request.

All databases were searched from inception to 27 February 2014. Duplicates were removed electronically using EndNote, leaving 4102 citations.

Inclusion criteria

We included reviews if they assessed the effects of social media health promotion interventions (description of eligible social media interventions described in Table 1) on health behaviour or health outcomes.

Data extraction

We extracted data on the following:

- intervention description;
- comparator;
- outcomes;
- review exclusion criteria;
- number of included studies;
- number of participants in intervention and control groups (enrolled and completed);
- country setting;
- population description including median age and percentage of females;
- description of population, analysis or interpretation by PROGRESS-Plus;
- outcome – summary and quantitative pooled result (if available);
- usage of social media (how much participants used the intervention), reach of the intervention and activities to increase engagement of the participants with the intervention (e.g. use of a moderator);
- confounders;
- adverse effects;
- risk of bias;
- applicability for PROGRESS-Plus populations discussed; and
- AMSTAR score.

Quality assessment of reviews

We used the AMSTAR tool (http://amstar.ca/Amstar_Checklist.php) to assess the quality of the systematic reviews.[26] We considered systematic reviews to be of high quality when they addressed all 11 items on the AMSTAR checklist.

TABLE 1
Definition of social media interventions

Social media format	Included	Excluded
Blogs and microblogs (e.g. Twitter)	If the intervention includes multi-way interaction	One-way messages and posts or direct contact with a health care provider
Content communities (e.g. YouTube, Pinterest)	If the intervention includes multi-way interaction	One-way messages and posts or direct contact with a health care provider
Discussion groups (e.g. chat rooms, online bulletin boards, discussion forums)	Synchronous or asynchronous discussion groups or boards	One-way messages and posts or direct contact with a health care provider
Emails	List servs that allow for communication, discussion and visible record of the discussion for others to view and comment	One-way emails (e.g. reminders)
Mobile applications (apps)	Apps that allow for communication and interaction with a group of people	Apps that allow a person to track and monitor their progress (e.g. weight loss, blood sugar, etc.) without a social component or apps used to communicate with a health care provider
SMS/text messages	If the messages remain posted for others to view	One-way text messages (e.g. reminders) or text messages with reply and/or feedback from health care provider/researchers
Virtual gaming worlds	If there is communication between multiple players (and there is a health outcome)	Online games without social and health components
Virtual social networks (e.g. Facebook)	If the intervention includes multi-way interaction	One-way messages and posts or direct contact with a health care provider
Webpages and Wikis	If the website/Wiki allows for multi-way interaction	One-way communication (e.g. education)

*Since there is no definitive date when social media phenomenon began, we chose not to apply a date limit. Instead, we focussed on search terms that describe the social media intervention and retrieved relevant material regardless of the date of publication.

Synthesis methods

The interventions and populations were too heterogeneous to pool results. We narratively summarized effects on participant-important outcomes for each type of intervention as well as process outcomes, including the fidelity of the intervention and reach and level of engagement (if measured) using effect sizes (if reported). We checked the extent to which the primary studies in the eligible systematic reviews were overlapping. Dichotomous outcomes are presented as relative risks, and continuous outcomes as weighted mean differences. We report the pooled results from systematic reviews that combined results statistically.

Health Equity Impact Assessment

We used the Ontario Ministry of Health and Long-Term Care Health Equity Impact Assessment (HEIA) tool (available at: http://www.health.gov.on.ca/en/pro/programs/heia/) to assess likely intended and unintended effects in priority populations (completed template available from the authors on request). To make these judgments about unintended effects and mitigation strategies, two from our team of researchers (JP, VW) reviewed data on Internet access and also considered known barriers and facilitators for specific populations based on our expertise in reviewing effects of interventions on health equity.[21,27] The HEIA tool is intended to help identify how a program, policy or other initiative will impact different groups of the population, the primary focus being barriers in access to programs.[28] We used data on access and use of social media platforms from the Canadian Internet Use Survey to measure access to Internet and Internet use behaviour (survey results available upon request).

Results

Results of search

The search strategy identified 4103 records after duplicates were removed. After screening abstracts and titles, 3957 records were excluded and 146 articles were retrieved for full-text screening. We excluded 135 systematic reviews because the interventions used one-way communication (e.g. one-way reminders for appointments) or used the Internet for treatment (e.g. cognitive-based therapy by Internet) or for one-way education or information messages, with no interaction among users or user-generated content (see Figure 1). A table of excluded studies is available upon request.

We included 11 systematic reviews in this overview (see Table 2 for the characteristics of these studies).

Description of reviews

Most of the systematic reviews focussed on online discussion boards or similar strategies, either as stand-alone interventions or in combination with other interventions. Only three reviews included studies that used the most common social media tools, Facebook (n = 19 unique studies) and Twitter (n = 9 unique studies).[8,9,30] Although they were included in the search criteria, none of the interventions in the systematic reviews were defined as mobile phone applications.

In the older studies included in the reviews, most of the discussion boards were ''closed'' spaces, where only study participants could access the discussion board (i.e. there was no interaction with external people or communities). For example, in the Chang et al. review[9] of online weight management using social media, 85% of the studies used a closed, researcher-developed website.

In the studies where social media was part of a complex intervention, it focussed on maintaining engagement with the other components of the intervention, to provide feedback on the intervention and a space to formulate questions and get answers. For example, in the Williams et al. review,[30] all of the 16 studies had social media as a component of a complex intervention where other components included websites with fact sheets and information or therapist-led email interactions.

In the 11 systematic reviews included, the populations were diverse in terms of age (children, youth, adults and older people), disease conditions (e.g. cancer, cardiovascular, asthma, depression, eating disorders) and sex/gender (i.e. no exclusion criteria related to sex/gender). One large systematic review of 98 studies of social media interventions for a broad range of health promotion activities included diverse populations in terms of ethnicity, socioeconomic status, age and education.[8]

Effects of social media interventions

We could not combine results to generate pooled meta-analyses. The results of each review are summarized in Table 3. We have reported effect sizes and confidence intervals when these have been available.

Of the 11 included reviews, seven reported mixed effects on health outcomes and health behaviours (details below). The remaining four reported benefits such as satisfaction, finding information and social support.[8,31-33]

Knowledge

The review by Newton & Ciliska[12] (AMSTAR score 7) reported on knowledge outcomes and found ''a statistically significant increase in knowledge'' about healthy lifestyle attitudes and behaviours.

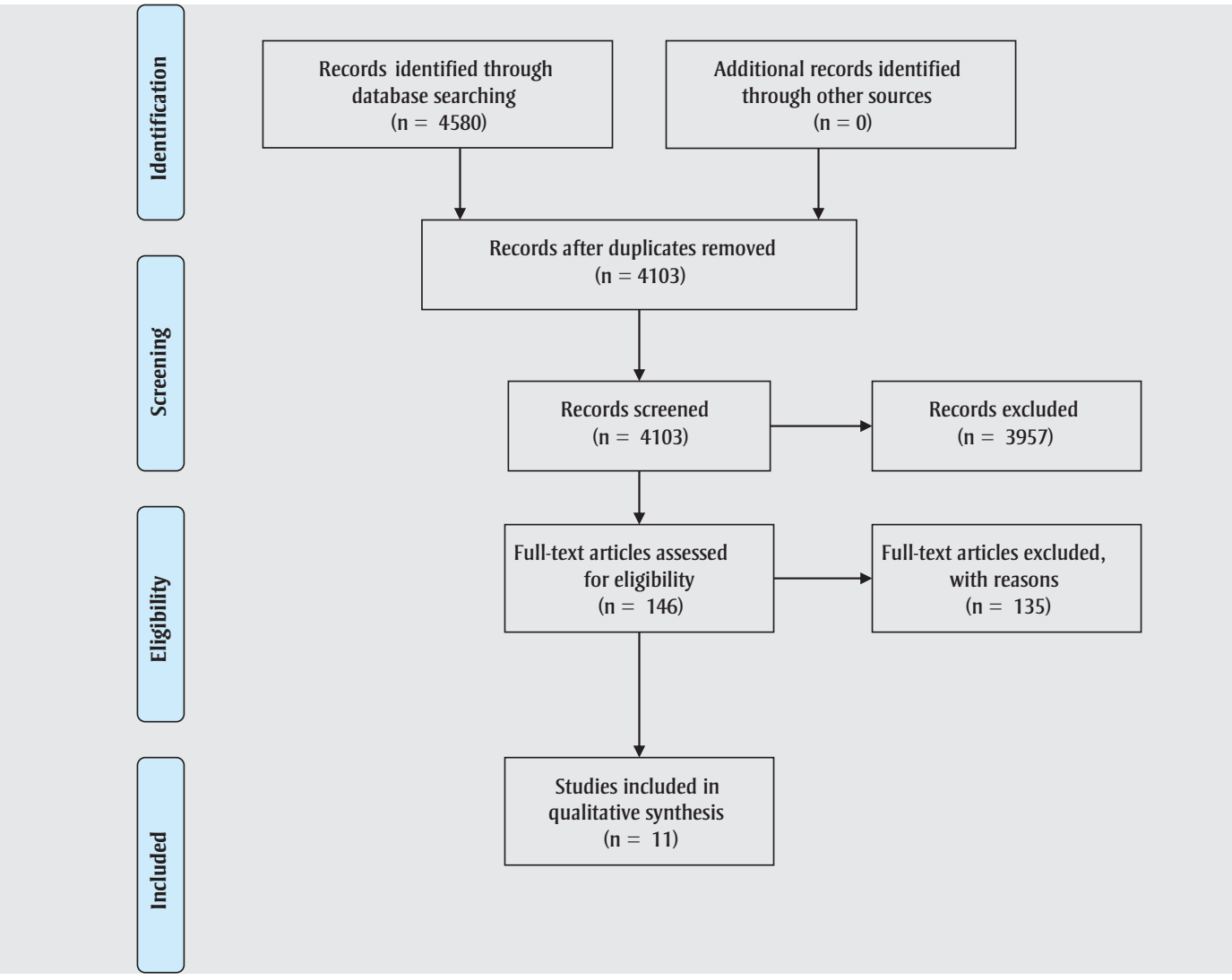
Weight loss

A review by Williams et al.[30] (AMSTAR score 9) pooled nine studies of social media interventions aimed at weight loss and found no difference between social media and control groups (weight 0.00 kg; 95% CI: −0.19 to 0.19 kg). However, another review, by Chang et al.[9] (AMSTAR score 5) included five of the same studies as Williams et al.[30] and reported that nine studies showed greater weight loss with the social media intervention than in the control group, but four studies showed no effect and two showed less weight loss among the social media group than those receiving face-to-face interventions. A third review, by Eysenbach et al.[34] (AMSTAR score 6), found ''mixed but mostly non-significant'' effects of social media on weight outcomes.

Behaviour change: physical activity

The review by Chang et al.[9] (AMSTAR score 5) reported that two studies showed

FIGURE 1
PRISMA 2009 flow diagram[29] showing the selection process to identify relevant systematic reviews



an increase in self-reported physical activity and three studies showed no difference in physical activity. Williams et al.[30] (AMSTAR score 9) conducted a meta-analysis of 12 studies and reported an increase in physical activity among the social media group (SMD 0.13; 95% CI: −0.04 to 0.30).

Behaviour change: diet

A review by Medina et al.[32] (AMSTAR score 3) examined online social media platforms for people with cardiovascular disease and described improved diet and quality of life among those using these platforms. The review by Chang et al.[9] (AMSTAR score 5) included one study that found "no statistically significant differences" in body mass index (BMI), waist-to-hip ratio, blood pressure or cholesterol following a dietary intervention.

Behaviour change: smoking

The review by Eysenbach et al.[34] (AMSTAR score 6) reported a higher rate of smoking cessation in a peer-to-peer online support group compared to a group without peer-to-peer support. However the rates in the peer-to-peer online plus psychoeducational intervention were similar to the group receiving a psychoeducational intervention alone.

Health care utilization

One study in the review by Medina et al.[32] (AMSTAR score 3) reported that the number of medical visits "decreased mildly" following an online support group intervention using a moderator. However, this did not persist in the second phase once the moderator was removed.[32] The Eysenbach et al.[34] review (AMSTAR score 6) included three studies that reported on health care utilization. One study within this review reported fewer calls to doctors following the social media intervention while another found an increase in calls to providers (effect sizes not provided but authors report $p < .05$).

Mental health outcomes

The Lai et al.[31] review (AMSTAR score 6), which included four studies with social media components, found that Internet-based cognitive behaviour therapy with social media interventions (online message board or support groups) reduced

TABLE 2
Characteristics of included studies—interventions, populations and outcomes

Citation	Population	Intervention	Eligibility criteria	Target outcome (length of follow-up)	Number of studies (number of studies with social media components)	Types of eligible studies	Country (number of studies)	AMSTAR score
Chang et al., 2012 [9]	Individuals of all ages using social media for weight management	Most interventions were message boards or chat rooms designed by the researchers; 2 studies used Facebook and one used Twitter	Report weight-related outcomes, include a social media component (web-based application that allow interaction in a virtual community)	Weight management (6 to 12 months)	20 (20)	RCT	USA (n = 14), Australia (n = 3), Canada (n = 2), UK (n = 1)	5
Eysenbach et al., 2004[34]	Various e.g. pregnant women, caregivers of people with Alzheimer disease, adults with diabetes, people with AIDS, young single mothers, adult smokers, etc.	Virtual communities, web-based discussion forums, chat rooms, mailing list, voice bulletin board that involved peer-to-peer interaction	Interventions needed to be a virtual community or have a virtual community component (a group of individuals who interact publicly through a computer communication network or other computer-based tool); focus broadly on health or health care issues; have outcomes that relate to knowledge, health, psychological or social outcomes, health service use include a control group	Health and social outcomes (10 weeks to 12 months)	38 (38)	RCT, CBA	Not reported	6
Griffiths, 2009[39]	Adults and adolescents; some participants with cancer, depression, chronic illness, HIV; caregivers	Internet support groups (e.g. bulletin boards, chatrooms or mailing lists, either alone or in combination)	Interventions included an online peer-to-peer support group; had a depression outcome; involved a unipolar depression Internet support group	Depression (12 weeks to 12 months)	28 (10)	RCT, pre-post, case series, cross-sectional, ITS	USA (n = 23), Europe (n = 4), Australia (n = 1)	9
Hong et al., 2012[35]	Adult cancer survivors	Online cancer support (e.g. websites, online forums, listservs, bulletin boards)	Interventions needed to use online cancer support or resources and report outcome measures to do with psychological, physical, information attainment, etc., focus on adult cancer survivors	Psychological, physical, information attainment outcomes (1 to 12 months)	24 (21)	RCTs, pre-post, qualitative reports	Not reported	3
Lai et al., 2014 [31]	Mostly adults	Web-based suicide prevention- including any intervention delivered by Internet (e.g. cognitive behavioural therapy, online support groups, message board)	Web-based suicide prevention strategies with a discussion of the efficacy, benefits or challenges of the intervention	Suicidal ideation (6 weeks to 12 months)	15 (4)	RCTs, pre-post case series, cohort, cross-sectional, qualitative, descriptive reports	USA	6
Medina et al., 2013[32]	Adults with cardiovascular disease	Online support group for people with cardiovascular disease (both moderated and unmoderated groups included)	Online support groups, patients with cardiovascular disease	Benefits and negative outcomes (1 study: 9 months; others: not reported)	4 (4)	CBA, cohort	USA (n = 3), UK (n = 1)	3

Continued on the following page

TABLE 2 (continued)
Characteristics of included studies—interventions, populations and outcomes

Citation	Population	Intervention	Eligibility criteria	Target outcome (length of follow-up)	Number of studies (number of studies with social media components)	Types of eligible studies	Country (number of studies)	AMSTAR score
Moorhead et al., 2013[8]	Mixed, from schoolchildren to older adults, various education, socioeconomic status, ethnicity	Communication between the general public and/or patients and/or health professionals about health issues using social media (Facebook (n = 13), blogs (n = 13), Twitter (n = 8), YouTube (n = 7), myspace (n = 5), Patients LikeMe (n = 4) and other types of social media (n = 53))	Interventions needed to focus primarily on all communication interactions within and between the general public and/or patients and/or health professionals about health issues using social media, including uses, benefits or limitations of social media for health communication	Use, benefits or limitations of social media(not reported)	98 (98)	RCTs, network analyses, cross-sectional, qualitative, descriptive reports, secondary data analyses	Mostly high income (not reported)	5
Nef et al., 2013[33]	Older than 55 years	Social networking sites	Needed to include social media intervention for people 55 years and older	Acceptance, harms (mental health) (2 studies reported follow-up: 7 weeks and 21 weeks)	18 (18)	CBA, cohort	High income; not specified for each study	3
Newton & Ciliska, 2006[12]	Grade 10 and undergraduate students. Median age range 15–20 years	All studies used the program "student bodies," which includes psychoeducational readings and reflection, Internet-based body image journal, asynchronous online discussion group	Interventions evaluating Internet-based prevention programs (guided or non-guided, synchronous or asynchronous, individual or group format)	Disordered eating attitudes/ behaviours (10 to 24 weeks)	5 (5)	RCT, CBA	US (all California)	7
Nieto et al., 2008[40]	Adults (median ages 45.5 and 47)	Internet support groups (e.g. email discussion lists)	Studies that evaluated the effectiveness of any treatment for patients with chronic pain using new information and communication technologies	Pain (3 to 12 months)	7 (2)		USA (n = 1), 1 not reported	3
Williams et al., 2014[30]	16 studies in adults, 6 included children and youth. 70% female in 10 studies with both sexes, 6 studies of women only	Online discussion boards allowing for the exchange of user-generated content	Social media interventions promoting healthy diet and exercise in the general population	Physical activity and diet behaviour (10 weeks to 24 months)	16 (16)	RCTs	USA (n = 10), Australia (n = 3) and 3 in other countries	9

Abbreviations: CBA, controlled before–after study; ITS, interrupted time series; RCT, randomized controlled trial.

suicidal ideation (effect sizes ranged from $d = 0.04–0.45$).

The review by Hong et al.[35] (AMSTAR score 3) studied the effects of Internet-based groups on depression among cancer survivors, principally breast cancer survivors. Participants valued the Internet-based tools positively, and most of the studies found a positive effect of social media groups. However, for the few interventions that were compared to another type of program (e.g. a face-to-face program), the social media intervention had similar results or was less effective (e.g. one study reported higher depression rates among the social media group than the face-to-face group).

TABLE 3
Results of included systematic reviews

Citation	Desirable outcomes	Harms or limitations	Usage, reach engagement	Conclusions of the review
Chang et al., 2012[9]	• Inconsistent effect on BMI and weight; concluded that few studies quantified effect • Inconsistent effect on physical activity levels (2 positive, 3 negative)	• Use of social media was low (25%), and 85% of studies used researcher-developed platforms that may not be as user-friendly and vibrant and connected to large community of users • Use of social media for weight management may reduce positive feelings associated with social media use	25% of users reported using social media sites	"We found that social media is being incorporated in online weight-management interventions largely through message boards and chat rooms with unclear benefits."
Eysenbach et al., 2004[34]	• Weight loss or healthy body weight: mixed but mostly nonsignificant results • Behaviour change: Of the 6 studies that looked at this outcome, abstinence rates were higher with peer support in 1, study and similar in the group with full psychoeducational intervention • Only 3 studies out of 12 looking at depression and social support reported an improvement • Effects for social support measures were mixed: some indicating significant effects and others not • 5 studies looked at glycosylated hemoglobin and only 1 showed significant improvement • Of the 3 studies of health care utilization, 1 reported a significant decrease, 2 reported increase in phone calls to providers	No adverse effects reported. The authors saw little commercial or professional interest in evaluating pure virtual communities. Studies investigating "natural" self-help are difficult to recreate in controlled setting as participants may have an intrinsic desire to participate in virtual communities and general recruitment may not capture the right population	Some studies found virtual community component not heavily used	"In view of the wide variation in interventions, measurement tools, and populations studied, and the lack of methodological rigour in the majority of studies reviewed, the effect of online support groups on health-related outcomes and health care resource use remains unclear."
Griffiths 2009[39]	• 3 of 4 multicomponent trials reported a reduction in symptoms of depression while 1 found no effect • The non-experimental studies had mixed findings • Multicomponent studies were significantly less likely to yield positive outcomes than stand-alone interventions • Outcome was not affected by the use of synchronous (chat room) compared to asynchronous (bulletin board, listserv/newsgroups) Internet support groups, whether or not the study reported using a moderator or whether the board was public, research and/or restricted access	No adverse effects reported	Not reported	"There is a need for high-quality research to investigate the effect of [Internet support groups] on depression outcomes."
Hong et al., 2012[35]	• Most studies reported positive effects of online support but none of the RCTs reported significant positive outcomes, e.g. no positive improvement in mood, adjustment to cancer, self-related health status, health-related QOL • 1 of the 4 RCTs reported improvements in emotional well-being but results for psychological well-being were mixed (1 study reported improvements while 1 reported more psychological distress in the intervention group)	1 study reported more psychological distress in the intervention group. The studies didn't include online cancer support resources such as Facebook. Limited number of studies	Not reported	"Preliminary but inconclusive evidence of positive outcomes"

Continued on the following page

TABLE 3 (continued)
Results of included systematic reviews

Citation	Desirable outcomes	Harms or limitations	Usage, reach engagement	Conclusions of the review
Lai et al., 2014[31]	No quantitative measure of benefits on suicidal ideation; 2 papers reported positive feedback from users who were in crisis	• Risk of low-quality information (only half evidence-based), possible breaches of confidentiality, and limits to access may not match cultural background of user • Risk of non-genuine messages (< 5% in one online support group) • Risk of "flaming" effect of hostile comments • Risk of Internet addiction, limited to literate clients • Possible safety concerns in acute crises	Not described	"Preliminary evidence that suggests the probable benefit of web-based strategies in suicide prevention"
Medina et al., 2013 [32]	Mutual support, support seeking as self-help, support given as stored currency, moderating information, dilemma of sharing, support as bad debt, reduced medical visits, reduced isolation, improved QOL (qualitative data/themes), and increased hope	• Dissatisfaction or frustration of not finding what they wanted • Risk for socially sensitive people, risk of lack of moderation of content, risk of unreliable data	Not described	"Online support groups are a large repository of quality information related to general and specific diseases, such as cardiovascular diseases, and an appropriate environment to foster or create a support community between participants."
Moorhead et al., 2013 [8]	• Increased interactions with others • More available, shared and tailored information • Increased accessibility and widening access to health information • Peer/social/emotional support • Public health surveillance • Potential to influence health policy	No adverse effects reported. Limitations included poor reliability, quality concerns, lack of privacy, unaware of risks of disclosure, harmful or incorrect advice, information overload, not sure how to apply information to personal situation, some media more effective for behaviour change, adverse health, negative health behaviours, deter people from visiting their health professionals	Not described, but some disparities in use need further investigation (e.g. more female users). Helpful as social/emotional support, particularly with connections where ties are strong, peer-to-peer interaction, one-sided/imbalance for professionals in professional-to-patient interactions needs to be managed, reliability/quality of social media is unregulated	"Although there are benefits to using social media for health communication, the information needs to be monitored for quality and reliability, and the users' confidentiality and privacy need to be maintained"
Nef et al., 2013[33]	Main benefit was knowing what was going on in younger family members' lives	No mental health harms identified nor increases in loneliness. Barriers described were lack of privacy; did not understand purpose of social media sites, technology was not user-friendly	Described as low acceptance and use	"Social networking sites have the potential to support today's and tomorrow's communication between older and younger family members"
Newton & Ciliska, 2006[12]	No difference in effect for eating disorder inventory or eating disorder examination questionnaire	None reported but the authors mention that an ethical concern for Internet-based interventions is the inability to detect and address serious eating disorder symptoms that could be detected in a face-to-face encounter	Completion in the intervention group ranged from 77%–92%	"No conclusive statements can be made regarding the impact of Internet prevention programs."
Nieto 2008[40]	The results were not aggregated. Both studies found positive results	No adverse effects reported	Not reported	"In general the results of the studies reviewed demonstrate that treatments based on new technologies are effective and efficient and that patients hold positive attitudes toward them."
Williams et al., 2014 [30]	Weight not statistically significantly different in 10 studies: SMD 0.00 (95% CI: −0.19 to 0.19). Levels of physical activity not statistically significantly different: SMD 0.13 (95% CI: −0.04 to 0.30), 12 studies	No adverse effects reported (but high dropout rate from intervention group). The authors reported some risks of confidentiality, cultural differences, hostile comments, fake messages, safety concerns in crises	23% of intervention group completed the study	"Despite its growing popularity, there is little evidence that social media interventions demonstrate a significant benefit for improving healthy diet and exercise."

Abbreviations: BMI, body mass index; CBA, controlled before–after study; CI, confidence interval; QOL, quality of life; RCT, randomized controlled trial; SMD, standardized mean difference.

Potential harms

Harms or adverse effects were not quantified in any of the systematic reviews. Most of the studies included in the reviews reported dropout rates of 20% or more.[9,30] The reasons for these attrition rates were not explored in the primary studies.

The reviews described possible harmful effects such as missed symptoms, concerns about quality of care, increased stress, dissatisfaction, privacy concerns and loneliness. Newton & Ciliska[12] raised the ethical concern that Internet-based interventions may miss serious symptoms that would have been detected in face-to-face encounters. Lai et al.[31] raised concerns about the quality of information provided for users of social media, a lack of confidentiality and the inability of counsellors and moderators to react on a timely manner to crises. In a qualitative analysis, Medina et al.[32] described participants' frustration or dissatisfaction due to misdiagnoses or lack of information or support as a limitation of social media. Nef et al.[33] (AMSTAR score 3) did not find any reported harms on mental health or loneliness, but described concerns among older adults about privacy and inappropriate content. Moorhead et al.[8] (98 included studies, AMSTAR score 5) mentioned poor reliability and quality of the health care information and lack of privacy as possible harms. None of the reviews reported an increase in negative or unhealthy behaviours.

What evidence was available on health equity?

The reviews we included did not present disaggregated analyses across characteristics associated with disadvantage. Three reviews suggested that results may be applicable to diverse populations, based on their findings, as follows:

- no difference between youth and adults in effectiveness of social media on healthy diets, behaviours and physical activity;[30]
- participants with lower baseline social support or social capital were more likely to use social media;[9] and
- social media users were disproportionately from lower-income households.[8]

Nef et al. [33] assessed qualitative studies of Internet use by older adults (people $\geq$ 55 years) and reported that the Internet helped this population maintain connections with family and friends, and that there was no evidence of increased loneliness or harm as a result of Internet use.[33] In their review, Lai et al.[31] reported that the anonymous nature of Internet-based activities could, in fact, help promote health-seeking behaviour in harder-to-reach at-risk groups. Hong et al.[35] reported that social media was helpful in reaching rural participants (though only one study included rural populations). Two reviews mentioned that literacy levels could affect the effectiveness of the intervention.[31,35] Only Moorhead et al.[8] mentioned that the social media materials could be adapted for different literacy levels.

Which design elements promote health equity?

Using the HEIA tool developed by the Ontario Ministry of Health and Long-term Care, we described the possible concerns for twelve populations, such as ethno-racial communities, age-related groups, sex/gender and physical disability and, where studies in the systematic reviews made reference to potential mitigation strategies, their proposed strategies.

The main concern common to several populations is the possibility of limited access to the Internet (e.g. homeless people or low-income older adults). To mitigate inequities, health promotion using social media may require providing access to the Internet and computers/mobile devices.

None of the reviews mentioned additional resources that may be needed for the behaviour changes promoted by the social media interventions, such as availability of walking paths, access to fitness facilities, affordability of co-interventions (such as nicotine patches for smoking cessation), access to affordable food and access to health care. However, these determinants and facilitators to behaviour changes should be considered in the underlying program theory and the development of any social media intervention.[36]

Since newer social media interventions are designed to build on individuals' existing social networks, people with few social networks may be at a disadvantage (e.g. low-income seniors have few ties other than their grandchildren[33]). However, Chang et al.[9] showed that people with few social networks tended to use social media more, suggesting they may benefit from these interventions.

Several reviews raised the acceptability of social media interventions as a concern. Acceptability may relate to cultural acceptability and norms (such as with one study designed for a Hebrew-speaking audience[31]) or to population-specific preferences (e.g. one review of older adults reported unfamiliarity with Facebook[33]). Several reviews proposed that user testing and acceptability testing would be useful to increase the likelihood that social media interventions will be taken up by the target populations.

The reviews reported that privacy concerns and confidentiality may be an issue for certain populations such as older adults and may affect the use of social media interventions. Quality control on social media sites, such as that provided by a moderator, might help reduce privacy concerns and encourage use.[8]

Some populations may be particularly sensitive to hostile or misleading comments. If so, these interventions may be designed to allow a moderator to limit access to the social media group to reduce the risk of inappropriate use.

Areas for further research

We did not find any examples of systematic reviews that focussed on using smartphone or tablet applications and social media for health promotion, possibly because smartphone applications have been only recently developed and tested. User-friendly design was described as an area for future development.

An area for further research is the use of well-known social media platforms (e.g. Facebook and Twitter) for health promotion interventions. Only 28 studies (included in 4 reviews) used well-known social media sites as the platform for the intervention;

the remainder used platforms developed by the researchers. These closed platforms did not take advantage of participants' existing social networks, but rather aimed at developing connections between people in the same health promotion/support research program so they could share experiences.

Discussion

The reviews in this overview suggest a potential to improve health outcomes and health-promoting behaviours in the targeted populations. However, increasing health inequity was also a risk because of issues to do with access to, acceptability of and the unmonitored quality of social media.

Future research should aim to identify which social media interventions are effective and describe all aspects of the interventions, including how they are implemented and utilized, using explicit criteria such as the TIDIER (Template for Intervention Description and Replication) checklist.[37] Research should also explicitly document any increased negative behaviours, stigmatization or exacerbation of existing health inequities if some populations are excluded.

Interventions that use the more commonly known social media sites may experience higher use and acceptability rates because they take advantage of existing social networks. Future research should assess these platforms.

We did not find disaggregated analyses across characteristics associated with disadvantage. However, some targeted studies reported that social media interventions were effective in youth and older adults,[30,33] in groups with lower socioeconomic status,[8] in different ethnicities,[31] and among rural participants.[35] Several reviews proposed that social media could help engage harder-to-reach populations and could be designed to overcome literacy and education gaps, provided there was access to technology. However, there was very little evidence available for these populations in the primary studies or the systematic reviews. Future systematic reviews and primary studies should collect and analyze the effect of the intervention by different population groups.

There is a need for qualitative research on the role of theory-based program design and evaluation, use of multiple components, user-centred design, and measurement of the implementation process (including use, interaction and satisfaction). When planning a social media intervention, the target population's baseline use of social media should be considered. Social media has the potential to reach harder-to-reach populations, Internet access being widely available across Canada.

Strengths and limitations

A strength of this overview is that we took a broad approach to allow us to examine the effects of various social media interventions across a wide range of health conditions. Despite our broad inclusion criteria, we only found reviews that compared minimal intervention conditions (e.g. access to non-interactive or limited versions of study websites).[30] We used rapid review methods to respond to a need identified by our knowledge user. We were limited by the quality of reporting in the systematic reviews: 5 of the 11 reviews scored 5 or less out of a possible 11 on the AMSTAR tool for quality because of limitations in the search strategy, eligibility criteria and documentation of results. In other words, almost half of the systematic reviews were of low quality. Only one review reported on effect sizes with confidence intervals; others provided a narrative summary or reported only *p* values. This limited our ability to assess the size of effects and confidence in the estimates.

The systematic reviews did not consistently monitor or report use of the social media interventions. Only four reported on participant use of the intervention and all reported low use.[8,9,30,34] More than 20% of participants dropped out of the studies, and one review reported that less than 25% of the participants used the social media on offer as part of the studies.[9] As a result, we cannot determine whether the lack of effect or the mixed effects were due to lack of use by participants or lack of effectiveness of the social media. Mixed effects may also be due to factors such as differences in populations, intervention design and implementation and/or concomitant interventions.

The HEIA tool provides a structured approach to assessing intended and unintended effects that help identify mitigation strategies. Ideally, however, this tool is used to inform the planning and development of interventions, and consultation and engagement with affected communities is essential.[38]

Finally, we used a rapid overview approach and therefore screening of the reviews identified by our search, data extraction and quality assessment was done by one author. We do not feel that this limitation affects the results of our overview.

Conclusion

Based on this overview of systematic reviews, effects of social media interventions are mixed or even small. There is insufficient evidence of the design and implementation features (e.g. intensity and duration of interventions) that could lead to improved effects. More research is needed on social media that engages with existing social networks (rather than research-only platforms), acceptability and use of social media, and assessment of both desirable and undesirable effects.

Acknowledgements

Funding for this project was provided by the Public Health Agency of Canada.

References

1. Neiger BL, Thackeray R, Van Wagenen SA, Hanson CL, West JH, Barnes MD, et al. Use of social media in health promotion: purposes, key performance indicators, and evaluation metrics. Health Promot Pract. 2012;13(2):159-64.

2. Public Health Agency of Canada. Public Health PHAC [Internet]. @PHAC_GC; 2015 [cited 2016 Jan 17]. Available from: https://twitter.com/phac_gc

3. Public Health Agency of Canada. Public Health Agency of Canada. Government Organisation [Internet]. Menlo Park (CA): Facebook; 2015 [cited 2016 Jan 17]. Available from: https://www.facebook.com/Public-Health-Agency-of-Canada-10860597051/time-line/

4. Davies J, Mai D, Williams M, Dhaliwal M, Brankley L, McColl K; Social Media & Technology Project Team. Environmental scan of social media at Ontario Public Health Units: analyzing the effectiveness of social media planning, implementation and evaluation at Health Units in Ontario. Guelph (ON): Wellington-Dufferin-Guelph Public Health; 2013.

5. Lenhart A, Purcell K, Smitth A, Zickuhr K. Social media and young adults [Internet]. Washington (DC): Pew Research Center; 2010 Feb 3 [cited 2015 Jan 14]. Available from: http://www.pewinternet.org/2010/02/03/social-media-and-young-adults/

6. Statistics Canada. Table 358-0153. Canadian Internet use survey, Internet use, by age group, Internet activity, sex, level of education and household income, occasional (percent) [Internet]. Ottawa (ON): CANSIM database; [modified 2013 Oct 28; cited 2014 Nov 04]. Available from: http://www5.statcan.gc.ca/cansim/a26?id = 3580153&retrLang = eng&lang = eng

7. Kietzmann JH, Hermkens K, McCarthy IP, Silvestre BS. Social media? Get serious! Understanding the functional building blocks of social media. Bus Horizons.2011;54(3):241-51.

8. Moorhead SA, Hazlett DE, Harrison L, Carroll JK, Irwin A, Hoving C. A new dimension of health care: systematic review of the uses, benefits, and limitations of social media for health communication. J Med Internet Res. 2013;15(4):e85. DOI: 10.2196/jmir.1933.

9. Chang T, Chopra V, Zhang C, Woolford SJ. The role of social media in online weight management: systematic review. J Med Internet Res. 2013;15(11):e262. DOI: 10.2196/jmir.2852.

10. Bailey JV, Murray E, Rait G, et al. Computer-based interventions for sexual health promotion: systematic review and meta-analyses. Int J STD AIDS. 2012;23(6):408-13. DOI: 10.1258/ijsa.2011.011221.

11. Murray E, Burns J, See TS, Lai R, Nazareth I. Interactive health communication applications for people with chronic disease. Cochrane Database Sys Rev. 2005(4): CD004274.

12. Newton MS, Ciliska D. Internet-based innovations for the prevention of eating disorders: a systematic review. Eat Disor. 2006;14(5):365-84.

13. Lorenc T, Petticrew M, Welch V, Tugwell P. What types of interventions generate inequalities? Evidence from systematic reviews. J Epidemiol Community Health. 2013;67(2): 190-3. DOI: 10.1136/jech-2012-201257.

14. Whitehead M. The concepts and principles of equity and health. Int J Health Services. 1992;22(3):429-45.

15. O'Connor D, Green S, Higgins JP. Chapter 5: Defining the review question and developing criteria for including studies. In: Higgins JP, Green S, editors. Cochrane handbook of systematic reviews of intervention: Cochrane Book Series Collaboration. Hoboken (NJ): John Wiley & Sons; 2011.

16. Meglic M, Lamut A, Sinkovec A, Yared W. Chapter 3: Online social media as a tool to improve cancer prevention and health promotion. In: Boosting innovation and cooperation in European cancer control: key findings from the European Partnership for Action Against Cancer. Martin-Moreno JM, Albreht T, Rados Krnel S [Eds] Ljubljana: National Institute of Public Health of the Republic of Slovenia; Brussels: World Health Organization on behalf of the European Observatory on Health Systems and Policies. 2013. ISBN 978-961-6911-22-1.

17. Sterne J. Social media metrics: how to measure and optimize your marketing investment. Hoboken (NJ): John Wiley & Sons; 2010.

18. Black AD, Car J, Pagliari C, et al. The impact of eHealth on the quality and safety of health care: a systematic overview. PLoS Med. 2011;8(1):e1000387. DOI: 10.1371/journal.pmed.1000387.

19. French B, Day E, Watkins C, et al. The challenges of implementing a telestroke network: a systematic review and case study. BMC Med Inform Decis Mak. 2013;13:125. DOI: 10.1186/1472-6947-13-125.

20. Jackson N, Waters E. Guidelines for systematic reviews in health promotion and public health taskforce. Criteria for the systematic review of health promotion and public health interventions. Health Promot Int. 2005;20(4):367-74.

21. O'Neill J, Tabish H, Welch V, et al. Applying an equity lens to interventions: using PROGRESS ensures consideration of socially stratifying factors to illuminate inequities in health. J Clinical Epidemiology. 2014;67(1): 56-64. DOI: 10.1016/j.jclinepi.2013.08.005.

22. Khangura S, Konnyu K, Cushman R, Grimshaw J, Moher D. Evidence summaries: the evolution of a rapid review approach. Syst Rev. 2012;1:10. DOI: 10.1186/2046-4053-1-10.

23. Hartling L, Guise JM, Kato E, et al. EPC Methods: an exploration of methods and context for the production of rapid reviews. Research White Paper. Rockville (MD): Agency for Healthcare Research and Quality; 2015.

24. Montori VM, Wilczynski NL, Morgan D, Haynes RB. Optimal search strategies for retrieving systematic reviews from Medline: analytical survey. BMJ. 2005;330(7482):68.

25. Sampson M, McGowan J, Lefebvre C, Moher D, Grimshaw J. PRESS: peer review of electronic search strategies. Ottawa (ON): Canadian Agency for Drugs and Technologies in Health; 2008.

26. Shea BJ, Hamel C, Wells GA, et al. AMSTAR is a reliable and valid measurement tool to assess the methodological quality of systematic reviews. J Clin Epidemiol. 2009;62(10):1013-20. DOI: 10.1016/j.jclinepi.2008.10.009.

27. Welch V, Brand K, Kristjansson E, Smylie J, Wells G, Tugwell P. Systematic reviews need to consider applicability to disadvantaged populations: inter-rater agreement for a health equity plausibility algorithm. BMC Med Res Method. 2012;12:187. DOI: 10.1186/1471-2288-12-187.

28. Ministry of Health and Long-Term Care. Health rquity impact assessment (HEIA) workbook. Toronto (ON): Ontario Ministry of Health and Long-Term Care; 2012.

29. Moher D, Liberati A, Tetzlaff J, Altman DG. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. BMJ. 2009;339:b2535.

30. Williams G, Hamm MP, Shulhan J, Vandermeer B, Hartling L. Social media interventions for diet and exercise behaviours: a systematic review and meta-analysis of randomised controlled trials. BMJ Open. 2014;4(2):e003926.

31. Lai MH, Maniam T, Chan LF, Ravindran AV. Caught in the web: a review of web-based suicide prevention. J Med Internet Res. 2014;16(1):e30. DOI: 10.2196/jmir.2973.

32. Medina EL, Loques Filho O, Mesquita CT. Health social networks as online life support groups for patients with cardiovascular diseases. Arq Bras Cardio. 2013;101(2):e39-45.

33. Nef T, Ganea RL, Muri RM, Mosimann UP. Social networking sites and older users - a systematic review. Int Psychogeriat. 2013; 25(7):1041-53.

34. Eysenbach G, Powell J, Englesakis M, Rizo C, Stern A. Health related virtual communities and electronic support groups: systematic review of the effects of online peer to peer interactions. BMJ. 2004;328(7449):1166.

35. Hong Y, Pena-Purcell NC, Ory MG. Outcomes of online support and resources for cancer survivors: a systematic literature review. Patient Educ Couns. 2012;86(3): 288-96. DOI: 10.1016/j.pec.2011.06.014.

36. Webb TL, Joseph J, Yardley L, Michie S. Using the internet to promote health behavior change: a systematic review and meta-analysis of the impact of theoretical basis, use of behavior change techniques, and mode of delivery on efficacy. J Med Internet Res. 2010;12(1):e4. DOI: 10.2196/jmir.1376.

37. Hoffmann TC, Glasziou PP, Boutron I, Milne R, Perera R, Moher D, et al. Better reporting of interventions: template for intervention description and replication (TIDieR) checklist and guide. BMJ. 2014;348:g1687. DOI: 10.1136/bmj.g1687.

38. Povall SL, Haigh FA, Abrahams D, Scott-Samuel A. Health equity impact assessment. Health Promot Int. 2014;29(4):621-33. DOI: 10.1093/heapro/dat012.

39. Griffiths KM, Calear AL, Banfield M. Systematic review on Internet support groups (ISGs) and depression (1): do ISGs reduce depressive symptoms?. J Med Internet Res. 2009;11(3):e40. DOI: 10.2196/jmir.1270.

40. Nieto R, Miro J, Huguet A. [New information and communication technologies in the treatment of chronic pain]. Rev Esp Anestesiol Reanim. 2008;55:426-33.

Regional variations in the economic burden attributable to excess weight, physical inactivity and tobacco smoking across British Columbia

H. Krueger, PhD (1, 2); J. M. Koot, BSc (2); D. P. Rasali, PhD (3, 4); S. E. Gustin, MPH (3); M. Pennock, MSc (5)

This article has been peer reviewed.

Abstract

Introduction: Prevalence rates of excess weight, tobacco smoking and physical inactivity vary substantially by geographical region within British Columbia (B.C.). The purpose of this study is to determine the potential reduction in economic burden in B.C. if all regions in the province achieved prevalence rates of these three risk factors equivalent to those of the region with the lowest rates.

Methods: We used a previously developed approach based on population-attributable fractions to estimate the economic burden associated with the various risk factors. Sex-specific relative risk and age/sex-specific prevalence data was used in the modelling.

Results: The annual economic burden attributable to the three risk factors in B.C. was about $5.6 billion in 2013, with a higher proportion of this total attributable to excess weight ($2.6 billion) than to tobacco smoking ($2.0 billion). While B.C. has lower prevalence rates of the risk factors than any other Canadian province, there is significant variation within the province. If each region in the province were to achieve the best prevalence rates for the three risk factors, then $1.4 billion (24% of the $5.6 billion) in economic burden could be avoided annually.

Conclusion: There are notable disparities in the prevalence of each risk factor across health regions within B.C., which were mirrored in each region's attributable economic burden. A variety of social, environmental and economic factors likely drive some of this geographical variation and these underlying factors should be considered when developing prevention programs.

Keywords: *economic burden of disease, populations at risk, risk factors, tobacco smoking, physical activity, body weight*

Highlights

- In British Columbia in 2013, the economic burden due to excess weight ($2.6 billion) was higher than for tobacco smoking ($2.0 billion) or physical inactivity ($1.0 billion).
- The economic burden of excess weight, physical inactivity and tobacco smoking differs across the 16 health regions in British Columbia.
- Reducing the prevalence of excess weight, physical inactivity and tobacco smoking in all the health regions to that of the region with the lowest rates would lower the total annual economic burden by one quarter, from $5.6 billion to $4.2 billion.
- Variation in the prevalence of excess weight, physical inactivity and tobacco smoking is greater within B.C. (24%) than between provinces (10%).
- The geographical variations between the health regions may help decide which prevention efforts should be directed to which areas.

Introduction

The annual economic burden of excess weight, physical inactivity and tobacco smoking was about $52.8 billion in 2013 in Canada.[1] A modest 1% annual relative reduction in the prevalence of these three risk factors can have a substantial health and economic impact over time at the population level, resulting in an estimated $8.5 billion annual reduction in economic burden in Canada by 2031.[2]

With a land mass of almost 10 million square kilometres, Canada is the world's second largest country. The country is divided into 10 provinces and 3 territories. The total population was about 35.2 million in 2013, with the provinces ranging in population from 146 000 in Prince Edward Island to 13.6 million in Ontario.[3] British Columbia (B.C.), the westernmost province, has a population of 4.7 million.

Of all the provinces, the prevalence of tobacco smoking, excess weight and physical inactivity were the lowest in B.C. in 2012. If age- and sex-specific prevalence rates from B.C. were applied to the

Author references:

1. School of Population and Public Health, University of British Columbia, Vancouver, British Columbia, Canada
2. H. Krueger & Associates Inc., Delta, British Columbia, Canada
3. Population and Public Health, British Columbia Provincial Health Services Authority (PHSA), Vancouver, British Columbia, Canada
4. Faculty of Kinesiology and Health Studies, University of Regina, Regina, Saskatchewan, Canada
5. Population Health Surveillance and Public Health Planning, British Columbia Ministry of Health, Vancouver, British Columbia, Canada

Correspondence: Hans Krueger, H. Krueger & Associates Inc., 4554 48B Street, Delta, BC V4K 2R8; Tel: 604-946-5464; Email: hans@krueger.ca

populations in other provinces, the annual economic burden attributable to these three risk factors would be reduced by $5.3 billion, or 10.0% of the $52.8 billion total economic burden of the risk factors.[1]

While B.C. has lower prevalence rates of these risk factors than any other province, there is significant variation within the province. B.C. is divided into five health authorities: Fraser Health, Vancouver Coastal Health, Vancouver Island Health, Interior Health and Northern Health. The health regions range in population from 0.3 million (Northern Health) to 1.7 million (Fraser Health). Each health authority (HA) is further subdivided into three or four health service delivery areas (HSDAs), with a population of between 73 000 (Northeast HSDA) and 748 000 (Fraser South HSDA).

The purpose of our study is to determine the potential reduction in economic burden in B.C. if all HSDAs in the province achieved prevalence rates of excess weight, physical inactivity and tobacco smoking equivalent to those of the HSDAs with the lowest rates.

Methods

Details of our base model, together with an update, have been previously described.[1,2,4] Briefly, we used an approach based on population-attributable fraction to estimate the economic burden associated with the three risk factors. This involves the following seven steps:

(1) estimate the prevalence of the three risk factors in the geographical regions of interest;
(2) estimate the causal relationship between the risk factor and comorbidities based on relative risk;
(3) calculate the population-attributable fraction taking into account the continuous nature of excess weight (from no excess weight to overweight to obese) and tobacco smoking (no, light, moderate and heavy smoking);
(4) estimate the direct costs of treating the comorbidities associated with the risk factors in the geographical regions of interest;
(5) adjust the direct costs for overlapping risk factors in a given person;
(6) estimate indirect costs;
(7) disaggregate the total economic burden to provide an estimate of the economic burden of each risk factor.

Prevalence rates for tobacco smoking, overweight/obesity and physical inactivity were drawn from the 2011/12 Canadian Community Health Survey (CCHS). People were considered overweight if their body mass index (BMI) was between 25 kg/m^2 and 29.9 kg/m^2 and obese if their BMI was equal to or greater than 30 kg/m^2, calculated based on self-reported height and weight. For youth aged 12 to 17 years, the Cole system of BMI was used to determine overweight and obesity rates.[5]

Tobacco smokers were grouped as light (< 10 cigarettes per day), moderate (10–19 cigarettes per day) and heavy (≥ 20 cigarettes per day) smokers based on the average number of cigarettes smoked per day according to the CCHS 2011/2012 Public Use Microdata File (PUMF).[6] All current smokers who identified themselves as occasional smokers were included in the ''light smoking'' category.

Physical inactivity rates were based on people categorized as ''inactive'' in the CCHS. Respondents were classified as active, moderately active or inactive based on an index of average daily leisure time physical activity over the past 3 months. For each leisure time physical activity the respondent engaged in, an average daily energy expenditure was calculated by multiplying the number of times the activity was performed by the average duration of the activity and the estimated energy cost (kilocalories per kilogram of body weight per hour) of the activity. The index was calculated as the sum of the average daily energy expenditures of all activities. Respondents were classified as physically inactive if their leisure energy expenditure was less than 1.5 kcal/kg/day. We made one adjustment to this base CCHS data, namely estimating the rates of overweight, obesity and physical inactivity for children aged younger than 12 years based on the sex-specific rates for 12- to 14-year-olds from the CCHS. We assumed that no children under the age of 12 smoked tobacco.

The sources and values for the relative risks associated with tobacco smoking,[7] excess weight[8] and physical inactivity[9] remain the same as in the previously published model.[1,2,4]

Calculating and adjusting costs

We estimated the economic burden (direct and indirect costs) associated with the risk factors in B.C. and each HA/HSDA in the province using a prevalence-based cost-of-illness approach. The cost estimates are expressed in 2013 Canadian dollars.

In our model, direct costs include hospital care, physician services, other health care professionals (excluding dental services), drugs, health research, public health, administration and ''other'' health care expenditures. In B.C., these costs equal $22.0 billion of the $27.1 billion in total health care expenditures, based on data extracted from the National Health Expenditure Database.[10] Costs excluded from the $27.1 billion were for other institutions* ($1.7 billion), dental services ($2.1 billion) and capital ($1.3 billion).

Expenditures within the categories of ''other health care professionals'' (dental services, vision care services, other) and ''other health spending'' (research and other) were not detailed for B.C. We assumed a distribution of these expenditures equivalent to the distribution in Canada. To distribute these $27.1 billion to B.C. HAs and HSDAs, we first derived the volume of acute care cases and days by HA and HSDA based on the patient's residence.[11] Thus, we attributed the days spent by a patient in a hospital in another region back to the patient's home region. We then used the distribution of acute care patient days by HA and HSDA to distribute the $8.2 billion in hospital expenditures in B.C. We distributed all other costs to the HAs and HSDAs based on the proportion of hospital costs attributed to that region.

Hospital care, physician care and drug costs by sex were allocated to each comorbidity based on 2008 data from the Economic Burden of Illness in Canada (EBIC) online tool.[12] The comorbidities associated with

*These are residential care facilities for the chronically ill or disabled who reside at the institution more or less permanently.

TABLE 1
Estimated prevalence of risk factors, total economic burden for multifactorial system, and disaggregated costs by risk factor[a]

	Population with RF, %	# individuals with RF	Direct cost per individual with RF, $	Indirect cost per individual with RF, $	Total cost per individual with RF, $	Total direct cost of RF, millions $	Total indirect cost of RF, millions $	Total cost of RF, millions $
Males								
Smokers								
Light	6.27	142 741	905	1655	2560	129.2	236.2	365.4
Moderate	3.90	88 701	1554	2830	4384	137.9	251.0	388.9
Heavy	3.91	89 029	2011	3635	5647	179.1	323.7	502.7
Subtotal-Male Smokers	14.07	320 471	1392	2530	3922	446.1	810.9	1257.0
Excess Weight								
Overweight	34.97	796 125	190	519	709	151.0	413.5	564.5
Obese	14.22	323 693	711	1592	2304	230.2	515.5	745.7
Subtotal-Male Excess Weight	49.18	1 119 818	340	830	1170	381.2	929.0	1310.2
Inactive	35.47	807 684	223	392	615	179.8	316.8	496.6
Subtotal-Males						1007.1	2056.7	3063.8
Females								
Smokers								
Light	6.48	149 275	636	1115	1750	94.9	166.4	261.3
Moderate	3.66	84 354	1132	1990	3122	95.5	167.9	263.4
Heavy	2.11	48 607	1794	3146	4940	87.2	152.9	240.1
Subtotal-Female Smokers	12.24	282 236	984	1726	2710	277.6	487.2	764.8
Excess Weight								
Overweight	23.05	531 239	280	685	965	148.8	363.7	512.5
Obesity	11.00	253 560	954	1940	2893	241.8	491.8	733.6
Subtotal-Female Excess Weight	34.05	784 799	498	1090	1588	390.6	855.5	1246.1
Inactive	40.36	930 262	183	383	566	169.8	356.7	526.5
Subtotal-Females						838.0	1699.3	2537.4
Both Sexes								
Smokers								
Light	6.37	292 016	767	1379	2146	224.1	402.7	626.7
Moderate	3.78	173 055	1349	2420	3769	233.4	418.9	652.2
Heavy	3.00	137 637	1935	3462	5397	266.3	476.6	742.8
Subtotal-Smokers	13.15	602 707	1201	2154	3355	723.7	1298.1	2021.8
Excess Weight								
Overweight	28.97	1 327 364	226	586	811	299.8	777.2	1 077.0
Obesity	12.60	577 253	818	1745	2563	472.0	1007.3	1 479.3
Subtotal-Excess Weight	41.57	1 904 617	405	937	1342	771.8	1784.5	2 556.3
Inactive	37.93	1 737 946	201	388	589	349.6	673.5	1 023.1
Total						1845.1	3756.1	5601.2

Abbreviation: RF, risk factor.

[a] Adjusted for multiple RFs in one individual.

TABLE 2
Estimated prevalence of risk factors, total economic burden for multifactorial system, and disaggregated costs by risk factor, British Columbia Health Authorities, 2013, by sex adjusted for multiple risk factors in one individual

	Population with RF, %	Number of individuals with RF, n	Direct cost per individual with RF, $	Indirect cost per individual with RF, $	Total cost per individual with RF, $	Total direct cost of RF, millions $	Total indirect cost of RF, millions $	Total cost of RF, millions $
Interior Health								
Smokers								
Light	7.78	55 791	682	1228	1910	38.0	68.5	106.5
Moderate	6.57	47 159	1114	2001	3115	52.5	94.4	146.9
Heavy	4.02	28 809	1693	3028	4721	48.8	87.2	136.0
Subtotal - Smokers	18.36	131 759	1058	1898	2956	139.3	250.1	389.4
Excess Weight								
Overweight	31.42	225 430	227	586	813	51.1	132.2	183.3
Obesity	15.12	108 516	793	1701	2494	86.1	184.6	270.7
Subtotal - Excess Weight	46.55	333 946	411	949	1359	137.2	316.7	454.0
Inactive	33.02	236 878	211	406	616	49.9	96.1	146.0
Total						326.4	663.0	989.4
Fraser Health								
Smokers								
Light	5.72	96 722	807	1448	2255	78.1	140.1	218.1
Moderate	2.84	47 920	1431	2560	3990	68.6	122.7	191.2
Heavy	2.78	47 053	1999	3586	5586	94.1	168.7	262.8
Subtotal - Smokers	11.34	191 696	1256	2251	3506	240.7	431.5	672.1
Excess Weight								
Overweight	30.12	509 054	216	561	777	110.2	285.4	395.6
Obesity	12.83	216 835	782	1670	2452	169.5	362.1	531.6
Subtotal - Excess Weight	42.96	725 889	385	892	1277	279.7	647.5	927.2
Inactive	41.62	703 405	193	372	565	135.9	261.9	397.7
Total						656.3	1340.8	1997.1
Vancouver Coastal Health								
Smokers								
Light	6.10	69 486	782	1402	2184	54.3	97.4	151.8
Moderate	2.46	28 029	1545	2779	4324	43.3	77.9	121.2
Heavy	1.49	16 920	2387	4255	6642	40.4	72.0	112.4
Subtotal - Smokers	10.05	114 436	1206	2161	3368	138.0	247.3	385.4
Excess Weight								
Overweight	24.65	280 721	223	583	806	62.5	163.8	226.3
Obesity	7.13	81 208	900	1892	2792	73.1	153.6	226.7
Subtotal - Excess Weight	31.79	361 929	375	877	1252	135.7	317.4	453.1
Inactive	38.35	436 704	188	362	550	82.0	158.2	240.2
Total						355.7	723.0	1078.7

Continued on the following page

TABLE 2 (continued)
Estimated prevalence of risk factors, total economic burden for multifactorial system, and disaggregated costs by risk factor, British Columbia Health Authorities, 2013, by sex adjusted for multiple risk factors in one individual

	Population with RF, %	Number of individuals with RF, n	Direct cost per individual with RF, $	Indirect cost per individual with RF, $	Total cost per individual with RF, $	Total direct cost of RF, millions $	Total indirect cost of RF, millions $	Total cost of RF, millions $
Island Health								
Smokers								
Light	6.67	50 179	827	1489	2316	41.5	74.7	116.2
Moderate	4.57	34 377	1363	2444	3807	46.9	84.0	130.9
Heavy	3.35	25 196	1981	3536	5517	49.9	89.1	139.0
Subtotal - Smokers	14.59	109 752	1260	2258	3518	138.3	247.9	386.1
Excess Weight								
Overweight	28.86	217 084	251	649	901	54.5	141.0	195.5
Obesity	14.99	112 728	862	1849	2711	97.2	208.4	305.6
Subtotal - Excess Weight	43.85	329 812	460	1059	1519	151.7	349.4	501.1
Inactive	32.64	245 496	227	437	664	55.8	107.3	163.0
Total						345.8	704.5	1050.2
Northern Health								
Smokers								
Light	7.10	20 154	749	1352	2101	15.1	27.3	42.4
Moderate	5.95	16 902	1172	2101	3273	19.8	35.5	55.3
Heavy	7.17	20 357	1406	2518	3924	28.6	51.3	79.9
Subtotal - Smokers	20.23	57 413	1106	1986	3092	63.5	114.0	177.5
Excess Weight								
Overweight	31.61	89 713	234	602	836	21.0	54.0	75.0
Obesity	18.72	53 135	781	1683	2464	41.5	89.4	130.9
Subtotal - Excess Weight	50.33	142 847	437	1004	1441	62.5	143.4	205.9
Inactive	38.66	109 736	217	416	634	23.8	45.7	69.5
Total						149.8	303.2	453.0

Abbreviation: RF, risk factor.

excess weight include some cancers (esophagus [ICD-10 code C15], colorectal [C18–20], pancreas [C25], postmenopausal breast [C50], corpus uteri, including endometrium [C54–55], ovary [C56] and kidney [C64]), type 2 diabetes (E11–14), hypertension (I10–15), ischemic heart disease (I20–25), pulmonary embolism (I26), cerebrovascular disease (I60–69), asthma (J45), gallbladder disease (K80–82), osteoarthritis (M15–19) and chronic back pain (M45–54). Comorbidities associated with physical inactivity include colorectal cancer (C18–20), breast cancer (C50), type 2 diabetes (E11–14), hypertension (I10–15), ischemic heart disease (I20–25), cerebrovascular disease (I60–69) and osteoporosis (M80–82). Comorbidities associated with tobacco smoking include cancers of the lip, oral cavity, pharynx, larynx [C00–14, 30–32], esophagus [C15], stomach [C16], colorectal [C18–20], liver [C22], pancreas [C25], trachea, bronchus, lung [C33–34], kidney [C64] and urinary bladder [C67]) as well as ischemic heart disease (I20–25), pulmonary embolism (I26), venous thromboembolism (I80–82), cerebrovascular disease (I60–69), aortic aneurism (I71), pneumonia (J12–18), chronic lung disease (J40–44), intestinal ischemia (K05) and cirrhosis of the liver (K70,74).

EBIC cost data was not sufficiently detailed for a number of these comorbidities, including type 2 diabetes (E11–14), pulmonary embolism (I26), aortic aneurysm (I71), venous thromboembolism (I80-82), intestinal ischemia (K55), gallbladder disease (K80–82) and chronic back pain (M45–54). In each of these situations, we estimated the costs based on the proportion of acute hospital days in 2011/12 for the disease of interest to the relevant comorbidity with EBIC 2008 costs. For example, hospital days for chronic back pain (M45–54) make up 21.6% and 19.6% (for men and women, respectively) of all hospital days for diseases of the musculoskeletal system and connective tissue (M00–99) in Canada in 2011/12. We therefore assumed that 21.6% and 19.6% of EBIC 2008 costs allocated to diseases of the musculoskeletal system and connective tissue (M00–99) for hospital care, physician care and drugs would be allocated to chronic back pain (M45–54).

These sex-specific direct care costs by comorbidity were then multiplied by the calculated risk factor–specific, sex-specific, and comorbidity-specific population-attributable fractions to calculate the direct care costs attributable to a given risk factor. We adjusted these direct costs in a multifactorial system to address double counting (previously described[4]).

Indirect costs

We calculated indirect costs (premature mortality, short- and long-term disability) following the method used in EBIC 1998 (a modified human-capital approach).[13]

Indirect costs attributable to premature mortality are based on the discounted present value of future production lost, including both the valuation of paid and unpaid work. Indirect costs attributable to short- and long-term disability are also based on lost production, taking into account both the severity and duration of the disability. Short-term disability is defined as a restriction of activity that is expected to last less than 6 months.

Specifically, the steps involved in estimating indirect costs were as follows:

(1) The diagnostic categories within EBIC 1998 that cover the comorbidities/diseases of interest were identified, and the direct and indirect costs for these categories were extracted.
(2) The extracted costs were used to determine a ratio between direct and indirect costs for each of the diagnostic categories, stratified by the specific category of indirect cost (i.e. short-term disability, long-term disability and premature mortality).
(3) The pertinent ratios (by diagnostic category and specific indirect cost category) were applied to the previously identified direct costs attributable to each risk factor to generate the equivalent indirect cost data.

HA- and HSDA-level analysis of risk factor reduction

After calculating the adjusted economic burden attributable to the three risk factors in B.C. and each HA and HSDA, we determined which region in the province had the lowest overall prevalence rate for each risk factor. The sex- and age-specific prevalence rates from each of these three lowest-prevalence regions were applied to the population of each remaining region. This allowed us to calculate the difference in annual economic burden for each region using actual prevalence rates and hypothetical prevalence rates from those in the comparator regions.

Results

We estimated the economic burden attributable to excess weight, tobacco smoking and physical inactivity in B.C. in 2013 at $5.6 billion, with $2.6 billion (45.6%) attributable to excess weight, $2.0 billion to tobacco smoking (36.1%) and $1.0 billion (18.3%) to physical inactivity (see Table 1).

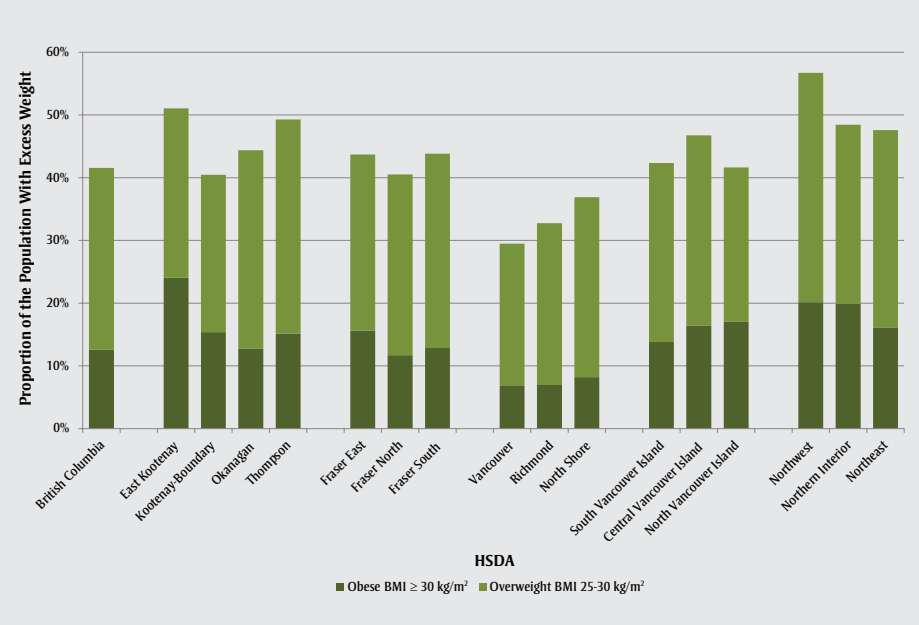
The annual risk factor-attributable economic burden per person is highest for all tobacco smokers ($3355), but ranges from $2146 for light smokers to $5397 for heavy smokers. The annual economic burden per person with excess weight is $1342 ($811 per overweight person and $2563 per obese person). While the annual economic burden per person with excess weight is substantially less than tobacco smoking, the high prevalence of excess weight (41.6%) compared to the prevalence of tobacco smoking (13.2%) in B.C. means that the total annual economic burden attributable to excess weight now exceeds that of tobacco smoking by 26%.

Among the HAs, the prevalence of smoking was higher than the provincial average in Interior Health, Northern Health and Vancouver Island Health, and the prevalence of excess weight was higher than the provincial average in all HAs except for Vancouver Coastal Health. Conversely, the prevalence of physical inactivity was lower than the provincial average in Interior Health and Vancouver Island Health. The prevalence of all three risk factors was above the provincial average in Northern Health (see Table 2). The total economic burden attributable to these three risk factors across HAs ranged from $453.0 million in Northern Health to $1997.1 million in Fraser Health.

The prevalence of excess weight varies by HSDA, from a low of 29.5% in the Vancouver HSDA to a high of 56.7% in the Northwest HSDA (B.C. average = 41.6%; see Figure 1). The prevalence of physical inactivity varies from a low of 27.1% in the Kootenay Boundary HSDA to a high of 43.8% in the Fraser North HSDA (B.C. average = 37.9%; see Figure 2). The prevalence of tobacco smoking varies from a low of 8.8% in the Richmond HSDA to a high of 21.3% in the Northeast HSDA (B.C. average = 13.2%; see Figure 3).

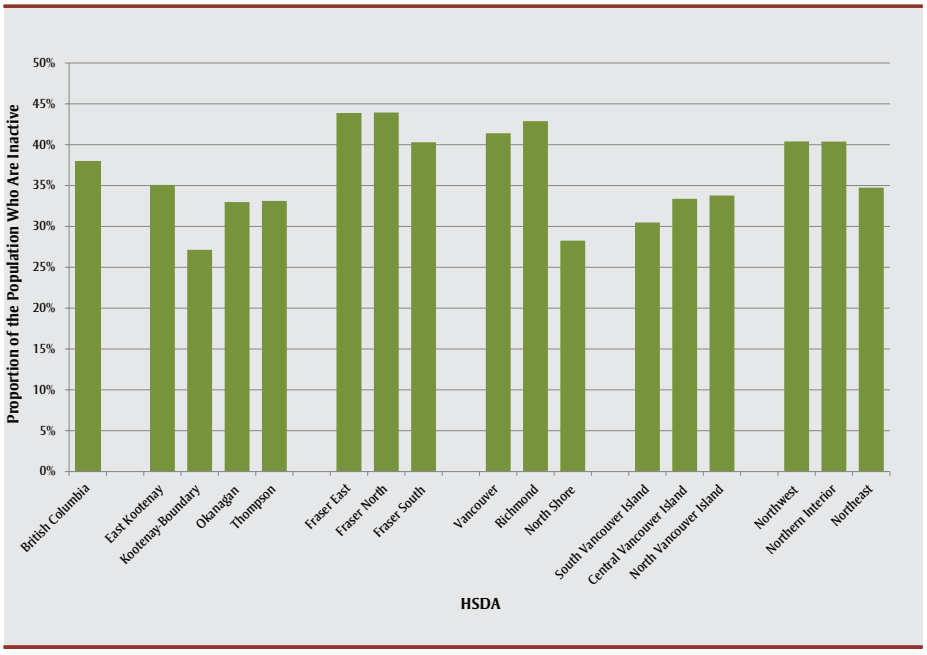
The variable prevalence rates of the three risk factors in each HSDA results in a varying economic burden per capita in each region (see Figure 4). The Richmond HSDA has the lowest per capita economic burden at $738, while the Northwest HSDA has the highest at $1766, more than double that of

FIGURE 1
Prevalence of excess weight in British Columbia, by excess weight category and HSDA, 2011/12



Abbreviations: BMI, body mass index; HSDA, health service delivery area.

FIGURE 2
Prevalence of physical inactivity in British Columbia, by HSDA, 2011/12



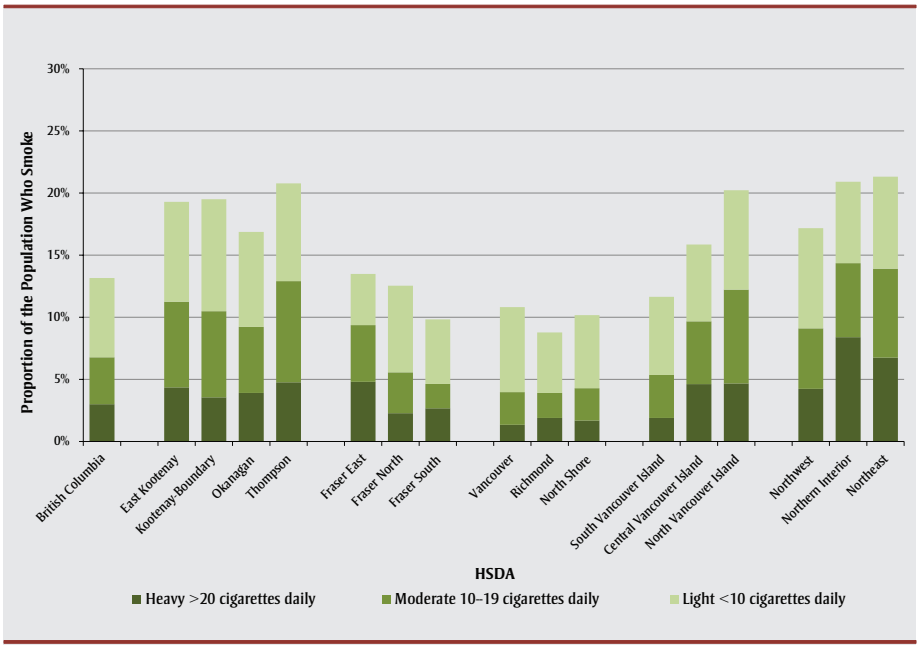
Abbreviation: HSDA, health service delivery area.

the Richmond HSDA. The provincial average per capita economic burden is $1222.

Applying the lowest sex- and age-specific prevalence rates for excess weight from the Vancouver HSDA, for tobacco smoking from the Richmond HSDA and for physical inactivity from the Kootenay Boundary HSDA to the population of each remaining HSDAs in the province would reduce the per capita annual economic burden by between $60 (in the Richmond HSDA) and $651 (in the Northwest HSDA) (see Figure 5).

The *total* annual reduction in economic burden would range between $12.1 million in the Richmond HSDA to $200.1 million in the Fraser South HSDA (see Figure 6). If all HSDAs were to achieve the best prevalence rates for the three risk factors, then $1362.2 million in economic burden could be avoided annually, comprising $449.8 million in direct costs and $912.4 million in indirect costs.

FIGURE 3
Prevalence of smoking in British Columbia, by smoking intensity and HSDA, 2011/12



Abbreviation: HSDA, health service delivery area.

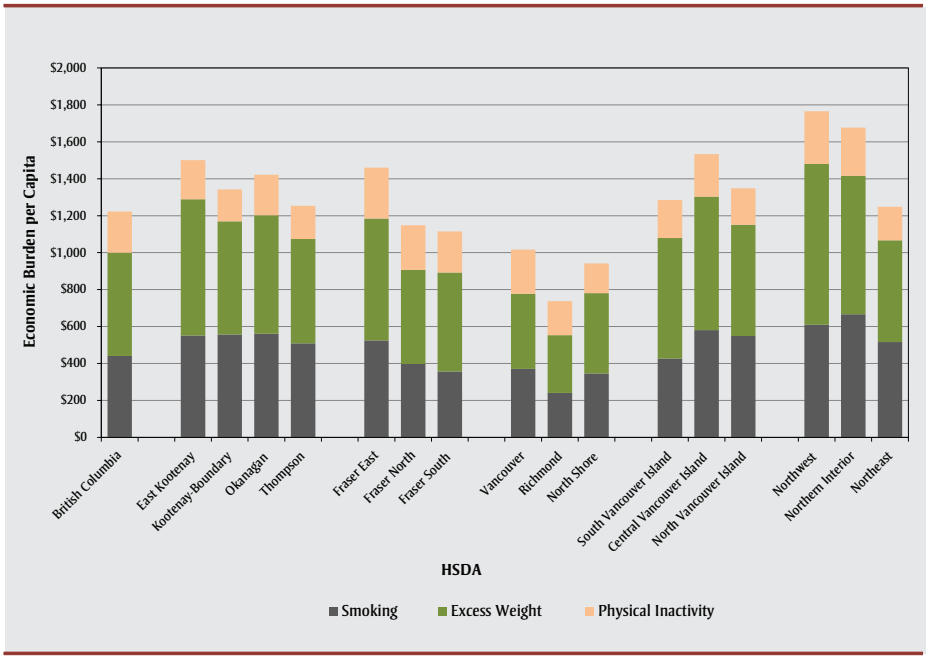
Discussion

We estimated the annual economic burden attributable to excess weight, tobacco smoking and physical inactivity in B.C. at $5.6 billion in 2013, with a higher proportion of this total attributable to excess weight ($2.6 billion) than to tobacco smoking ($2.0 billion). While B.C. has lower prevalence rates of the risk factors than any other Canadian province,[1] rates vary significantly within the province. If each HSDA in the province were to achieve the best prevalence rates for the three risk factors, then $1.36 billion in economic burden could be avoided annually. This suggests that a 24% reduction in the economic burden attributable to excess weight, tobacco smoking and physical inactivity in B.C. is possible if all regions achieved rates of these risk factors that are best in the province. It is important to note, however, that a reduction in economic burden is not equivalent to cost savings. Even for direct costs, the majority of resources freed up over time will likely be re-allocated (intentionally or unintentionally) elsewhere within health care.

A similar analysis using age- and sex-specific prevalence rates from B.C. applied to populations living in the other Canadian provinces indicated that the annual economic burden in Canada attributable to these three risk factors would be reduced by $5.3 billion, or 10.0% of the $52.8 billion total economic burden of the risk factors.[1] The intraprovincial variation in the prevalence of the risk factors thus seems to be substantially higher than the variation between provinces.

This study identified notable disparities in the prevalence of each risk factor across

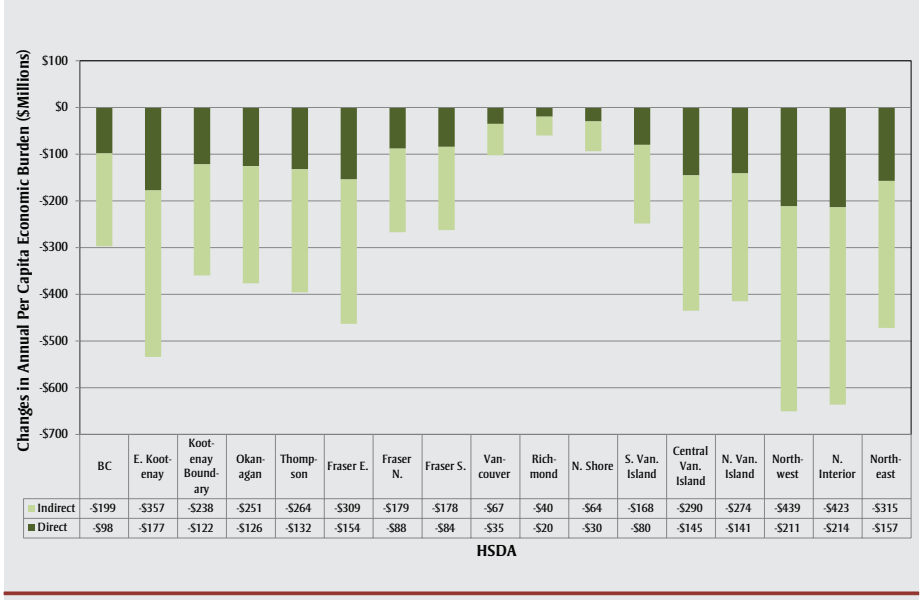
FIGURE 4
Economic burden per capita in British Columbia: smoking, excess weight and physical inactivity, by HSDA, 2013



Abbreviation: HSDA, health service delivery area.

health regions, which were mirrored in each region's attributable economic burden. Rates of excess weight were much lower in Vancouver Coastal Health than all other health authorities. Physical inactivity levels were typically much higher in regions with a higher population density (particularly in the Fraser North, Fraser East, Vancouver and Richmond HSDAs) compared to more rural populations. Conversely, smoking rates were much lower in urban areas than rural areas. Risk factor rates were almost always above the provincial average in the north of the province (Northwest, Northern Interior and Northeast HSDAs).

FIGURE 5
Changes in annual per capita economic burden in British Columbia based on best risk factor rates, by HSDA and direct/indirect costs ($Millions), 2013



	BC	E. Kootenay	Kootenay Boundary	Okanagan	Thompson	Fraser E.	Fraser N.	Fraser S.	Vancouver	Richmond	N. Shore	S. Van. Island	Central Van. Island	N. Van. Island	Northwest	N. Interior	Northeast
Indirect	-$199	-$357	-$238	-$251	-$264	-$309	-$179	-$178	-$67	-$40	-$64	-$168	-$290	-$274	-$439	-$423	-$315
Direct	-$98	-$177	-$122	-$126	-$132	-$154	-$88	-$84	-$35	-$20	-$30	-$80	-$145	-$141	-$211	-$214	-$157

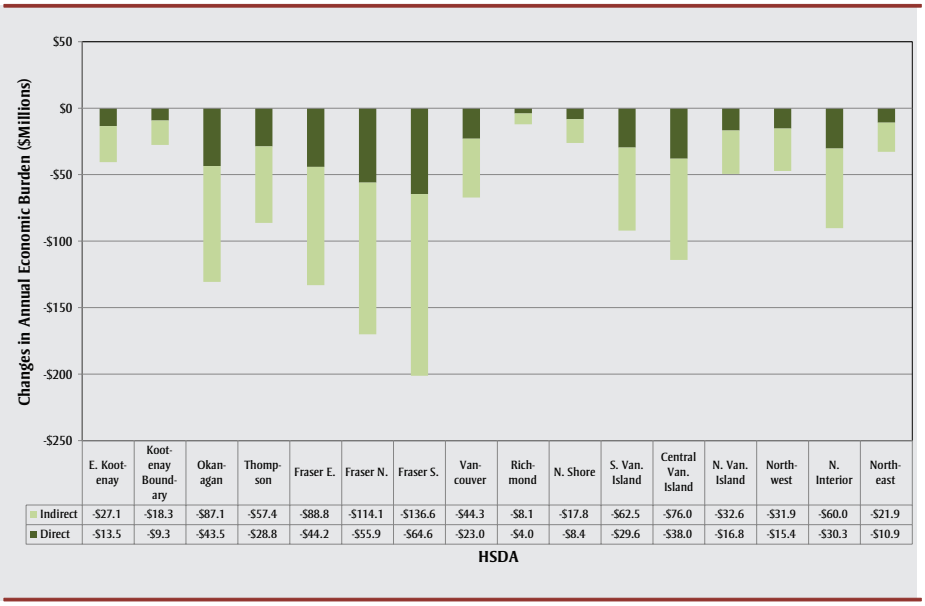
Abbreviations: BC, British Columbia; HSDA, health service delivery area.
Note: Sensitivity analysis suggests that these costs may vary by +/-17%.

The obesity epidemic has been labelled by some as the "new tobacco" based on both its rapidly increasing prevalence worldwide and the tide of associated health consequences. Rates of tobacco smoking have decreased dramatically in recent decades, and this progress should reinforce that similar successes are also possible for other modifiable risk factors.[14,15] We have learned from our experiences with smoking that a comprehensive, multipronged approach is required to achieve substantial reductions.[16] The reduction in smoking rates could not be solely attributed to one or two interventions; rather it was the culmination of economic and policy interventions, community-based interventions and clinical interventions that acted synergistically to lower smoking rates to where they are now. We have also learned that to see a meaningful reduction in the prevalence of risk factors, a long-term approach is required. The problem of tobacco smoking was not solved by a quick fix, and it is unlikely that other modifiable risk factors will be either. Instead, interventions require multigenerational approaches that span beyond the immediate political cycle.

For the purpose of this study, we focussed on the costs associated with individual-level risk factors, but also acknowledged that excess weight, physical inactivity and tobacco smoking are strongly influenced by a variety of social, environmental and economic factors. These determinants are likely to drive some of the geographical variation that we observed in this study, and these underlying factors should also be considered in an effort to promote health equity. Not everyone has an equal opportunity to make healthy choices, and any population-level interventions should address chronic disease risk factors while acknowledging the social determinants of health.

The inclusion of indirect costs in any economic analysis is controversial given that a variety of approaches exist, all of which generate very different results.[17-20] In 1998, EBIC used a modified human-capital approach[†], changing to the friction cost

FIGURE 6
Changes in annual economic burden in british Columbia based on best risk factor rates, by HSDA and direct/indirect costs ($Millions), 2013



Abbreviation: HSDA, health service delivery area.
Note: Sensitivity analysis suggests that these costs may vary by +/-17%.

method[‡] in 2008. The resulting indirect costs vary substantially (see Table 3).

If the friction cost method were applied to the current model, the indirect economic burden attributable to the three risk factors in B.C. would be reduced from $3756 million to $238 million. The focus of the friction cost method is on lost production from the ''perspective of firms, consumers and society, without accounting for the potential income lost on an individual basis,''[2,p.452] nor does it value potential time lost due to morbidity or mortality. That is, while smoking may reduce a person's life by an average of 11 to 12 years,[22] the friction cost method only applies a value on the time period that it takes to replace this person in the workforce. Placing an economic value on time lost due to disability and premature mortality (as in the modified human-capital approach) allows us to compare the broader effect of the risk factors on society as a whole, rather than from a narrow focus on production losses.

Strengths and limitations

Despite all efforts to optimize the accuracy of the analysis, some limitations remain. Most studies, including this one, categorize people with a BMI between 25 kg/m^2 and 29.9 kg/m^2 as overweight. This range, especially the lower end, has been historically dynamic, however.[16] Recent research has suggested that a more appropriate lower boundary with respect to negative health effects might be 27 kg/m^2,[23] or even below 25 kg/m^2 for certain people, particularly those of Asian descent.[24] This is relevant to the current study as a high proportion of people in B.C. identify as a visible ethnic minority (24.8%),[25] with some regions much higher than others. For example, in the Richmond HSDA, 44% of people identify as being of Chinese origin, 8.0% as South Asian, and 5.5% as Filipino. Using a cut-off of 25 kg/m^2 for this population may underestimate their excess weight-attributable economic burden.

The method of scaling up from direct to indirect costs depends on the assumption that the ratios of costs have not changed over time. In addition, the source for the relative risks associated with smoking[7] and physical inactivity[9] adjust for known confounding factors in generating disease-specific relative risks. The meta-analyses for the relative risks associated with overweight and obesity, however, did not include physical

TABLE 3
Economic burden of illness in Canada by diagnostic category, indirect costs as a percentage of direct costs

	EBIC 1998 (Human capital)			EBIC 2008 (Friction)		
Diagnostic Category	Mortality, %	Morbidity, %	Total, %	Mortality, %	Morbidity, %	Total, %
Malignant and other neoplasms	431	46	478	3.5	8.8	12.3
Endocrine, nutritional and metabolic diseases	64	55	119	0.4	2.5	2.9
Cardiovascular diseases	121	50	171	0.8	2.3	3.1
Respiratory diseases / Infections	48	99	146	0.3	46.8	47.1
Digestive diseases	32	33	65	0.4	2.7	3.2
Musculoskeletal diseases	5	514	519	0.0	24.1	24.2

Abbreviation: EBIC, economic burden of illness in Canada.

[†]In the human-capital approach, sex- and age-specific average earnings are combined with productivity trends and years-of-life lost due to a specific disease/condition to estimate unrealized lifetime earnings. An important criticism of this method is that it places a higher value on the years of life lost for someone with higher earning potential. In particular, unpaid work and leisure time are not explicitly accounted for. EBIC 1998 addressed this issue by explicitly valuing non-productive time.

[‡]The friction-cost method attempts to measure only actual production losses to society during the friction period between the start of an absence from work (resulting from short-term absence, long-term absence, disability and mortality) and when original productivity levels are restored.

inactivity as a potentially confounding risk factor,[8] which may lead to an overestimate of the economic burden attributable to excess weight. On the other hand, relative risks calculated in this meta-analysis are based on a combination of studies including both self-reported and objective measures of BMI while our model uses the prevalence of excess weight based on self-reported height and weight, which may lead to an underestimate of the economic burden attributable to excess weight. Previous sensitivity analysis also suggests that the true economic burden may vary by $+/-17\%$ of our best estimate.[2] Finally, the allocation of non-hospital costs to HAs and HSDAs in proportion to the allocation of hospital-related costs may over- or underestimate these costs in a given region of the province.

Conclusion

Our findings suggest that the economic burden of excess weight, physical inactivity and tobacco smoking are substantial and vary considerably between health regions in B.C. However, by reducing the prevalence of each of the three risk factors across the province to that of the region with the lowest prevalence, the associated direct and indirect costs could be reduced by about one quarter. Knowing this, prioritizing prevention initiatives should be at the forefront of system- and community-level changes. The economic evidence we present also suggests that various regions within B.C. demand specific attention. In particular, the geographical variations between health authorities and HSDAs may act as a guideline for where region-specific prevention efforts may be most valuable. A variety of social, environmental and economic factors likely drive some of this geographical variation and these underlying factors should be considered when developing prevention programs in an effort to promote health equity.

Acknowledgements

This study was carried out as a part of a joint work plan in population health surveillance programs between the Ministry of Health and Provincial Health Services Authority (PHSA). The authors thank Lydia Drasic (Executive Director, BCCDC Operations and Chronic Disease Prevention, PHSA) and Silas Brownsey (Executive Director, Population and Public Health, BC Ministry of Health) for sponsoring the study project.

References

1. Krueger H, Krueger J, Koot J. Variation across Canada in the economic burden attributable to excess weight, tobacco smoking and physical inactivity. Can J Public Health. 2015; 106(4):e171-7. DOI: 10.17269/cjph.106.4994.

2. Krueger H, Turner D, Krueger J, Ready AE. The economic benefits of risk factor reduction in Canada: tobacco smoking, excess weight and physical inactivity. Can J Public Health. 2014;105(1):e69-78.

3. Statistics Canada. CANSIM [Internet]. Ottawa (ON): Statistics Canada; [cited 2014 Sep 29]. Available from: http://www5.statcan.gc.ca/cansim/

4. Krueger H, Williams D, Ready AE, Trenaman L, Turner D. Improved estimation of the health and economic burden of chronic disease risk factors in Manitoba. Chronic Dis Inj Can. 2013;33(4):236-46.

5. Cole TJ, Bellizzi MC, Flegal KM, Dietz WH. Establishing a standard definition for child overweight and obesity worldwide: international survey. BMJ. 2000;320(7244):1240-3.

6. Statistics Canada. Canadian Community Health Survey: Public Use Microdata file, 2011/2012 [Internet]. Ottawa (ON): Statistics Canada; [date modified: 2013 Nov 13]; [Statistics Canada, Catalogue No.: 82M0013X 2013001]. Available from: http://www5.statcan.gc.ca/olc-cel/olc.action?ObjId = 82M0013X2013001&ObjType = 46&lang = en

7. Pirie K, Peto R, Reeves GK, Green J, Beral V. The 21st century hazards of smoking and benefits of stopping: a prospective study of one million women in the UK. Lancet. 2013;381 (9861):133-41. DOI: 10.1016/S0140-6736(12) 61720-6.

8. Guh DP, Zhang W, Bansback N, Amarsi Z, Birmingham CL, Anis AH. The incidence of co-morbidities related to obesity and overweight: a systematic review and meta-analysis. BMC Public Health. 2009;9:88. DOI: 10.1186/1471-2458-9-88.

9. Katzmarzyk PT, Janssen I. The economic costs associated with physical inactivity and obesity in Canada: an update. Can J Appl Physiol. 2004;29(1):90-115.

10. Kuchciak C, Fortin G, Ariste R, et al. National health expenditure trends, 1975 to 2013. Ottawa (ON): Canadian Institute for Health Information; 2013.

11. Ministry of Health. HealthIdeas [Internet]. Victoria (BC): Ministry of Health; [cited 2014 Jul 1]. Available from: http://public.healthideas.gov.bc.ca/portal/page/portal/HealthIdeas

12. Population Health Economics, Public Health Agency of Canada. Economic burden of illness in Canada, 2005-2008: protecting Canadians from illness [Internet]. Ottawa (ON): Public Health Agency of Canada; [cited 2014 Nov 1]. Available from: http://ebic-femc.phac-aspc.gc.ca/index.php

13. Policy Research Division, Health Canada. Economic burden of illness in Canada, 1998. Ottawa (ON): Health Canada; 2002.

14. McLean D, Williams D, Lamont S, Krueger K. Community-based prevention: reducing the risk of cancer & chronic disease. Toronto (ON): University of Toronto Press; 2013.

15. Record NB, Onion DK, Prior RE, et al. Community-wide cardiovascular disease prevention programs and health outcomes in a rural county, 1970-2010. JAMA. 2015;313(2):147-55. DOI: 10.1001/jama.2014.16969.

16. Krueger H, Williams D, Kaminsky B, McLean D. The health impact of smoking and obesity and what to do about it. Toronto (ON): University of Toronto Press; 2007.

17. Goeree R, O'Brien BJ, Blackhouse F, Agro K, Goering P. The valuation of productivity costs due to premature mortality: a comparison of the human-capital and friction-cost methods for schizophrenia. Can J Psychiatry. 1999;44:455-63.

18. Hutubessy RC, van Tulder MW, Vondeling H, Bouter LM. Indirect costs of back pain in the Netherlands: a comparison of the human capital method with the friction cost method. Pain. 1999;80(1):201-7.

19. Lofland JG, Locklear JC, Frick KD. Different approaches to valuing the lost productivity of patients with migraine. Pharmacoeconomics. 2001;19(9):917-25.

20. Yabroff KR, Bradley CJ, Mariotto AB, Brown ML, Feuer EJ. Estimates and projections of value of life lost from cancer deaths in the United States. J Natl Cancer Inst. 2008; 100(24):1755-62.

21. Tranmer JE, Guerriere DN, Ungar WJ, Coyte PC. Valuing patient and caregiver time: a review of the literature. Pharmacoeconomics. 2005;23(5):449-59.

22. Jha P, Ramasundarahettige C, Landsman V, et al. 21st-century hazards of smoking and benefits of cessation in the United States. N Engl J Med. 2013;368(4):341-50. DOI: 10.1056/NEJMsa1211128.

23. Hu FB, Willet WC, Li T, Stampfer MJ, Colditz GA, Manson JE. Adiposity as compared with physical activity in predicting mortality among women. N Engl J Med. 2004; 351(26):2694-703.

24. WHO Expert Consultation. Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. Lancet. 2004;363(9403):157-63.

25. BC Stats socio-economic profiles [Internet]. Victoria (BC): BC Stats [cited 2014 Nov 1]. Available from: http://www.bcstats.gov.bc.ca/StatisticsBySubject/SocialStatistics/SocioEconomicProfilesIndices/Profiles.aspx

Erratum

This erratum is being published to correct the error in footnote b of Tables 2 and 4 of the following article:

MacPherson M, de Groh M, Loukine L, Prud'homme D, Dubois L. Prevalence of metabolic syndrome and its risk factors in Canadian children and adolescents: Canadian Health Measures Survey Cycle 1 (2007-2009) and Cycle 2 (2009-2011). Health Promot Chronic Dis Prev Can. 2016;36(2):32-40.

Before correction

[b] These figures are published with reservation as $0.16 \leq CV \geq 0.33$.

After correction

[b] These figures are published with reservation as $0.16 \leq CV \leq 0.33$.

The editors regret this error and are grateful to Janine Clarke for bringing it to their attention.