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# How perceptions of community environment influence health behaviours: using the Analysis Grid for Environments Linked to Obesity Framework as a mechanism for exploration

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## Abstract

**Introduction:** Overweight and obesity are influenced by a complex interplay of individual and environmental factors that affect physical activity and healthy eating. Nevertheless, little has been reported on people's perceptions of those factors. Addressing this critical gap and community partner needs, this study explored how people perceived the influence of micro- and macroenvironmental factors on physical activity and healthy eating.

**Methods:** Community partners wanted the study results in a format that would be readily and easily used by local decision makers. We used photovoice to engage 35 community members across four municipalities in Alberta, Canada, and to share their narratives about their physical activity and healthy eating. A combination of inductive and deductive analysis categorized data by environmental level (micro vs. macro) and type (physical, political, economic, and sociocultural), guided by the Analysis Grid for Environments Linked to Obesity Framework.

**Results:** Participants conceptualized health-influencing factors more broadly than physical activity and healthy eating to include "community social health." Participants spoke most often about the influence of the microenvironment ( $n = 792$  ANGELO Framework coding tallies) on their physical activity, healthy eating and community social health in comparison to the macroenvironment ( $n = 93$ ). Photovoice results provided a visual narrative to community partners and decision makers about how people's ability to make healthy choices can be limited by macroenvironmental forces beyond their control.

**Conclusion:** Focussing future research on macro- and microenvironmental influences and localized community social health can inform practice by providing strategies on how to implement healthy changes within communities, while ensuring that research and interventions echo diverse people's perceptions.

**Keywords:** *environment, photovoice, ANGELO Framework, physical activity, eating behaviour*

## Introduction

Prevalence of overweight and obesity is growing at an alarming rate, with the number of adults with body mass index equal to or greater than 25 kg/m<sup>2</sup> increasing from 857 million worldwide in 1980 to

2.1 billion in 2013.<sup>1</sup> These escalating rates of overweight and obesity are of concern given their association with a number of chronic diseases<sup>2,3</sup> and significant economic burdens, particularly within health care systems.<sup>4</sup> This increasing prevalence can be attributed to multiple

## Highlights

- Since overweight and obesity are influenced by a complex interplay of individual and environmental factors that affect physical activity and healthy eating, this study, which used photovoice, reports on people's perceptions of those factors.
- Participants identified microenvironment settings (e.g. homes, schools, workplaces) more often than broader macroenvironmental influences (e.g. public and private sectors) as affecting their physical activity and healthy eating.
- At the microenvironment level, participants most often described the physical environment as shaping their ability to be physically active.
- When participants talked about healthy eating, they described the influence of the sociocultural and economic environments as almost equal to that of the physical environment.
- Participants conceptualized health-influencing factors more broadly than physical activity and healthy eating to include "community social health."
- Photovoice allowed local decision makers to see how residents perceived their local community environments from a visual and narrative perspective.

individual-level factors (e.g. age and sex) and environmental features (e.g.

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including physical, economic, sociocultural and political environments)<sup>5,6</sup> that affect physical activity and food consumption.

Historically, public health practitioners have sought to identify a single cause for the complex factors that contribute to obesity.<sup>7</sup> This narrow focus has recently evolved to include the study of complex interactions between the behaviour of people and their environments.<sup>5,8,9</sup> Socioecological approaches recognize that health behaviours (i.e. unhealthy eating and physical inactivity) that contribute to the development of obesity are a result of larger social systems<sup>10</sup> typically beyond people's control. This interplay between people and their environments reveals potential new approaches to interventions.<sup>11,12</sup> People are affected by their interactions with other people, organizations and policies in their communities; thus, influencing factors at each ecological level will help foster the development of environments that support physical activity and healthy eating.<sup>13</sup>

The complex interactions of the various environmental factors that influence obesity are referred to as "obesogenic environments."<sup>5</sup> The obesogenicity of an environment can be defined as the sum of a multiple set of conditions that constrains people to adopt a healthy diet and active lifestyle.<sup>5</sup> The dynamic, multilevel nature of obesogenic environments creates operational difficulties for practitioners, decision makers and researchers who are seeking opportunities to prevent and reduce obesity.<sup>12</sup> Despite these challenges, many experts agree that broader policy and environmental changes have the greatest potential for improving population health and are best suited to addressing the complexity of obesogenic environments.<sup>14,15</sup>

Still, there is a relative paucity of literature on perceptions of how multiple environmental levels influence physical activity and healthy eating behaviours, a critical perspective given the influence of environments on obesity.<sup>5,10</sup> Among socioecological approaches,<sup>6</sup> the ANGELO (ANalysis Grid for Environments Linked to Obesity) Framework recognizes two levels of environment:<sup>5</sup> the microenvironment setting, which includes places where people or groups gather for specific purposes, for example, homes, workplaces or

schools, and the macroenvironment sector, which includes the broader environment influenced by public and private sectors, such as groups of industries and services. Within the micro- and macro-environments, the ANGELO Framework includes four types of environment: physical (what is available); political (what are the rules); economic (what are the costs); and sociocultural (what are the attitudes and beliefs).<sup>5</sup> Some examples of how different environmental levels influence physical activity and eating behaviours within the ANGELO Framework include

- Macrosociocultural environment: advertisements of high-fat foods on television during sporting events;
- Microsociocultural environment: local role models advocating for eliminating sugar-sweetened beverages in school settings;
- Macropolitical environment: governmental regulation of the construction of sidewalks in new residential developments;
- Micropolitical environment: parental restriction on children walking or bicycling to the local recreation facility;
- Macrophysical environment: a network of bike lanes in a community;
- Microphysical environment: neighbourhood yards kept up with flowers, shrubs and trees;
- Macroeconomic environment: prices of food and drink at a fast-food chain; and
- Microeconomic environment: an indoor walking track available to seniors for free.

Understanding how people perceive these environmental levels and types can help clarify what environmental attributes affect health. We can use this information strategically to promote physical activity and healthy eating and to get a nuanced public health understanding of how elements of obesogenic environments influence behaviour.

The objective of this project was to understand people's perceptions of the influence of micro- and macrolevel community environmental factors on physical activity and healthy eating, that is, elements that are significant in characterizing obesogenic environments and identifying appropriate local intervention.

### Contextual background

This project was one phase of Community Health and the Built Environment (CHBE),

a larger research project investigating the integrated role of built and social environments in community interventions for obesity and chronic disease prevention.<sup>16</sup> CHBE was a three-year (2007–2010) project that took place in four communities in Alberta, Canada. The researchers worked closely with community partners (key stakeholders from each community) to collaborate on developing and implementing the project. We used a community-based, participatory approach to ensure that project results were relevant for community policy and practice as well as for research.

### Methods

We used photovoice<sup>17</sup> to understand people's perceptions of their physical activity and healthy-eating environments while engaging community members and building support for environmental change. In this approach, participants are asked to take photographs of their community and to then share their stories about those photographs.<sup>18</sup> The photo-stories have the potential to elicit critical discussion on community issues by providing an array of visual and narrative data that can be shared with key decision makers and other community stakeholders.<sup>18</sup> We decided that photovoice was the best methodology because community partners had identified the importance of visual representations for decision makers (rather than the purely narrative data that would be obtained through interviews or focus groups).

### Setting

Four communities were involved in this study. St. Paul and Bonnyville are two smaller rural municipalities in northern Alberta, each with a population of about 6000, serving larger populations of 10 000 from surrounding communities.<sup>19,20</sup> St. Paul has a rich agricultural tradition, while Bonnyville serves the oil and gas industry.<sup>19,20</sup>

North Central Edmonton, an urban inner-city community, comprises 11 neighbourhoods (with a total population of 41 026)<sup>21</sup> within the urban core of the city of Edmonton, in the northern half of Alberta. Medicine Hat and its suburb, Redcliff, are urban communities in the southernmost part of Alberta. Medicine Hat is a large urban municipality (population of 61 097).<sup>22</sup> Major sources of industry

include agriculture, manufacturing, and oil and gas. Redcliff borders Medicine Hat and shares a large number of resources and services with the larger municipality. These communities were selected as a continuation of previous community–university partnership research on chronic disease prevention.<sup>16,23,24</sup>

### Participants

In the spring of 2009, between 7 and 10 residents from each of the four communities were recruited to participate in the study. In total, 35 participants took part, which was enough to reach data saturation. Of these, 74.3% were women; 71.4% were 35 years or older; and 40% reported an annual household income of less than \$50,000. A variety of mechanisms were used to recruit the general population as well as minority or harder-to-reach populations: via local newspaper articles, posters at key locations such as community centres and local libraries, and word-of-mouth and mass emails through local partner organizations such as family and community service agencies, not-for-profit organizations and local government. To be eligible for the study, participants had to be 16 years or older, live in the community, and be willing to commit 4 to 5 hours over a few weeks to participate in interviews conducted in English.

Research ethics approval was obtained from the Health Research Ethics Board (Panel B), University of Alberta, prior to the start of this project.

### Data collection

The participants took part in a one-on-one in-person semi-structured interview to find out their perceptions of community, physical activity and healthy eating. The interviews, conducted by a trained research assistant familiar with the community, lasted about 60 minutes. The primary purpose of the first interview was to build rapport with participants while a secondary purpose was to gain an initial understanding of the local community. At the end of this interview, participants were provided with a digital camera and shown how to operate it. They then had two weeks to take photographs with a “focus on things in your community that make it easier or harder ... to be physically active and eat healthy foods.” To minimize the researchers’ influence, the directions were loosely structured,

allowing participants to take photographs of whatever they felt influenced their physical activity and healthy eating.

The developed photographs were returned to the participants, who met with a research team member for one-on-one in-person semi-structured interviews at a central community location (e.g. local library).<sup>24</sup> These in-depth follow-up interviews gave the study participants a chance to share the stories behind their photographs. The participants selected the most meaningful and representative photographs for discussion in the interview and described why they took that particular photo. Further questions led to understanding the association between the photo content and physical activity and/or healthy eating. The photographs were discussed until the allotted time of 90 minutes was reached to respect the participants’ time; each participant discussed an average of 13 photographs. Interviews were audio-recorded.

The interviews were conducted to gain a greater understanding of individual and community issues important to each participant<sup>24</sup> by eliciting a variety of stories across each community and exploring each story in-depth. The research team and community partners determined that focus groups, which are often used in photovoice projects,<sup>17,18</sup> could jeopardize the depth of data shared by participants, particularly given the potential breadth of this study topic. Further, the community partners identified a critical need to elicit a vivid story of participants’ experiences and their identification of detailed perceptions on community-specific topics to support local decision making and future public health action.

### Analysis

The combination of visual and narrative results stemming from photovoice methodology lends itself well to dissemination among local decision makers and stakeholders.<sup>17</sup> This methodology also allowed our community partners to present the study data and findings in a format that would be readily used by local decision makers. To facilitate knowledge translation to the community, we used the ANGELO Framework<sup>5</sup> during data analysis to systematically explore participants’ perceptions of community environments. This framework was deemed appropriate for this study as it has been used before to

help identify areas for intervention,<sup>25</sup> and to conceptualize obesogenic environments and organize data.<sup>12,26</sup>

All interviews were transcribed and coded using NVivo10 qualitative software version 10 (QSR International Pty Ltd., Melbourne, AUS). As the purpose of this analysis was to examine people’s perceptions of micro- and macrolevel environmental influences elicited by the participants’ photo-stories, coding focussed on the follow-up interview. In the follow-up interviews, participants reflected on the photographs they had selected and, with those as context, discussed how their community environments influenced their physical activity and healthy eating behaviours. Following this elicitation approach, the selected photographs were used to support the analysis of the interviews to help illustrate the context of the participants’ narratives.

Photovoice methodology recommends that data is analyzed with the participants.<sup>17,18</sup> In this project, that critical stage of analysis occurred during the follow-up interview where participants led the analysis of their photographs, assigning meaning to the images and explaining the meaning to the interviewer.<sup>24</sup> The interview guide was used, as needed, to spur conversation, but its primary focus was to capture the main ideas behind each photograph and elicit meaning rather than lead the participant to a specific insight. After all the interviews had been completed, the researchers undertook a second, organizational stage of analysis where the meaning identified by the participants was categorized into broader themes, guided by the ANGELO Framework. This staged approach retained the participants’ active role in revealing meaning, while respecting the time they committed to participating in the photo-taking exercise and two in-depth interviews. While the participants were not included in the second stage of data analysis, they were invited to review and revise summaries of their quotes for the photographs selected to represent broader categories and themes to be included in reports of study findings and presented at community events and beyond. Participant review of the revised summaries helped the researchers confirm the categorization of excerpts and themes within the ANGELO Framework.

To facilitate categorization of data during the second stage of analysis, the interview transcripts were initially double-coded by two trained researchers using an inductive coding scheme that retained the meaning explained by the participants. The use of an initial inductive approach to coding allows for themes to be considered independently of the complexity of the interrelationships between environment types. Next, the researchers identified excerpts from the transcript that fell within one or more of the four environment types: physical, economic, political and sociocultural. Specifically, excerpts were deductively assigned into micro- and macroenvironmental levels using a coding scheme; examples presented by Swinburn et al.<sup>5</sup> were used as a conceptual guide. The excerpts were then further classified into physical activity and healthy-eating categories. A third category, “community social health,” which comprised indirect influences on participants’ physical activity and healthy eating, emerged from the participants’ narratives during coding.

Following coding, we assessed the extent of coder agreement. Given the intentionally multidisciplinary nature of the research expertise on the coding team (i.e. anthropology, nutrition, health promotion, physical activity), 100% consistency was neither expected nor sought; rather the intent was to determine the extent of coding overlap. In cases of coder agreement, the code was assigned a numeric score of one. Excerpts on which original coders did not agree were scored as 0.5. Scores were tallied to provide a descriptive representation of the participants’ perceptions of community environment types (physical, political, sociocultural and economic) and levels (micro and macro) with respect to physical activity, healthy eating, and community social health.

## Results

Participants were invited to describe the environmental influences in their physical activity and healthy eating behaviours, but they also talked about other health-related behaviours. Specifically, they discussed how everyday broader characteristics of the community environment encountered in everyday life affected their well-being and quality of life, implicating a relationship between positive states of well-being/quality of life with the enhanced capacity to take positive steps

towards their own health. Participants’ perceptions and thoughts on these broader characteristics make up the category “community social health.” For example, some participants spoke about the importance of the local library (an element of the microphysical environment) in providing an opportunity for positive mental activity for all residents, but especially older adults. When asked how a photograph of a birdhouse in her backyard was related to her health, a participant explained: “[it is] very calming, very pleasing ... definitely enjoyable” (micro-sociocultural environment). In another example, a participant suggested that local business initiatives for women indirectly improve the community (microeconomic environment). In these examples, the local library, the birdhouse and the local bursary program do not directly relate to individual- or community-level physical activity or healthy eating, but are critical as participants perceived them as important contextual elements for those “healthy” behaviours and their overall well-being. (See Tables 1 and 2 for representative quotes about the microenvironment settings and macroenvironment sectors, respectively, by environment types and the physical activity, healthy eating, and community social health categories.)

Figure 1 summarizes the coding tallies according to the ANGELO Framework. Participants spoke most often about the influence of the microenvironment (n = 792 coding tallies) on their physical activity (n = 323.5 coding tallies), healthy eating (n = 114.5 coding tallies) and community social health (n = 354 coding tallies).

Within the microenvironment, participants most often described the physical environment (323.5 coding tallies) as shaping their ability to be physically active: the physical infrastructure in their community, from parks, indoor recreation facilities and public swimming pools to sidewalks, crosswalks and shaded areas. In contrast, with respect to healthy eating, they spoke to almost the same degree about the various influences of physical (e.g. availability of grocery stores and cafeterias), sociocultural (e.g. social gatherings involving food and supporting local food businesses) and economic (e.g. affordable pricing in supermarkets) micro-environments on their food behaviours. For example one participant spoke about

the relevance of the availability (micro-physical environment) and aesthetics (microsociocultural environment) of healthy food in grocery stores: “The vegetable displays and the selection we have available are excellent. I don’t understand why so many people buy junk food. I think the community is well served by the local grocery stores for healthy food options” (see Figure 2).

The influence of the economic environment on the three categories was highlighted equally among participants. Participants mentioned the concurrent influence of the microeconomic environment on physical activity, healthy eating and community social health, suggesting that financial costs influence people’s decisions to be physically active and/or eat healthy food and affect the social health of their community. For instance, the high costs associated with accessibility to local recreation facilities and to a diet rich in vegetables and fruits was mentioned as a restriction on people’s abilities to adopt healthy behaviours. Despite this, almost all of the other categories were discussed more frequently than the microeconomic environment, implicating economics as a relatively straightforward foundational element relative to the more complicated interplay of physical, sociocultural and political factors that influence people in potentially more subtle ways.

This complex, subtle interplay may explain why the micropolitical environment was rarely revealed in the healthy-eating category. For instance, only a few participants mentioned micropolitical environmental factors such as family rules or local school policies about healthy eating, as described here: “We had a couple [of vending machines], but I think the school decided to replace them with ... more healthy ones.”

In contrast, a common, shared micro-sociocultural theme across the three categories was social interactions. The opportunity to meet people in the community and strengthen their social connections with others was perceived by participants as affecting their physical activity, healthy and unhealthy eating, and community social health. For instance, a participant talked about a no-cost physical activity opportunity in his community and added: “[The Taekwondo class] is wonderful for us, but better than

**TABLE 1**  
**Sample quotes about the microenvironment setting, by category (physical activity, healthy eating and community social health) and environment type, according to the Analysis Grid for Environments Linked to Obesity (ANGELO) Framework**

Microenvironment setting <sup>a</sup>		
<b>Physical activity</b>	Physical environment	"[The trees on the streets] are very beautiful, and it looks so nice and shady and cool. I like taking the shady routes on hot days."
	Economic environment	"The walking track [in the gym] is available for seniors free ... That is somewhere that I can go and it doesn't cost anything."
	Political environment	"The hours that you can swim [at the lake] are limited."
	Sociocultural environment	"[My bike] is the best, easiest way to get around where [I] live ... it is just a huge part of my local life."
<b>Healthy eating</b>	Physical environment	"[Name of grocery store redacted] is an asset [to] the community, and they promote local food."
	Economic environment	"Growing your own vegetables ... you know the benefits that you get from that as well as ... reducing the cost ..."
	Political environment	"I think a lot is dictated [by] what kids want. Like when I am with my friends the first thing they will ask is where the kids want to eat."
	Sociocultural environment	"We are eating out too much, way more than I thought ... but yes, I think ... the eating out ... [gives us] a lot of social time ... with other people."
<b>Community social health</b>	Physical environment	"I think the library is a great asset to the town and particularly to seniors.... They have just renovated that library and made it very nice."
	Economic environment	"There are bursaries available for women who want to set up a business.... [The neighbourhood] is getting a lot better."
	Political environment	"Graffiti is one thing that is illustrative of problems that need deeper solutions than they are getting."
	Sociocultural environment	"So much of what gets me out of the house and into the community is chatting with the neighbours and getting to know people and building a safer, stronger, unified group of people in the neighbourhood."

<sup>a</sup> Includes places where people or groups gather for specific purposes, e.g. home, workplaces, schools.

that is the social connection. The parents that I have met in there and connected with and the kids that I have met in there and connected with are people that wouldn't normally be in my social circle ... and I think that hopefully I would be a role model for kids as well."

The influence of macroenvironments (n = 93 coding tallies) on participants' physical activity (n = 43), healthy eating (n = 4) and community social health (n = 46) was mentioned far less often than that of microenvironments (Figure 1), especially when discussing healthy eating. Participants referred to the influence of the macropolitical environment on physical activity and community social health most frequently. They mentioned governmental health policies that aim to promote the well-being of the general population. Most described how local government policies and programs affected their ability to be physically active in their community, as exemplified by one participant: "We don't have a city councillor ... specific to this neighbourhood, so then you just have to pick one out of the blue ... I have emailed [them] about physical activity things and [they] have never done anything about it." When raised by participants, the macropolitical environmental factors concerning (un)healthy eating encompassed policies such as the

provincial government's on healthy eating in schools and farmers' markets food regulations.

Many participants referred to how they did not feel they had control over the political climate in their local communities; for example, when reflecting on the macrophysical environment influencing physical activity, one participant noted that: "there [are] a lot of old sidewalks that are in very bad repair... [We] have complained about it [to town council, but] it has pretty much fallen on deaf ears" (see Figure 3). Similarly, a macrophysical environmental factor to do with healthy eating was the lack of a bicycle network, which was described as affecting access to grocery stores by those without a car. The lack of a public transportation system (in rural communities) was also described as a factor affecting people's abilities to be mobile and reach food outlets (macrophysical environment for healthy eating) and community services in general (macrophysical environment for community social health).

Participants described a wide array of examples of macroeconomic environmental factors, including the public investment in physical activity infrastructure such as bike paths/sidewalks, the pricing strategies adopted by fast-food

corporations and financial support from municipal governments to promote community assets such as greenhouses. Macrosociocultural environmental factors included policies to promote a culture of traffic safety for drivers, pedestrians and cyclists (physical activity); campaigns and advertisements of fast-food corporations to increase consumption (healthy eating); and zoning bylaws and landscaping regulations (community social health).

Using the ANGELO Framework to organize how participants conceptualized their physical activity and healthy eating in their community with respect to the different environment types and settings was critical for the sharing of information back to decision makers in the communities. For this aspect of the project, each community determined the best way to meaningfully engage decision makers and the general public in the display of the results. This included presentations to council, static displays at local libraries, interactive community map displays, PechaKucha style presentations at local farmers' markets or community events, and hard-copy and electronic summary reports that were shared with local decision makers and community practitioners. The changes that were facilitated in each community as a result of this dissemination were unique. For example, in one community the

**TABLE 2**  
**Sample quotes about the macroenvironment sector, by category (physical activity, healthy eating and community social health) and environment type, according to the Analysis Grid for Environments Linked to Obesity (ANGELO) Framework**

Macroenvironment sector <sup>a</sup>		
<b>Physical activity</b>	Physical environment	“It is just pure scary going across that bridge when there [are] trucks coming by you at 80 to 90 kilometres per hour.... People are afraid to cycle.... I have spoken to the department of highways ... but no changes have been made yet.”
	Economic environment	“The city only invested \$35,000 for the on-road bike lane program.”
	Political environment	“[The sidewalks have been] left out because this was a town subdivision; this wasn’t a separate commercial venture by a land owner. This was the town’s own design and they didn’t put sidewalks in.”
	Sociocultural environment	“So [the town] is working to make the crosswalk, designed crosswalks more recognizable so people will actually go a few yards or metres over to get to it. So I think the streetscape design [creating a culture of safety] is going to really help as far as pedestrians getting across safely.”
<b>Healthy eating</b>	Physical environment	“There is a large population of [name of ethnic group redacted] in the community and they can’t drive, so they are trapped, really trapped in the community. [The municipality has] talked about putting in a bike path for them to get to the larger city safely ... but this has not happened yet.”
	Economic environment	“[Name of fast-food chain] encourages you to eat more. Two litres of pop for only a few pennies more than a few ounces of pop ... They are encouraging you to eat more than you need to or want to.”
	Political environment	“[Licensing boards] have stricter rules for farmers’ markets than they do for stores ... Everything has to be inspected.”
	Sociocultural environment	“[Name of fast-food chain] spent billions of dollars in advertising, and billions of dollars in research on, you know, colour schemes and everything else that might entice you to eat more while you are there.”
<b>Community social health</b>	Physical environment	“Today [the bus] went to one of the senior lodges and picked up a bunch of people that do not drive, [who] are stuck in their places ... and took them to whatever they wanted to do.... [This] is a really good thing that this town has.”
	Economic environment	“The greenhouses in the community have been having some financial troubles; they were trying to get some money from the government to help support their businesses.”
	Political environment	“The provincial government [is] trying to have people have a quality of life [with] less people ... in hospital and emergency.... I think that the feds are doing it too, but the city here [is] stuck in a time warp, back a lot of years, and it is unfortunate.”
	Sociocultural environment	“I think [downtown] is the heart of our community.... I feel that [the town council] should put a bylaw that any place in town, uptown should be presentable. Even [if] it is vacant you can make it look attractive without spending a lot of money.”

<sup>a</sup> Includes the broader environment influenced by public and private sectors, such as groups of industries and services.

display of the photographs and stories led to a municipal policy change to sidewalk/trail maintenance programs, and in another the development and sustained implementation of a children/youth outdoor free play program.<sup>16</sup>

## Discussion

In this section, we explore specific elements related to the macroenvironment sector and microenvironment setting. We then reflect critically on the implications of study results for future interventions that target community environments to promote health.

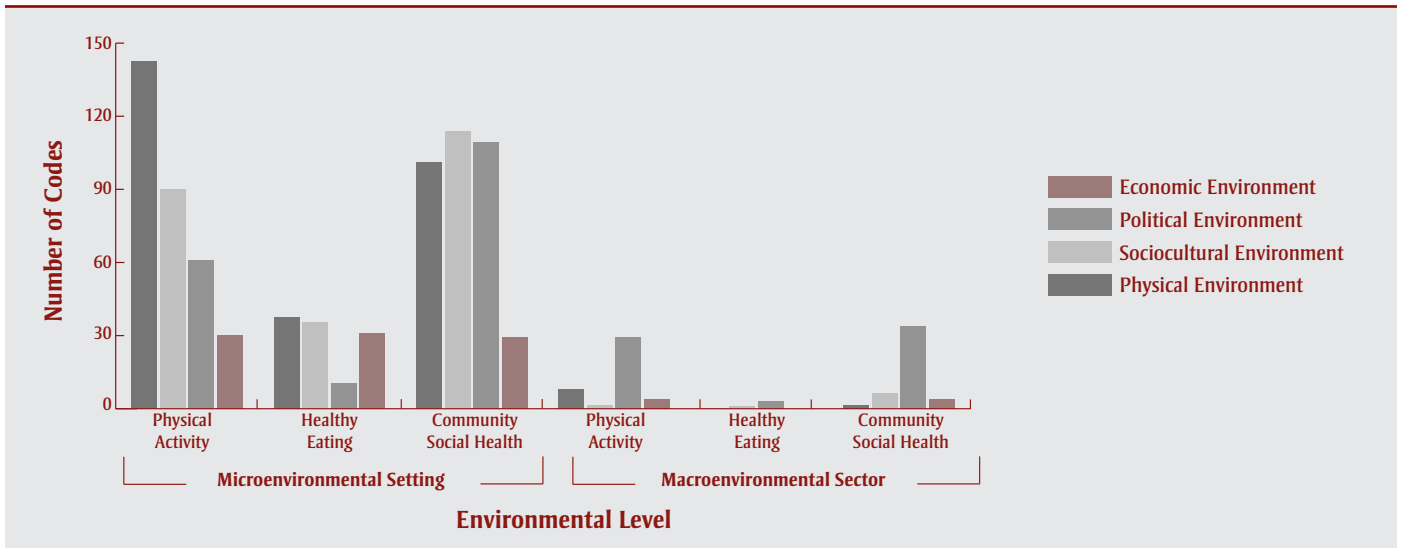
### Macroenvironment sector

Our analysis suggested that participants did not readily recognize the influence of the macroenvironment on their physical activity and healthy eating behaviours and community social health (see

Figure 1). This lack of immediate recognition does not negate the influence that this sector can have on obesogenic behaviours,<sup>12</sup> but reinforces the notion that those influences can be subtle, if not insidious. For example, participants rarely considered their eating behaviours to be shaped by macroenvironmental factors, which indicates an under- or distal awareness about the food industry and governmental influences on dietary options. Participants focussed on their immediate food environments, which were more directly within their locus of control, sharing their experiences with grocery stores and personal gardens. While these local embodiments of food are most obvious, public health practitioners should be concerned about building the public’s recognition of the macroenvironmental factors, such as media and food production systems, that shape food-related decision making.<sup>12</sup>

In contrast to their consideration of healthy eating, participants more often mentioned the influence of macropolitical environments on the physical activity and community social health categories, easily describing the role of policies in creating supportive environments. The influence of the broad macroenvironments was discussed less frequently and in less depth than elements within the participants’ microenvironments. This may be a function of the study’s focus on “community,” but also can be explained by the fact that researchers<sup>12</sup> and policy-makers<sup>27</sup> have consistently paid more attention to individual approaches when analyzing and creating strategies to tackle obesity, especially through behavioural correlates of diet and activity. This emphasis on personal responsibility can be seen as blaming people for their choices, neglecting the reality that people’s unhealthy choices are often shaped and constrained by

**FIGURE 1**  
Summary of the coding tallies, by type and level of environment and by category, according to the Analysis Grid for Environments Linked to Obesity (ANGELO) Framework



macroenvironmental forces<sup>5</sup> that are created and propagated by societal milieu.

Advocating for action is something that may be within the reach of community residents, with impact at both micro- and macroenvironment levels, over a longer term. Through photovoice, policy advocacy could focus on engaging local governments to be more active in creating supportive community environments to prevent obesity and chronic disease.<sup>28</sup> For instance, our project participants could

share their photographs and related photo-stories with many levels of stakeholders, including researchers, practitioners and policy makers, capitalizing on opportunities to relay their messages for policy and environmental change (e.g. presentations, newsletters, media advisories, etc.) and affecting action in their communities.

**Microenvironment setting**

Participants overwhelmingly described the microenvironmental influences on their

physical activity, healthy eating, and community social health. This may be due to many factors. First, they were asked to focus on their local communities and, thus, may have limited themselves to their microenvironment. Second, people are frequently inundated with information emphasizing the personal responsibility to make healthy choices. Researchers, governments and media messaging do not usually include the role of external factors in creating the obesogenic environment, and the general public is at the mercy of the knowledge accessible to them. Third, the microenvironment may have been where the participants felt the most locus of (perceived) control,<sup>2</sup> which may have facilitated their identification of a greater number of influential factors.

**FIGURE 2**  
Participant's photograph of a shelf in the grocery store representing the microenvironment setting



How participants discussed the influence of the physical, sociocultural, political and economic environments on their physical activity, healthy eating and community social health varied greatly within the microenvironment setting. For the microeconomic environment, representation was consistent across categories, suggesting that socioeconomic factors pose critical barriers to physical activity, healthy eating and community social health.<sup>12,29</sup> This suggests that public health policy should develop a variety of actions that focus on reducing socioeconomic barriers,<sup>14</sup> such as decreasing the costs of healthy foods and subsidizing gym memberships for low-income families, allowing for comprehensive approaches to obesity prevention to be strengthened. Local rules



**FIGURE 3**  
**Participant's photograph of a sidewalk in need of repair**  
**representing the macrophysical environment sector**



and regulations can also shape people's abilities to be healthy (micropolitical environment).<sup>14,15</sup> For example, studies suggest that expanding hours of operation at recreation facilities and increasing local regulations (e.g. via neighbourhood associations) that ensure people's right to live in a safe, aesthetically pleasant, healthy environment have a positive effect on healthy behaviours.<sup>14,15</sup>

For the physical environment, participants often spoke about how the physical activity resources available in their community affected their ability to be active, which reinforces associations between infrastructure and active living found in previous studies.<sup>6,14</sup> Finally, the sociocultural environment (e.g. cultural preferences and socialization with neighbours) was described as important to physical activity, healthy eating and community social health, findings that have been documented elsewhere.<sup>12,25</sup> This underscores the need for careful and nuanced investigations of exactly how sociocultural environments constrain or encourage health-promoting behaviours and affect community social health.<sup>12</sup>

### **Strengths and limitations**

This exploratory study was bounded by its methodological approach, including a purposeful overlap in coding for the different categories and environmental levels and types, resulting in some excerpts being double- or triple-coded to reflect the inherent complexity and interrelated nature of environmental forces relative to obesity. Some might argue that even if participants repeat things many times it

does not necessarily mean it is important or that there is a deeper meaning in what they are saying; we do not feel that this is the case here, as meaning was assigned by participants and then reflected in the categorization of excerpts into thematic categories.

The relative quantity of themes populating each type and level of environment in this analysis could be misleading, and may suggest that the microenvironment settings predominate given that the large majority of themes fell in this category. This, however, may be a superficial assessment of the data. The participants were asked to photograph things in their environment that influence their abilities to be physically active and eat healthy food—and were asked to do this in a two-week period. This is a relatively short time to internalize and complete the task, and do so in a way that captures the subtleties of environments. For participants, physical attributes seemed the easiest or most obvious to photograph, whereas capturing political environment features, for instance, may have required more time or thought. Yet, elements of the more intangible environments emerged during discussions around the participants' photographs, suggesting that the microenvironment settings and physical environment attributes were gateways to discussion—and potentially action—on the macroenvironment levels and the sociocultural, economic and political aspects of community environments relative to their health. While not all elements of the ANGELO Framework were readily captured in photographs, it was the rich pool of photovoice data that allowed for

all elements of the ANGELO Framework to be populated with narrative interview data. As the interview progressed, many participants' stories transcended the original topic raised by the photo and invoked more complex threads of meaning.

Despite the study's small sample size, the results show interesting patterns in residents' perceptions of how community environments influence their physical activity and healthy eating behaviours. In addition, the themes evoked by the participants were similar across the communities, suggesting their relative importance in our society. Building on this exploratory study, future research should explore the differences in perceptions between different settings (e.g. urban versus rural communities) and population groups (e.g. seniors versus youth) to allow for more practical and settings-based recommendations for programs, policies and interventions. As is typical with deep, exploratory studies, generalizability of the findings is neither expected of nor appropriate for this work.

Although the project data was collected in 2009, these findings hold important implications for research and practice in obesity reduction and prevention. The ANGELO Framework is widely used in obesity and chronic disease prevention research. This study demonstrates how it can be used to inform and stimulate local health promotion as well as as an effective way to translate community knowledge. Presenting the community attributes by environment type and level allows researchers and decision makers to more clearly understand and picture how different elements of the community environment influence people's decisions about healthy behaviours and how local action can be tailored to address specific gaps and opportunities in the community.

### **Implications for research and practice**

The project findings had immediate implications for the four participating communities when the photographs, stories and analysis were shared back with community partners, decision makers and community members through a variety of different mechanisms (e.g. formal council presentations, open houses at local libraries, community reports, etc.). They particularly helped local decision makers see from a visual and narrative perspective how residents perceived their community

environments, something that could not have been possible with quantitative data alone. This sharing of the data led to local community action to address some of the issues raised by participants (e.g. a maintenance program for community trails). Photographs and narratives also showed the decision makers that the ability to make healthy choices can be limited by macroenvironmental forces that are beyond the people's control. Thus, in this community-based participatory research project, the results reinforced the decisive role of decision makers in providing supportive policies and infrastructure that encourage their community population to eat healthy food and be physically active.

While this study had important implications at a local level, the results raise two important questions that researchers, practitioners and decision makers should consider more broadly when developing interventions, programs or policies that aim to improve community environments to support physical activity and healthy eating:

(1) Is there an implicit focus (in academia and civil society) on the microenvironment setting because that is what the public sentiment is driving?

The participants emphasized the effect that the microenvironment can have on their physical activity and healthy eating, which may stem from their understanding and interpretation of the common discourse on personal responsibility concerning these behaviours.<sup>27</sup> While some people may embrace socialized "healthy" ideals, others resist them. Future systems-level research should seek to explore people's perceptions of the macroenvironment in greater depth to determine at what level the under-awareness of its effects is a function of the sociocultural (e.g. magazines and TV shows) and political (e.g. interventions targeting individuals or small groups) environmental forces. Systems-level research is needed to determine the reason for such a dedicated focus on the microenvironment setting<sup>3</sup> in academia to the detriment of a comprehensive understanding of the mechanisms of macroenvironment intervention.

(2) What is the significance of the connection between microenvironment settings and macroenvironment sectors for policy and practice purposes?

While microenvironmental interventions and policies are important for practitioners and decision makers to demonstrate local obesity reduction efforts, it is also crucial that practice and policy leaders recognize that people may be unaware or unable to articulate the effect of the macroenvironment on them. There is a need to explore the interplay between microenvironment settings and macroenvironment sectors, dominant health discourses, and individual interpretations, reproductions and resistances to these dominant discourses to inform population health interventions that will appropriately address the complexities of both policy change and worldwide obesity trends. For instance, practitioners and decision makers could undertake macro-level interventions such as food policies and municipal planning.<sup>12,14</sup> Public health messaging could emphasize macroenvironmental influences on food and physical activity behaviours, raising people's awareness of and capacity to navigate these issues.<sup>30</sup> Finally, research could seek to reveal how macroenvironment sectors (e.g. food industry practices) shape the microenvironment and illuminate the effects on population health.<sup>6,12</sup> Addressing the lack of public recognition about the potentially significant role of macroenvironmental interventions may engender a critical mass of public support for population-level interventions, rather than individual-level interventions. Nonetheless, it is important that practitioners and decision makers consider the relevant local context when developing programs, interventions and policies, while understanding the current large focus placed on personal responsibility within current political realities.

## Conclusion

Our results indicate that researchers should seek to better understand the complex interplay between microenvironmental and macroenvironmental factors while exploring how people interpret these levels relative to prevailing health and social discourses. Given the specific emphasis the study participants placed on microenvironmental factors such as socio-economic barriers, the study findings will help practitioners and decision makers target interventions and policies within microenvironments. A strategic focus on these areas will help to guide micro- and macrolevel interventions overall, while

ensuring that research and practice respond to the diversity of perceptions about physical activity, healthy eating and community environments.

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# Estimating bias in derived body mass index in the Maternity Experiences Survey

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## Abstract

**Introduction:** The objective of this study was to assess bias in the body mass index (BMI) measure in the Canadian Maternity Experiences Survey (MES) and possible implications of bias on the relationship between BMI and selected pregnancy outcomes.

**Methods:** We assessed BMI classification based on self-reported versus measured values. We used a random sample of 6175 women from the MES, which derived BMI from self-reported height and weight, and a random sample of 259 women who had previously given birth from the Canadian Health Measures Survey (CHMS), which derived BMI from self-reported and measured height and weight. Two correction equations were applied to self-reported based BMI, and the impact of these corrections on associations between BMI and caesarean section, small-for-gestational age (SGA) and large-for-gestational age (LGA) births was studied.

**Results:** Overall, 86.9% of the CHMS subsample was classified into the same BMI category based on self-reported versus measured data. However, misclassification had a substantial effect on the proportion of women in underweight and obese BMI categories. For example, 14.5% versus 20.8% of women were classified as obese based on self-reported data versus measured data. Corrections improved estimates of obesity prevalence, but over- and underestimated other BMI categories. Corrections had nonsignificant effects on the associations between BMI and SGA, LGA, and caesarean section.

**Conclusion:** While there was high concordance in BMI classification based on self-reported versus measured height and weight, bias in self-reported based measures may slightly over- or underestimate the risks associated with a particular BMI class. However, the general trend in associations is unaffected.

**Keywords:** *body mass index, self-reported prepregnancy weight, self-reported height, reproductive outcomes, validity*

## Highlights

- Bias in measurement of body mass index (BMI) may have implications on the association between BMI and some pregnancy outcomes, such as caesarean, small-for-gestational age and large-for-gestational age births.
- The authors assessed BMI classification based on self-reported versus measured values using random samples of women from the Maternity Experiences Survey and from the Canadian Health Measures Survey.
- Discrepancies in the proportion of women in BMI categories were highest for women classified as being underweight or obese based on self-reported height and weight, but overall, there was high concordance between BMI classes based on self-reported versus measured data.
- BMI derived from self-reported data appears to be a justifiable and reasonable way to identify overall trends in the association between prepregnancy BMI and pregnancy outcomes.

## Introduction

Maternal prepregnancy body mass index (BMI) is an important predictor of certain pregnancy outcomes. Both high and low BMI are associated with increased risks of adverse outcomes for the mother and child, such as caesarean section, small-for-gestational age (SGA) and large-for-gestational age (LGA) births.<sup>1-3</sup>

Population-level BMI information is often derived from self-reports of height and weight. Past research has demonstrated that such self-reported data tend to overestimate height and underestimate weight, resulting in an underestimation of overweight and obesity (BMI  $\geq 25.0$  kg/m<sup>2</sup>).<sup>4-6</sup> Directly measured data provide more accurate information but are expensive to collect. Consequently, self-reported data

will continue to be a source of prepregnancy BMI information. This makes it important to understand the magnitude and impact of any bias in these data.

The Maternity Experiences Survey (MES), conducted in 2006–2007, gathered information from a nationally representative sample of women who had given birth in Canada in 2005–2006.<sup>7</sup> These data included self-reported height and prepregnancy weight; these were used to derive

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prepregnancy BMI in this population and study its associations with adverse pregnancy outcomes. In 2007–2009, the Canadian Health Measures Survey (CHMS) collected self-reported and measured height and weight for a national representative sample of Canadians, including females of reproductive age.<sup>8</sup> Although CHMS data cannot be directly linked to the MES, their availability for a similar period as MES data provides an opportunity to examine a subset of the population comparable to that from which the MES was drawn, to estimate the degree of bias in MES BMI data and determine possible implications of this bias on well-established relationships between prepregnancy BMI and selected pregnancy outcomes.

## Methods

### Data

The 2006–2007 MES was a cross-sectional survey of a stratified random sample of 6421 women who had a singleton live birth in Canada in 2005–2006 (5–13 months prior to data collection).<sup>7</sup> We focussed on a subset of 6175 respondents aged 18 to 44 years whose prepregnancy BMI data, derived from self-reported height and weight, were available. Each MES record was weighted, so this subset represents a population of 74 000 women.

The 2007–2009 CHMS was the first cycle of a national survey of physical health measures collected through in-person interviews and direct measurement. It captured data on height and weight, along with many other determinants of health. It included 259 women who were aged 18 to 44 years old, had ever had a live birth, had complete data on two measures of BMI, one based on self-reported height and weight and the other on measured height and weight, were not currently pregnant and had a child younger than 5 years old in their household.

Like the MES, each CHMS record was weighted, representing a population of 1 386 500 women. The sampling weights in both the MES and the CHMS took into consideration the sample design and non-response; they were calculated within weighting classes, which generally corresponded to the strata used to draw the

sample. Detailed information on the development, methodology (including sample design and weighting) and content of both surveys has been reported elsewhere.<sup>7,8</sup>

### Analysis

The MES and CHMS samples were compared across variables common to both datasets and identified in other studies as associated with BMI bias, namely maternal BMI based on self-reported height and weight, age and education.<sup>9,10</sup> Ethnicity was categorized differently in the two surveys and could not be compared. BMI was categorized according to the World Health Organization standard as underweight (BMI < 18.5 kg/m<sup>2</sup>), normal weight (18.5–24.9 kg/m<sup>2</sup>), overweight (25.0–29.9 kg/m<sup>2</sup>) or obese (BMI ≥ 30.0 kg/m<sup>2</sup>).<sup>11</sup> Using our CHMS subsample, we assessed the magnitude and direction of bias by cross-tabulating the BMI values based on self-reported and measured height and weight.

We applied two correction equations (Box 1) to the BMI based on self-reported values to derive corrected BMI distributions. The first equation was derived by Connor Gorber et al.<sup>9</sup> based on data for adult women in the 2005 Canadian Community Health Survey (CCHS). This “reduced model” equation is a simple linear regression of BMI derived from measured data on BMI derived from self-reported data as more complex models (i.e. models with covariates or nonlinear models) provided no predictive advantage.\* Although Connor Gorber et al.<sup>9</sup> derived correction equations separately for men and women, only an overall sample size for both sexes was reported (n = 2029), suggesting that the reduced model was derived using a subsample of approximately 1000 women.

The value of using the Connor Gorber et al.<sup>9</sup> correction equation is that it had been validated against more complex equations and found to have the same corrective value. In addition, the 2005 period for the CCHS was similar to the prepregnancy time period for MES women whose babies were born in 2005–2006.<sup>7</sup> However, because this equation was for all adult women regardless of whether they had ever given birth, we derived a second correction equation using the same methods

but based on the CHMS (described earlier) subsample of 259 women who had been selected as most similar to the MES population, namely women aged 18 to 44 years who had ever had a live birth and had a child younger than 5 years in the household (see Box 1).

Finally, using rate ratios (RRs), the associations between prepregnancy BMI and three adverse pregnancy outcomes—caesarean delivery, SGA and LGA—were compared for uncorrected and corrected BMI distributions in the MES. SGA was defined as weight below the 10<sup>th</sup> percentile for gestational age and LGA as weight above the 90<sup>th</sup> percentile for gestational age.<sup>12</sup>

All analyses were carried out using sampling weights. We computed results from unrounded weighted components; however, weighted sample sizes were rounded to the nearest hundred, according to Statistics Canada reporting guidelines, as unrounded estimates overstate precision. With the exception of the overall subsample sizes, unweighted counts are not reported to be consistent with Statistics Canada’s disclosure control standards. We calculated 95% confidence intervals using the bootstrap method, which accounts for the variability introduced by the sample design and weighting adjustments.<sup>13</sup> In

#### Box 1. Correction equations for BMI derived from self-reported data

Correction 1. Regression coefficients calculated from the 2005 CCHS for a subsample of adult women (≥ 18 years), regardless of birth history (unweighted n ≈ 1000).<sup>9</sup>

Corrected BMI =  $-0.12 + 1.05 \times$  BMI derived from self-reported height and weight

Correction 2. Regression coefficients calculated from the 2007–2009 CHMS subsample of women (18–44 years) who had ever had a live birth, with a child younger than 5 years in the household (unweighted n = 259 women)

Corrected BMI =  $-0.44 + 1.05 \times$  BMI derived from self-reported height and weight

\* Table 4 in Connor Gorber et al.<sup>9</sup> shows the correction equation in the “Women” subsection of the table under the title “Reduced Model.”

addition, because the CHMS subsample was small and its survey design complex, using a normal approximation to the binomial distribution was not appropriate, particularly for small proportions. As a result, we applied a logit transformation to all CHMS-based analysis.<sup>14</sup> The logit transformation interval was obtained by constructing a t-distribution-based Wald interval for the logit transformation of the proportion (p), and transforming the limits back to the original scale. It is based on the assumption that  $\log(\hat{p}/(1-\hat{p}))$  is approximately normal. Logit transformation was not needed for MES-based analyses because of the larger size of the MES sample and simpler sample design. All analyses were carried out using SAS Enterprise Guide version 5.1 (SAS Institute, Cary, NC, USA).

## Results

Except when noted, all results are weighted estimates. Table 1 shows maternal BMI derived from self-reported height and weight, age and education distributions in the MES and CHMS subsamples.

Only the age distribution varied substantially: the CHMS sample was older, with 43.2% aged 35 to 44 years old compared to 17.6% of the MES sample. A higher proportion of CHMS women reported being overweight or obese and a smaller proportion reported university education; however, these differences were more moderate.

When BMIs based on self-reported and measured values were compared in the CHMS sample, 14.5% of the self-reported sample was classified as obese versus 20.8% of the measured sample (Table 2, columns A and B). Most of this misclassification was because 23.6% of the women classified as overweight based on self-reported data were classified as obese based on measured data (Table 3). A similar degree of misclassification was observed among women classified as underweight based on self-reported data, with 24.5% of these women actually having normal BMIs. The degree of misclassification was lower among women whose BMI corresponded with normal weight or obese BMI. Overall, 86.9% of the CHMS

subsample was classified into the same BMI category based on self-reported versus measured data.

Table 2 (columns C and D) and Table 4 show corrected BMI distributions after applying the two correction equations (Box 1) to BMI derived from self-reported height and weight in the CHMS and MES. Comparing BMI values based on measured data to corrected values in the CHMS subsample indicated that Correction 1 (derived from the CCHS subsample of adult women) was better at correcting for the underestimation of obesity than Correction 2 (derived from the CHMS subsample of women aged 18–44 years who had ever had a live birth, with a child younger than 5 years in the household). However, Correction 2 was better at correcting the prevalence of other BMI categories. Though both corrected BMI distributions improved estimates of obesity prevalence, both resulted in overestimation of overweight and underestimation of underweight prevalence. Applying correction equations to MES data had a similar effect on the BMI distribution in that

**TABLE 1**  
**Distribution of body mass index, maternal age and educational attainment among mothers aged 18–44 years, in the 2006–2007 Maternity Experience Survey, and women aged 18–44 years with a child aged less than 5 years in the household in the 2007–2009 Canadian Health Measures Survey**

	MES			CHMS		
	N	%	(95% CI)	N	%	(95% CI)
<b>BMI<sup>a</sup></b>						
Underweight	4 400	6.0	(5.4 – 6.7)	89 500	6.5	(2.2 – 17.2)
Normal	43 900	59.3	(58.0 – 60.6)	725 600	52.3	(41.6 – 62.9)
Overweight	15 500	21.0	(19.9 – 22.1)	370 000	26.7	(20.1 – 34.6)
Obese	10 200	13.7	(12.8 – 14.6)	201 400	14.5	(8.2 – 24.3)
<b>Age, years</b>						
18–24	11 600	15.3	(14.5 – 16.1)	118 500	8.5	(2.9 – 22.9)
25–29	25 300	33.8	(33.0 – 34.7)	278 600	20.1	(14.0 – 27.9)
30–34	25 200	33.3	(32.4 – 34.2)	391 100	28.2	(21.2 – 36.5)
35–44	13 200	17.6	(16.7 – 18.5)	598 300	43.2	(32.7 – 54.2)
<b>Educational attainment</b>						
Less than high school graduate	5 300	7.0	(6.3 – 7.6)	91 100	6.6	(2.2 – 17.9)
High school graduate	14 500	19.4	(18.4 – 20.5)	330 300	23.9	(15.8 – 34.3)
Some post-secondary, including certificates or diplomas below a bachelor's degree	28 100	37.6	(36.4 – 38.9)	541 300	39.1	(30.4 – 48.5)
University (bachelor's or higher) degree	26 700	36.0	(34.8 – 37.2)	422 300	30.5	(19.5 – 44.3)
<b>Total</b>	<b>74 000</b>			<b>1 386 500</b>		

**Abbreviations:** BMI, body mass index; CHMS, Canadian Health Measures Survey; MES, Maternity Experience Survey.

**Note:** Not all columns add up to 74 000 (MES) or 1 386 500 (CHMS) due to rounding and some missing information on educational attainment (< 1% missing in MES, < 0.2% missing in CHMS).

<sup>a</sup> For the MES, BMI is based on self-reported prepregnancy weight and height; for the CHMS, BMI is based on self-reported weight and height at the time of data collection.

**TABLE 2**  
**Distribution of body mass index derived from measured and self-reported height and weight, and after applying two correction equations, 2007–2009 Canadian Health Measures Survey, subsample of women aged 18–44 years with a child less than 5 years in the household**

BMI	A Measured height and weight		B Self-reported height and weight		C Corrected 1 <sup>a</sup>		D Corrected 2 <sup>b</sup>	
	%	(95% CI)	%	(95% CI)	%	(95% CI)	%	(95% CI)
Underweight	5.0	(1.3 – 17.7)	6.5	(2.2 – 17.2)	2.0	(0.4 – 16.2)	3.7	(0.9 – 14.3)
Normal weight	49.3	(38.3 – 60.5)	52.3	(41.6 – 62.9)	46.9	(34.4 – 59.7)	50.0	(39.5 – 60.3)
Overweight	24.9	(17.9 – 33.5)	26.7	(20.1 – 34.6)	32.2	(23.4 – 42.4)	30.9	(23.6 – 39.2)
Obese	20.8	(12.7 – 32.1)	14.5	(8.2 – 24.3)	18.3	(10.0 – 31.0)	15.5	(9.3 – 24.7)

**Abbreviations:** BMI, body mass index; CI, confidence interval.

<sup>a</sup> Corrected 1 refers to regression coefficients calculated from the 2005 Canadian Community Health Survey for women ≥ 18 years regardless of birth history (unweighted n ≈ 1000).<sup>9</sup>

<sup>b</sup> Corrected 2 refers to regression coefficients calculated from the 2007–2009 Canadian Health Measures Survey subsample of women aged 18–44 years with a child < 5 years in the household (unweighted n ≈ 259).<sup>9</sup>

subsample (Table 4). Figures 1 and 2 illustrate BMI distributions before and after corrections were applied to the CHMS and MES subsamples, respectively.

Observed rates and corresponding RRs of uncorrected and corrected BMI distributions to caesarean, SGA and LGA births are shown in Table 5 and Figures 3a–c. Corrections had a negligible effect on the association between prepregnancy BMI and caesarean birth; nonsignificant increases were observed for associations with SGA and nonsignificant decreases for associations with LGA. For SGA, both corrections increased its association with being underweight, from an RR of 2.36 (95% CI: 1.67–3.34) to 2.65 (95% CI: 1.74–4.01) for Correction 1 and 2.83 (95% CI: 1.94–4.11) for Correction 2. For LGA, corrections generally decreased the association with being overweight or obese, for overweight prepregnancy BMI from an RR of 1.55 (95% CI: 1.27–1.89) to 1.28 (95% CI: 1.05–1.56) following Correction 1 and 1.41 (95% CI: 1.16–1.72) following Correction 2, and for obese prepregnancy BMI from an RR of 1.92 (95% CI: 1.54–2.39) to 2.10 (95% CI: 1.72–2.58)

following Correction 1 and 1.88 (95% CI: 1.52–2.31) following Correction 2.

### Discussion

It is well established that low and high prepregnancy BMI are associated with adverse pregnancy outcomes.<sup>1–3</sup> However, the potential impact of biased BMI measures on these associations has not been studied in Canada.

We found overall high concordance between BMI classification based on self-reported and measured data in the CHMS subsample, though misclassification had a substantial effect on the proportion of women in underweight and obese BMI categories. Transformations to correct for possible misclassification in data on BMI in the MES resulted in variable nonsignificant changes in the associations between prepregnancy BMI and pregnancy outcomes.

The high concordance between BMI classes based on self-reported and measured values in our CHMS sample is consistent with results from other studies of

adult women.<sup>10,15,16</sup> Although we cannot ascribe these findings to the MES, the Connor Gorber et al.<sup>9</sup> study found that the age of Canadian women did not significantly influence bias in BMI measures, but that lower education and self-reporting a height and weight combination that indicated overweight was associated with underestimating BMI.<sup>9</sup> In comparison with the CHMS, women in the MES were younger and appeared more educated and less overweight. This suggests that the tendency to underestimate BMI due to erroneous self-reported height and weight may be lower in the MES than in the CHMS. Younger age and lower weight among MES participants compared to CHMS women was expected, as MES data refer to the prepregnancy period while CHMS data refer to postpregnancy; women will be younger and generally weigh less prepregnancy than postpregnancy.<sup>17</sup>

In reproductive health, the extremes of the BMI distribution pose the greatest risk of adverse pregnancy outcomes. We observed that associations based on both reported and corrected prepregnancy BMI

**TABLE 3**  
**Classification of body mass index (BMI) derived from self-reported versus measured height and weight, 2007–2009 Canadian Health Measures Survey, subsample of women aged 18–44 years with a child less than 5 years in the household**

BMI from self-reported height and weight	BMI from measured height and weight				Total (N)
	Underweight (%)	Normal weight (%)	Overweight (%)	Obese (%)	
Underweight	75.5	24.5	0	0	89 500
Normal weight	< 1	90.8	8.9	< 1	725 600
Overweight	0	< 1	75.4	23.6	370 000
Obese	0	< 1	< 1	99.4	201 400

**Abbreviation:** BMI, body mass index.

**TABLE 4**  
**Distribution of prepregnancy body mass index based on self-reported height and weight and after applying two correction equations, 2006–2007 Maternity Experience Survey, subsample of women aged 18–44 years**

	Distribution of self-reported height and weight			Corrected 1 <sup>a</sup>			Corrected 2 <sup>b</sup>		
	n	%	(95% CI)	n	%	(95% CI)	n	%	(95% CI)
<b>Underweight</b>	4 400	6.0	(5.4 – 6.7)	2 400	3.2	(2.7 – 3.7)	3 300	4.5	(3.9 – 5.0)
<b>Normal weight</b>	43 900	59.3	(58.0 – 60.6)	39 500	53.5	(52.2 – 54.8)	41 500	56.1	(54.8 – 57.5)
<b>Overweight</b>	15 500	21.0	(19.9 – 22.1)	19 100	25.8	(24.7 – 27.0)	17 500	23.7	(22.5 – 24.8)
<b>Obese</b>	10 200	13.7	(12.8 – 14.6)	12 900	17.5	(16.5 – 18.5)	11 700	15.8	(14.8 – 16.7)
<b>Total</b>	74 000			74 000			74 000		

**Abbreviation:** CI, confidence interval.

**Note:** Not all columns add up to 74 000 due to rounding

<sup>a</sup> Corrected 1 refers to regression coefficients calculated from the 2005 Canadian Community Health Survey for women ≥ 18 years regardless of birth history (unweighted n ≈ 1000).<sup>9</sup>

<sup>b</sup> Corrected 2 refers to regression coefficients calculated from the 2007–2009 Canadian Health Measures Survey subsample of women 18–44 years with a child < 5 years in the household (unweighted n ≈ 259).

showed well-established dose-response patterns of underweight BMI increasing the risk for SGA birth, and overweight and obese BMI increasing the risk for LGA and caesarean birth.<sup>1–3</sup> However, there were no statistically significant changes in these patterns after corrections were applied to the MES data. This suggests that self-reported height and weight measures can be reliably used to study patterns of association between prepregnancy BMI and certain pregnancy outcomes.

The lack of significant impact of bias on these associations is encouraging as it suggests that collecting self-reported height and prepregnancy weight when direct measurement is not feasible is justifiable. Not only could such data capture the health effects of prepregnancy BMI, they could also be used to assess the effectiveness of public health programs

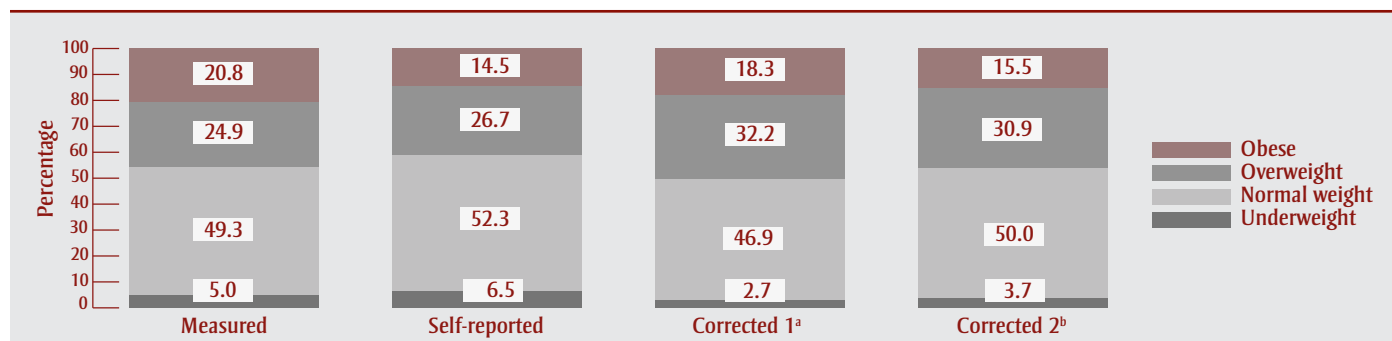
that promote healthy prepregnancy weight. Accurate monitoring and evaluation of population weights and intervention outcomes is an essential component in tackling the complex issue of unhealthy population weights.<sup>18</sup>

Although we observed no significant changes in the pattern of associations after correcting the MES data, the impact of bias on the BMI–outcome association could vary depending on the direction of the bias and the nature of the BMI–outcome relationship. Consequently, associations could be under- or overestimated. The nonsignificant increase in association between the underweight category of BMI and SGA after correction likely resulted from those in the underweight category being the most underweight and therefore at most risk of an SGA birth. The tendency towards a decrease in the association

between overweight and obese and LGA likely resulted from women in these categories having lower BMIs than those classified as overweight or obese based on self-reported height and weight. These women were thus at lower risk of having an LGA birth. Note that even if BMI based on self-reported height and weight overestimates the obese BMI–LGA association, the population burden of LGA due to obesity may still be underestimated because obesity derived from self-reported height and weight is underestimated.

A study on the impact of bias in self-reported gestational weight gain on low and high birthweight had findings similar to ours;<sup>19</sup> another study on the impact of bias in prepregnancy BMI on five pregnancy outcomes (including SGA and LGA)<sup>20</sup> found that associations were not significantly impacted, though reporting

**FIGURE 1**  
**Body mass index distribution derived from measured height and weight, self-reported height and weight and after applying two correction equations, 2007–2009 Canadian Health Measures Survey, subsample of women aged 18–44 years with a child less than 5 years in the household**

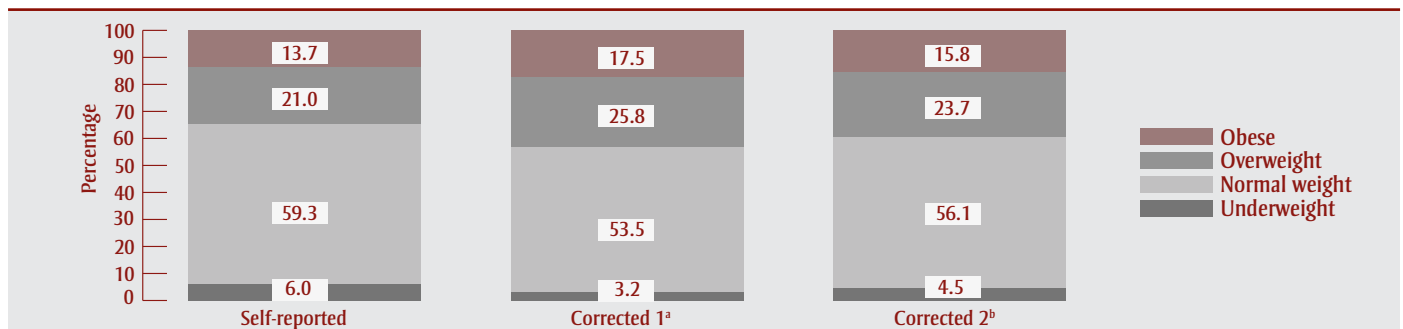


<sup>a</sup> Corrected 1 refers to regression coefficients calculated from the 2005 Canadian Community Health Survey for women ≥ 18 years regardless of birth history (unweighted n ≈ 1000).<sup>9</sup>

<sup>b</sup> Corrected 2 refers to regression coefficients calculated from the 2007–2009 Canadian Health Measures Survey subsample of women 18–44 years with a child < 5 years in the household (unweighted n ≈ 259).<sup>9</sup>



**FIGURE 2**  
**Prepregnancy body mass index distribution derived from self-reported height and prepregnancy weight and after applying two correction equations, 2006–2007 Maternity Experiences Survey, subsample of women aged 18–44 years**



<sup>a</sup> Corrected 1 refers to regression coefficients calculated from the 2005 Canadian Community Health Survey for women  $\geq 18$  years regardless of birth history (unweighted  $n \approx 1000$ ).<sup>9</sup>

<sup>b</sup> Corrected 2 refers to regression coefficients calculated from the 2007–2009 Canadian Health Measures Survey subsample of women 18–44 years with a child  $< 5$  years in the household (unweighted  $n \approx 259$ ).<sup>9</sup>

error attenuated associations. Studies of BMI bias and other outcomes, such as weight-related chronic diseases (e.g. diabetes and high blood pressure) also found that associations can be underestimated<sup>21</sup> or overestimated.<sup>22</sup> The negligible effect of adjustment on the BMI-caesarean section pattern suggests that other risks for caesarean are more dominant and independent of prepregnancy BMI.

### Strengths and limitations

Our study has several limitations. Due to the absence of measured height and weight in the MES, we used data from a CHMS subsample of women aged 18 to 44 years who had ever had a live birth and had a child younger than 5 years in their household, to estimate BMI bias in the MES. Other studies have shown that the

validity of such transportability is increased when equations are derived from the same population and in a similar time period.<sup>23–25</sup> We used available parameters in the CHMS (e.g. age and history of a live birth) to obtain the most suitable comparison group. Nevertheless, our populations were not exactly the same. Therefore, bias in the two populations may not be exactly the same, though the

**TABLE 5**  
**Association between adverse outcomes and prepregnancy body mass index based on self-reported height and weight and after applying two correction equations, 2006–2007 Maternity Experiences Survey, subsample of women aged 18–44 years**

	Self-reported		Corrected 1 <sup>a</sup>		Corrected 2 <sup>b</sup>	
	Rate (%)	Rate ratio (95% CI)	Rate (%)	Rate ratio (95% CI)	Rate (%)	Rate ratio (95% CI)
<b>Caesarean birth</b>						
Underweight	20.7	0.86 (0.65 – 1.13)	20.4	0.88 (0.60 – 1.30)	21.3	0.92 (0.66 – 1.27)
Normal weight (ref)	23.4	1.00	22.6	1.00	22.8	1.00
Overweight	29.4	1.36 (1.17 – 1.58)	28.6	1.37 (1.19 – 1.58)	29.3	1.40 (1.21 – 1.61)
Obese	37.5	1.96 (1.66 – 2.31)	36.3	1.96 (1.68 – 2.29)	36.6	1.96 (1.67 – 2.30)
<b>Small-for-gestational-age birth</b>						
Underweight	17.1	2.36 (1.67 – 3.34)	19.9	2.65 (1.74 – 4.01)	20.2	2.83 (1.94 – 4.11)
Normal weight (ref)	8.0	1.00	8.6	1.00	8.2	1.00
Overweight	7.5	0.93 (0.71 – 1.20)	7.3	0.84 (0.65 – 1.07)	7.2	0.86 (0.67 – 1.12)
Obese	6.1	0.74 (0.53 – 1.03)	6.2	0.70 (0.53 – 0.94)	6.2	0.74 (0.55 – 1.01)
<b>Large-for-gestational-age birth</b>						
Underweight	4.7	0.46 (0.27 – 0.79)	4.2	0.42 (0.17 – 1.02)	3.9	0.38 (0.18 – 0.80)
Normal weight (ref)	9.6	1.00	9.4	1.00	9.6	1.00
Overweight	14.2	1.55 (1.27 – 1.89)	11.7	1.28 (1.05 – 1.56)	13.1	1.41 (1.16 – 1.72)
Obese	17.0	1.92 (1.54 – 2.39)	17.9	2.10 (1.72 – 2.58)	16.6	1.88 (1.52 – 2.31)

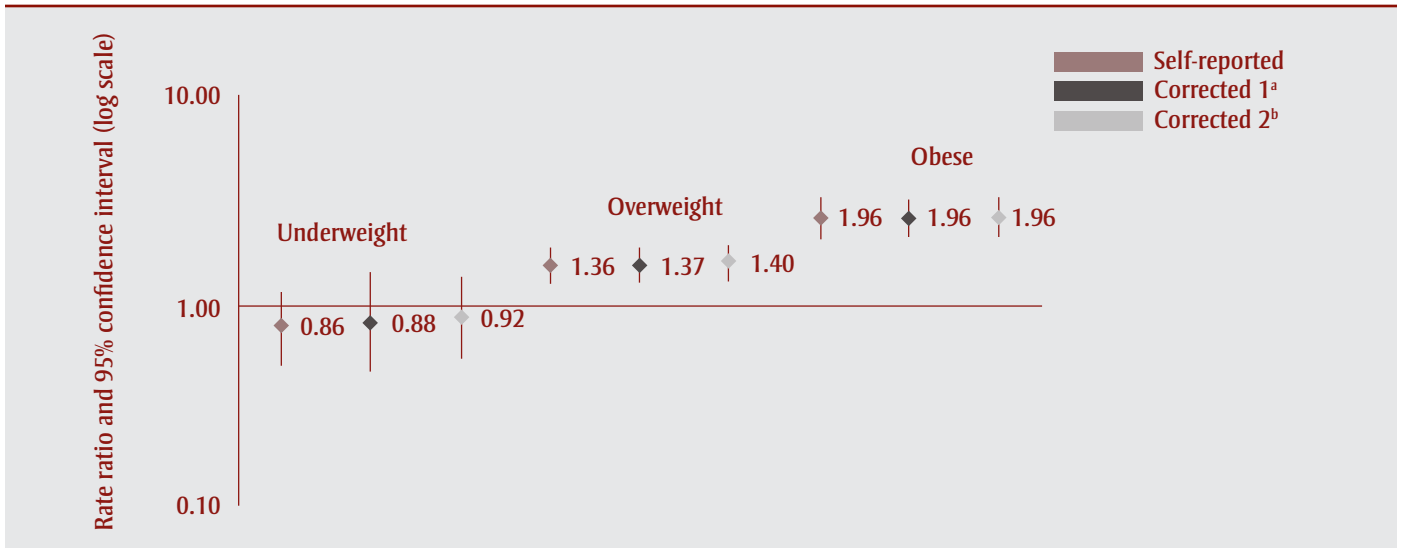
**Abbreviation:** CI, confidence interval; ref, reference group.

**Note:** Sample sizes for each weight category correspond to those shown in Table 4.

<sup>a</sup> Corrected 1 refers to regression coefficients calculated from the 2005 Canadian Community Health Survey for women  $\geq 18$  years regardless of birth history (unweighted  $n \approx 1000$ ).<sup>9</sup>

<sup>b</sup> Corrected 2 refers to regression coefficients calculated from the 2007–2009 Canadian Health Measures Survey subsample of women 18–44 years with a child  $< 5$  years in the household (unweighted  $n \approx 259$ ).<sup>9</sup>

**FIGURE 3a**  
**Association between caesarean births and prepregnancy body mass index based on self-reported height and prepregnancy weight and after applying two correction equations, 2006–2007 Maternity Experiences Survey, subsample of women aged 18–44 years**



<sup>a</sup> Corrected 1 refers to regression coefficients calculated from the 2005 Canadian Community Health Survey for women  $\geq 18$  years regardless of birth history (unweighted  $n \approx 1000$ ).<sup>9</sup>

<sup>b</sup> Corrected 2 refers to regression coefficients calculated from the 2007–2009 Canadian Health Measures Survey subsample of women 18–44 years with a child  $< 5$  years in the household (unweighted  $n \approx 259$ ).<sup>9</sup>

nature of BMI bias has been found to be similar in prepregnant women and the general population of adult women.<sup>26,27</sup>

We applied the same correction across BMI categories despite evidence of differential bias in categories. Though this differential bias suggests that category-specific corrections may be more

appropriate, more complex correction models that take the BMI category and other covariates into consideration (e.g. models based on polynomial or spline regression) have not shown that they produced corrections in reporting error significantly better than this simpler approach.<sup>9</sup>

In addition, analysis of bias by BMI categories does not allow for an unrestricted assessment of the relationship between bias and BMI derived from self-reported data, and the consequent impact of this bias on the BMI–outcome association. However, the BMI categorization we used is well established and has public health and clinical relevance.

**FIGURE 3b**  
**Association between small-for-gestational age births and prepregnancy body mass index based on self-reported height and prepregnancy weight and after applying two correction equations, 2006–2007 Maternity Experiences Survey, subsample of women aged 18–44 years**

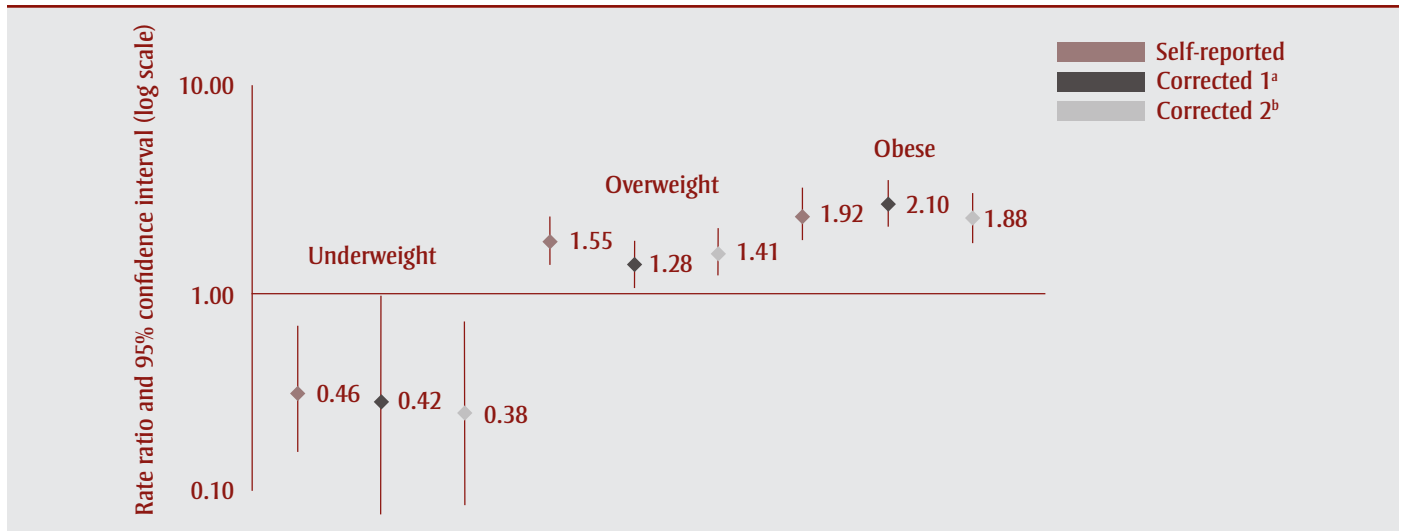


<sup>a</sup> Corrected 1 refers to regression coefficients calculated from the 2005 Canadian Community Health Survey for women  $\geq 18$  years regardless of birth history (unweighted  $n \approx 1000$ ).<sup>9</sup>

<sup>b</sup> Corrected 2 refers to regression coefficients calculated from the 2007–2009 Canadian Health Measures Survey subsample of women 18–44 years with a child  $< 5$  years in the household (unweighted  $n \approx 259$ ).<sup>9</sup>

FIGURE 3c

Association between large-for-gestational age births and prepregnancy body mass index based on self-reported height and weight and after applying two correction equations, 2006–2007 Maternity Experiences Survey, subsample of women aged 18–44 years



<sup>a</sup> Corrected 1 refers to regression coefficients calculated from the 2005 Canadian Community Health Survey for women  $\geq 18$  years regardless of birth history (unweighted  $n \approx 1000$ ).<sup>9</sup>

<sup>b</sup> Corrected 2 refers to regression coefficients calculated from the 2007–2009 Canadian Health Measures Survey subsample of women 18–44 years with a child  $< 5$  years in the household (unweighted  $n \approx 259$ ).<sup>9</sup>

Finally, as our focus was on assessing the impact of potential bias on BMI rather than on the BMI–pregnancy outcomes per se, we only calculated crude associations, which do not reflect the independent effect of prepregnancy BMI on the outcome.

## Conclusion

While the level of concordance between BMI classification derived from self-reported and measured data among women of reproductive age is high, possible bias in BMI derived from self-reported data may slightly over- or underestimate BMI associations, depending on the pregnancy outcome. Nonetheless, BMI derived from self-reported data appears to be a justifiable and reasonable way to identify overall trends in the association between prepregnancy BMI and certain pregnancy outcomes.

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# Childhood overweight and obesity trends in Canada

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## Abstract

**Introduction:** Excess weight is a key risk factor for chronic disease, and the systematic collection, analysis and reporting of key trends are important to surveillance of overweight and obesity.

**Methods:** We used univariate analyses to calculate current prevalence estimates of excess weight among Canadian children and youth.

**Results:** Almost 1 in 7 children and youth is obese. Rates vary based on sociodemographic factors such as age, sex, socioeconomic status and place of residence. Overall, the rates of excess weight have been relatively stable over the past decade.

**Conclusion:** Ongoing monitoring of childhood obesity will provide useful information to assist with sustained actions to promote healthy weights.

**Keywords:** *overweight, obesity, children, youth, sociodemographic factors*

## Highlights

- The surveillance of overweight and obesity trends in children and youth is important in informing research, programs and policies.
- The authors analyzed information from several national population-based surveys, including those with objectively measured data, to provide an update on excess weight in childhood in Canada.
- Almost 1 in 7 children and youth is obese.
- Rates of overweight and obesity vary based on factors such as age, sex, socioeconomic status and place of residence.

## Introduction

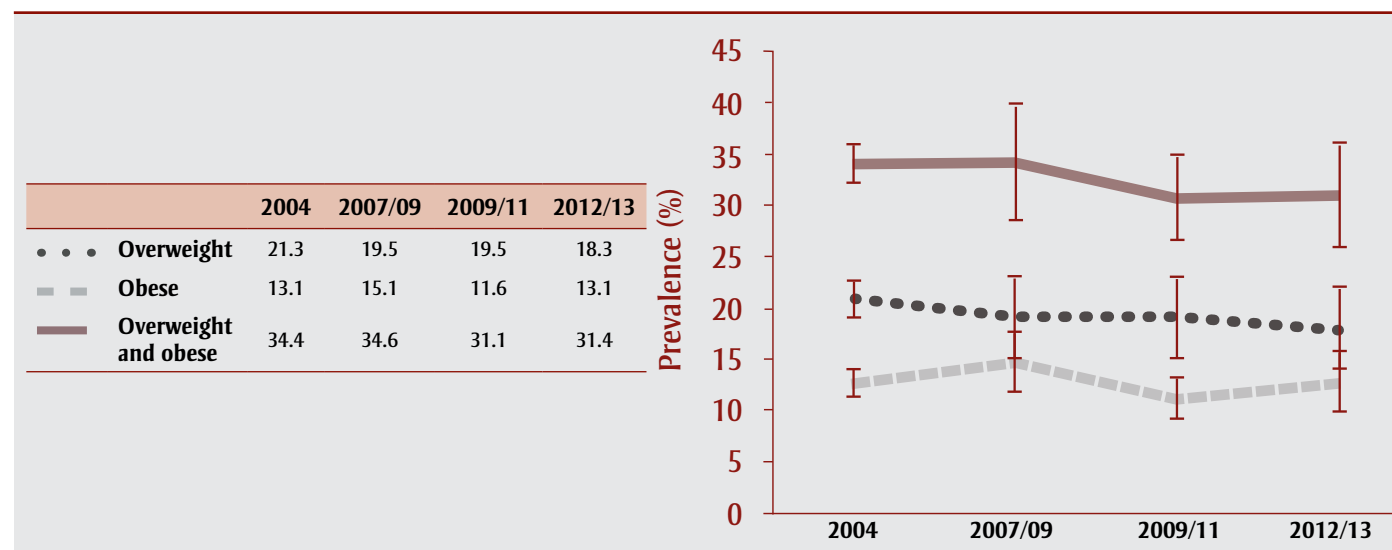
Since obesity is a major risk factor for chronic disease,<sup>1</sup> it takes a significant toll on the health care system, the economy and the quality of life of Canadians.<sup>2</sup> Over the last four decades, the prevalence of

obesity among children and youth in Canada has increased significantly.<sup>3</sup> As a result, they are increasingly diagnosed with a range of obesity-related health conditions previously seen almost exclusively among adults, including type 2 diabetes, high cholesterol, high blood pressure, depression, sleep apnea and joint

problems.<sup>1</sup> The added concern is that childhood obesity is known to track into adulthood.<sup>2</sup>

We previously reported on trends and projections in obesity among Canadians

**FIGURE 1**  
Prevalence of overweight and obesity, ages 6 to 17 years, Canada, 2004–2012/13



Source: Statistics Canada, Canadian Community Health Survey 2004 and Canadian Health Measures Survey 2007/09, 2009/11, and 2012/13.

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overall.<sup>4</sup> Regular reporting on childhood obesity as part of the Chronic Disease and Injury Indicator Framework<sup>5</sup> (CDIIF) provides basic breakdowns of the prevalence of obesity among children and youth by age, sex and sociodemographic factors. In this article, we build on this reporting by providing additional breakdowns using the variables already contained within the CDIIF, which are important to guide research, programs and policy in Canada. Updated trends in childhood overweight (in addition to obesity), trends in both overweight and obesity according to age and sex, an examination of sex differences

in the distribution of overweight and obesity by income adequacy (a key sociodemographic factor) and an examination of the distribution of obesity by place of residence elaborate and supplement the surveillance information contained within the CDIIF.

## Methods

### Data and data sources

Body mass index (BMI) is an indirect measure of adiposity (body fat) that correlates with health outcomes, both in the

short and the long term.<sup>6</sup> The Public Health Agency of Canada bases its weight charts on World Health Organization (WHO) growth reference charts: children whose BMI is two standard deviations (SDs) or more above the mean are considered obese and whose BMI is between one and two SDs above the mean are considered overweight.<sup>7</sup>

The statistics in this paper are based on the results from national population-based surveys. Self-reported measures of height and weight in children have been consistently available for many years, and since

**TABLE 1**  
Sociodemographic determinants of childhood obesity, ages 6 to 17 years, Canada, 2004–2012/13

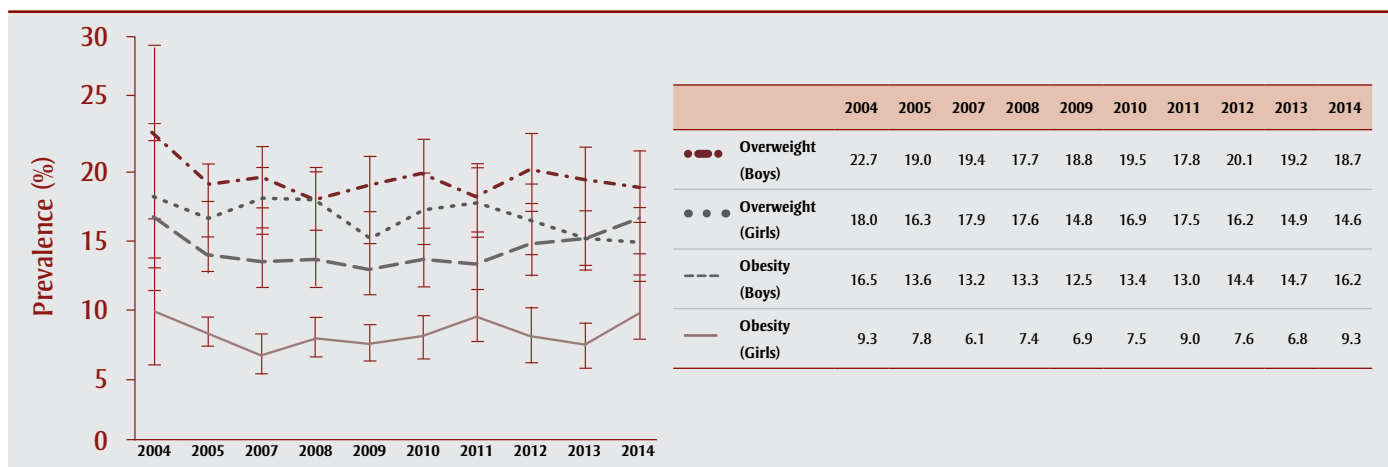
		Sociodemographic determinants			
		Prevalence (%)	95% CI	Prevalence (%)	95% CI
<b>Sex</b>		<b>Boys</b>		<b>Girls</b>	
<b>Overweight</b>	<b>2004</b>	22.1	19.8–24.4	20.2	18.0–22.5
	<b>2007/09</b>	20.8	16.3–25.4	18.1	14.7–21.5
	<b>2009/11</b>	19.4	14.8–24.0	20.2	15.4–25.1
	<b>2012/13</b>	18.7	15.2–22.2	18.6	12.4–24.8
<b>Obesity</b>	<b>2004</b>	15.5	13.4–17.7	10.6	8.9–12.3
	<b>2007/09</b>	17.9	14.4–21.4	11.9	8.6–15.3
	<b>2009/11</b>	14.7	11.8–17.6	8.2	5.5–11.0
	<b>2012/13</b>	15.3	9.8–20.7	10.8	8.2–13.4
<b>Overweight &amp; obesity</b>	<b>2004</b>	37.6	34.9–40.4	30.8	28.3–33.3
	<b>2007/09</b>	38.7	32.8–44.7	30.0	24.1–35.9
	<b>2009/11</b>	34.5	28.7–40.2	28.2	22.5–34.0
	<b>2012/13</b>	33.3	28.7–37.9	28.9	21.8–35.9
<b>Age group</b>		<b>Ages 6 to 11</b>		<b>Ages 12 to 17</b>	
<b>Overweight</b>	<b>2004</b>	22.1	19.7–24.6	20.3	18.3–22.3
	<b>2007/09</b>	21.0	16.8–25.3	18.0	14.1–22.0
	<b>2009/11</b>	19.0	15.5–22.5	19.9	15.0–24.8
	<b>2012/13</b>	16.2	11.7–20.8	20.1	16.4–23.8
<b>Obesity</b>	<b>2004</b>	13.9	11.9–16.0	12.3	10.6–14.0
	<b>2007/09</b>	14.6	11.6–17.6	15.3 <sup>f</sup>	10.1–20.5
	<b>2009/11</b>	13.3	10.2–16.3	10.2	7.1–13.3
	<b>2012/13</b>	9.6	7.3–11.9	16.6	11.6–21.7
<b>Overweight &amp; obesity</b>	<b>2004</b>	36.1	33.3–38.8	32.6	30.3–34.9
	<b>2007/09</b>	35.6	32.4–38.8	33.3	25.9–40.8
	<b>2009/11</b>	32.3	29.3–35.2	30.1	23.7–36.5
	<b>2012/13</b>	25.8	20.5–31.1	36.8	30.0–43.5

**Source:** Statistics Canada, Canadian Community Health Survey 2004 and Canadian Health Measures Survey 2007/09, 2009/11, and 2012/13.

**Abbreviation:** CI, confidence interval.

<sup>f</sup> Interpret with caution due to high sampling variability (coefficient of variation between 16.6% and 33.3%).

**FIGURE 2**  
Prevalence of overweight and obesity by sex, ages 12 to 17 years, Canada, 2004–2014



Source: Statistics Canada, Canadian Community Health Survey 2004–2014.

2007, the Canadian Health Measures Survey (CHMS) has routinely collected objectively measured anthropometric data. We used the Canada Health Survey (1978/79) to gather objectively measured BMI data for children aged 2 to 17 years; annual cycles of the Canadian Community Health Survey (2004 to 2014) for self-reported BMI data for children and youth aged 12 to 17 years and objectively measured BMI data for children aged 6 to 17 years for 2004; and the Canadian Health Measures Survey (2007/09, 2009/11 and 2012/13) for objectively measured BMI data for children and youth aged 5 to 17 years.

### Analyses

We examined trends and current estimates in childhood obesity using the WHO classification system. To reduce misclassification and bias (based on sex) in self-reported estimates, these data were adjusted using a correction factor that was established based on comparisons of self-reported and objective measures of weight status.<sup>8</sup> Descriptive analyses were completed using SAS Enterprise Guide version 5.1 (SAS Institute Inc., Cary, NC, USA). Relationships between variables were examined using chi-square tests, with significance at 0.05, to determine *p* values. Findings were weighted to reflect the

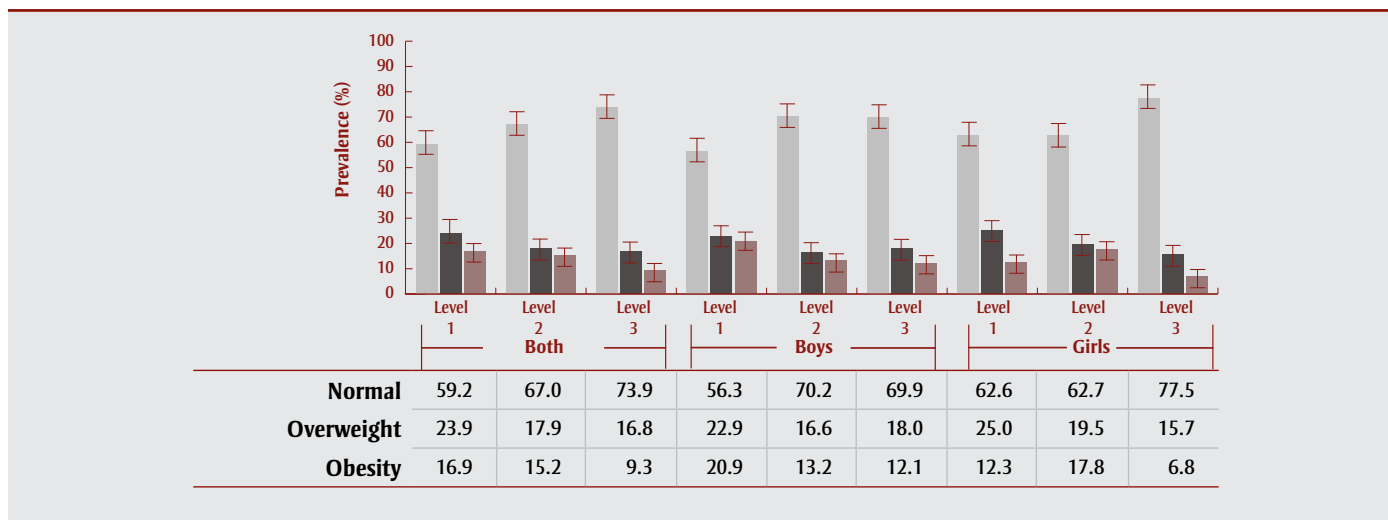
Canadian household population and 95% confidence intervals were calculated using bootstrap re-sampling methods. Trends over 10 years are reported, where possible.

## Results

### Trends

In 1978/79, about one in four children (23.3%; 95% CI: 20.5–26.0) was overweight or obese.<sup>9</sup> This proportion is now closer to one in three (31.4%; 95% CI: 26.4–36.4).

**FIGURE 3**  
Prevalence estimates of excess weight by income adequacy level, ages 5 to 17 years, Canada, 2012/13



Source: Statistics Canada, Canadian Health Measures Survey 2012/13.

Note: Level 1 is the lowest household income adequacy level while Level 3 is the highest.

Although objectively measured estimates of excess weight among children and youth have doubled over the past four decades, measures of childhood obesity have remained stable over the last 10 years (Figure 1).

### Sex

Differences in excess weight may arise due to biological reasons, such as sex-based patterning of fat distribution and energy requirements, or societal and cultural gender-based norms, such as food choices and body satisfaction.<sup>10</sup> Examining objectively measured excess weight over time and comparing these weights between the sexes at each time point does not show any significant difference (Table 1). However, when examining self-reported estimates, the prevalence of obesity among boys is significantly higher than that among girls (Figure 2), and rates of overweight appear to have remained stable.

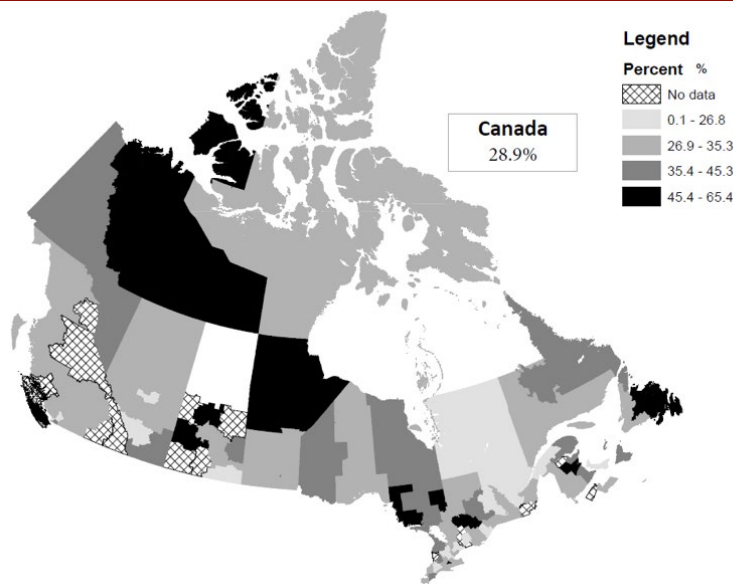
### Age

As individuals age, changes in activity patterns, hormone levels and muscle mass may all contribute to changes in weight status. In Canada, obesity appears to significantly increase through childhood and adolescence. Based on estimates from 2012/13, 8.5% (95% CI: 6.2–10.9) of 5- to 9-year-olds, 12.9% (95% CI: 7.2–18.6) of 10- to 14-year-olds and 18.2% (95% CI: 12.5–24.0) of 15- to 17-year-olds are obese. In comparison, the 2012/13 rates of overweight are 15.4% (95% CI: 11.5–19.3), 23.0% (95% CI: 16.4–29.6) and 17.1% (95% CI: 12.5–21.7) for the same age ranges, with age-based differences in excess weight not as apparent for overweight as for obesity. Trends in excess weight over the past decade do not differ significantly between age groups (Table 1).

### Socioeconomic status

Low-income population groups are known to be at increased risk of obesity.<sup>11</sup> Income adequacy level\* was found to be significantly associated ( $p = .02$ ) with childhood obesity, while having healthier weights was more likely for those with better access to income. Figure 3 shows the prevalence estimates of excess weight by income adequacy level for both sexes and for each sex.

**FIGURE 4**  
Prevalence of overweight and obesity by local health region



Source: Statistics Canada, Canadian Community Health Survey 2013/14, ages 12 to 17 years.

### Place of residence

While the national average prevalence of excess weight in children and youth is 28.9% (95% CI: 27.4–30.4, CCHS 2013-14), regional differences are observed (Figure 4). International comparisons also demonstrate similar rates: the prevalence of obesity among children is 13.1% (95% CI: 10.2–16.1) in Canada (6–17 years), 16.9% (95% CI: 14.9–19.2) in the United States (2–19 years, using CDC growth charts)<sup>12</sup> and 20% in the United Kingdom (2–15 years).<sup>13</sup>

### Conclusion

The stable trends in childhood obesity over the past decade are encouraging. Nevertheless, excess weight remains prevalent. Ongoing monitoring of childhood obesity will provide useful information to assist with sustained actions to promote healthy weights.

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\* Household income adequacy is a measure of income that takes into consideration the number of individuals within a household who share the total income, allowing a fair comparison between families, regardless of size.



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# Call for papers: The food environment in Canada

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## At-a-Glance

# Furanyl-fentanyl overdose events caused by smoking contaminated crack cocaine — British Columbia, Canada, July 15–18, 2016\*

S. A. Klar, MPH (1); E. Brodtkin, MD (1); E. Gibson (1); S. Padhi, MD (1); C. Predy (2); C. Green, MHSc (1); V. Lee, MD (1)

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On July 15 2016, Surrey Memorial Hospital's emergency department notified the medical health officer on call of a sharp increase in opioid overdose events in Surrey, Fraser Health Authority, in British Columbia, Canada. During July 15–18, the number of persons with suspected opioid overdose evaluated in Surrey Memorial Hospital's emergency department increased approximately 170%, from an average of four suspected cases per day during the period January–June 2016 to 43 (nearly 11 per day) during the 4-day period (Figure). Most patients (22 [51%]) became unconscious after smoking what they believed to be crack cocaine. The majority of overdose events occurred within a small

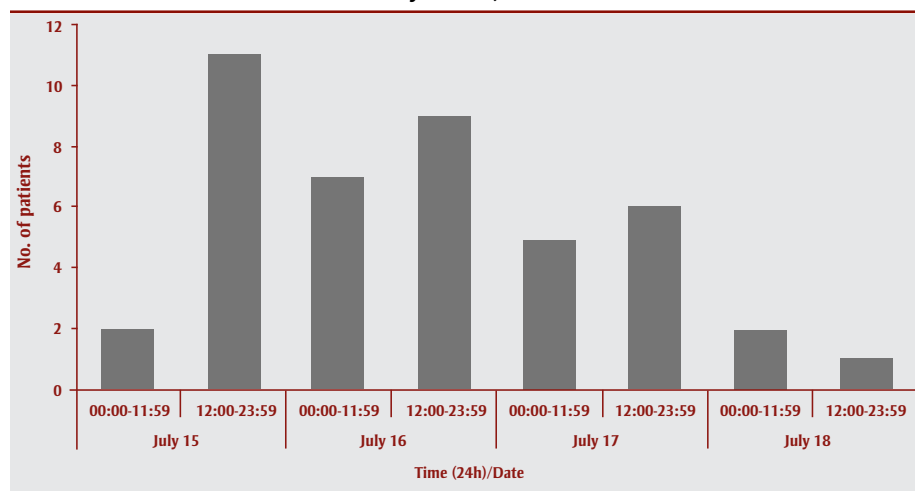
geographic area in Surrey that has a high population of homeless persons and persons who use illicit drugs, including opioids and crack cocaine. Most cases occurred in males (36 cases [84%]); the average age of the patients was 42 years (range = 18–63 years). Forty (93%) patients were brought to the emergency department by ambulance. A total of 37 (86%) patients received injectable naloxone before arriving in the emergency department, including 12 who received it only from community members, 16 who received it only from paramedics, five who received it from both community members and paramedics, one who received it from the fire department and paramedics, and one

who received it from the fire department, community, and paramedics; for two patients, the source of naloxone was not known. Reports from first responders, the community, and emergency department staff members indicated that patients required high doses of injectable naloxone, in some cases up to 3.0 mg (usual dose = 0.4 mg). Thirty-five (81%) patients were treated and discharged within a few hours, two patients left without being seen by a health care provider, and six patients were admitted to the hospital; among these, three were transferred to the intensive care unit, one of whom died.

Local laboratories do not always have capacity for quantitative fentanyl testing or detection of new analogs. The immunoassay urinalysis testing kits used at the local hospital laboratory (Sure Step [Alere Innovacon]) only detect fentanyl and norfentanyl. Therefore, select samples obtained by local police and the hospital were sent to the Health Canada Drug Analysis Service; these tested positive for a combination of furanyl-fentanyl and cocaine.

During July 15–18, Fraser Health Authority, in collaboration with community partners including police and persons who use illicit drugs, distributed warnings throughout the community and organized training sessions on naloxone administration in the affected area. Approximately 100 persons, many at high risk for overdose, were trained and received naloxone kits through the Take Home Naloxone program.†

**FIGURE**  
Number of suspected opioid overdoses (n = 43) evaluated at Surrey Memorial Hospital, by time of arrival in the emergency department — British Columbia, Canada, July 15–18, 2016



\* The text of this paper is identical in content to the primary article published in the journal *Morbidity and Mortality Weekly Report* as a “Notes from the Field” report released electronically on September 22, 2016, having met the guidelines for simultaneous publication as set forth by the International Committee of Medical Journal Editors ([www.icmje.org](http://www.icmje.org)).

† <http://www.healthlinkbc.ca/healthfiles/hfile118.stm>

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British Columbia is currently experiencing a public health emergency related to increases in drug-related overdose deaths, especially associated with opioids such as fentanyl. A similar increase has been reported in the United States,<sup>1,2</sup> where alerts have been issued regarding fentanyl- and fentanyl analog-adulterated pills, and furanyl-fentanyl has been detected during postmortem examinations.<sup>3,4</sup>

Laboratory investigations and community reports at the time of this event indicate that the spike in overdose events likely resulted from a batch of crack cocaine from one dealer, which was adulterated with furanyl-fentanyl, a fentanyl analog that had not previously circulated in this community. Based on reports from patients, community organizations providing services in the area on that weekend, and police, ambulance, and fire services, the substance was consumed by persons who had a longstanding history of drug use but who might not have used opioids regularly. There have been police reports of cocaine contaminated with fentanyl in the neighboring city of Delta<sup>5</sup> and of United States overdose events from cocaine contaminated with acetylfentanyl in King County, Washington.<sup>6</sup>

This is the first reported cluster of overdose events caused by crack cocaine contaminated with furanyl-fentanyl in North America. Persons who use illicit drugs, health care providers, first responders, and poison control centers should be alert for symptoms of opioid overdose even when the drug consumed is reported to be a nonopioid, such as crack cocaine. Rapid distribution of naloxone kits with training to community organizations and populations at high risk, and provision of naloxone kits to patients evaluated for suspected opioid overdoses in emergency departments, could help mitigate the impact of opioid overdoses.

## Acknowledgements

Staff of the Emergency Department at Surrey Memorial Hospital; British Columbia Ambulance Service; Surrey Fire Service, British Columbia; Surrey Royal Canadian Mounted Police, British Columbia; Drug Overdose Alert Partnership, British Columbia; British Columbia Centre for Disease Control; Health Canada Drug Analysis Service (Burnaby); British Columbia Drug and Poison Information Centre; community organizations and

persons who reversed overdoses and helped with distribution of naloxone kits and health warnings.

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# Erratum

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This erratum is being published to correct a reference error and a related error in the third paragraph of the following article:

Harland E, Griffith J, Lu H, Erickson T, Magsino K. Health behaviours associated with indoor tanning based on the 2012/13 Manitoba Youth Health Survey. *Health Promot Chronic Dis Prev Can.* 2016;36(8):149-62.

## ***Before correction***

“Ever use” of tanning beds before the age of 25 was found to significantly increase melanoma risk,<sup>8-9</sup> and correlations have also been found between indoor tanning and basal and squamous cell carcinoma.<sup>9-11</sup>

### ***with reference 8 as the following:***

8. Colantonio S, Bracken MB, Beecker J. The association of indoor tanning and melanoma in adults: systematic review and meta-analysis. *J Am Acad Dermatol.* 2014;70(5):847-57. doi: 10.1016/j.jaad.2013.11.050.

## ***After correction***

“Ever use” of tanning beds before the age of 35 was found to significantly increase melanoma risk,<sup>8-9</sup> and correlations have also been found between indoor tanning and basal and squamous cell carcinoma.<sup>9-11</sup>

### ***with reference 8 as the following:***

8. Boniol M, Autier P, Boyle P, Gandini S. Cutaneous melanoma attributable to sunbed use: systematic review and meta-analysis. *BMJ.* 2012;345:e4757. doi: 10.1136/bmj.e4757.

***Please note that the relative risk for first exposure to sunbed use starting before age 35 years and confidence interval reported in the Boniol et al. article were corrected on 13 December 2012. See doi: 10.1136/bmj.e8503.***

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## Other PHAC publications

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Frize M, Martirosyan H, **Subaskaran J**, **McFaul SR**, **Skinner R**, **Tiv M**. Classification of undetermined deaths by poisoning: suicidal or unintentional. *IFMBE Proceedings*; 2016. doi: 10.1007/978-3-319-32703-7\_158.

**Rao DP**, **Orpana H**, Krewski D. Physical activity and non-movement behaviours: their independent and combined associations with metabolic syndrome. *Int J Behav Nutr Phys Act*. 2016;13(26). doi: 10.1186/s12966-016-0350-5.

Tonelli M, Parkin P, Leduc D, Brauer P, Pottie K, **Jaramillo Garcia A**, **Martin W**, **Connor Gorber S**, **Ugnat A-M**, **Ofner M**, Thombs BD. Recommendations on screening for developmental delay. *CMAJ*. 2016;188(8):579-587. doi: 10.1503/cmaj.151437.

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