Examining the Role of the School Food Environment in Moderating Sugar-sweetened Beverage Consumption Among Adolescents in Alberta and Ontario, Canada: Cross-sectional and Longitudinal Evidence from the COMPASS Study

by

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AUTHOR'S DECLARATION

This thesis consists of material all of which I authored or co-authored: see Statement of Contributions included in the thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public.

STATEMENT OF CONTRIBUTIONS

This thesis consists in part of three manuscripts that have been submitted for publication. Exceptions to sole authorship:

Chapter 3: Godin, K.M., Chaurasia, A., Hammond, D., & Leatherdale, S.T. (Accepted, December 2017). Food purchasing behaviours and sugar-sweetened beverage consumption among Canadian secondary school students in the COMPASS study. Published online in the *Journal of Nutrition Education and Behavior*.

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Chapter 5: Godin, K.M., Hammond, D., Chaurasia, A., & Leatherdale, S.T. (Submitted, March 2018). Examining changes in school vending machine beverage availability and sugar-sweetened beverage intake among Canadian adolescents participating in the COMPASS study: A longitudinal assessment of provincial school nutrition policy compliance and effectiveness. Under review in the *International Journal of Behavioral Nutrition and Physical Activity*.

As lead author of these three chapters, I was responsible for conceptualizing the study design, contributing to the data collection, conducting the data analysis, and drafting and submitting manuscripts. My co-authors provided guidance during each step of the research and provided feedback on draft manuscripts.

Under Dr. Scott Leatherdale's supervision, I also prepared the remaining chapters in this thesis, which were not written for publication.

ABSTRACT

Adolescents represent the greatest consumers of sugar-sweetened beverages (SSBs) in Canada, which is concerning, given the numerous adverse health outcomes associated with frequent SSB intake. Provincial school nutrition policies represent one population-level strategy intended to promote healthy dietary choices among Canadian youth. Both the *Alberta Nutrition Guidelines for Children and Youth* (*ANGCY*) and Ontario's *Policy/program Memorandum no. 150* (*P/PM 150*) recommend restrictions in SSB availability in school food outlets (e.g., cafeterias, vending machines, etc.) to decrease students' access to products. There exists a broad range of contextual factors outside of schools that influence youths' dietary choices; influences within other environments (e.g., the home, community, and larger regulatory contexts) can support or undermine school-based interventions, and should be accounted for in the development and evaluation of these initiatives.

This dissertation research used the socioecological model as a theoretical framework to examine the role of the school context in influencing Canadian adolescents' SSB intake in Alberta and Ontario. The objectives were to (i) characterize Canadian adolescents' SSB consumption patterns; (ii) describe school food environment characteristics in Canadian secondary schools; (iii) describe how these characteristics reflect school-level compliance with provincial school nutrition policies; (iv) identify associations between school food environment characteristics and measures of students' SSB intake; and, (v) identify potentially promising contexts and/or strategies for future population-level initiatives to reduce adolescents' SSB intake. Three manuscripts served these objectives using student- and school-level data from the COMPASS study. The first two manuscripts represent cross-sectional analyses (2013/14), while the third manuscript includes longitudinal analyses (2013/14 to 2015/16).

The first manuscript examined how several food purchasing behaviors (i.e., sources of meals/snacks) within and outside of the school context are associated with adolescents' SSB consumption, and whether these associations vary by province. This study identified that most of the food purchasing behaviours were significantly and positively associated with greater rates of SSB consumption. Meal/snack purchases on weekends (versus weekdays) and from food outlets off-school property (versus on-school property) had a greater association with SSB consumption. The research identified a significantly higher rate of SSB intake among Albertan participants and a number of interesting interaction effects between province and various food purchasing behaviours, providing evidence that students' rate of SSB intake may be related to differences in provincial school nutrition policies.

The second manuscript provided a scoping assessment of several characteristics of the secondary school food environment (i.e., comprising features of the school and school neighbourhood) in Alberta and

Ontario, provincial differences across these school characteristics, as well as whether these characteristics are associated with students' SSB consumption rate. This study identified that participants had access to several potential sources of SSBs during their time in school; most schools were within walking distance of one or more external food outlets and a considerable proportion of schools stocked various types of SSBs in their vending machines. SSBs were significantly less available in Ontario schools' vending machines compared to those in Alberta, suggesting that *P/PM 150* is more effective than the *ANGCY* at restricting SSB availability in school vending machines. Few of the school food environment characteristics assessed were significantly associated with students' SSB intake.

The third manuscript examined changes in product availability within secondary schools' beverage vending machines, changes in students' weekday intake of SSBs over time, and the associations between these measures of beverage availability and SSB intake. Schools were separated into three policy groups: 'Alberta'; 'Ontario public schools'; and, 'Ontario private schools'. Most SSB types examined were least available in Ontario public schools' vending machines across all time points. Generally, vending machine beverage availability did not vary significantly over time. Across all policy groups, participants' rate of soft drinks consumption decreased as they progressed through secondary school, while their intake of sweetened coffees/teas increased; other SSB outcome measures remained fairly stable. Students in Alberta reported the greatest frequency of SSBs intake across all time points and measures. There was limited evidence that changes in vending machine beverage availability was significantly associated with students' SSB consumption.

This dissertation enhances our current understanding of Canadian adolescents' SSB intake patterns, the Canadian secondary school food environment, and the successes and shortcomings of school nutrition policies. This work signals the need for continued efforts to reduce adolescents' SSB intake. This dissertation illustrates that the school food environment represents a source of SSBs for Canadian adolescents, since most schools are nearby external food outlets and many schools have SSBs available for sale within school vending machines. However, this research highlights that schools are one of many contexts that influences adolescents' dietary behaviours, and efforts to limit the in-school availability of SSBs in vending machines have a limited impact on measures of adolescents' SSB intake. This research signals the need for school-based interventions to be supported by parallel population-level initiatives that encourage healthy dietary choices among Canadians.

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LIST OF ABBREVIATIONS

AB	Alberta
ANGCY	*Alberta Nutrition Guidelines for Children & Youth*
BMI	Body mass index
CCHS	Canadian Community Health Survey
CI	Confidence interval
CMRL	CanMap RouteLogistics
COMPASS	Cannabis use, Obesity Mental health Physical activity Alcohol use Smoking Sedentary behaviour study
Co-SEA	COMPASS School Environment Application
DMTI	Desktop Mapping Technologies Inc.
EPOI	Enhanced Points of Interest
HDL	High-density lipoprotein
HFCS	High-fructose corn syrup
ON	Ontario
P/PM 150	*Policy/program Memorandum no. 150*
SE	Standard error
SES	Socioeconomic status
SD	Standard deviation
SSB	Sugar-sweetened beverage
VIF	Variance inflation factor
WHO	World Health Organization

Chapter 1
Introduction

1.1 Key definitions and scope

The overarching aim of this dissertation research was to examine the consumption and availability of sugar-sweetened beverages (SSBs). There is considerable variation in how this beverage category has been defined in previous research, as well as what specific beverage types it comprises. The following definitions are intended to clarify the key beverages of interest within this current research:

Sugar-sweetened beverages are a category of beverages sweetened with added sugars. SSBs comprise a wide variety of beverages, including regular sodas, soft drinks, fruit drinks (i.e., beverages with <100% fruit juices), sports drinks, energy drinks, many alcoholic drinks, flavoured milk products, and sweetened coffees and teas. Other names for SSBs include "nutritively-sweetened beverages" and "calorically-sweetened beverages".

Added sugars are defined as any fructose-containing sweetener added to foods and beverages in processing (Lustig, Schmidt, & Brindis, 2012). Added sugars comprise sucrose, honey, molasses, high-fructose corn syrup, and various other nutritive sweeteners (Bray, Nielsen, & Popkin, 2004).

Sugary drinks are a category of beverages sweetened with free sugars, which is broader than added sugars (Jones, Veerman, & Hammond, 2017). The beverage category includes all SSBs in addition to beverages containing 100% juice.

Free sugars include sugars added to foods and beverages, plus sugars naturally present in honey, syrups, fruit juices, and fruit juice concentrates (World Health Organization, 2015a). These sugars are metabolized the same way as added sugars (World Health Organization, 2015a).

"Diet" beverages are broadly defined as beverages sweetened with contain low-calorie sweeteners. Many SSB types are available in diet versions, including sodas, soft drinks, sports drinks, energy drinks, and sweetened coffees and teas.

Low-calorie sweeteners are sugar substitutes that have zero calories. These sweeteners may be artificially-manufactured or naturally-occurring and derived from plants. Other names for low-calorie sweeteners include "alternative sweetener" and "sugar substitutes". Examples of common low-calorie sweeteners include aspartame, saccharin, sorbitol, stevia, and xylitol.

As mentioned, SSBs were the primary focus of this dissertation research, and these beverages were conceptualized using the above-stated definition. The availability of other beverage categories/types (e.g., 100% juices, water, flavoured milk) was also assessed, with the aim of better understanding the full complement of beverages available in Canadian secondary schools' vending machines.

The literature review was conducted bearing in mind the variation in how SSBs have been conceptualized in previous research. As such, when SSBs are referred to in a general sense, these references reflect more than one SSB type (i.e., providing a sense of the beverage category versus discrete beverage types). For example, much of the research (particularly, systematic reviews and meta-analyses) on the health impacts of SSBs does not distinguish between SSB types and instead refers to the category as a whole; this lack of specificity is thus reflected in Section 1.3, which details these health concerns. However, appreciating the important distinctions between SSB types (i.e., in their nutrient content, availability, etc.), general efforts were made to be explicit about specific SSB types when synthesizing the existing literature.

1.2 SSB consumption among Canadian adolescents

Adolescents are the largest consumers of SSBs in Canada, and many Canadian youth consume these beverages regularly (Jones et al., 2017). The nationally-representative 2004 Canadian Community Health Survey (CCHS) identified that 53.0% of males and 35.0% of females aged 14-18 years consumed soft drinks the day before they were surveyed, while 35.0% and 34.0% of males and females within this age group reported consuming fruit drinks (Garriguet, 2008). Beverages accounted for nearly one-fifth of adolescents' total energy intake (Garriguet, 2008), which likely reflects the popularity of SSBs among youth and the beverages' high energy density. Another analysis of 2004 CCHS data assessed adolescents' consumption of a wider range of beverages, and concluded that beverage intake patterns among Canadian youth include beverages that are predominantly sugar-sweetened (Danyliw, Vatanparast, Nikpartow, & Whiting, 2011). Data from the 2015 CCHS are not yet publicly available, but will soon provide a more contemporary estimate of Canadian adolescents' SSB consumption. Data from the 2014/15 Canadian Health Measures Survey reported that 16.0% youth aged 5-17 report drinking SSBs daily (Public Health Agency of Canada, 2017), which is a considerably lower proportion than the 2004 CCHS estimates. This finding may reflect decreases in Canadian youths' SSB consumption over time, mirroring trends in the United States (Kit, Fakhouri, Park, Nielsen, & Ogden, 2013; Miller, Merlo, Demissie, Sliwa, & Park, 2017). However, it is also likely that the wide age range (i.e., inclusion of both children and adolescents) skews the proportion of daily SSB consumers downwards, since SSB intake tends to increases as youth progress from childhood to adolescence (Garriguet, 2008).

Beyond these nationally-representative surveys, a number of studies have investigated Canadian adolescents' SSB intake in various regions across the country. Vanderlee et al. assessed beverage intake among secondary school-aged youth within Ontario and Prince Edward Island and identified that 80.3% of the adolescents reported consuming at least one SSB during the previous day, while 44.1% reported consuming three or more SSBs (Vanderlee, Manske, Murnaghan, Hanning, & Hammond, 2014). Fruit drinks and sodas were the most popular SSBs among participants, while consumption of sweetened coffee beverages and energy drinks were reported less frequently (Vanderlee et al., 2014). Another study set in Ontario identified considerable variation in secondary school students' SSB intake, with one-third of students reporting no SSB consumption in a usual school week and 13.7% reporting consuming at least one SSB daily (Jones, Hammond, Reid, & Leatherdale, 2015). Further, a systematic review identified that diets of school-aged Indigenous youth in Canada are largely characterized by an excessive consumption of energy-dense, nutrient-poor "other foods" like SSBs (Gates, Skinner, & Gates, 2015).

Other Canadian studies have focused on discrete beverage types, as opposed to a broader range of SSBs collectively. In particular, there has been considerable concern in recent years surrounding adolescents' energy drink consumption, and several studies have demonstrated that Canadian adolescents consume energy drinks frequently (Azagba, Langille, & Asbridge, 2014; Gupta, Wang, Collette, & Pilgrim, 2013; Hamilton, Boak, Ilie, & Mann, 2013; Reid, Hammond, McCrory, Dubin, & Leatherdale, 2015). For example, one study of secondary school students in Ontario identified that nearly one-fifth of participants consumed energy drinks at least once in a usual week (Reid et al., 2015). Sodas represent another specific SSB type of interest in previous research. A provincially-representative study in British Columbia reported that 42.3% of adolescents reported drinking soda during the previous day (Mâsse, de Niet-Fitzgerald, Watts, Naylor, & Saewyc, 2014).

While these studies provide evidence that SSBs are popular among Canadian youth, they also highlight the paucity of Canadian literature investigating adolescents' SSB consumption patterns. Our most comprehensive nationally-representative data are more than a decade old and may not reflect current SSB intake trends. Other investigations of Canadian adolescents' SSB intake have been limited to relatively few jurisdictions across the country and/or focus on a select SSB type, rather than more general beverage consumption patterns. Much of the research has relied on measures of adolescents' dietary intake within the past day (e.g., via a 24-hour recall method), which may not represent their usual consumption patterns. For example, it appears that no studies to date have examined Canadians youths' SSB consumption on weekdays versus weekend days, yet they are key contextual differences (i.e., in settings, activities, etc.) between these periods that would likely impact adolescents' SSB intake. Finally, the

existing literature is dominated by cross-sectional studies, and there is a need for longitudinal assessments of Canadian adolescents' SSB intake (Danyliw et al., 2011).

1.3 Health concerns

The popularity of SSBs among Canadian adolescents is concerning, given their associated health consequences. Previous literature has described specific concerns surrounding the added sugars and caffeine in these beverages, as well as associations between SSB intake and many ill health conditions.

1.3.1 Added sugar intake

A primary concern with SSBs centres on their high levels of added sugars, as these beverages represent a major dietary source of added sugars (Harrington, 2008; Hu & Malik, 2010; Malik, Schulze, & Hu, 2006; Malik et al., 2010; Malik, Popkin, Bray, Despres, & Hu, 2010; Malik & Hu, 2011; Vartanian, Schwartz, & Brownell, 2007). This finding reflects the nature of the general food supply, since the vast majority of beverages available at Canadian grocery retailers contain added sugars (Acton, Vanderlee, Hobin, & Hammond, 2017). Data from the 2004 CCHS demonstrate that added sugars intake peaks during adolescence, from which it remains relatively stable across the lifespan, and that soft drinks were the single greatest source of both total and added sugars in adolescents' diets (Brisbois, Marsden, Anderson, & Sievenpiper, 2014). There is no quantitative recommendation for added sugars intake in Canada, reflecting the lack of evidence to support a single quantitative added sugar guideline covering all health issues (Ruxton, Gardner, & McNulty, 2009). The forthcoming percentage daily value for *total sugars* on the Nutrition Facts table on prepackaged food and beverages will be based on 100 grams, though Health Canada states that this value is not a recommended level of intake; rather, it is the amount of total sugars that is "consistent with a healthy eating pattern…where sugars come mostly from fruit, vegetables and plain milk" (Health Canada, 2018). The World Health Organization (WHO) also lacks a recommendation for added sugars; however, they recommend that individuals limit their intake of *free sugars* to <10% of their total energy intake, and state that further limiting intake to ≤5% is preferable (World Health Organization, 2015a).

These calls for reductions in sugar intake stem from the known health effects of sugar. Fructose, the central component of added sugars, is metabolized in the liver, where it yields adverse effects akin to those caused by alcohol (Lustig et al., 2012). These effects are thought to independently contribute to numerous chronic conditions, including hypertension, insulin resistance, diabetes, and liver damage (Lustig et al., 2012). Fructose also contributes to elevated serum uric acid levels and hyperinsulinemia (Hu & Malik, 2010; Johnson et al., 2009), which are both independent risk factors for obesity and metabolic syndrome (Johnson et al., 2007). There are unique concerns with high-fructose corn syrup

(HFCS), a specific type of added sugar (Bray et al., 2004; Drewnowski & Bellisle, 2007; Lustig et al., 2012; Te Morenga, Mallard, & Mann, 2013). Researchers believe HFCS may be digested, absorbed, and metabolized differently than other sweeteners, trigger adverse changes in metabolic function (e.g., changes to insulin secretion and leptin production) that can increase individuals' risk of these chronic conditions, promote positive energy imbalance, and contribute to weight gain (Bray et al., 2004). Johnson and colleagues (2009) posited that excessive HFCS (i.e., which they defined as >50 g/day - slightly more than the amount of HFCS in a can of Pepsi) is one of the key contributors to metabolic syndrome and type II diabetes. Some researchers attest that the negative health effects of added sugar intake are compounded by their addictive properties, since sugar can activate the same "pleasure" centre circuitry of the brain that is activated by drugs of abuse and alcoho1 (Garber & Lustig, 2011; Lustig et al., 2012). However, much of this supporting research stems from animal studies (Avena, Rada, & Hoebel, 2008), and a recent review found little evidence for sugar addiction based upon DSM-V criteria for substance use disorders and brain imaging studies (Corwin & Hayes, 2014). Despite the mixed evidence about the dependency-inducing properties of added sugars, the available evidence clearly signals that SSBs are a chief dietary source of added sugars among adolescents and these sugars are not consistent with a healthy diet.

1.3.2 Caffeine

The caffeine found in many SSBs represents an additional concern associated with consumption of SSBs. The caffeine content of SSBs can range from <5mg/serving (chocolate milk) to 141 mg/serving (certain varieties of energy drinks); the caffeine content carbonated sodas, iced teas, and sweetened coffee beverages falls between these extremes (McCusker, Goldberger, & Cone, 2006). Energy drinks vary greatly in their caffeine content (Reissig, Strain, & Griffiths, 2009) and often are available in large non-re-sealable containers intended to be consumed in one sitting (Harris & Munsell, 2015). For example, a 32-oz can of Monster Energy contains 320 mg of caffeine and 108 g of sugar. There have been few investigations of caffeine intake and the main dietary sources of caffeine among Canadian adolescents; however, a recent nationally-representative American study identified that sodas provided one-third (33.0%) of adolescents' total caffeine intake, making it the largest source, followed by tea (28.0%), coffee (25.0%), and energy drinks (10.0%) (Drewnowski & Rehm, 2016). There is no established minimum "safe" level of caffeine intake in youth populations, due to the paucity of studies examining the physiological and psychological effects of caffeine on children and adolescents (Temple, 2009). Health Canada has yet to develop definitive recommendations for adolescents' caffeine intake; however, they suggest that adolescents limit their daily caffeine consumption to 2.5 mg per their weight in kilograms (i.e., representing 150 mg of caffeine for a 60 kg adolescent) (Health Canada, 2012).

Numerous studies have examined the potential health effects of caffeinated beverages, particularly, energy drinks, among adolescents. A recent review listed caffeine physiological dependence, withdrawal symptoms (i.e., headache, drowsiness, irritability, and decreased reaction time and attention after caffeine use is discontinued), caffeine intoxication (i.e., which may include cardiovascular and abdominal effects, seizures, and agitation, and in very rare cases, death), sleep disturbances, anxiety, and restlessness among the chief physiological consequences associated with excessive caffeine and/or energy drink intake among adolescents (Harris & Munsell, 2015). There are unique concerns about mixing alcohol with energy drinks (Blankson, Thompson, Ahrendt, & Patrick, 2013); however, most energy drink–related emergency visits are attributed to energy drink intake alone (Harris & Munsell, 2015). Researchers speculate that youth are more vulnerable to the adverse physiological effects of caffeine than adults, since childhood and adolescence are critical developmental periods characterized by rapid growth, the establishment of eating patterns and taste preferences, and ongoing brain development (Temple, 2009). Energy drink intake is also associated with various risk behaviours among youth, including alcohol use, smoking, sensation seeking, and illicit drug use (Arria, Bugbee, Caldeira, & Vincent, 2014; Harris & Munsell, 2015; James, Kristjánsson, & Sigfúsdóttir, 2011; Reissig et al., 2009; Temple, 2009), although there is a paucity of longitudinal studies that have determined the direction of these associations.

1.3.3 Overweight and obesity

Several reviews suggest that SSBs contribute to weight gain and obesity in adults and children (Harrington, 2008; Hu & Malik, 2010; Malik et al., 2006; Malik, Willett, & Hu, 2009; Malik et al., 2010; Malik & Hu, 2011; Te Morenga et al., 2013). Energy imbalance, which occurs when energy intake exceeds energy expenditure, is speculated to be the primary mediator between SSB consumption and weight gain (Harrington, 2008; Hu & Malik, 2010; Malik et al., 2006; Malik et al., 2010; Malik et al., 2010; Te Morenga et al., 2013; Vartanian et al., 2007). SSBs are often described as a source of "empty calories", since they typically provide significant energy but few to no nutrients. Individuals tend to not account for energy consumed through liquid forms as they do for energy from solid foods (DiMeglio & Mattes, 2000; Harrington, 2008; Vartanian et al., 2007), and thus often do not compensate for energy consumed through drinks by reducing their energy intake in later eating occasions. Other explanations for the association between SSB consumption and increased energy intake include the low satiety of sugary drinks, their ability to incite feelings of hunger, their tendency to calibrate consumers to a higher level of sweetness that affects their preferences in other foods, and their ability to increase individuals' appetites for other unhealthy foods and beverages (Drewnowski & Bellisle, 2007; Malik et al., 2006; Schulze et al., 2004; Vartanian et al., 2007; World Health Organization, 2003). Given the purported association between

SSB intake and overweight and obesity, SSB consumption may contribute to the development of obesity-associated diseases (e.g., metabolic syndrome, osteoarthritis, cardiovascular disease, etc.).

1.3.4 Other adverse health outcomes

There are associations between SSB intake and other markers of poor metabolic and cardiovascular health among adolescents, independent of overweight/obesity. A nationally representative study of American adolescents identified a positive and significant correlation between SSB consumption and higher serum uric acid levels and systolic blood pressure, even after controlling for BMI and other confounders (Nguyen, Choi, Lustig, & Hsu, 2009). Other analyses from the same national surveillance study reported that increased SSB consumption was independently associated with increased insulin resistance, systolic blood pressure, waist circumference, and decreased high-density lipoprotein (HDL) concentrations among adolescents (Bremer, Auinger, & Byrd, 2010). Similarly, an Australian cohort study found that teenage males and females who reported an increased intake of SSBs over the two-year follow-up period showed a significant increase in waist circumference and serum triglycerides and decreased HDL concentrations, after controlling for changes in BMI, compared to those whose SSB consumption remained the same (Ambrosini et al., 2013).

Numerous studies have demonstrated that SSB consumption is predictive of a lower intake of many vitamins and nutrients in youth (Fiorito, Marini, Mitchell, Smiciklas-Wright, & Birch, 2010; Frary, Johnson, & Wang, 2004; Libuda et al., 2009; Vartanian et al., 2007). A systematic review found strong evidence that SSB consumption was inversely related to intake of calcium, protein, fibre, and various vitamins, suggesting that SSBs likely displace more nutritious foods or are often consumed alongside other nutrient-poor foods (Vartanian et al., 2007). The association between SSB intake and nutrient inadequacies is concerning, since there is evidence that vitamins and minerals (particularly, calcium) have a protective effect on bone health (Greer & Krebs, 2006) and against the development of chronic disease (Fairfield & Fletcher, 2002).

Finally, the association between the development of dental caries and consumption of sugary foods and beverages in children and adolescents is well-explored and well-established (Heller, Burt, & Eklund, 2001; Sohn, Burt, & Sowers, 2006; Touger-Decker & van Loveren, 2003; Warren et al., 2009; World Health Organization, 2003). Sugars are an optimal substrate for oral bacteria, which cause a decrease the mouth's pH levels, ultimately contributing to tooth demineralization. Likewise, the acids (e.g.., citric, carbonic, and phosphoric acid) in these beverages can cause irreversible dental erosion (World Health Organization, 2003). The consequences of these effects are not limited to oral health; the Canadian Dental

Association asserts that dental disease can negatively impact the youths' dietary and sleep quality (Canadian Dental Association, 2007).

1.4 Calls for efforts to reduce SSB intake

In light of the varied health concerns associated with SSB intake, there is a clear, universal recommendation within the public health nutrition literature for individuals to reduce their SSB intake. There is no consensus on what qualifies as a "safe" intake of SSBs (Te Morenga et al., 2013; World Health Organization, 2015a), which likely reflect the wide variation in these products (i.e., in their sugar content, energy- and nutrient-density, other ingredients, etc.). While consuming small servings of SSBs infrequently is unlikely to jeopardize an otherwise healthy diet, the lack of a threshold making it difficult to determine what constitutes as an "excessive" SSB intake. Regardless, there is clear evidence to support the need for population-level reductions in SSB intake, particularly among adolescents, since they are presently the largest consumers of SSBs in Canada (Jones et al., 2017) and there is a strong tendency for dietary habits to track into adulthood (Craigie, Lake, Kelly, Adamson, & Mathers, 2011).

Several national organizations have advocated for initiatives to reduce SSB consumption among Canadians that reflect a public health approach, addressing community- and societal-level determinants of SSB intake (Canadian Diabetes Association, 2016; Childhood Obesity Foundation, 2013; Dietitians of Canada, 2016; Heart and Stroke Foundation of Canada, 2014; Ogilvie, 2016). Researchers and public health organizations alike have made targeted recommendation to diverse stakeholders groups, including the food industry, schools, and policy makers, to support broader environmental changes to reduce SSB consumption among individuals (Ebbeling, Pawlak, & Ludwig, 2002; Heart and Stroke Foundation of Canada, 2014; Institute of Medicine, 2007; World Health Organization, 2003).

1.5 Ecological framework

Ecological models of health describe how aspects of social, environmental, and political environments have a profound influence on individuals' behaviours, such as dietary choices. These models are guided by three core principles: (i) there are multiple levels that influence health behaviours; (ii) interaction occurs between these levels; and, (iii) interventions to improve health behaviours should account for these numerous levels of influence (Bronfenbrenner, 1979). These models assert that our "toxic environment", comprising a collection of adverse ecological factors (e.g., high availability and pervasive marketing of unhealthy food/beverages, social norms that promote poor dietary choices, etc.), can thwart individual efforts to improve health behaviours (Ebbeling et al., 2002).

The socioecological health promotion framework is a well-established ecological model (McLeroy, Bibeau, Steckler, & Glanz, 1988). Within the socioecological health promotion framework, the levels of influence range from proximal (e.g., intrapersonal and interpersonal factors) to distal levels (e.g., community factors and public policy), as summarized in Figure 1. Intrapersonal factors include individual characteristics, such as biological and genetic factors, knowledge, attitudes, behaviours, and skills. Interpersonal factors include formal and informal social networks, such as family and peer networks. Institutional factors include the organizational characteristics of social institutions (e.g., schools, workplaces, etc.), and rules and regulations for operation. Community factors include characteristics of organizations, institutions, and informal networks with defined community boundaries (e.g., a neighbourhood, city, region, etc.). Public policy includes policies at all levels of government that have implications for individuals' behaviours. The following sections describe factors that have been associated with youths' SSB intake in previous research, across various levels in the socioecological health promotion framework.

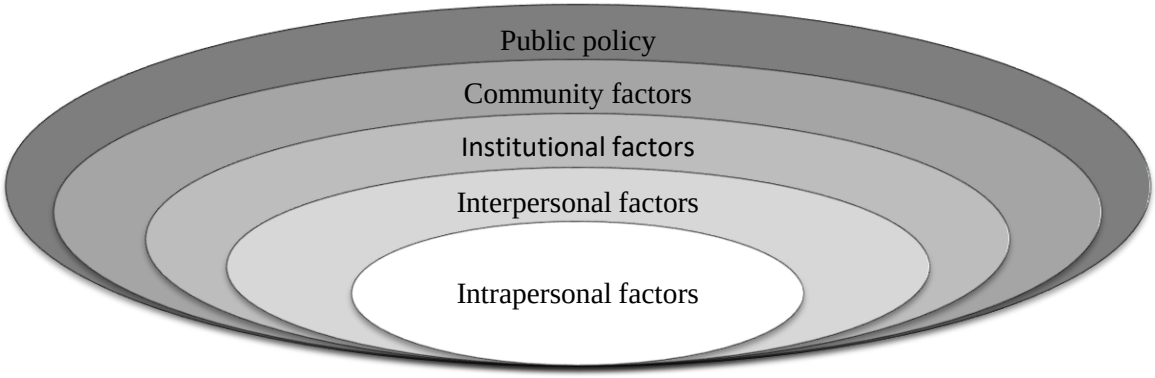

Figure 1: Socioecological health promotion framework, adapted from McLeroy et al. (1988).

1.5.1 Intrapersonal factors

There has been considerable investigation of the various intrapersonal-level characteristics that predict SSB consumption among youth, including non-modifiable and modifiable factors.

1.5.1.1 Age

SSB intake tends to increases as youth progress from childhood to adolescence (Berkey, Rockett, Field, Gillman, & Colditz, 2004; Danyliw et al., 2011; Garriguet, 2008; Grimes, Riddell, Campbell, & Nowson, 2013; Grimm, Harnack, & Story, 2004; Larson, DeWolfe, Story, & Neumark-Sztainer, 2014; Lytle, Seifert, Greenstein, & McGovern, 2000; Storey, Forshee, & Anderson, 2006), corresponding to decreases in overall diet quality during this developmental transition (Alberga, Sigal, Goldfield, Prud'Homme, &

Kenny, 2012). These age-related changes may reflect adolescents' greater autonomy over food choice (Todd, Street, Ziviani, Byrne, & Hills, 2015), as they generally have greater independence and more spending money to make their own food purchases. Adolescents are also more sensitive to influences from peers and food and beverage marketing, which can shape food choices and preferences (Todd et al., 2015). While there is strong evidence for the age-related changes in SSB intake *between* childhood and adolescence, there has been relatively little investigation of how patterns of SSB consumption vary *within* adolescence. A cross-sectional study of Canadian secondary school students identified a lower prevalence of SSB intake among older students relative to younger students, which suggests that SSB intake may decrease as adolescents progress through secondary school (Vanderlee et al., 2014). Another Canadian cross-sectional study reported that older adolescent males had a greater intake of energy drinks than younger males, while female adolescents demonstrated the opposite trend (Reid et al., 2015). There are no published Canadian studies that use linked longitudinal data to assess changes in SSB consumption as youth progress through adolescence.

1.5.1.2 Gender

Males have a higher frequency of overall SSB consumption than females (Berkey et al., 2004; Boyce, 2004; Grimm et al., 2004; Park, Sherry, Foti, & Blanck, 2012; Park, Blanck, Sherry, Brener, & O'Toole, 2012; Reid et al., 2015; Vanderlee et al., 2014; Wiecha, Finkelstein, Troped, Fragala, & Peterson, 2006). Gender differences in intake of energy drinks and sports drinks are particularly apparent. For example, a nationally-representative American study identified that male adolescents were approximately twice as likely as females to report consuming both energy drinks and sports drinks within the past week (Park et al., 2012). Research from the Canadian COMPASS study identified a similar association between being male and energy drink consumption (Reid et al., 2015).

1.5.1.3 Ethnicity

Research from the United States has identified a significant association between ethnicity and SSB consumption among adolescents, and the nature of this association appears to vary by SSB type. For example, previous research has identified that White adolescents have significantly lower sports and energy drink intake than other ethnicity groups (Larson et al., 2014), but a higher intake of soft drinks (Park et al., 2012; Rajeshwari, Yang, Nicklas, & Berenson, 2005; Storey et al., 2006). Few Canadian studies have investigated how SSB consumption varies by ethnicity. However, one study reported that off-reserve Aboriginal adolescents were significantly more likely to consume these energy drinks compared to other groups (Reid et al., 2015). Though the exact mechanisms linking ethnicity and SSB

intake are unclear, the purported association between these two factors should be accounted for in models of individuals' SSB consumption.

1.5.1.4 Socioeconomic status

Previous research suggests that SSB intake may be associated with socioeconomic status (SES), often measured via parents' educational attainment. However, the evidence is mixed; studies either find an inverse association between SSB intake and SES (Ambrosini et al., 2013; Clifton, Chan, Moss, Miller, & Cobiac, 2011; Grimes et al., 2013) or no association (Larson et al., 2014). A recent systematic review examined associations between SES and various predictors of children's dietary behaviours (Zarnowiecki, Dollman, & Parletta, 2014). The review identified that children from low SES families had more SSBs and energy-dense snacks and fewer fruits and vegetables available at home (Zarnowiecki et al., 2014). The review also identified that, relative to their high SES counterpart, children from low SES families had less nutrition-related knowledge, and their parents were less likely to model healthy dietary behaviours (Zarnowiecki et al., 2014). Although this review focused on children, the findings also likely extend to adolescents, since availability, accessibility, nutrition-related knowledge, and social influences are among the many factors that influence adolescents' dietary choices (Neumark-Sztainer, Story, Perry, & Casey, 1999; Shannon, Story, Fulkerson, & French, 2002). Some studies of youth behaviour use youths' personal spending money in lieu of more traditional measures of SES. For example, a Canadian study identified that secondary school students that have their own spending money were more likely to report energy drink consumption that those without, and speculated that the relatively high cost of these energy drinks may represent a barrier that discourages those without their personal spending money from purchasing these beverages (Reid et al., 2015).

1.5.1.5 Other dietary behaviours

Several studies have identified associations between SSB consumption and other markers of unhealthy dietary patterns. For example, studies in Canada and the United States demonstrate an association between reveal using fast food restaurants and SSB consumption among youth (Larson, Neumark-Sztainer, Laska, & Story, 2011; Wiecha et al., 2006). Likewise, a study examining American adolescents' diets reported strong, positive associations between SSB intake and consuming a variety of energy-dense, nutrient-poor foods (e.g., desserts, fried food, and meats) (Ranjit, Evans, Byrd-Williams, Evans, & Hoelscher, 2010). These associations may reflect these food and beverage items being served together (e.g., in fast-food restaurants), or these items having common characteristics that make them desirable dietary choices among adolescents (i.e., related to perceptions of taste, cost, convenience, value, etc.) (Neumark-Sztainer et al., 1999; Shannon et al., 2002).

1.5.1.6 Weight intentions

There is evidence that intentions and/or behaviours to lose weight is associated with infrequent or low SSB consumption (Bleich & Wolfson, 2014; Park et al., 2012; Vanderlee et al., 2014). Since SSBs are a considerable source of energy and added sugars, weight-conscious individuals may substitute these beverages for low-calorie alternatives to decrease their total energy intake. Interestingly, a Canadian study found that secondary school students that were dieting were more likely to consume energy drinks compared to their non-dieting counterparts (Reid et al., 2015). The authors speculated that youth use these products for their caffeine and other stimulants (e.g., taurine, guarana, etc.), as a means of compensating for the energy that they are not consuming from food sources while they diet. Other studies have identified body image and the perceived effects on health and appearance as key determinants of dietary choices in general among adolescence (Neumark-Sztainer et al., 1999).

1.5.2 Interpersonal factors

1.5.2.1 Peers

Peer social influences have a considerable role in influencing adolescents' dietary behaviours (Salvy, De La Haye, Bowker, & Hermans, 2012). There is a strong correlation between individuals' SSB intake and that of their peers (Bruening et al., 2014; van der Horst et al., 2008), which may reflect shared values, activities, and attitudes that either promote or discourage SSB consumption. This correlation is more pronounced among secondary school versus middle school students (Bruening et al., 2014), suggesting that peer influences become more important as children develop into adolescents. Peers also contribute to diet-related social norms. A recent Canadian qualitative study identified that the social context is a key reason for energy drink consumption among adolescents; they often consumed these products in social situations with friends and reported that peer influence promoted their energy drink consumption (McCrory et al., 2017). Perceptions of peers' SSB intake are more strongly associated with youths' personal SSB intake than their peers' actual SSB consumption, which is concerning since youth typically overestimate how frequently their peers consume SSBs (Perkins, Perkins, & Craig, 2010). There is also evidence that the demonstrated ability to purchase one's own snacks and meals is marker of social status among adolescents (Vine, Elliott, & Raine, 2014), representing another, less direct, peer social influence.

1.5.2.2 Parents and families

Parents and families also shape adolescents' SSB intakes through social influences, as well as by moderating the availability of food and beverages in the home. Parents have a strong social influence on their teenage children's dietary choices, despite the greater autonomy and role of peer influences that accompany adolescence (Pedersen, Grønhøj, & Thøgersen, 2015; Reicks et al., 2015; van der Horst et al.,

2008). From an early age, youths' understanding of appropriate diet-related choices (i.e., when, where, what, and how much) greatly reflects what they have observed and been taught via their family's eating practices, and these influences have long-term impact on individuals' eating patterns (Savage, Fisher, & Birch, 2007). Indeed, parental modelling is a powerful determinant of adolescents' dietary patterns (Reicks et al., 2015), including their SSB intake (Loth, MacLehose, Larson, Berge, & Neumark-Sztainer, 2016), and exerts a stronger influence than what parents verbally encourage/discourage their children from consuming (Pedersen et al., 2015).

Parents are often responsible for grocery shopping and food preparation for the family. This role affords parents considerable control over what is available at home and, thus, what food and beverages are accessible to their children. Indeed, there is a strong association between adolescents' perceptions of the availability of various food and beverages at home and their intake of these products (Pearson, Ball, & Crawford, 2011; Reicks et al., 2015), and there is evidence that adolescents primarily consume the majority of their SSBs at home (Clifton et al., 2011). There is an inverse relationship between adolescents' SSB intake and a composite measure of the quality of the home food environment (Loth et al., 2016), further highlighting the importance of this context for moderating adolescents' SSB intake. A nationally-representative Canadian study assessing adolescents' after-school (i.e., the period between 3-6 PM) snack choices identified that these snacks generally consist of energy-dense, nutrient-poor foods, and that fruit drinks and soft drinks were among the most commonly chosen items (Gilbert, Miller, Olson, & St-Pierre, 2012). Though the researchers did not report sources of after-school snacks, it is likely that many of these beverages were consumed at home, since youth often return to this setting soon after school. These findings signal the important influence that parents and the home environment have on adolescents' dietary choices.

1.5.3 Institutional factors

1.5.3.1 Schools

Schools represent an important institutional context for youth, and many studies related to youth health behaviours are conducted in this setting for various reasons. Youth spend much of their time at school, where they are exposed to programs, policies, and people that may influence their behaviours. As such there is an opportunity to strategically leverage this influence in order to promote healthy behaviours among youth through school-based interventions. School-based interventions represent a promising population-level strategy for improving youth health behaviours (Wang et al., 2015). These initiatives are often universal (i.e., they do not target youth on the basis of gender, SES, age, or other demographic characteristics), and are thus considered an equitable type of prevention effort (Ebbeling et al., 2002).

1.5.3.1.1 School food environment – school food outlets

Canadian youth typically have at least one meal and some snacks during their time in school, thus, assessments of the school food environment (i.e., comprising, in part, features of food outlets within schools and in the school neighbourhood) can elucidate the factors that shape youths' meal and snack choices during their time in school. Previous research suggests that the nutritional quality of food and beverages available in Canadian school food outlets is questionable, and tends to be lower in secondary schools compared to elementary schools (Mâsse & de Niet, 2013; Rideout, Levy-Milne, Martin, & Ostry, 2007). A large cross-sectional study of schools in British Columbia reported that "junk" food is widely available in school food outlets, and that three-quarters of secondary schools' beverage vending machine slots contained "less-healthy" beverage choices (e.g., soda, iced tea, sports drinks, and fruit drinks) (Rideout et al., 2007). Most Canadian studies have assessed the availability of food and beverages in school food outlets specifically in the context of provincial school nutrition policies (described in greater detail in Section 1.5.5.1). Many of these studies identify that policy-restricted items, including SSBs, are frequently available in Canadian schools (Olstad, Downs, Raine, Berry, & McCargar, 2011; Olstad, Lieffers, Raine, & McCargar, 2011; Orava, Manske, & Hanning, 2016; Vine et al., 2017).

The availability of unhealthy beverages in secondary schools would be concerning if in-school SSB availability predicted students' SSB intake, although there is mixed evidence for the association. A Canadian study in British Columbia identified that the in-school availability of SSBs is significantly and positively associated with moderate and high SSB consumption in adolescents (Mâsse et al., 2014). Similar findings have been reported in American studies, but among primarily children in elementary or middle school (Grimm et al., 2004; Johnson, Bruemmer, Lund, Evens, & Mar, 2009; Park, Sappenfield, Huang, Sherry, & Bensyl, 2010; Wiecha et al., 2006). Researchers contend that the availability of particular foods and beverages in schools may increase students' consumption of these items by increasing their accessibility, shaping students' perceptions of appropriate dietary choices, and thus, influencing food selections (Rideout et al., 2007). However, other international studies demonstrate that the availability of SSBs in schools is not associated with adolescents' SSB intake (Park et al., 2012; Rovner, Nansel, Wang, & Iannotti, 2011; van der Horst et al., 2008). Rovner and colleagues (2011) identified that while elementary school students' dietary choices were influenced positively or negatively by school vending machines (depending on what products were available), there was no similar association among secondary school students.

Overall, there is no consensus on how SSB availability in school food outlets impacts adolescents' SSB consumption. Our understanding of these relationships largely derives from studies of children, who do not have the same degree of autonomy (dietary or otherwise) as adolescents. Further, much of the

available literature is from the United States, which is a very different context than Canada, owing to the existence of the National School Lunch Program, the federally-funded meal program that offers low-cost or free school lunches to students in public and non-profit private schools. The lack of recent Canadian studies examining these associations in secondary schools represents an important research gap.

1.5.3.1.2 School food and nutrition initiatives

There has been considerable attention in recent years on food and nutrition initiatives set in schools. School-based food and nutrition initiatives can potentially influence youths' diets through changes to the school food environment that promote healthy behaviours, while discouraging less healthy behaviours through various means. McKenna (2010) outlined school policy options to support healthy eating among youth, including nutrition standards for food and beverages sold in schools, meal and snack programs, restrictions of food and beverage marketing within schools, nutrition education, and policies that moderate students' accessibility to unhealthy items in school neighbourhood food outlets. The review identified that few evaluation studies, in Canada or beyond, have demonstrated a positive impact of school nutrition standards on food availability and students' dietary choices (McKenna, 2010). The review found some evidence to support behaviour-focused nutrition education (i.e. versus strictly knowledge-focused), especially when combined with food services and other initiatives, and limited evidence for the other policy options (McKenna, 2010). Overall there is a lack of understanding of promising practices related to school-based food and nutrition initiatives in Canada.

1.5.4 Community factors

Individuals, their social networks, and institutions exist within communities. Features of the school neighbourhood and larger food environment may impact adolescents' SSB consumption through various means, including moderating the availability and accessibility of these products.

1.5.4.1 School food environment – school neighbourhood

Many Canadian schools are within close proximity of neighbourhood food outlets (e.g., grocery stores, fast food places, restaurants, variety stores, etc.), which students are able to visit while traveling to and from school and during breaks. A study of a large sample of Canadian schools representing a wide range of geographical and sociodemographic areas found that nearly three-quarters (74.0%) of schools had at least one type of food outlet within a kilometre radius, and that restaurants were the most common food outlet within walking distance of schools (Seliske, Pickett, Boyce, & Janssen, 2009a; Seliske, Pickett, Boyce, & Janssen, 2009b). Other research suggests that the density and types of food outlets near schools may vary by the SES profile of the neighbourhood (Moore & Diez Roux, 2006; Seliske et al., 2009b). A

Canadian study identified a positive correlation between school neighbourhood SES and the number of food outlets in the school neighbourhood (Seliske et al., 2009b).

School neighbourhood food outlets compete with school food outlets (e.g., cafeterias, school vending machines, etc.), since they offer an alternative source of meals and snacks to students during their time in school, are not restricted by school nutrition policies in what they can serve, and generally have a larger variety of items available for purchase. Canadian studies have identified a positive association between availability of food outlets within walking distance of their school and students' snack and meal purchases in these venues (Laxer & Janssen, 2013; L. Seliske, Pickett, Rosu, & Janssen, 2013). For these reasons, schools' proximity to food outlets represents one factor that may undermine the impact of school nutrition policies on encouraging healthy dietary choices among adolescents (Vine et al., 2014).

There is mixed evidence supporting an association between the presence of school neighbourhood food outlets and adolescents' SSB consumption. A recent systematic review of 30 articles found little evidence that retail food environment near schools has an impact on students' food purchases and dietary outcomes, including SSB intake, and concluded that future interventions targeting the food environment around schools need careful evaluation (Williams et al., 2014a). Other research reported a positive association between adolescents' SSB intake and access to food outlets in the school neighbourhood (Davis & Carpenter, 2009), while another study identified an inverse association (van der Horst et al., 2008). Indeed, van der Horst and colleagues (2008) found that a higher density of food stores within the school neighbourhood predicted lower soft drink consumption among Dutch adolescents, and speculated that the presence of a greater range of food stores increases the variety of food and beverages students can access, including healthier alternatives to SSBs. Few Canadian studies have examined how school neighbourhood food outlets impact adolescents' SSB intake, although a study in Quebec identified no association between school neighbourhood characteristics (e.g., the number of and proximity to fast food places and convenience stores) and children's SSB intake (Lebel et al., 2016).

1.5.4.2 Larger food environment

The school food environment is embedded within a larger food environment in communities that moderates individuals' dietary choices and propensity to consume SSBs. In Canada, SSBs are available for sale within most food outlets (e.g., grocery stores, convenience stores, etc.) and in various other settings, including hospitals, community centres, shopping centres, and schools (Chaumette, Morency, Royer, Lemieux, & Tremblay, 2009; McDonald, Karamlou, Wengle, Gibson, & McCrindle, 2006; Naylor, Bridgewater, Purcell, Ostry, & Wekken, 2010). The widespread availability of SSBs is one factor that likely encourages SSB intake among youth, since their food and beverages preferences and intake

patterns are largely influenced by what products are familiar and available to them (Savage et al., 2007). Indeed, numerous studies have found that where less nutritious foods and beverages are highly available, adolescents have a greater intake of these items and fewer healthier foods (Cullen et al., 2003; Cullen & Zakeri, 2004; Kubik, Lytle, Hannan, Perry, & Story, 2003).

1.5.5 Public policy

The more proximal levels of the socioecological model that were previously described are shaped by public policies. Public policies that are relevant to adolescents' SSB intake include provincial school nutrition policies and broader food and nutrition policies that reach the general population.

1.5.5.1 Provincial school nutrition policies

All Canadian provinces have established policies that set the standard for what food and beverages are appropriate for schools. These policies vary in their strictness and enforcement, as exemplified by the contrast between school nutrition policies in Alberta and Ontario. The *Alberta Nutrition Guidelines for Children & Youth* (*ANGCY*) were first released in 2008 and updated in 2012, and provide voluntary food-related recommendations across childcare, schools, and community centre settings (Government of Alberta, 2012) (see Appendix A). These guidelines aim to "assist Albertans to create an environment which provides and promotes healthy food choices and healthy attitudes about food" (Government of Alberta, 2012). In Ontario, the Ministry of Education introduced its new school food and beverage policy, *Policy/program Memorandum no. 150* (*P/PM 150*) in 2010, which took effect on September 2011 (Ontario Ministry of Education, 2016) (see Appendix B). *P/PM 150* is mandatory in Ontario publicly-funded elementary, middle, and secondary schools, and apply to all venues on school property (e.g., cafeterias, vending machines, and tuck shops), meal programs, and events on school property. *P/PM 150* does not apply to the lunches and snacks that students bring from home.

Both *ANGCY* and *P/PM 150* have explicit guidelines regarding SSBs. The *ANGCY* classifies fruit-flavoured drinks, soft drinks, sports and energy drinks, and sweetened hot or cold drinks as 'choose least often foods' in secondary schools, meaning that schools should choose small portion sizes of these products if they are served. Alberta's guidelines also caution schools about serving beverages containing caffeine or artificial sweeteners. Ontario's *P/PM 150* is more restrictive in its SSB-related guidelines than the *ANGCY*. Ontario public secondary schools are only permitted to carry the following beverages (with the starred beverages permitted <20% of the time): plain water, plain or flavoured milk beverages (≤ 2% milk fat or ≤ 5 g fat; sugar: ≤ 28 g; and, calcium: ≥ 25% daily value/serving), yogurt drinks (≤ 3.25% milk fat or ≤ 3 g fat/serving), plain or flavoured soy/milk alternatives beverages (fortified with calcium and vitamin D), vegetable or fruit juices or blends (100% juice, pulp, or purée and unsweetened/no sugar

added), hot chocolate (≤ 2% milk fat or ≤ 5 g fat; sugar: ≤ 28 g; and, calcium: ≥ 25% daily/serving), decaffeinated coffee and tea*, iced-tea* (≤ 40 calories /serving, decaffeinated), and "other beverages"* (≤ 40 calories/serving, caffeine-free). All energy drinks, sports drinks, <100% juices, caffeinated drinks, and soft drinks/flavoured water/ades with >40 calories are not permitted for sale within school outlets.

Few studies have assessed how provincial school nutrition policies impact students' SSB intake in Canada. A study in British Columbia found that schools that complied with mandatory school food guidelines were significantly less likely to have SSBs available within school, although they did not assess the corresponding effect on students' SSB consumption (Mâsse & de Niet, 2013). Evaluation studies in Prince Edward Island and Nova Scotia identified that the provincial school nutrition policies in these jurisdictions had a favourable impact on students' dietary behaviours, including decreases in SSB intake (Fung, McIsaac, Kuhle, Kirk, & Veugelers, 2013; Mullally et al., 2010); however, the participants in these studies were children, and it is unclear if there were similar improvements in the diet quality of older students. Overall, there is a paucity of evaluation data on provincial school nutrition policies in Canada, particularly related to their impact on adolescents' dietary behaviours.

Research from other countries suggest that the evidence for the effectiveness of jurisdictional-level school nutrition policies is mixed. Two systematic reviews supported these school nutrition policies as a means of reducing youths' SSB intake (Levy, Friend, & Wang, 2011; Vézina-Im et al., 2017). However, one review largely comprised American studies of children (Levy et al., 2011) and the other combined school nutrition policies and school 'environmental changes' into one intervention category (Vézina-Im et al., 2017), making the effectiveness of school nutrition policies, in particular, unclear. Studies specifically of school nutrition policies and their ability to decrease on adolescents' SSB intake are relatively few. A natural experiment in the United States identified that policies restricting the in-school sale of SSBs were associated with lower in-school SSB access and purchasing among adolescents, but only if all SSBs were banned from school food outlets (i.e., not just sodas) (Taber, Chriqui, Powell, & Chaloupka, 2012). However, students' SSB intake appeared to be largely independent of the comprehensiveness of the school nutrition policies, since differences in in-school SSB access was only modestly associated with adolescents' SSB overall consumption (Taber et al., 2012). Since in-school food and beverage availability appear to have a greater influence on children's (versus adolescents') dietary choices (see Section 1.5.3.1.1), it is plausible that school nutrition policies may be relatively limited in their ability to moderate adolescents' SSB intake.

Provincial school nutrition policies may be limited in their ability to reduce adolescents' SSB consumption for various reasons. First, these policies cannot prevent youth from accessing SSBs outside

of school (Taber et al., 2012). Restriction in the in-school availability of unhealthy, desirable foods can be proceeded by students bringing more of these restricted items into school from home or other food outlets (Cullen, Watson, & Zakeri, 2008) or by consuming more of these items in other setting (Finkelstein, French, Variyam, & Haines, 2004; Vecchiarelli, Takayanagi, & Neumann, 2006; Vézina-Im et al., 2017). Indeed, Vine and colleagues (2014) noted an increase in students buying lunch at food outlets off-school property after the implementation of *P/PM 150* (Vine et al., 2014). Second, school-level incompliance with provincial school nutrition policies may undermine their effectiveness, particularly in the absence of formal monitoring of policy compliance and with voluntary guidelines. Several studies have identified poor compliance with these policies in Canada (Olstad et al., 2011; Olstad et al., 2011; Orava et al., 2016; Vine et al., 2017), and one evaluation of the *ANGCY* in particular concluded that "uptake may continue to falter under the current voluntary approach" (Olstad, 2014). However, if adolescents' SSB intake is independent of SSB availability in school, this factor is likely less important. Third, it is unlikely that changes in school food outlet offering will impact students' dietary behaviours if students are not in the habit of using these outlets in the first place. There has been limited investigation of Canadian youths' use of school food outlets for meal and snack purchases; however, a recent study identified that Ontario secondary students reported purchasing lunch from their school cafeteria a mean of 1.1 days a school week, which was considerably less often than the number of days they brought a home-packed lunch (Jones et al., 2015). Fourth, many school nutrition policies (including *ANGCY* and *P/PM 150*) comprise solely of school nutrition standards (McKenna, 2010), and thus primarily moderate students' in-school access to restricted items, with less consideration for the many other factors that influence dietary choices (e.g., food and nutrition-related knowledge, skills, attitudes, etc.). Comprehensive school nutrition policies containing other policy components would represent a more holistic approach to school nutrition initiatives (McKenna, 2010). Finally, schools represent one of many contexts that influence youths' behaviours; the effectiveness of school nutrition policies is likely to be modest without parallel changes in the broader food environment (Taber et al., 2012).

1.5.5.2 Broader food and nutrition policies

While provincial school nutrition policies are primarily oriented on influencing *youths'* dietary patterns in Canada, other food and nutrition-related provincial and federal policies have a broader population-level reach. In particular, regulations surrounding SSB marketing, nutrition labelling, and pricing are key topics within the current social and political discourse in Canada that have implications for SSB consumption among Canadians in general, including adolescents.

The marketing of food and beverages greatly influence youths' food preferences, knowledge, purchases, and consumption patterns (Cairns, Angus, Hastings, & Caraher, 2013), making it a clear target for policy

regulation. Children and adolescents are a key demographic for SSB-related marketing efforts, which have evolved in recent years to include non-traditional marketing media that are accessible and appealing to youth audiences (e.g., social media, "adver-gaming", etc.) (Cairns et al., 2013). In addition to advertising, the beverage industry plays a prominent role as a sponsor of events and programs widely attended and viewed by youth. For example, the Coca-Cola Company represents the longest continuous sponsor of the Olympic Games (PyeongChang 2018, 2018), and its logo was ubiquitous in the 2018 Winter Games. Likewise, researchers recently identified that the beverage industry has a salient presence in Guatemalan secondary schools via advertisements and donated, logo-bearing sporting equipment, and suggested that the industry is using the unregulated school environment to access a key subgroup of consumers (Godin, Chacon, Barnoya, & Leatherdale, 2017). The profound influence of food and beverage marketing has compelled numerous governments within Canada to take political action to restrict their content and reach. For example, for over three decades Quebec has banned all commercial advertising directed at children through its *Consumer Protection Act*, which appears to have had positive effects on individuals' dietary choices (Dhar & Baylis, 2011). Despite the numerous regulatory challenges and social and legal barriers associated with food and beverage marketing restrictions (Harris, Pomeranz, Lobstein, & Brownell, 2009), there appears to be political will to support these restrictions across Canada. Indeed, Health Canada recently sought feedback from Canadians on their proposed approach to restricting the marketing of unhealthy food and beverages to children, and this type of legislation is currently in review in Canada's House of Commons (Health Canada, 2017).

Nutrition labelling is another policy intervention with relevance to individuals' dietary choices, and is considered to be a cost-effective approach to encouraging consumers to making healthier selections (Novak & Brownell, 2012). Most prepackaged foods and beverages in Canada are required to bear a Nutrition Facts table, which is typically displayed on the back or side of the product packaging. Though these tables display the amount of energy and total sugar in a product or product serving, many individuals struggle to meaningful interpret this quantitative information on the present iteration of the Nutrition Facts table (Hobin et al., 2016). To address some of these challenges, Health Canada's forthcoming changes to food and beverage packaging include the addition of a percentage daily value for total sugars to Nutrition Facts tables, greater uniformity in serving sizes, and changes in how sugars are displayed in products' ingredient lists (Health Canada, 2018). Front-of-package labels that contain less complex, often qualitative representations of a product's nutrient content have emerged, using symbols like guiding stars, traffic lights, and warning labels to inform consumers of a product's nutritional characteristics (e.g., energy density, sugar content, health impacts, etc.) and encourage healthier choices (Roberto & Khandpur, 2014). A recent Canadian experimental study found that the presence of front-of-

package labels that signal the high sugar content of sugary beverages reduced the probability of participants selecting a sugary drink and encouraged them to choose an alternative with less sugar, although these trends were not statistically significant (Acton & Hammond, 2018). Future evaluation studies will enable us to further elucidate the impact nutrition labeling changes can have on consumers' dietary choices.

Pricing is another key factor in individuals' dietary choices (Neumark-Sztainer et al., 1999; Shannon et al., 2002), and thus represents a mechanism to reduce SSB intake through policy interventions. SSBs are often inexpensive relative to other more healthful beverage alternatives, making them widely accessible and appealing. To counter this force, specific SSB taxes have been applied in various jurisdictions globally and have yielded positive impacts on individuals' dietary behaviours (Escobar, Veerman, Tollman, Bertram, & Hofman, 2013; Niebylski, Redburn, Duhaney, & Campbell, 2015). Given these apparent successes, a 2016 Senate report recommended a new SSB tax as part of a larger initiative to promote healthy weights among Canadians (Ogilvie, 2016). While an SSB tax-related bill has not yet been tabled in Canada, two recent studies using experimental and simulation modelling methods generated evidence that such a tax would effectively discourage and reduce Canadians' SSB purchases (Acton & Hammond, 2018; Jones et al., 2017).

Public policies, such as those related to SSB marketing, nutrition labelling, and pricing, may affect adolescents' dietary choices directly (e.g., by discouraging from choosing a particular product at the point-of-purchase) or indirectly by moderating a factor within a more proximal level of the socioecological model. For example, it is conceivable that restrictions on SSB marketing to youth would result in SSBs being less of a social norm among those in this age group, thus reducing the social pressure to consume these drinks. Likewise, the increased price of SSBs as a result of an SSB tax may impact the availability of these products within schools and homes, since school food providers and parents would be discouraged from purchasing these products. It is necessary to recognize the interrelationships between factors within and across levels of influence within the socioecological in order to understand the various systems that impact adolescents' SSB intake, and identify potential intervention strategies.

1.6 Summary and identified gaps

SSBs are popular among Canadian adolescents, and associated with numerous adverse health consequences. There are important limitations to our current understanding of Canadian youths' SSB consumption, including a lack of studies that assess intake of several types of SSBs (i.e., providing a more comprehensive sense of SSB intake patterns), adolescents' SSB intake within periods beyond a single day (i.e., given the popularity of 24-hour recall method in dietary assessments), and the contexts that promote

or discourage adolescents' purchase and consumption of SSBs. The existing Canadian literature primarily comprises cross-sectional studies, and there is a need for longitudinal assessments of Canadian adolescents' SSB intake (Danyliw et al., 2011).

The socioecological model of health suggests that individuals' dietary behaviours reflect factors across numerous levels of influence. The available evidence suggests that interpersonal factors, such as peer and family influences, are important predictors of adolescents' SSB intake. More distal factors, such as aspects of institutional, community, and public policy contexts, may impact dietary outcomes through both direct and indirect means (e.g., by shaping social influences). Schools are an important institution for youth, and various school-level initiatives have been implemented to establish a school food environment that supports healthy dietary choices among students. There have been few studies that have characterized the school food environment in Canada or assessed students' purchases of meals and snacks within this setting. Much of what is known about the school food environment and its impact on students' dietary behaviours derives from studies in elementary schools and the United States. Within the broader literature, there is an identified need for further study of the associations between factors in the school environment and adolescents' dietary behaviours, and particularly how these associations vary as a function of time (van der Horst et al., 2008).

Provincial school nutrition policies exist across Canada, and seek to discourage students' consumption of less healthful food and beverages by restricting their availability within school food outlets. However, there have been few formal evaluations of these policies in Canada, particularly those assessing their impact on adolescents' SSB intake, and researchers have identified this as an important gap in the literature (Vanderlee et al., 2014). There have been limited evaluations of how schools' compliance with provincial school nutrition policies varies over time, and no examination of the impact these changes have on students' dietary behaviours in Canada. Given the heterogeneity in these policies across the country, there is a unique opportunity to conduct cross-provincial examinations of policy implementation and effectiveness at improving youths' dietary behaviours (McKenna, 2010), although no such study has been conducted to date.

There is a need to support population-level reductions in Canadian adolescents' SSB intake. Presently, schools represent the *de facto* setting for youth health promotion initiatives, including those striving to improve students' dietary outcomes. A better understanding of adolescents' SSB consumption patterns, the school food environment, and the role that provincial school nutrition policies play in moderating the availability of SSBs in the school food environment would be valuable for directing future interventions to achieve meaningful reductions in adolescents' SSB consumption in Canada.

1.7 Study aims & objectives

To address these gaps in the literature, this dissertation research answered the following questions:

1. What is the weekly rate at which adolescents in Alberta and Ontario consume three categories of SSBs (soft drinks, sweetened coffees/teas, and energy drinks)?
    a. To what extent does SSB consumption vary by province?
    b. To what extent does SSB consumption vary as a function of time?
2. What sources of meals and snacks (i.e., food outlets on and off school property) are popular among adolescents in Alberta and Ontario on weekdays and weekends?
    a. What is the association between adolescents' meal and snack purchasing behaviours and their SSB consumption?
    b. To what extent do these association vary by province?
3. To what extent are SSBs accessible within the school food environment in secondary schools in Alberta and Ontario, based on their availability in school vending machines and the presence of food outlets (i.e., food stores, restaurants, and variety stores) within the school neighbourhood?
    a. To what extent do these characteristics vary by province?
    b. How does the in-school vending machine availability of SSBs reflect compliance with provincial school nutrition policies in Alberta and Ontario?
    c. How does vending machine beverage availability vary as a function of time?
    d. How do changes in vending machine beverage availability within secondary schools reflect changes in compliance with provincial school nutrition policies in Alberta and Ontario as a function of time?
4. To what extent are school food environment characteristics (i.e., SSB availability within school vending machines, accessibility of water fountains, and presence of food outlets within the school neighbourhood) associated with weekday SSB consumption among adolescents from secondary schools within Alberta and Ontario?
    a. To what extent do these associations vary as a function of time?

1.8 Dissertation organization

This dissertation is composed of six chapters, including this introduction. Chapter 2 describes the methods of the host study used to answer these research questions. Chapters 3, 4, and 5 consist of manuscripts submitted for publication, which collectively answer the overarching research questions. Chapter 6 summarizes and compares the findings from the three manuscripts, contextualizes the findings within the existing literature, highlights strengths and weaknesses of the dissertation, and identifies implications for public health, policy, and future research.

Chapter 2
General Methods of the COMPASS Host Study

2.1 Overview

This chapter provides an overview of the general methods of the **C**annabis use, **O**besity **M**ental health **P**hysical activity **A**lcohol use **S**moking **S**edentary behaviour study (COMPASS), which served as the host study for this dissertation. (Please see Chapter 3 Chapter 4 Chapter 5 for a more detailed description of the methods specific to this dissertation research.) COMPASS is a nine-year longitudinal prospective cohort study (2012/13-2021/22) designed to collect hierarchical data annually from a sample of adolescents attending Canadian secondary schools (i.e., schools comprising Grades 9-12) to examine how aspects of the school environment influence student health behaviours and outcomes (Leatherdale et al., 2014). There is a wide range of student-level outcomes examined within COMPASS, including various dietary behaviours; physical activity; obesity; sedentary behaviour; tobacco, alcohol, and cannabis use; mental health-related outcomes; academic achievement; and school connectedness. School-level data are collected on school programs, policies, resources, and aspects of the school built environment.

COMPASS was conceived in Ontario, and included data exclusively from schools in Ontario for its first school year (2012/13). The study expanded to Alberta in its second year (2013/14), and to various other jurisdictions in Canada and internationally more recently. This dissertation research used three school years (2013/14-2015/16) of COMPASS data derived from schools in Alberta and Ontario. Detail on the ongoing study's sampling methods, ethics, data sources, measures, and data linkage procedures are included below. Further details on the host study methods are available in print (Leatherdale et al., 2014) and online (www.compass.uwaterloo.ca).

2.2 Sampling

2.2.1 School-level sampling

Participating school boards in Ontario and Alberta are purposefully sampled, and required to meet the following eligibility criteria: (i) English-speaking; (ii) approved the study protocol; and, (iii) permitted the use of active-information passive-consent parental permission protocols. Information on these eligibility criteria are gleaned by reviewing school boards' websites or contacting school boards' administration. School boards that meet these criteria are sent a school board COMPASS recruitment package via courier mail or email. These recruitment packages include a school board invitation letter, project brochure, school board response form, copies of data collection tools, and student permission materials. School

boards that approve COMPASS are asked to notify all eligible schools within the board of their decision using an email template provided by the COMPASS school recruitment coordinator.

All eligible schools within eligible school boards that approve the study are approached to participate. Participating schools are required to meet the following eligibility criteria (i) secondary school with students in Grade 9 to Grade 12; (ii) minimum enrolment of 100 students per grade; (iii) operate in a standard school/classroom setting; and, (iv) permit active-information passive-consent parental permission protocols. The principal at each school receives a COMPASS recruitment package via courier mail, which includes a school invitation letter, project brochure, school response fax-back form, and copies of data collection tools. The sampling protocol for recruiting private schools is slightly different than that of publicly-funded schools, since private schools are independently governed. Private schools are approached directly with a recruitment package. Schools that accept the invitation to participate in COMPASS are sent a welcome package, which included further study information (e.g., data collection procedures).

2.2.2 Student-level sampling

Parents/guardians of students attending participating schools receive a mailed information letter that provides study details. Parents/guardians that do not want their child to participate can withdraw their child from the study by contacting the COMPASS recruitment coordinator using the phone number or email address provided within the information letter. All students whose parents passively consent for their child to participate are eligible to participate, facilitating whole-school sampling. Other large-scale Canadian school-based research studies have used a similar in-class whole-school sampling method, including SHAPES, the PLAY-ON study, and the School Smoking Profile Project (Leatherdale, McDonald, Cameron, & Brown, 2005; Leatherdale, Manske, Faulkner, Arbour, & Bredin, 2010; Leatherdale & Papadakis, 2011). Additional information on school board, school, and student recruitment are available elsewhere (Thompson-Haile & Leatherdale, 2013).

2.3 Ethics

The University of Waterloo Office of Research Ethics and participating school boards' internal committees approved all aspects of the study protocol.

COMPASS uses an active-information passive-consent permission protocol to obtain permission from parents/guardians of students enrolled in school that are participating in COMPASS. Students aged 18 years or older do not require parental permission to participate in the study. Parents/guardians receive a letter or automated phone message describing the study aims and procedures two weeks prior to the actual

in-school data collection. Parents/guardians are instructed on how they can contact the research team should they prefer that their child did not participate in the study or if they have any questions about the study protocol. Students whose parents do not contact the research team to opt their child out of the study are eligible to participate. Students are informed of their ability to withdraw from the study at any point during the consent process or during data collection without consequence.

An active-information passive-consent permission protocol was chosen for several reasons. Studies that use active-consent procedures in school-based research are prone to increasing the homogeneity of participants within schools, inflating estimates of between-school variance estimates, and necessitating a greater sample size (White, Hill, & Effendi, 2004). Response bias may also be introduced due to participants' potential reluctance to participate on account of their personal information being collected (i.e., on a signed informed consent form), which is particularly true with younger students and when questionnaires contain sensitive content (White et al., 2004). Active consent protocols are associated with low student participation rates in school-based studies, which further contributes to misrepresentative sample demographics (Thompson-Haile, Bredin, & Leatherdale, 2013).

Student participants did not receive any compensation for participating in the study; however, each participating schools was provided with a $200 honorarium as a token of appreciation.

2.4 Data Sources

2.4.1 COMPASS Student Questionnaire

The COMPASS Student Questionnaire, shown in Appendix C, is the source of all student-level COMPASS. Detailed information on the development of this questionnaire, including how content areas and outcome measures were selected, is reported elsewhere (Bredin & Leatherdale, 2014). The questionnaire is a 12-page machine-readable paper booklet. The page length is reflective of the balance of ensuring the questionnaire covers a wide variety of content areas, while allowing the questionnaire to be completed by students within a single class period. Content areas were selected for their science- and practice-based significance. These content areas include core, demographic, and supplementary measures. Core measures include obesity, alcohol use, tobacco use, marijuana use, physical activity, and sedentary behaviour. Several measures reflect public health guidelines or recommendations for youth populations (e.g., healthy eating-related questions reflect nutrition guidelines within *Canada's Food Guide*).

2.4.2 COMPASS School Environment Application

Data on schools' built environment (e.g., the in-school availability of SSBs) are collected using the COMPASS School Environment Application (Co-SEA). The Co-SEA is a mobile application developed

by COMPASS investigators to efficiently and robustly measure aspects of the school environment (comprising the school grounds and resources within schools), particularly those related to physical activity and healthy eating (Leatherdale, Bredin, & Blashill, 2014). The Co-SEA contains a series of questions adapted from two previously validated audit tools designed to measure schools' food and physical activity environments (Jones et al., 2010; van der Horst et al., 2008). The application also allows data collectors to store photos of built environment features and include notes directly in the application, representing supplementary sources of direct observation data. The Co-SEA is compatible with most mobile devices with an internal camera (e.g., smart phones from major mobile device platforms and tablets) and does not require an internet connection. The Co-SEA was tested in a convenience sample of COMPASS schools and refined accordingly prior to being used in the COMPASS study. Further information on the Co-SEA can be found elsewhere (Leatherdale et al., 2014).

2.4.3 Built environment data

Data on the school neighbourhood (e.g., schools' proximity to various SSB retailers) are captured through the CanMap RouteLogistics (CMRL) spatial information database and Enhanced Points of Interest (EPOI) data resource from the Desktop Mapping Technologies Inc. (DMTI) (CanMap RouteLogistics & Enhanced Points of Interest, 2015).

Previous Canadian studies have used these databases to examine how neighbourhood features influence health behaviours (Chan & Leatherdale, 2011; Lane, Leatherdale, Dubin, & Hammond, 2012; Leatherdale et al., 2010). The CMRL provides high quality street map and land use data, while the EPOI contains data on the location of specific services, facilities, and businesses within communities. Specifically, these databases are used to determine the number of various points of interest within a one-kilometre circular buffer of participating COMPASS schools. This buffer represents a distance that individuals can walk in 10-15 minutes (i.e., during travel to/from school or during lunch and other breaks during school) (Apparicio, Cloutier, & Shearmur, 2007; Austin et al., 2005; Pikora et al., 2002). The use of this circular buffer is also consistent within other related research (Laxer & Janssen, 2013; Seliske et al., 2009a).

2.5 Data collection protocols

For each school, collection of student and Co-SEA COMPASS data take place within a single day. One or more COMPASS data collectors are on-site for each data collection to facilitate the student questionnaire administration, complete the school built environment assessment, and answer student, parent, and/or staff questions and concerns. COMPASS data collectors are typically graduate students or, in the case of schools in rural and remote settings, a school public health nurse.

Teachers administer the COMPASS student questionnaire during a designated class period. Students completed the questionnaire in approximately 35 to 40 minutes. Teachers are provided with detailed instructions for implementing the survey to ensure consistency, to protect student confidentiality, and to ensure a smooth data collection. Further details on the survey protocols are available in print (Leatherdale et al., 2014) and online (www.compass.uwaterloo.ca).

2.6 Measures

2.6.1 SSB consumption measures

Frequency of SSB consumption is the general outcome of interest within this dissertation research. Specific outcome measures pertained to participants' consumption of three distinct SSB categories (soft drinks, sweetened coffees/teas, and energy drinks) and a composite SSB measure over three time periods (weekdays, weekend days, and full week). In total, there were twelve SSB consumption-related variables, as summarized in Table 1. Chapter 3 included all twelve SSB measures, while Chapters 4 and 5 used only the four weekday measures of SSB intake, since these chapters were focused on associations between students' SSB intake and aspects of the school food environment (i.e., where students spend time on weekdays but not weekends).

The COMPASS student questionnaire asked participants to indicate the number of days during a usual school week (0-5 days) and weekend (0-2 days) that they consume each of the following: (i) "sugar-sweetened beverages (soda pop, Kool-Aid, Gatorade, etc.)"; (ii) "high-energy drinks (Red Bull, Monster, Rock Star, etc.)"; and, (iii) "coffee or tea with sugar (cappuccino, Frappuccino, iced-tea, iced-coffees, etc.)". This first SSB category (i.e., containing soda, fruit drinks, and sports drinks) is referred to as "soft drinks" herein. Participants were advised not to include diet drinks when reporting their soft drink intake. The COMPASS student questionnaire that contains these questions is shown in Appendix C.

Participants' responses to these questions were used directly to derive the dissertations measures of SSB intake relating to the number of weekdays/weekend days participants reported consuming each of soft drinks, sweetened coffee/teas, and energy drinks. For the *weekday* measures, these variables ranged in possible values from 0-5 days, while the *weekend* measures ranged from 0-2 days. Participants' *weekly* SSB intake measures were derived by summing the number of weekdays and weekends they reported consuming each category. Possible values for these outcomes ranged from 0-7 days.

Table 1: List of the twelve SSB-consumption related measures assessed in the dissertation.

Measure
Weekday SSB intake
weekdays reporting soft drink intake
weekdays reporting sweetened coffee/tea intake
weekdays reporting energy drink intake
Composite weekday SSB score
Weekend SSB intake
weekend days reporting soft drink intake
weekend days reporting sweetened coffee/tea intake
weekend days reporting energy drink intake
Composite weekend SSB score
Weekly SSB intake
days reporting soft drink intake in a typical week
days reporting sweetened coffee/tea intake in a typical week
days reporting energy drink intake in a typical week
Composite weekly SSB score

Participants' intake of all 3 SSB categories were assessed through composite SSB scores for each of the three time periods. These scores were derived by summing their weekday/weekend/weekly consumption (in days) of each of the three SSBs category. Possible values for participants' *weekday* composite SSB score ranged from 0 (indicating no consumption of any beverage category on any day) to 15 (indicating use of all three SSB categories every weekday). Possible values for participants' *weekend* composite SSB score ranged from 0 (indicating no consumption of any beverage category on any day) to 6 (indicating use of all three SSB categories every weekend day). Participants' *weekly* composite SSB score ranged in possible values from 0 (indicating no use of any beverage category on any day) to 21 (indicating use of all 3 SSB categories every day). These composite scores were intended to reflect a more comprehensive measure of participants' total SSB intake, in addition to their consumption of discrete SSB categories.

2.6.2 Student-level covariates

2.6.2.1 Control variables

Student-level control variables were chosen due to their purported association with adolescents' SSB intake (as described in Chapter 1). These variables included participants' self-reported gender, grade, ethnicity, weight status, personal weekly spending money, truancy, and weight goal. These variables are listed in Table 2.

Table 2: List of the student-level covariates assessed in the dissertation research.

Measure
Control variables
Gender
Grade
Ethnicity
Weight status
Personal weekly spending money
Truancy
Weight goal
Food purchasing behaviours
weekdays reporting eating home-packed lunch at school
weekdays reporting purchasing lunch from the school cafeteria
weekdays reporting purchasing snacks from school vending machines
weekdays reporting purchasing lunch in fast food places/restaurants
weekdays reporting purchasing snacks from convenience food outlet off-school property
weekend days reporting purchasing food from fast food places/restaurants
weekend days reporting purchasing snacks from convenience food outlets

Gender categories include 'male' and 'female'. *Grade* categories ranged from Grade 9-12. Grade was used in lieu of age (a related measure) since is more useful to school stakeholders since planning is done according to grade, rather than age. *Ethnicity* categories included 'White', 'Aboriginal', 'Asian', 'Black', 'Latin', and 'Other'. Participants were able to check all ethnicities that they felt applied to them. Those who indicated only one ethnicity were coded as being of that ethnicity. Participants that indicated more than one ethnicity were coded as 'Other'. *Weight status* categories included 'underweight', 'healthy weight', 'overweight', 'obese', and 'missing'. Weight status is assessed via students' self-reported height (converted to metres) and weight (in kilograms). Participants' BMIs were calculated using these data (BMI=kg/m2) and classified into BMI categories using World Health Organizations classifications, adjusted for age and sex (World Health Organization, 2015b). Participants who reported not knowing their weight and/or height or did not answer this question were coded as 'missing'. *Personal weekly spending money* categories included '$0', '$1-$20', '$21-100', '>$100', and 'I don't know/missing'. *Truancy* categories included 'skipped 0 classes in last four weeks' and 'skipped 1+ classes in last four weeks'. Truancy was included as a control variable, since it is a reflection of risk behaviour and rebellion, and risk behaviours may contribute to certain SSB intake patterns among adolescents (e.g., given the identified association between energy drink intake and risk behaviours in adolescence). *Weight goal* categories included 'not trying to do anything about my weight', 'gain weight', 'lose weight', and 'stay the same weight'.

2.6.2.2 Food purchasing variables

Chapter 3 examined adolescents' food purchasing behaviours on weekdays and weekends. The five weekday behaviours assessed included the number of school days (0-5) that participants typically (i) eat a home-packed lunch at school; (ii) purchase lunch in the school cafeteria; (iii) purchase snacks from school vending machines; (iv) purchase lunch in fast food places/restaurants; and, v) purchase snacks from convenience food outlets (e.g., vending machine, corner store, snack bar) off-school property. The two weekend behaviours included the number of weekend days (0-2) that participants typically: (i) purchase food from fast food places/restaurants; and, (ii) purchase snacks from convenience food outlets.

2.6.3 School-level explanatory variables

2.6.3.1 Control variables

School-level variables included province, school type (public versus private), geographic location, and school neighbourhood median household income. Categories of geographic location included 'rural or small population centre', 'medium urban population centre' and 'large urban population centre', and were classified according to Statistics Canada's definitions (Statistics Canada, 2015). School neighbourhood median household income were derived from the 2011 National Household Survey (i.e., representing the most closest wave of survey data to the COMPASS data used in this dissertation, as the survey is conducted every five years) (Statistics Canada, 2013), and corresponded to schools' postal codes. All school-level explanatory variables are listed in Table 3.

2.6.3.2 Assessments of school beverage availability

The Co-SEA data were used to examine the in-school accessibility of water fountains (including coolers and bottle filling stations) and the availability of each of soft drinks, sweetened coffees/teas, and energy drinks (i.e., reflecting the outcome measures) in vending machines. These data were also used to assess what specific beverage types (e.g., sugar-containing carbonated soft drinks, 100% juices, water, plain milk, etc.) were available within schools' vending machines.

Measures of the accessibility of water fountains were derived from data collectors' assessments of the presence of fountains ('yes', 'no'), if there was an adequate number of fountains ('yes', 'no'), if the fountains were easy to locate ('yes', 'no'), and the proportion of fountains that appeared to work ('none', 'some', 'all'). Schools were defined as having 'highly accessibility of water fountains' if (i) fountains were present; (ii) there was an adequate number of fountains; (iii) they were easy to locate; and, (iv) all of the fountains worked. Otherwise, the school was classified as having 'low accessibility of water fountains'.

Table 3: List of the school-level covariates assessed in this dissertation work.

Measure
Control variables
Province
School type
Geographic location
School neighbourhood median household income
Assessment of school beverage availability
In-school accessibility of water fountains
Availability of soft drinks in school vending machines
Availability of sweetened coffees/teas in school vending machines
Availability of energy drinks in school vending machines
Availability of sugar-containing carbonated soft drinks in school vending machines
Availability of sugar-containing non-carbonated soft drinks in school vending machines
Availability of sugar-containing sports drinks in school vending machines
Availability of flavoured milk in school vending machines
Availability of diet carbonated soft drinks in school vending machines
Availability of diet non-carbonated soft drinks in school vending machines
Availability of diet sports drinks in school vending machines
Availability of plain white milk in school vending machines
Availability of 100% fruit juice in school vending machines
Availability of bottled water in school vending machines
Assessments of school neighbourhood food outlets
Access to restaurants within 1-km buffer of school
Access to variety stores within 1-km buffer of school
Access to food stores within 1-km buffer of school

To assess the availability of each of soft drinks, sweetened coffees/teas, and energy drinks (i.e., SSBs categories that correspond to the outcome measures) in schools' vending machines, two research associates independently screened photos of vending machines, applying the criteria shown in Table 4. A sample photo of a school vending machine from the Co-SEA is shown in Figure 2. Availability was considered as binary ('available', 'unavailable'). For example, if a school had one or more soft drink available in one or more of its vending machines, it was classified as having soft drinks available. The reviewers then compared their independent assessments of beverage availability, and collectively re-evaluated the assessments they disagreed on, until they reached consensus.

Table 4: Inclusion and exclusion criteria used to classify specific beverages into 'soft drinks', 'sweetened coffees/teas', and 'energy drinks', when assessing the availability of these sugar-sweetened beverage (SSB) categories in school vending machines.

SSB category	Beverages included	Beverages excluded
Soft drinks	• 100% fruit juice blends (e.g., 100% fruit drink, containing added fruit concentrate) • <100% fruit drinks (e.g., fruit punch) • Non-diet flavoured waters (e.g., regular Vitamin Water) • Non-diet soda (e.g., Coke Zero) • Non-diet sports drinks (e.g., Gatorade)	• 100% juice (e.g., 100% orange juice) • Diet/sugar-free flavoured waters (e.g., Vitamin Water Zero, Aquafina Flavor Splash) • Diet soda (e.g., Coca-Cola) • Diet sports drinks (e.g., G2)
Sweetened coffees/teas	• Non-diet iced tea • Non-diet other tea beverage (e.g., Arizona tea drinks) • Non-diet coffee beverage (e.g., Starbucks Frappuccino)	• Diet iced tea • Diet/sugar-free other tea beverage • Diet/ sugar-free coffee beverage
Energy drinks	• Regular energy drinks	• Diet/sugar-free energy drinks

Figure 2: Sample photo from the Co-SEA displaying the contents of a school vending machine.

The reviewers had a high level of agreement (>95.0%) with respect to the availability of soft drinks, sweetened coffees/teas, and energy drinks within schools' vending machines, demonstrating the high reliability of these data (Table 5).

Table 5: Agreement between two independent reviewers' assessments of availability of soft drinks, sweetened coffees/tea, and energy drinks within school vending machines, based on photographs from the Co-SEA, between 2013/14-2015/16 of the COMPASS study.

	2013/14 n = 89 schools	**2014/15** n = 87 schools	**2015/16** n = 81 schools[1]
Proportion of times reviewers agreed on schools' soft drinks availability (%)	88/89 (98.9)	83/87 (95.4)	79/80 (98.8)
Proportion of times reviewers agreed on schools' sweetened coffee/tea availability (%)	87/89 (97.8)	85/87 (97.7)	79/80 (98.8)
Proportion of times reviewers agreed on schools' energy drink availability (%)	89/89 (100.0)	86/87 (98.9)	80/80 (100.0)
Total proportion of times reviewers agreed on schools' beverage availability (%)	264/267 (98.9)	254/261 (97.3)	238/240 (99.2)

[1] One school was missing Co-SEA data.

To provide a more detailed examination of the available beverages in school vending machines, the availability of ten beverage categories (e.g., sugar-containing carbonated soft drinks, 100% juices, water, plain white milk, etc.) within the vending machines was also assessed. For each vending machine, COMPASS data collectors counted the number of distinct (i.e., in size, flavour, cost, etc.) products within each category, irrespective of the number of slots these products occupied. For example, a vending machine containing several slots of small and large cartons of each of chocolate and strawberry milk, was counted as having four types of flavoured milk (i.e., two flavours*two sizes). Likewise, a vending machine containing cans and bottles of regular (i.e., non-diet) Pepsi, Coca-Cola, and Sprite would be counted as having six sugar-containing carbonated soft drinks (i.e., three flavours*two sizes) available. For schools with numerous beverage vending machines, the number of products within each beverage category was summed across the machines.

2.6.3.3 Assessments of school neighbourhood food outlets

The DMTI built environment data were used to examine the presence of three types of food outlets within a one-kilometre circular buffer of schools: restaurants, variety stores, and food stores. 'Restaurants' included establishments in which prepared foods/beverages were sold for on-premise or immediate consumption, such as sit-down and fast food restaurants. 'Variety stores' included establishments in which a wide assortment of low-cost food and non-food items were sold. 'Food stores' included supermarkets and specialized grocery stores. The presence of each food outlet was considered as binary; schools had either 'zero' or 'one or more' of each food outlet within their buffer.

2.7 Data linkage procedures

Student-level data from the 2013/14, 2014/15, and 2015/16 schools years used in this dissertation research were linked through codes assigned to student participants based on their responses to a series of questions on the cover page of the COMPASS study questionnaire. Individual students' responses to these questions should not vary between years of data collection (i.e., since questions relate to things like certain letters of their middle name) and do not allow them to be personally identifiable. This process enables participants to be tracked using this identifier while maintaining their anonymity. In instances where >1 participant has identical student codes, other questions (e.g., related to the students' socio-demographic characteristics) are used to distinguish between participants. Certain circumstances prevent participants' data from being linked between years, including students transferring schools, parents refusing from allowing their child to participate one year of the study, students on spare or absent from class on a data collection day, and/or participants providing inaccurate data on the data linkage questions.

This linkage process was tested in the COMPASS validation study (Bredin & Leatherdale, 2013). More recent evaluations of the linkage process reported high linkage rates (~80% success) and no significant differences between linked- and non-linked COMPASS student data across dietary outcomes, BMI, and other obesity-related characteristics, unlike substance-use behaviours (Qian, Battista, Bredin, Brown, & Leatherdale, 2015). These findings minimize concerns regarding representativeness of using the linked sample in longitudinal analyses in the present dissertation research.

School-level data from the 2013/14, 2014/15, and 2015/16 schools years were linked through each school's assigned unique identifier. Reasons for schools not being linked included schools dropping out of the study or joining the study part way through the dissertation's three-year study period. Longitudinal student- and school-level data were merged on the basis of school identifier and transposed into long format for all longitudinal modelling (described in Chapter 5).

Chapter 3

Food purchasing behaviours and sugar-sweetened beverage consumption among Canadian secondary school students in the COMPASS study

Status: In press in the *Journal of Nutrition Education and Behavior*.

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Overview

Objectives: To examine whether several food purchasing behaviors (i.e., sources of meals or snacks) are associated with adolescents' SSB consumption and whether these associations vary by province.

Design: Cross-sectional observational study.

Setting: Alberta and Ontario, Canada.

Participants: Secondary school students from Alberta (n = 3300) and Ontario (n = 37999) participating in Year 2 (2013/14) of the COMPASS study.

Main Outcome Measures: Participants' self-reported frequency of consuming three SSB types (soft drinks, sweetened coffees/teas, and energy drinks) in a typical week.

Analysis: Hierarchical Poisson regression analyses.

Results: Participants from Alberta had a significantly ($P < .05$) higher rate of consuming SSBs and purchasing meals or snacks from school food outlets compared with their Ontario counterparts. Most of the food purchasing behaviors were significantly ($P < .05$) and positively associated with greater rates of SSB consumption. Meal or snack purchases on weekends (versus weekdays) and from food outlets off school property (versus on school property) had a greater association with SSB consumption. Eating a home-packed lunch was protective against SSB consumption across models.

Conclusions and Implications: Adolescents' food purchasing behaviors have a significant impact on their propensity for SSB consumption. These data demonstrate potentially important contexts for SSB consumption and have implications for possible settings and strategies for future interventions to reduce adolescents' SSB intake.

Keywords: sugar-sweetened beverages; secondary schools; adolescent; nutrition policy.

3.1 Introduction

Adolescents are the largest consumers of SSBs in Canada (Jones et al., 2017), and many Canadian adolescents consume SSBs daily (Vanderlee et al., 2014). SSBs comprise a variety of beverages containing added sugars, including regular (i.e., non-diet) sodas, fruit drinks, sports drinks, energy drinks, flavoured dairy drinks, and sweetened coffees/teas. Excess SSB consumption is associated with an increased risk of obesity (Hu & Malik, 2010; Malik et al., 2010; Te Morenga et al., 2013), lower intake of vitamins and nutrients (Frary et al., 2004; Vartanian et al., 2007), and cardiovascular disease (Ambrosini et al., 2013; Bremer et al., 2010). Adolescents are a priority group for interventions to decrease SSB intake, particularly since dietary habits may persist into adulthood (Craigie et al., 2011).

Schools represent a viable setting for population health interventions directed at youth, due to their population coverage, the time adolescents spend in school, and the presence of policies, programs, and infrastructure that may influence students' behaviour. Canadian provincial school nutrition policies consistently recommend limiting the sale of SSBs in school food outlets (e.g., cafeterias and vending machines), although these policies differ in their scope. For example, *ANGCY* offers voluntary recommendations related to the sale of beverages within several youth-oriented settings, including to limit availability of caffeinated and/or sweetened (both sugar- and artificially-sweetened) beverages while ensuring access to water, milk, fortified soy beverages, and 100% vegetable and fruit juices (Government of Alberta, 2012). In contrast to Alberta's voluntary approach to school nutrition policy, the Ontario Ministry of Education implemented *P/PM 150*, which is mandatory in publicly-funded schools effective September 2011 (Ontario Ministry of Education, 2016). The policy prohibits the sale of many SSBs in public secondary schools, including <100% juice drinks, all sports drinks, all energy drinks, and "other" beverages (e.g., soft drinks, flavoured waters, and ades) and iced teas containing >40 calories or caffeine (Ontario Ministry of Education, 2016).

While each Canadian province has developed school nutrition policies to support healthy school foods, previous research demonstrates that Canadian schools do not consistently comply with these policy recommendations, given the availability of policy-noncompliant products for sale through Canadian school food outlets (McIsaac, Shearer, Veugelers, & Kirk, 2015; Orava et al., 2016; Vine et al., 2017). Further, there is evidence that there a higher degree of noncompliance with school nutrition policies (i.e., and thus, a greater availability of less healthful foods and beverages) among schools in provinces voluntary school nutrition policies (Vine et al., 2017), perhaps due to the numerous barriers to voluntarily adopting guidelines (Callaghan, Mandich, & He, 2010; McIsaac et al., 2015; Vine et al., 2014). It is unclear how adolescents' use of school food outlets relates to SSB intake, in part, due to the limited data on adolescents' food purchasing behaviours and how these decisions relate to diet quality. Although

earlier Canadian studies have identified associations between SSB intake and weekday lunch behaviours (Jones et al., 2015; Woodruff, Hanning, & McGoldrick, 2010), there has been limited examination of snack purchasing and weekend food purchasing behaviours and their relation to SSB consumption among adolescents.

This study examined how various meal/snack purchasing behaviours on weekdays and weekends are associated with adolescents' weekly consumption of three types of SSBs (soft drinks, sweetened coffees/teas, and energy drinks) in a sample of adolescents from Alberta and Ontario. This study also investigated how these associations vary by province, to test the hypothesis that the magnitude of the association between SSB consumption and purchases from school food outlets is greater among adolescents in Alberta compared to Ontario, as a possible reflection of voluntary versus mandatory provincial school nutrition policies.

3.2 Methods

3.2.1 Design

COMPASS is a nine-year longitudinal prospective cohort study (2012/13-2021/22) designed to collect hierarchical data annually from a sample of adolescents attending secondary schools (i.e., schools comprising Grades 9-12) in Alberta and Ontario, Canada. This study used data from Year 2 of COMPASS (2013/14). The University of Waterloo Office of Research Ethics and participating school boards' internal committees reviewed and approved all aspects of the study protocol.

3.2.2 Sample

The COMPASS recruitment process was multi-stage. First, participating school boards were purposely selected based on the following criteria: (i) English-speaking; (ii) approval of the study protocol; and, (iii) permission for use of active information passive consent parental permission protocols. A passive consent protocol was chosen, since active consent procedures are associated with low student participation rates in school-based studies, falsely inflated between-school variance, misrepresentative sample demographics, and the ability to identify individual participants (Thompson-Haile et al., 2013). All schools within eligible school boards were approached to participate. Participating schools were required to meet the following criteria: (i) secondary school with students in Grade 9 to Grade 12; (ii) minimum enrolment of 100 students per grade; and, (iii) operated in a standard school/classroom setting. The Year 2 sample comprised 89 secondary schools from Alberta (n=10) and Ontario (n=79).

Parents/guardians of students attending participating schools received a study information letter. Parents/guardians who did not want their child to participate could withdraw their child from the study by

contacting a COMPASS recruitment coordinator via telephone or email. All students whose parents passively consented for their child to participate were eligible to participate. Students were able to withdraw from the study at any point in time. A total of 57229 students were enrolled in the Year 2 schools within Alberta (n=4700) and Ontario (n=52529). Ultimately, 79.2% (n=45298) of students enrolled in Year 2 COMPASS schools participated in the study. Students missing data on outcome and/or control variables (i.e., relating to SSB consumption and socio-demographic characteristics, described below) were excluded from analyses (n=3999, 8.8%), with the exception of participants with missing body mass index (BMI) data. The final sample comprised 41299 participants, representing 70.2% (n=3300) and 72.3% (n=37999) of students enrolled at COMPASS schools in Alberta and Ontario, respectively.

3.2.3 Data sources

All student-level data (i.e., outcome, control, and explanatory variables) were collected through the COMPASS Student Questionnaire, which is a paper-based questionnaire comprising questions on many health, social, and academic outcomes. The questionnaire previously underwent, and performed well in, validity and reliability testing (Leatherdale, Laxer, & Faulkner, 2014; Leatherdale & Laxer, 2013).

3.2.4 Outcome variables

Participants were asked to indicate the number of days during a usual school week (0-5 days) and weekend (0-2 days) that they consume each of the following: (i) "sugar-sweetened beverages (soda pop, Kool-Aid, Gatorade, etc.)"; (ii) "high-energy drinks (Red Bull, Monster, Rock Star, etc.)"; and, (iii) "coffee or tea with sugar (cappuccino, Frappuccino, iced-tea, iced-coffees, etc.)". This first SSB category (i.e., containing soda, fruit drinks, and sports drinks) is referred to as "soft drinks" herein. Participants were advised not to include diet drinks when reporting their soft drink intake. Consistent with previous research (Godin et al., 2017), participants' responses to these questions were used to generate the four SSB-related outcome variables of interest: weekly rate of each of soft drink, sweetened coffee/tea, and energy drink consumption, and a composite SSB score.

Participants' weekly rate of the three SSB categories examined were derived by summing the number of weekdays and weekends they reported consuming each category. Possible values for these three outcomes ranged from 0-7 days/week. Participants' intake of all three SSB categories were assessed through a composite SSB score derived by summing their weekly consumption (in days) of each category. Possible values for this score ranged from 0 (indicating no use of any beverage category on any day) to 21 (indicating use of all three SSB categories every day). This composite score was intended to reflect a

more comprehensive measure of participants' total SSB consumption, in addition to their consumption of discrete SSB categories.

3.2.5 Control and explanatory variables

Control variables included gender, grade, ethnicity, weight status [i.e., BMI (kg/m^2) category based on reported height and weight, and World Health Organizations classifications, adjusted for age and sex (World Health Organization, 2015b)], personal weekly spending money, truancy, and weight goal. The weight status variable was categorical and comprised five levels: "underweight", "healthy weight", "overweight", "obese", and "missing" (i.e., for participants that were missing BMI data).

Potential explanatory variables described adolescents' food purchasing behaviours on weekdays and weekends. The five weekday behaviours included the number of school days (0-5) that participants typically (i) eat a home-packed lunch at school; (ii) purchase lunch in the school cafeteria; (iii) purchase snacks from school vending machines; (iv) purchase lunch in fast food places/restaurants; and, (v) purchase snacks from convenience food outlets (e.g., vending machine, corner store, snack bar) off-school property. The two weekend behaviours included the number of weekend days (0-2) that participants typically: (i) purchase food from fast food places/restaurants; and, (ii) purchase snacks from convenience food outlets.

3.2.6 Analyses

Descriptive statistics were used to characterize the sample. Chi square analyses and two-sided Wilcoxon rank sum procedures were conducted to examine provincial differences across categorical and non-normally distributed continuous variables, respectively.

Prior to developing multivariate models, two preliminary exploratory analyses were performed. First, PROC GLIMMIX was used to generate unconditional means models without any variables and with a random intercept term (i.e., null models) to examine the significance of the between-school variance for each of the four outcomes. For each outcome, we used the school-level variance term to calculate the intra-class correlation, which represents the proportion of the total variance in the SSB-related outcome that is due to differences across schools. Second, the variance inflation factors (VIFs) of the potential explanatory variables were examined using the VIF option in PROC REG for each outcome variable to assess risk of collinearity prior to modelling. While there are no formal criteria for deciding if a VIF is large enough to affect predicted values, it is generally accepted that VIFs exceeding 4 warrant further investigation, while VIFs exceeding 10 are signs of serious collinearity.

Using Generalized Estimating Equations, hierarchical Poisson regression models were developed to identify how adolescents' food purchasing behaviours are associated with the four outcomes, which reflect counts. To control for the clustered nature of the study (i.e., students within the same school are more likely to be similar across outcomes than students at different schools, and therefore not independent), a repeat subject representing "school" and an exchangeable (compound symmetric) covariance matrix were specified. The modeling approach taken was consistent with related research (Godin et al., 2017). A separate model was developed for each SSB outcome using a multi-step process. First, a series of univariate analyses was undertaken to identify if each potential explanatory variable was independently associated with each outcome. To be reasonable but yet not too restrictive at this screening stage, variables that were not statistically significantly ($P > .2$) in the univariate models were removed from the analysis. Second, all significant variables from this first screening stage were included in a joint, multivariate model. Control variables were included in each model, regardless of their statistical significance to minimize confounding.

Three strategies were used to assess the effect of province on the associations between outcome variables and food purchasing behaviours: (i) stratification by province (i.e., running a separate model for each province), (ii) including province as a main effect; and, (iii) examining interaction effects between province and food purchasing behaviours (i.e., also including province as a main effect). All analyses were performed using SAS version 9.4 (SAS Institute, Cary NC).

3.3 Results

3.3.1 Participants' socio-demographic characteristics

Within the total sample, there was roughly an equal representation of males and females and across the four grades (Table 6). Most participants were white (75.1%) and had a healthy weight (57.6%). The predominant weight goal was to lose weight, reported by 41.2% of participants. There were significant provincial differences in participants' socio-demographic and behavioural characteristics (Table 6 & Table 7).

Table 6: Characteristics of a sample of secondary school students participating in Year 2 of the COMPASS study from Alberta (n=3300) and Ontario (n=37999), Canada.

	Total n (%)	**Alberta** n (%)	**Ontario** n (%)	*P* value [a]
Gender				0.63
Female	20733 (50.2)	1670 (50.6)	19063 (50.2)	
Male	20566 (49.8)	1630 (49.4)	18936 (49.8)	
Grade				<.001
9	10657 (25.8)	487 (14.8)	10170 (26.8)	
10	10876 (26.3)	1065 (32.3)	9811 (25.8)	
11	10329 (25.0)	939 (28.4)	9390 (24.7)	
12	9437 (22.9)	809 (24.5)	8628 (22.7)	
Ethnicity				<.001
White	31003 (75.1)	2440 (73.9)	28563 (75.2)	
Aboriginal	1432 (3.5)	354 (10.7)	1078 (2.8)	
Asian	2114 (5.1)	128 (3.9)	1986 (5.2)	
Black	1498 (3.6)	58 (1.8)	1440 (3.8)	
Latin	765 (1.8)	12 (0.4)	753 (2.0)	
Other	4487 (10.9)	308 (9.3)	4179 (11.0)	
Weekly spending money				<.001
$0	6557 (15.9)	464 (14.1)	6093 (16.0)	
$1-$20	11893 (28.8)	612 (18.5)	11281 (29.7)	
$21-$100	11019 (26.7)	943 (28.6)	10076 (26.5)	
>$100	6621 (16.0)	755 (22.9)	5866 (15.5)	
I don't know/missing	5209 (12.6)	526 (15.9)	4683 (12.3)	
Weight status				<.001
Underweight	643 (1.6)	55 (1.7)	588 (1.5)	
Healthy weight	23793 (57.6)	1795 (54.4)	21998 (57.9)	
Overweight	5883 (14.3)	479 (14.5)	5404 (14.2)	
Obese	2647 (6.5)	270 (8.2)	2377 (6.3)	
Missing	8333 (20.2)	701 (21.2)	7632 (20.1)	
Truancy				<.001
Skipped 0 classes in last four weeks	29406 (71.2)	2091 (63.4)	27315 (71.9)	
Skipped 1+ classes in last four weeks	11893 (28.8)	1209 (36.6)	10684 (28.1)	
Weight goal				<.001
Not trying to do anything about weight	9406 (22.8)	891 (27.0)	8515 (22.4)	
Gain weight	7444 (18.0)	478 (14.5)	6966 (18.3)	
Lose weight	17015 (41.2)	1365 (41.4)	15650 (41.2)	
Stay the same weight	7434 (18.0)	566 (17.1)	6868 (18.1)	

[a] Pearson's chi-squared test used to examine differences by province.

3.3.2 Participants' food purchasing behaviours and SSB consumption

Table 7 demonstrates that participants reported most frequently eating a home-packed lunch at school (mean 3.01 days in a typical school week); however, school cafeterias and fast food places/restaurants were also common lunch sources. Participants from Alberta were more likely to make purchases from

food outlets on- and off-school property on weekdays, compared to their Ontario counterpart. Participants reported consuming soft drinks most frequently (mean 2.69 days in a typical week) and energy drinks least frequently (mean 0.45 days in a typical week). The rate of SSB intake was significantly greater, across all categories, among participants from Alberta. Descriptive analyses demonstrated varying patterns of SSB intake; both no use and daily use of SSBs were common, particularly with respect to soft drink consumption. For example, 22.8% of participants indicated no use of soft drinks within a typical week, while 9.9% reported drinking soft drinks daily.

3.3.3 Preliminary analyses

The unconditional means (i.e., random-intercepts) models demonstrated significant between-school variation across all outcome variables. School-level differences accounted for 1.9%, 0.8%, 1.9%, and 1.6% of the variability in students' weekly rate of consuming soft drinks, sweetened coffees/teas, and energy drinks, and their composite SSB score, respectively, when controlling for individual-level variance (Table 27). The pre-modelling collinearity diagnostics revealed minimal risk of collinearity, as none of the VIFs exceeded two (Table 28).

3.3.4 Multivariate models

All seven explanatory variables were significantly independently associated with each of the four outcome variables within the univariate analyses. As such, all seven variables were jointly included in a multivariate model for each outcome. Within this joint model stage, the parameter estimates corresponding to the food purchasing behaviours were similar across models that were stratified by province. For most explanatory variables, the 95% confidence intervals across the province-stratified models overlapped. However, within the models for weekly soft drink consumption, the 95% CIs corresponding to the frequency of purchasing lunch in the school cafeteria variable did not overlap between the province-stratified models, but were quite close. The analysis proceeded to the strategy of including province as a main effect in each model.

Table 7: Self-reported food purchasing behaviours and SSB consumption among a sample of secondary school students participating in Year 2 of the COMPASS study from Alberta (n=3300) and Ontario (n=37999), Canada.

	Total Mean ± SD	**Alberta** Mean ± SD	**Ontario** Mean ± SD	*P* value [a]
Weekday food purchasing behaviours [b]				
Freq. of eating home-packed lunch at school	3.01 ± 1.97	2.64 ± 2.00	3.05 ± 1.97	<.001
Freq. of purchasing lunch from the school cafeteria	1.01 ± 1.41	1.10 ± 1.44	1.00 ± 1.41	<.001
Freq. of purchasing snacks from school vending machines	0.30 ± 0.82	0.75 ± 1.19	0.26 ± 0.76	<.001
Freq. of purchasing lunch in fast food places/restaurants	0.83 ± 1.28	1.13 ± 1.42	0.80 ± 1.27	<.001
Freq. of purchasing snacks from convenience food outlet off-school property	0.45 ± 0.99	0.71 ± 1.21	0.43 ± 0.96	<.001
Weekend food purchasing behaviour [c]				
Freq. of purchasing food from fast food places/restaurants	0.54 ± 0.60	0.49 ± 0.60	0.55 ± 0.60	<.001
Freq. of purchasing snacks from convenience food outlets	0.22 ± 0.49	0.21 ± 0.49	0.22 ± 0.49	0.17
Weekly SSB consumption				
Soft drinks [d]	2.69 ± 2.28	2.91 ± 2.30	2.68 ± 2.27	<.001
Sweetened coffees/teas [d]	2.06 ± 2.37	2.20 ± 2.37	2.04 ± 2.37	<.001
Energy drinks [d]	0.45 ± 1.26	0.82 ± 1.68	0.42 ± 1.22	<.001
Composite SSB score [e]	5.21 ± 4.08	5.93 ± 4.50	5.14 ± 4.03	<.001

SSB = sugar-sweetened beverage
[a] Two-sided Wilcoxon rank sum procedure used to examine differences by province.
[b] Number of days in a typical school week (Mon.-Fri., 0-5 days).
[c] Number of days in a typical weekend (Sat.-Sun., 0-2 days).
[d] Number of days participants report consuming SSBs in a typical week (Mon.-Sun., 0-7 days).
[e] A composite score, ranging from 0-21, representing the sum of participants' weekly rates of consuming the three distinct SSB categories.

'Province' was significantly associated (P <.05) with all but one of the SSB outcomes (weekly rate of sweetened coffee/tea consumption) in multivariate models containing only control variables. Specifically, being from Alberta was associated with a greater number of days of SSB consumption among participants, after adjusting for control variables. However, the effect of province lost its statistical significance after adding the food purchasing behaviour variables. After adjusting for the control variables and province, most food purchasing behaviours examined were significantly associated with increases in participants' days of SSB consumption (Table 8). Conversely, 'eating a home-packed lunch' was protective against days of SSB consumption across all models. Generally, the effects sizes associated with weekend food purchasing behaviours were greater than that of weekday behaviours. Likewise, use of off-

school property food outlets was associated with greater increases in participants' days of SSB consumption than use of school food outlets. However, the magnitude of the difference in effects sizes between food outlets on-school property versus off-school property is less than that of weekend versus weekday food purchasing behaviours. Further, there was an overlap in the confidence intervals of the purchasing from school vending machine variables and off-school property weekday food purchasing variables in the models for weekly sweetened coffees/teas consumption and weekly energy drink consumption. Figure 3 shows the adjusted rates from the final composite SSB score model.

Table 8: Food purchasing behaviour-related correlates of weekly SSB consumption among secondary school students (n=41299) from Alberta and Ontario, Canada, participating in Year 2 of the COMPASS study.

	Weekly SSB consumption [a] Adjusted rate [b] (95% CI)			
	Composite SSB score [c]	Soft drinks	Sweetened coffees/teas	Energy drinks
Province				
Ontario	1.00	1.00	1.00	1.00
Alberta	1.03 (0.97-1.10)	1.02 (0.98-1.07)	0.95 (0.87-1.05)	1.13 (1.00-1.29)
Weekday food purchasing behaviours [d]				
Freq. of eating home-packed lunch at school	0.98 (0.97-0.98) ***	0.99 (0.99-1.00) *	0.98 (0.97-0.99) ***	0.92 (0.91-0.93) ***
Freq. of purchasing lunch in the school cafeteria	1.03 (1.02-1.03) ***	1.03 (1.02-1.04) ***	1.03 (1.02-1.03) ***	1.02 (1.01-1.03) **
Freq. of purchasing snacks from a school vending machine	1.05 (1.04-1.06) ***	1.01 (0.99-1.02)	1.05 (1.03-1.06) ***	1.13 (1.11-1.15) ***
Freq. of purchasing lunch in fast food places/restaurants	1.07 (1.07-1.08) ***	1.07 (1.07-1.08) ***	1.06 (1.05-1.08) ***	1.07 (1.06-1.09) ***
Freq. of purchasing snacks from convenience food outlets off-school property	1.08 (1.07-1.09) ***	1.07 (1.06-1.08) ***	1.06 (1.05-1.07) ***	1.14 (1.12-1.15) ***
Weekend food purchasing behaviours [e]				
Freq. of purchasing food from fast food places/restaurants	1.17 (1.15-1.18) ***	1.19 (1.18-1.21) ***	1.11 (1.09-1.13) ***	1.20 (1.17-1.23) ***
Freq. of purchasing snacks from convenience food outlets	1.13 (1.12-1.15) ***	1.11 (1.10-1.13) ***	1.08 (1.06-1.10) ***	1.32 (1.28-1.36) ***

SSB = sugar-sweetened beverage
*P <.05, ** P <.01, *** P <.001
[a] Number of days participants reported consuming SSBs in a typical week (Mon.-Sun., 0-7 days).
[b] Rates adjusted for all other variables in the column, in addition to gender, grade, province, ethnicity, weekly spending money, weight status category, truancy, and weight goal.
[c] A composite score, ranging from 0-21, representing the sum of participants' weekly rates of consuming the three distinct SSB categories.
[d] Number of days in a typical school week (Mon.-Fri., 0-5 days).
[e] Number of days in a typical weekend (Sat.-Sun., 0-2 days).

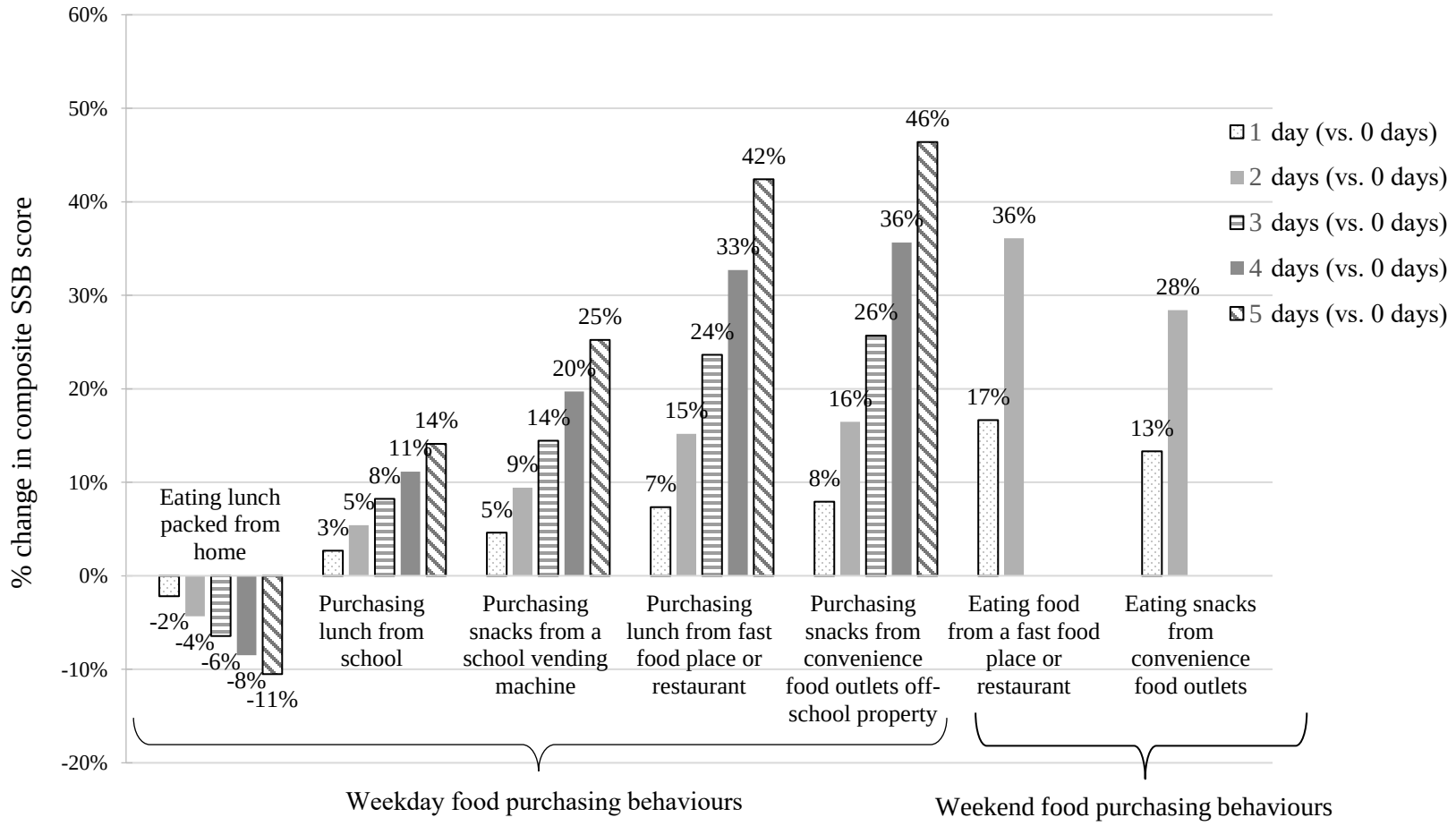

Figure 3: Percent change in composite SSB score associated with different frequencies of food purchasing behaviours, controlling for all control and explanatory variables.

Interaction effects between province and all food purchasing behaviours were also tested. Of the 28 interaction effects tested in total (i.e., seven interaction effects * four outcomes), only one was significant at P <.05 (Figure 4). This effect suggests that the more frequently a student purchases lunch from the school cafeteria, the greater their rate of weekly soft drink consumption, especially among students in Alberta. A number of interaction effects were significant at P <.10 in the weekly soft drinks model as well, including the interaction between province and weekday frequency of bringing a home-packed lunch, weekday frequency of purchasing snacks from a school vending machine, and weekday/weekend frequency of purchasing snacks from convenience food outlets off-school property. For all of these effects, the association between the food purchasing behaviour and frequency of soft drinks consumption was more pronounced among students from Alberta.

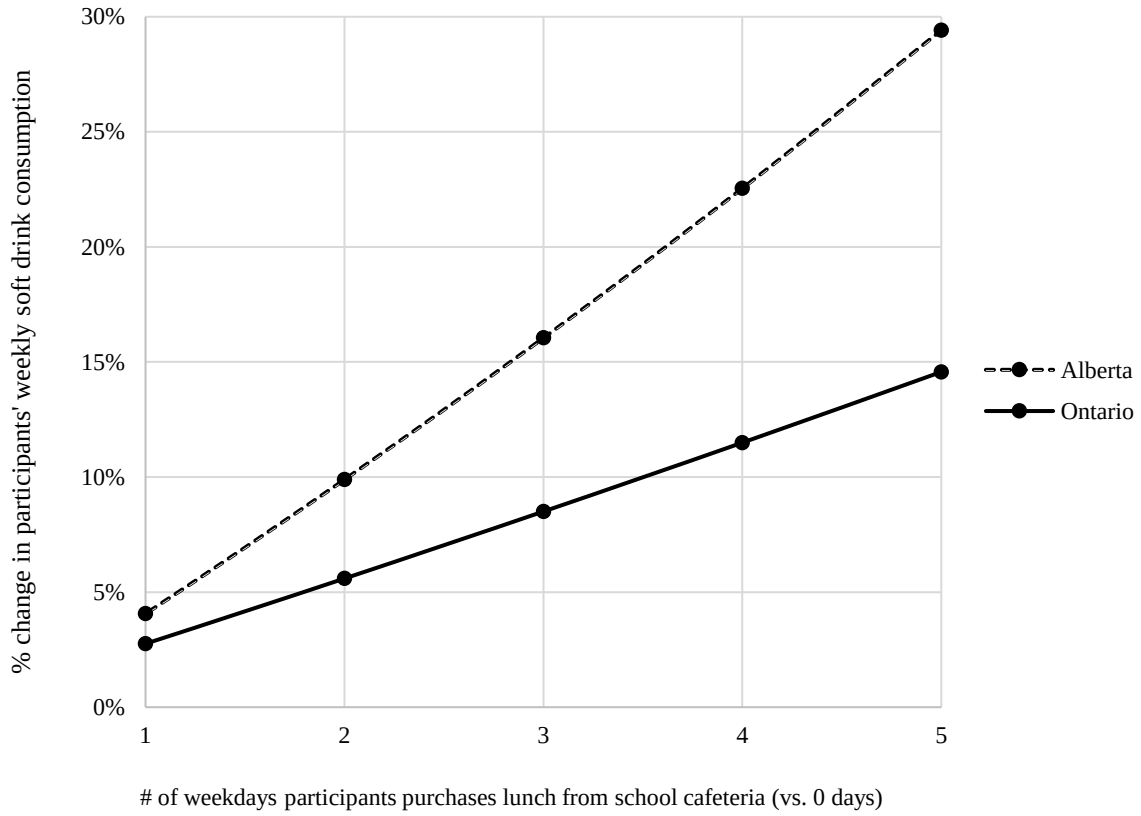

Figure 4: Percent change in rate of weekly soft drink consumption, as a function of province and the number of weekdays participants purchase lunch from their school cafeteria.

Supplementary material for this chapter can be found in Appendix E.

3.4 Discussion

This study identifies the associations between adolescents' weekday and weekend food purchasing behaviours and their SSB intake. These data demonstrate potentially important contexts for adolescents' SSB consumption and have implications for possible settings and strategies for future interventions to reduce youths' SSB consumption.

This study identified that weekend food purchasing behaviours have a greater association with adolescents' days of SSB consumption compared to their weekday food choices. There has been a limited investigation of differences in adolescents' dietary behaviours on weekends versus weekdays (e.g., due to the popularity of 24-hour dietary recall in many nutrition surveys, which are often administered in schools and, thus, on weekdays), precluding the ability to compare this result with previous Canadian literature. An Australian study identified that female adolescents demonstrated comparable SSB consumption on weekdays and weekend days, while males showed a more than three-fold increase in their SSB intake on weekends relative to weekdays (Smith, Straker, & Kerr, 2015). However, to our knowledge, these findings have not been replicated in other contexts. Differences in dietary intake and behaviours on weekdays versus weekends likely reflect variation in the physical and social contexts in which adolescents spend their time in these two periods. For example, since Canadian youth do not go to school on weekends, they have more time for leisure activities (e.g., eating out for meals, shopping, etc.) on weekends. The difference in the magnitude of the association between frequency of SSB intake and weekday versus weekend dietary behaviours may be useful in informing decisions on prioritizing settings and strategies for reducing adolescents' SSB intake. Previous research demonstrates that school-based initiatives have limited influence on students' SSB intake during their leisure time (Vecchiarelli et al., 2006), implying that there are minimal "carry-over" intervention effects. This finding, coupled with this current study's results, suggest that broader population-level strategies (i.e., those centred on the larger food, home, and media environments that surround youth throughout the week) to reduce access to and attractiveness of SSBs are likely better poised to address adolescents' consumption of these products.

This study's findings demonstrate that adolescents regularly use school food outlets for food purchases, and that these purchases represent an important predictor of SSB consumption. Previous Canadian studies reported similar associations (Jones et al., 2015; Woodruff et al., 2010), although neither examined snack nor weekend purchasing behaviours. It is plausible that these associations reflect the presence of SSBs in schools, given evidence that many Canadian secondary schools have less healthful beverages available for sale (Orava et al., 2016; Vine et al., 2017). However, this cannot be inferred, since the availability of SSBs in school food outlets was not examined within this study. Purchasing meals and snacks from food outlets off-school property appears to be a greater correlate of SSB consumption among adolescents than

purchasing from school food outlets. Canadian adolescents tend to have at least one, if not many more, food outlets within close proximity of their schools (Seliske et al., 2009a; Seliske et al., 2009b; Vine & Elliott, 2014). These outlets, being off-school property, are exempt from school nutrition policies and not restricted in their availability of SSBs and other policy-noncompliant products. Given the popularity of food outlets within schools and the school neighbourhood for lunch/snack purchases, an opportunity exists to modify the school food environment to improve youths' dietary outcomes (e.g., through efforts to limit students' access to off-school property food outlets and increase the availability and appeal of healthier choices in school food outlets).

This study's results demonstrate that eating a packed lunch from home is not associated with increased rate of SSB consumption, although the effect sizes are modest. Encouragingly, this was the predominant lunch choice among participants, consistent with previous Canadian research (Jones et al., 2015; Woodruff et al., 2010). Since home-packed lunches are exempt from school nutrition policies, they may include SSBs and other unhealthy products. However, since home-prepared meals are often more nutritious than purchased meals (Woodruff et al., 2010), school stakeholders should encourage adolescents to eat a healthy home-packed lunch (e.g., through in-school cooking classes focused on nutritious lunch preparation and developing students' food skills). Further, this finding underscores the importance of parents/guardians having the necessary resources (e.g., food skills/knowledge, time, access to affordable and healthy food, etc.) to ensure their children have a nutritious home-packed school lunch.

This study found that, compared to those in Ontario, participants from Alberta had a higher rate of both consuming SSBs (across all beverage categories) and purchasing meals/snacks from food outlets in their school. These descriptive findings support the study hypothesis that the magnitude of the relationships between SSB consumption and food purchasing behaviours are greater among Albertan participants, reflecting Alberta's voluntary provincial school nutrition policies and the resulting greater availability of noncompliant beverages in schools. The interaction effects identified further supports the study hypothesis, and underscores the need for continued evaluation of school nutrition policies. Canadian studies have demonstrated that these policies can have a favourable impact on youths' dietary behaviours and the quality the school food environment (Fung et al., 2013; Watts, Mâsse, & Naylor, 2014). However, there are several limitations that prevent current school nutrition policies from achieving this potential, including a lack of consistency, clarity, enforcement, and government resources to support policy implementation and adherence (Vine et al., 2017; Vine & Elliott, 2014), suggesting that these policies can be strengthened to better support a healthier school food environment.

3.4.1 Strengths and limitations

This research has many strengths. This study boasts a large sample size drawn from two provinces and 89 schools, representing a variety of socioeconomic and geographic contexts. The questionnaire captured multiple days of dietary behaviours, which is a better representation of participants' typical diets compared to methods that inquire about consumption within shorter timeframes (e.g., 24 hour recall) (Vanderlee et al., 2014). This study also extends previous COMPASS analyses that have focused exclusively on soft drinks (Jones et al., 2015), by examining participants' consumption of several varieties of SSB, reflecting the diversity of products available on the market.

There are limitations to this study, many of which reflect the challenges inherent in secondary data analysis. This study is cross-sectional, and is therefore unable to report that the associations noted are causal. Measures of participants' SSB consumption likely underestimate adolescents' true SSB intake due to the unit of measure used (i.e., as compared to volume or number of servings of SSBs consumed) and since certain SSBs (e.g., sweetened dairy-based) are not captured on the questionnaire. While the questionnaire collects data on many food purchasing behaviours, it is impossible to distinguish between the contribution of different environments (e.g., school food outlets, food outlets surrounding schools, home, etc.) to participants' reported SSB intake. As such, interpretations of findings reflect assumptions that adolescents' purchase meals/snacks represent possible sources of the SSBs they consume. The observed associations may be due to other individual-level factors not examined in the present analyses. This study used self-reported data, which may introduce social desirability and recall bias, resulting in participants underreporting their SSB consumption and/or misrepresenting their height/weight (Elgar, Roberts, Tudor-Smith, & Moore, 2005). Further, the research design used in the study could not adequately account for all of the potentially relevant provincial differences that may affect SSB consumption in a cross-sectional study, which impeded on the ability to robustly test the study hypothesis relating to differing provincial school nutrition policies. By the same token, the significant effects described (e.g., between province and discrete food purchasing behaviours) may be due to noise in the data, given that the variables represent approximations of adolescents' actual dietary behaviours. These effects should be interpreted with caution. Finally, COMPASS uses a convenience sample of schools and is therefore not provincially- or nationally-representative. However, these findings may be relevant in similar contexts.

3.5 Implications for research and practice

Many adolescents purchase lunch/snacks from food outlets on- and near-school property, and these behaviours are important predictors of SSB consumption. Strategies to improve the school food

environment to promote healthier dietary choices include increasing accessibility and use of water fountains, stocking healthy choices in prominent places, offering these choices at an attractive cost, and eliciting student feedback on menus (Callaghan et al., 2010). Interventions to discourage students from visiting off-school property food outlets include policies to limit the development of new fast-food restaurants in school neighbourhoods (Laxer & Janssen, 2013), extending the scope of provincial school nutrition policies to other venues (e.g., community centres) (Vine & Elliott, 2014), and closed campus policies (Vine et al., 2014). There has been limited evaluation of these interventions in Canada, reflecting a priority area for future research.

Schools should provide a supportive context to encourage eating home-packed lunches (Vine et al., 2014), which may include an attractive designated eating space, allowing sufficient time for eating, and access to microwaves and refrigerators. Nutrition education and programs to develop students' food skills may also be helpful in increasing students' interest and ability to prepare healthy meals (Hersch, Perdue, Ambroz, & Boucher, 2014). These strategies may counteract some of the existing social barriers to eating a home-prepared lunch cited by adolescents, including a desire for autonomy over food choice and perceptions that purchasing lunch is a marker of social status (Vine et al., 2014).

Though this study identified some evidence suggesting that school characteristics are important determinants of students' rate of SSB intake, the findings demonstrate that other contexts (e.g., the larger food, home, and media environments) may be more appropriate settings for population-health interventions to reduce adolescents' SSB consumption. Examples of these broader initiatives include including implementing a new tax on SSBs and artificially-sweetened beverages and banning advertising of foods and beverages to children; the recent Canadian Senate report recommended that the federal government implement these interventions among several other policies to improve Canadians' diets (Ogilvie, 2016). Future evaluation studies will be instrumental in identifying the effectiveness of these broader population health interventions.

Chapter 4

Examining associations between school food environment characteristics and sugar-sweetened beverage consumption among Canadian secondary school students in the COMPASS study

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Overview

Objective: To examine associations between Canadian adolescents' SSB consumption and several school food environment characteristics, and to investigate differences in these characteristics between schools in provinces with voluntary (Alberta) versus mandatory (Ontario) provincial school nutrition policies.

Design: We used a questionnaire to assess the number of weekdays participants consumed three SSB categories (soft drinks, sweetened coffees/teas, and energy drinks) and various socio-demographic and behavioural characteristics. We examined the in-school water fountain accessibility, vending machines contents, and presence of various food outlets within schools' 1-km buffer. We developed hierarchical Poisson regression models to identify associations between student- and school-level characteristics and students' SSB outcomes.

Setting: Alberta and Ontario, Canada.

Subjects: Adolescents (n= 41829) from 89 secondary schools.

Results: Many schools had vending machines containing SSBs, and most had ≥1 restaurant and/or food store within a 1-km buffer. SSB availability and frequency of SSB consumption were significantly greater in Alberta. The availability of sweetened coffees/teas in school vending machines and access to restaurants within school's 1-km buffer were associated with increased SSB intake in three of the final models. Overall, the school food environment-level characteristics examined had a modest to negligible impact on student days of SSB intake.

Conclusions: We identified that the school food environment characteristics examined here had little impact on adolescents' days of SSB consumption. While schools should adopt or maintain a comprehensive policy approach to discourage students' SSB intake, population-level interventions focusing on other contexts (e.g., home and community) are needed to complement existing school-based interventions.

Keywords: sugar-sweetened beverage; schools; nutrition policy; youth; Canada.

4.1 Background

Reducing SSB consumption represents an important aim for population-level dietary interventions, particularly those targeting adolescents. SSBs comprise a variety of beverages containing added sugars, including regular (i.e., non-diet) soft drinks, fruit drinks, sports drinks, energy drinks, flavoured milk drinks, and sweetened coffees/teas. Recent studies demonstrate that adolescents are the largest consumers of SSBs in Canada (Jones et al., 2017), and many youth consume SSBs daily (Garriguet, 2008; Lo et al., 2008; Vanderlee et al., 2014). SSBs are a major source of added sugars and energy in adolescents' diets, and often have negligible nutritional value (Hu & Malik, 2010). Previous research has identified associations between SSB intake and adverse health outcomes, including an increased risk of overweight/obesity (Hu & Malik, 2010; Malik et al., 2010; Te Morenga et al., 2013), lower intake of vitamins and nutrients (Frary et al., 2004; Vartanian et al., 2007), dental caries (Gupta et al., 2013), and cardiovascular disease (Ambrosini et al., 2013; Bremer et al., 2010). Given the popularity of SSBs among adolescents, the negative health impacts associated with these beverages, and the tendency for dietary habits to persist into adulthood, adolescents are a priority group for population-level interventions to decrease SSB intake.

There has recently been considerable attention on how environmental factors may influence dietary behaviours. Ecological models of health describe how individuals' health behaviours are shaped by various levels of influence, ranging from broader contextual factors (e.g., socio-cultural, political, and physical environments) to individual-level factors (e.g., those related to biology, individual socioeconomic characteristics, and lifestyle choices) (McLeroy, Bibeau, Steckler, & Glanz, 1988). These models suggest that interventions to improve individuals' dietary behaviours should reflect and account for these more distal contexts.

Many studies have examined the influence of the school food environment on adolescents' dietary behaviours. The school food environment comprises, in part, the facilities in which food and beverages are sold or otherwise available, both within the school grounds and the school neighbourhood. Canadian provincial school nutrition policies are intended to facilitate students' healthy dietary choices, often through modifications to the school food environment, though these policies vary in their scope. For example, *ANGCY* provides voluntary recommendations for schools and other youth-oriented settings (Government of Alberta, 2012), while Ontario's *P/PM 150* offers mandatory guidelines for publicly-funded elementary, middle, and secondary schools (Ontario Ministry of Education, 2016). Effective September 2011, *P/PM 150* prohibited the sale of many SSBs in public secondary schools, including < 100% juice drinks, all sports drinks, all energy drinks, and "other" drinks (e.g., soft drinks, flavoured waters, and ades) and iced teas containing >40 calories or caffeine (Ontario Ministry of Education, 2016).

The following beverages are considered "sell-most (≥80%)": plain water, milk and milk-based beverages (plain or flavoured) that meet specific fat, sugar, and calcium requirements, fortified milk alternative beverages (plain or flavoured), 100% juices (no sugar added), and hot chocolate beverages that meet specific fat, sugar, and calcium requirements. "Sell-less (≤20%)" beverages include decaffeinated coffees/teas and "other" drinks with ≤40 calories and without caffeine.

Previous research has demonstrated that adolescents that purchase meals/snacks from food outlets at school (e.g., vending machines and cafeterias) and off-school property (e.g., fast food and other restaurants and convenience food outlets) have a higher rate of SSB intake than those that do not make such purchases (Godin, Chaurasia, Hammond, & Leatherdale, 2018; Jones et al., 2015). Likewise, certain studies identify associations between SSB consumption and access to food retailers in the school neighbourhood (Davis & Carpenter, 2009; Wiecha et al., 2006) and SSB availability in school food outlets (Mâsse et al., 2014; Park et al., 2010; Wiecha et al., 2006). Further, recent studies have found significant variation in students' SSB consumption between schools (Godin et al., 2018; Johnson et al., 2009; Lebel et al., 2016; Lien et al., 2014). This literature demonstrates the impact that schools may have on adolescents' SSB intake, highlighting a viable opportunity to decrease adolescents' SSB consumption through initiatives seeking to improve the quality of the school food environment.

The primary objective of this study was to examine how several modifiable characteristics of the school food environment are associated with adolescents' weekday rate of consuming three SSB types (soft drinks, sweetened coffees/teas, and energy drinks) in a sample of adolescents from Alberta and Ontario, Canada, in order to identify possible opportunities for initiatives to discourage SSB intake. Secondary objectives included to investigate differences in aspects of the school food environment between the two provinces, as a reflection of their distinct nutrition policies. The overall hypothesis was that greater access to SSBs within the school food environment would be positively associated with adolescents' SSB intake, and that SSB availability would be greater in Albertan schools, given the voluntary nature of their provincial school nutrition policy.

4.2 Methods

4.2.1 Design

COMPASS is a prospective cohort study designed to collect hierarchical data from a sample of Canadian secondary school (Grades 9-12) students (Leatherdale et al., 2014). This study used data from Year 2 of COMPASS (2013/14), since it was the first year to include Albertan schools and it boasts the largest school and participant sample sizes. The University of Waterloo Office of Research Ethics and

appropriate school board review panels reviewed and provided received ethics clearance for COMPASS protocols. Further details on the host study methods are available in print (Leatherdale et al., 2014) and online (www.compass.uwaterloo.ca).

4.2.2 Sample

Participating school boards and schools were purposely selected due to their use of active information passive consent parental permission protocols. The school sample comprised 89 secondary schools in Alberta (n=10) and Ontario (n=79). The relatively small number of schools in Alberta compared to Ontario reflects COMPASS' inception in Ontario. All students enrolled in the 89 Year 2 COMPASS schools (n=57229) whose parents passively consented for them to participate were eligible to participate. Ultimately, 79.2% (n=45298) of these students completed the questionnaire. The response rate was similar between provinces: 75.8% in Alberta and 79.5% in Ontario. We excluded students missing data on outcome and/or control variables from the analyses (n=3469, 7.7%); however, we included participants missing BMI data. The final sample comprised 41829 participants, representing 92.3% of those that completed the questionnaire, from Alberta (n=3300) and Ontario (n=38499).

4.2.3 Data sources

Student data were collected through the COMPASS Student Questionnaire, which is a paper-based questionnaire comprising questions on basic demographic information, and a variety of health, social, and academic outcomes. Students completed the survey during class in approximately 35 to 40 minutes. All students present during the data collection were able to complete the questionnaire, enabling collection of whole-school samples.

School-level data were collected through the Co-SEA and the DMTI built environment resource. The Co-SEA is a mobile application containing a series of questions adapted from two previously validated audit tools designed to efficiently measure schools' food and physical activity environments (Jones et al., 2010; van der Horst et al., 2008). The Co-SEA also allows data collectors (i.e., most often COMPASS research assistants, though occasionally local public health nurses in rural/remote communities) to store photos of built environment features, and include notes within the application, representing supplementary sources of direct observation data. For each school, data collectors conducted the Co-SEA audits on the same day that students completed the questionnaire. The Co-SEA was tested in a convenience sample of schools and refined accordingly prior to being used in the COMPASS study. The DMTI provides data on the type, location, and number of various points of interest (e.g., grocery stores, restaurants, etc.) within various circular buffers surrounding schools. Further detail on these data sources is available elsewhere (CanMap RouteLogistics & Enhanced Points of Interest, 2015; Leatherdale et al., 2014).

4.2.4 Outcome variables

Consistent with previous research (Godin et al., 2017), we selected outcomes that reflect weekday SSB consumption (versus weekend or weekly), since Canadian youth only attend school on weekdays, and our objective was to examine the impact of school characteristics on students' SSB intake.

The questionnaire asked participants to indicate the number of days during a usual school week (0-5 days) that they consume each of the following: (i) "sugar-sweetened beverages (soda pop, Kool-Aid, Gatorade, etc.)"; (ii) "high-energy drinks (Red Bull, Monster, Rock Star, etc.)"; and, (iii) "coffee or tea with sugar (cappuccino, Frappuccino, iced-tea, iced-coffees, etc.)". We refer to the "sugar-sweetened beverage" category as "soft drinks" herein.

We used participants' responses to these questions to derive the study's four measures of SSB intake: number of weekdays participants reported consuming each of soft drinks, sweetened coffee/teas, and energy drinks, and a composite weekday SSB score. The first three outcome variables reflect distinct beverage categories, and range in possible values from 0-5 days. For the fourth outcome variable, we assessed participants' intake of all three SSB categories captured on the questionnaire through a composite score. We calculated this score by summing participants' weekday consumption (in days) of each category. Possible values for this score ranged from 0 (indicating no consumption of any beverage category on any day) to 15 (indicating use of all three SSB categories every weekday).

4.2.5 Control variables

We included both student- and school-level control variables in our analyses. Student-level control variables included gender, grade, ethnicity, weight status [i.e., BMI (kg/m^2) category based on reported height and weight, and World Health Organizations classifications, adjusted for age and sex (World Health Organization, 2015b)], personal weekly spending money, truancy, and weight goal.

School-level control variables included school type (public versus private), geographic location, and school neighbourhood median household income. Categories of geographic location included "rural or small population centre", "medium urban population centre" and "large urban population centre", and were classified according to Statistics Canada's definitions (Statistics Canada, 2015). School neighbourhood median household income were derived from the 2011 National Household Survey (i.e., representing the most recent data available at the time of COMPASS Year 2, as the survey is conducted every five years) (Statistics Canada, 2013), and corresponded to schools' postal codes.

4.2.6 Variables describing school beverage availability and school neighbourhood food outlets

Using the Co-SEA data, we examined the in-school accessibility of water fountains (including coolers and bottle filling stations) and the availability of each of soft drinks, sweetened coffees/teas, and energy drinks (i.e., reflecting the outcome measures) in vending machines. Further, we used the Co-SEA data to assess what specific beverage types (e.g., sugar-containing carbonated soft drinks, 100% juices, water, plain milk, etc.) were available within schools' vending machines.

We assessed the accessibility of water fountains via data collectors' assessments of the presence of fountains ('yes', 'no'), if there was an adequate number of fountains ('yes', 'no'), if the fountains were easy to locate ('yes', 'no'), and the proportion of fountains that appeared to work ('none', 'some', 'all'). We defined schools as having 'highly accessibility of water fountains' if (i) fountains were present; (ii) there was an adequate number of fountains; (iii) they were easy to locate; and, (iv) all of the fountains worked. Otherwise, we classified the school as having 'low accessibility of water fountains'.

To assess the availability of each of soft drinks, sweetened coffees/teas, and energy drinks in schools' vending machines, two research associates independently screened photos of vending machines, applying the criteria shown in Table 4. We considered availability as binary ('available', 'unavailable'). For example, if a school had one or more soft drink available in one or more of its vending machines, we classified it as having soft drinks available. The reviewers then compared their independent assessments of beverage availability, and collectively re-evaluated the assessments they disagreed on, until they reached consensus.

Although many previous studies have limited their investigation of school food outlets to vending machines (Park et al., 2010; Park et al., 2012; Vine et al., 2017; Wiecha et al., 2006), we had intended to include measures relating to SSB availability in other school food outlets, including cafeterias and tuck shops (i.e., small school stores that primarily sell to-go snacks/beverages). However, these data were not consistently available, as these outlets operate for a limited period each day, which did not always coincide with the timing of data collections. Further, school cafeterias are often operated by external private companies in Canada. As such, COMPASS researchers were frequently denied permission to enter and/or photograph these food outlets. Given this limitation of having objective cafeteria/tuck shop data across all schools, we noted the food outlets present within each school but did not report on SSB availability in those contexts. As such, we only assessed SSB availability in vending machines as we had comprehensive objective data on SSB availability in school vending machines.

Finally, we used the DMTI built environment data to examine the presence of three types of food outlets within a one-kilometre circular buffer of schools: restaurants, variety stores, and food stores. 'Restaurants' included establishments in which prepared foods/beverages were sold for on-premise or immediate consumption, such as sit-down and fast food restaurants. 'Variety stores' included establishments in which a wide assortment of low-cost food and non-food items were sold. 'Food stores' included supermarkets and specialized grocery stores. The one-kilometre buffer represents a distance that individuals can walk in 10-15 minutes (e.g., during travel to/from school or during lunch/other school breaks) (Apparicio et al., 2007; Austin et al., 2005; Pikora et al., 2002). We considered the presence of each food outlet as binary; schools had either 'zero' or 'one or more' of each outlet within their buffer.

4.2.7 Analyses

We used descriptive statistics to characterize the student and school samples. We conducted Chi square analyses, two-sided Wilcoxon rank sum procedures, and Fisher's Exact Test to examine provincial differences across categorical variables (i.e., student-level characteristics), non-normally distributed continuous variables (i.e., outcome variables, which reflect rates), and categorical variables with small cell counts (i.e., school-level characteristics), respectively.

Using Generalized Estimating Equations, we developed hierarchical Poisson regression models to identify how student- and school-level variables are associated with the four SSB consumption outcomes, while controlling for the clustered nature of the study (i.e., students are nested within schools). We also assessed risk of multicollinearity between the potential explanatory variables prior to modelling via VIFs for each outcome variable. While there are no formal criteria for deciding if a VIF is large enough to affect predicted values, it is generally accepted that VIFs exceeding 4 warrant further investigation, while VIFs exceeding 10 are signs of serious collinearity.

We took a three-step approach to modelling, consistent with previous research examining the impact of the school context on youth health outcomes (Haug, Torsheim, & Samdal, 2008; Hobin et al., 2012). In Step 1, PROC GLIMMIX was used to generate unconditional means models without any variables and with a random intercept term (i.e., null models) to examine the significance of the between-school variance for each outcome. Significant school-level variation would suggest that aspects of the school environment have an important bearing on students' SSB intake, warranting further exploration of school-level variables. For each outcome, we used the school-level variance term to calculate the intra-class correlation, which represents the proportion of the total variance in the SSB-related outcome that is due to differences across schools.

In Step 2, we performed a series of univariate regression analyses to examine the independent association between each explanatory variable and each outcome variable. These models contained only the variable being tested, and thus did not include student- or school-level control variables. Explanatory variables that were not significantly associated ($P \geq 0.2$) with an outcome variable were not considered in subsequent joint models for that outcome.

Third, we used a sequential block-wise modeling approach to develop joint models for each SSB outcome variable. We added variables to the models one block at a time, progressing from those most proximal to adolescents (i.e., student-level variables) to those most distal (e.g., school area-level variables), reflecting layers of influence within ecological models of health. Once a block of variables was added to a model, we removed any variables that were not significant ($P < .2$) within the block one at a time, beginning with the least significant variable. If none of the variables in a block were significant at this level, we removed the entire block from the model before proceeding to the next block and re-starting this process. As such, only variables that were significant at $P < .2$ were retained in the final models. We included student- and school-level control variables into every model in which they appear, regardless of their statistical significance. We postulated that provincial school nutrition policies influence students' SSB consumption by mediating in-school SSB availability (i.e., in-school SSB availability is a reflection of province). As such, we assessed the association between school beverage availability variables and students' SSB consumption without including province as a covariate. We performed all analyses using SAS version 9.4 (SAS Institute, Cary NC).

4.3 Results

Table 9 describes the characteristics of the student sample. Within the total sample, there was roughly an equal representation of males and females and across the four grades. Most participants were white (75.0%) and had a healthy weight (57.5%). The predominant weight goal was to lose weight, reported by 41.2% of participants. Participants reported drinking soft drinks an average of 1.75 days in a typical school week, making soft drinks the SSB category consumed most frequently, followed by sweetened coffees/teas (mean 1.41 weekdays). Frequency of SSB consumption was significantly greater across all SSB-related outcomes among participants from Alberta, relative to their Ontario counterparts.

Table 9: Characteristics of the sample of secondary school students participating in Year 2 of the COMPASS study from Alberta (n=3330) and Ontario (n=38499).

Characteristic	Total	Alberta	Ontario	
Socio-demographic and behavioural	n (%)	n (%)	n (%)	p value [a]
Gender				0.601
Female	20946 (50.1)	1682 (50.5)	19264 (50.0)	
Male	20883 (49.9)	1648 (49.5)	19235 (50.0)	
Grade				<0.001
9	10824 (25.9)	491 (14.7)	10333 (26.8)	
10	11023 (26.3)	1077 (32.3)	9946 (25.8)	
11	10448 (25.0)	951 (28.6)	9497 (24.7)	
12	9534 (22.8)	811 (24.4)	8723 (22.7)	
Ethnicity				<0.001
White	31395 (75.0)	2462 (73.9)	28933 (75.2)	
Aboriginal	1451 (3.5)	357 (10.7)	1094 (2.8)	
Asian	2136 (5.1)	129 (3.9)	2007 (5.2)	
Black	1533 (3.7)	58 (1.7)	1475 (3.8)	
Latin	778 (1.9)	12 (0.4)	766 (2.0)	
Other	4536 (10.8)	312 (9.4)	4224 (11.0)	
Weekly spending money				<0.001
$0	6641 (15.9)	469 (14.1)	6172 (16.0)	
$1-$20	12053 (28.8)	619 (18.6)	11434 (29.7)	
$21-$100	11141 (26.6)	951 (28.5)	10190 (26.5)	
>$100	6711 (16.1)	762 (22.9)	5949 (15.5)	
I don't know/missing	5283 (12.6)	529 (15.9)	4754 (12.3)	
Weight status				<0.001
Underweight	647 (1.6)	55 (1.7)	592 (1.5)	
Healthy weight	24055 (57.5)	1809 (54.3)	22246 (57.8)	
Overweight	5968 (14.3)	484 (14.5)	5484 (14.2)	
Obese	2688 (6.4)	275 (8.3)	2413 (6.3)	
Missing	8471 (20.2)	707 (21.2)	7764 (20.2)	
Truancy				<0.001
Skipped 0 classes in last four weeks	29759 (71.1)	2105 (63.2)	27654 (71.8)	
Skipped 1+ classes in last four weeks	12070 (28.9)	1225 (36.8)	10845 (28.2)	
Weight goal				<0.001
Not trying to do anything about weight	9506 (22.7)	897 (26.9)	8609 (22.4)	
Gain weight	7553 (18.1)	482 (14.5)	7071 (18.4)	
Lose weight	17224 (41.2)	1381 (41.5)	15843 (41.1)	
Stay the same weight	7546 (18.0)	570 (17.1)	6976 (18.1)	
Weekday SSB consumption [b]	Mean ± SD	Mean ± SD	Mean ± SD	p value [c]
Freq. of consuming soft drinks	1.75 ± 1.73	1.94 ± 1.74	1.73 ± 1.72	<0.001
Freq. of consuming sweetened coffees/teas	1.41 ± 1.73	1.52 ± 1.73	1.40 ± 1.73	<0.001
Freq. of consuming energy drinks	0.31 ± 0.92	0.58 ± 1.23	0.29 ± 0.88	<0.001
Composite SSB score [d]	3.46 ± 3.01	4.04 ± 3.32	3.41 ± 2.98	<0.001

SSB = sugar-sweetened beverage

[a] Chi square analyses used to examine differences by province.

[b] Number of days in a typical school week (Mon.-Fri., 0-5 days).

[c] Two-sided Wilcoxon rank sum procedure used to examine differences by province.

[d] A composite score, ranging from 0-15, representing the sum of participants' weekday rates of consuming the three distinct SSB categories.

The school sample was quite diverse, reflecting varied geographic and socioeconomic neighbourhoods (Table 10). Nearly all schools (n=85, 95.5%) had at 1+ beverage vending machine. Nearly half (n=44, 49.4%) of schools had non-diet soft drinks available in 1+ vending machine, while no schools carried energy drinks. A significantly higher proportion of Albertan schools had sugar-sweetened soft drinks and coffees/teas available. Overall, most schools were within a 1-km circular buffer of restaurants (85.4%) and food stores (78.6%). Table 11 provides a detailed breakdown of schools' beverage vending machine contents. Most schools demonstrated that most schools (n=75, 84.3%) had 100% fruit juices available in their vending machine(s), making it the most common beverage available, followed by water (n=65, 73.0%) and diet carbonated soft drinks (n=61, 68.5%). Few schools sold sugar-containing sports drinks (n=11, 12.4%), sugar-containing carbonated soft drinks (n=15, 16.9%), and diet sports drinks (n=20, 22.5%) through their beverage vending machine(s). The availability of sugar-containing soft drinks (carbonated and non-carbonated) and sports drinks in vending machines was significantly greater in Alberta versus Ontario.

The pre-modelling collinearity diagnostics revealed minimal risk of collinearity, as none of the VIFs exceeded 3. With Step 1 of the modeling process, the null models demonstrated significant between-school variation across all four SSB-related outcome variables (Table 12). We identified significant (P <.001) between-school variation for all four SSB-related outcomes. School-level differences accounted for 1.8%, 0.8%, 2.0%, and 1.6% of the variability in students' number of weekdays consuming soft drinks, sweetened coffees/teas, energy drinks, and their weekday composite score, respectively, when controlling for individual-level variance.

Table 10: Characteristics of the sample of schools participating in Year 2 of the COMPASS study from Alberta (n= 10) and Ontario (n=79).

Characteristic	Total n (%)	Alberta n (%)	Ontario n (%)	p value [a]
School-level control variables				
School type				0.999
Public	83 (93.3)	10 (100.0)	73 (92.4)	
Private	6 (6.7)	0 (0.0)	6 (7.6)	
Location				0.003
Rural or small population centre	44 (49.5)	10 (100.0)	34 (43.0)	
Medium urban population centre	14 (15.7)	0 (0.0)	14 (17.7)	
Large urban population centre	31 (34.8)	0 (0.0)	31 (39.3)	
Neighbourhood median income				0.095
$25000 - 50000	7 (7.9)	0 (0.0)	7 (8.9)	
$50001-75000	62 (69.6)	5 (50.0)	57 (72.1)	
$75000 +	20 (22.5)	5 (50.0)	15 (19.0)	
Food outlets present within school				
Cafeteria				0.176
Not present	7 (7.9)	2 (20.0)	5 (6.3)	
Present	82 (92.1)	8 (80.0)	74 (93.7)	
Tuck shop				0.266
Not present	80 (89.9)	8 (80.0)	72 (91.1)	
Present	9 (10.1)	2 (20.0)	7 (8.9)	
Beverage vending machines				0.999
No machines present	4 (4.5)	0 (0.0)	4 (5.1)	
1 machine present	11 (12.4)	1 (10.0)	10 (12.7)	
2 machines present	24 (27.0)	3 (30.0)	21 (26.6)	
3+ machines present	50 (56.1)	6 (60.0)	44 (55.7)	
School beverage availability				
Accessibility of water fountains				0.999
High	71 (79.8)	8 (80.0)	63 (79.8)	
Low	18 (20.2)	2 (20.0)	16 (20.2)	
Availability of soft drinks in vending machines				<0.001
Unavailable	45 (50.6)	0 (0.0)	45 (57.0)	
Available	44 (49.4)	10 (100.0)	34 (43.0)	
Availability of sweetened coffees/teas in vending machines				<0.001
Unavailable	73 (82.0)	3 (30.0)	70 (88.6)	
Available	16 (18.0)	7 (70.0)	9 (11.4)	
Availability of energy drinks in vending machines				N/A [b]
Unavailable	89 (100.0)	10 (100.0)	79 (100.0)	
Available	0 (0.0)	0 (0.0)	0 (0.0)	
School neighbourhood food outlets				
Access to restaurants within 1-km buffer of school				0.347
No	13 (14.6)	0 (0.0)	13 (16.5)	
Yes	76 (85.4)	10 (100.0)	66 (83.5)	
Access to variety stores within 1-km buffer of school				0.041
No	52 (58.4)	9 (90.0)	43 (54.4)	
Yes	37 (41.6)	1 (10.0)	36 (45.6)	
Access to food stores within 1-km buffer of school				0.111
No	19 (21.4)	0 (0.0)	19 (24.0)	
Yes	70 (78.6)	10 (100.0)	60 (76.0)	

[a] Fisher's Exact Test used to examine differences by province.
[b] Statistic could not be computed due to lack of variability within measure.

Table 11: Contents of beverage vending machines within Year 2 COMPASS schools from Alberta (n= 10) and Ontario (n=79).[a]

Beverage type	Total n (%)	Alberta n (%)	Ontario n (%)	p value [b]
SSBs				
Sugar-containing carbonated soft drinks (e.g., non-diet Coca-Cola, non-diet Sprite, etc.)				0.020
0 drinks available	74 (83.1)	6 (60.0)	68 (86.1)	
1 drink available	6 (6.7)	0 (0.0)	6 (7.6)	
2 drinks available	3 (3.4)	1 (10.0)	2 (2.5)	
3+ drinks available	6 (6.7)	3 (30.0)	3 (3.8)	
Sugar-containing non-carbonated soft drinks (e.g., non-diet lemonade, fruit drinks, iced tea, etc.)				0.001
0 drinks available	43 (48.3)	0 (0.0)	43 (54.4)	
1 drink available	3 (3.4)	1 (10.0)	2 (2.5)	
2 drinks available	11 (12.4)	1 (10.0)	10 (12.7)	
3+ drinks available	32 (36.0)	8 (80.0)	24 (30.4)	
Sugar-containing sports drinks (e.g., Gatorade, PowerAde, etc.)				< 0.001
0 drinks available	78 (87.6)	4 (40.0)	74 (93.7)	
1 drink available	3 (3.4)	2 (20.0)	1 (1.3)	
2 drinks available	2 (2.2)	1 (10.0)	1 (1.3)	
3+ drinks available	6 (6.7)	3 (30.0)	3 (3.8)	
Flavoured milk (e.g., strawberry, chocolate milk)				0.279
0 drinks available	47 (52.8)	7 (70.0)	40 (50.6)	
1 drink available	10 (11.2)	1 (10.0)	9 (11.4)	
2 drinks available	4 (4.5)	1 (10.0)	3 (3.8)	
3+ drinks available	28 (31.5)	1 (10.0)	27 (34.2)	
Non-SSBs				
Diet carbonated soft drinks (e.g., Diet Coke, Coke Zero, Sprite Zero, etc.)				0.950
0 drinks available	28 (31.5)	4 (40.0)	24 (30.4)	
1 drink available	10 (11.2)	1 (10.0)	9 (11.4)	
2 drinks available	8 (9.0)	1 (10.0)	7 (8.9)	
3+ drinks available	43 (48.3)	4 (40.0)	39 (49.4)	
Diet non-carbonated soft drinks (e.g., diet lemonade, Fresca, diet iced tea, etc.)				0.356
0 drinks available	46 (51.7)	7 (70.0)	39 (49.4)	
1 drink available	11 (12.4)	2 (20.0)	9 (11.4)	
2 drinks available	12 (13.5)	0 (0.0)	12 (15.2)	
3+ drinks available	20 (22.5)	1 (10.0)	19 (24.1)	
Diet sports drinks (e.g., G2, Powerade Zero, etc.)				0.235
0 drinks available	68 (76.4)	6 (60.0)	62 (78.5)	
1 drink available	4 (4.5)	1 (10.0)	3 (3.8)	
2 drinks available	4 (4.5)	0 (0.0)	4 (5.1)	
3+ drinks available	13 (14.6)	3 (30.0)	10 (12.7)	
Plain white milk				0.924
0 drinks available	65 (73.0)	9 (90.0)	56 (70.9)	
1 drink available	7 (7.9)	0 (0.0)	7 (8.9)	
2 drinks available	11 (12.4)	1 (10.0)	10 (12.7)	
3+ drinks available	6 (6.7)	0 (0.0)	6 (7.6)	
100% fruit juice				0.999
0 drinks available	14 (15.7)	1 (10.0)	13 (16.5)	
1 drink available	3 (3.4)	0 (0.0)	3 (3.8)	
2 drinks available	37 (41.6)	5 (50.0)	32 (40.5)	
3+ drinks available	35 (39.3)	4 (40.0)	31 (39.2)	
Water				0.017
0 drinks available	24 (27.0)	0 (0.0)	24 (30.4)	
1 drink available	22 (24.7)	4 (40.0)	18 (22.8)	

2 drinks available	28 (31.5)	6 (60.0)	22 (27.9)
3+ drinks available	15 (16.9)	0 (0.0)	15 (19.0)

SSB = sugar-sweetened beverage
[a] Schools without beverage vending machines (n=4) were coded as having '0 drinks available' within each beverage category.
[b] Fisher's Exact Test used to examine differences by province.

Table 12: School-level variance and intra-class correlation for each SSB-related outcome, derived from unconditional means models without any variables and with a random intercept term (i.e., null models).

Outcome variable	School-level variance Estimate ± SE	p value	Intra-class correlation
Weekday freq. of consuming soft drinks [a]	0.053 ± 0.009	<.001	1.8%
Weekday freq. of consuming sweetened coffees/teas [a]	0.024 ± 0.005	<.001	0.8%
Weekday freq. of consuming energy drinks [a]	0.017 ± 0.003	<.001	2.0%
Weekday composite SSB score [b]	0.145 ± 0.026	<.001	1.6%

SSB = sugar-sweetened beverage
[a] Number of days in a typical school week (Mon.-Fri., 0-5 days).
[b] A composite score, ranging from 0-15, representing the sum of participants' weekday rates of consuming the three distinct SSB categories.

Table 13 depicts the findings of the univariate Poisson regression analyses between each outcome variable and each potential explanatory variable (Step 2). Note that for these, and all other, Poisson regression models, the rates represent the exponentiated beta coefficients. Few school-level explanatory variables were significantly associated with the outcome variables. For example, no school-level explanatory variables demonstrated a significant independent association with students' weekday rate of soft drink consumption. As such, no school-level variables were included in the joint model for weekday soft drink consumption.

Table 13: Univariate analyses for modifiable school-level factors in relation to students' weekday consumption of SSBs among secondary school students (n= 41829) from Alberta and Ontario, Canada, participating in Year 2 of the COMPASS study.

Variable type	Weekday SSB consumption [a]			
	Composite SSB score [b]	Soft drink	Sweetened coffees/teas	Energy drinks
	Rate [c] (95% CI)	Rate [c] (95% CI)	Rate [c] (95% CI)	Rate [c] (95% CI)
School beverage availability				
Accessibility of water fountains				
High	1.00	1.00	1.00	1.00
Low	0.98 (0.93-1.04)	0.97 (0.92-1.03)	0.99 (0.94-1.05)	0.97 (0.80-1.19)
Availability of soft drinks in school vending machines				
Unavailable	1.00	1.00	1.00	1.00
Available	**1.03 (0.99-1.08)**	1.03 (0.97-1.09)	1.00 (0.95-1.05)	**1.22 (1.04-1.42) ***
Availability of sweetened coffees and teas in school vending machines				
Unavailable	1.00	1.00	1.00	1.00
Available	**1.05 (0.99-1.12)**	1.01 (0.95-1.00)	1.04 (0.97-1.12)	**1.32 (1.06-1.65) ***
School neighbourhood food outlets				
Access to restaurants within 1-km buffer of school				
No	1.00	1.00	1.00	1.00
Yes	**1.04 (0.99-1.09)**	1.00 (0.95-1.06)	**1.05 (1.00-1.11) ***	**1.18 (0.96-1.45)**
Access to variety stores within 1-km buffer of school				
No	1.00	1.00	1.00	1.00
Yes	0.97 (0.93-1.02)	0.97 (0.92-1.03)	1.01 (0.96-1.06)	**0.86 (0.73-1.01)**
Access to food store within 1-km buffer of school				
No	1.00	1.00	1.00	1.00
Yes	**1.03 (0.99-1.08)**	1.00 (0.95-1.05)	**1.06 (1.00-1.11) ***	1.11 (0.89-1.39)

SSB = sugar-sweetened beverage

[a] Number of weekdays participants reported consuming SSBs in a typical school week (Mon.-Fri., 0-5 days).

[b] A composite score, ranging from 0-15, representing the sum of participants' weekday rates of consuming the three distinct SSB categories.

[c] Rates represents the exponentiated beta coefficients; bold values are statistically significant (P <.20).

*P <.05, ** P <.01, *** P <.001

Table 14 provides an example of the block-wise joint model development (Step 3), as applied to the composite SSB score outcome. The four final models are shown in Table 15. Four school-level explanatory variable were included in the joint model. Though all included variables were significantly (P <.20) and positively associated with the SSB-related outcomes in the final models, the effect sizes of these associations were quite modest. For example, the rate of 1.08 denotes that students consume sweetened coffees/teas at an 8% greater rate (i.e. in terms of number of weekdays) when sweetened coffees/teas are available in their school vending machine, controlling for all other variables.

Table 14: Student- and school-level correlates of participants' weekday composite SSB score [a] (n= 41829): an illustration of the block-wise modelling process. [b]

Characteristics	**Student-level control variables**	**Student-level control + school beverage availability variables**	**Student-level control + school beverage availability + school neighbourhood variables**	**Student-level control + school beverage availability + school neighbourhood food outlets + school-level control variables**
	Adjusted rate [c] (95% CI)	Adjusted rate [c] (95% CI)	Adjusted rate [c] (95% CI)	Adjusted rate [c] (95% CI)
Student-level control				
Gender				
Female	1.00	1.00	1.00	1.00
Male	1.13 (1.10-1.16) ***	1.13 (1.10-1.16) ***	1.13 (1.10-1.16) ***	1.13 (1.10-1.16) ***
Grade				
9	1.00	1.00	1.00	1.00
10	0.98 (0.96-1.01)	0.98 (0.96-1.00)	0.98 (0.96-1.00)	0.98 (0.96-1.00)
11	0.95 (0.93-0.98) **	0.95 (0.93-0.98) **	0.95 (0.93-0.98) **	0.95 (0.93-0.98) **
12	0.93 (0.90-0.96) ***	0.93 (0.89-0.96) ***	0.93 (0.89-0.96) ***	0.93 (0.90-0.96) ***
Ethnicity				
White	1.00	1.00	1.00	1.00
Aboriginal	1.21 (1.16-1.27) ***	1.21 (1.16-1.26) ***	1.21 (1.16-1.26) ***	1.21 (1.16-1.26) ***
Asian	0.92 (0.88-0.97) ***	0.92 (0.88-0.97) ***	0.92 (0.88-0.97) ***	0.93 (0.88-0.97) ***
Black	1.23 (1.18-1.29) ***	1.23 (1.18-1.29) ***	1.23 (1.18-1.29) ***	1.24 (1.19-1.30) ***
Latin	1.01 (0.96-1.07)	1.01 (0.96-1.07)	1.01 (0.96-1.07)	1.01 (0.96-1.07)
Other	1.09 (1.06-1.12) ***	1.09 (1.06-1.12) ***	1.09 (1.06-1.12) ***	1.09 (1.06-1.12) ***
Weekly spending money				
$0	1.00	1.00	1.00	1.00
$1-$20	1.14 (1.10-1.17) ***	1.14 (1.10-1.17) ***	1.14 (1.10-1.17) ***	1.14 (1.10-1.17) ***
$21-$100	1.21 (1.18-1.25) ***	1.21 (1.18-1.25) ***	1.21 (1.18-1.25) ***	1.21 (1.18-1.25) ***
>$100	1.29 (1.26-1.33) ***	1.29 (1.26-1.33) ***	1.29 (1.26-1.33) ***	1.29 (1.26-1.33) ***

I don't know	1.12 (1.09-1.16) ***	1.12 (1.09-1.16) ***	1.12 (1.09-1.16) ***	1.12 (1.09-1.16) ***
Weight status				
Healthy weight	1.00	1.00	1.00	1.00
Underweight	1.06 (1.00-1.13)	1.06 (1.00-1.13)	1.06 (1.00-1.13)	1.06 (1.00-1.13)
Overweight	0.99 (0.97-1.02)	0.99 (0.97-1.02)	0.99 (0.97-1.02)	0.99 (0.97-1.02)
Obese	1.09 (1.05-1.13) ***	1.09 (1.05-1.13) ***	1.09 (1.05-1.13) ***	1.09 (1.05-1.13) ***
Missing	1.09 (1.07-1.12) ***	1.09 (1.07-1.12) ***	1.09 (1.07-1.12) ***	1.09 (1.07-1.12) ***
Truancy				
Skipped 0 classes in last four weeks	1.00	1.00	1.00	1.00
Skipped 1+ classes in last four weeks	1.31 (1.28-1.34) ***	1.31 (1.28-1.34) ***	1.31 (1.28-1.34) ***	1.31 (1.28-1.34) ***
Weight goal				
Not trying to do anything about weight	1.00	1.00	1.00	1.00
Gain weight	1.03 (1.00-1.06)	1.03 (1.00-1.06)	1.03 (1.00-1.06)	1.03 (1.00-1.06)
Lose weight	0.95 (0.93-0.97) ***	0.95 (0.93-0.97) ***	0.95 (0.93-0.97) ***	0.95 (0.93-0.97) ***
Stay the same weight	0.94 (0.92-0.97) ***	0.94 (0.92-0.97) ***	0.94 (0.92-0.97) ***	0.94 (0.92-0.97) ***
School beverage availability				
Availability of soft drinks in school vending machines				
Unavailable		1.00	---	---
Available		1.00 (0.96-1.05)	---	---
Availability of sweetened coffees and teas in school vending machines				
Unavailable		1.00	1.00	1.00
Available		1.05 (0.99-1.11)	1.05 (1.00-1.11) *	1.08 (1.03-1.13) **
School neighbourhood				
Access to restaurants within 1-km buffer of school				
No			1.00	---
Yes			1.03 (0.96-1.10)	---
Access to food store within 1-km buffer of school				
No			1.00	---
Yes			0.99 (0.92-1.05)	---
School-level control				
School type				
Public				1.00
Private				0.89 (0.82-0.98) *
Location				
Rural or small population centre				1.00
Medium urban population centre				0.94 (0.90-0.98) **
Large urban population centre				0.94 (0.90-0.98) **

Neighbourhood median income	
$25000 - 50000	1.00
$50001-75000	0.94 (0.89-1.01)
$75000 +	0.93 (0.86-1.00)

[a] A composite score, ranging from 0-15, representing the sum of participants' weekday rates of consuming soft drinks, sweetened coffees/teas, and energy drinks.
[b] Table omits variables that were not significantly associated with outcome in prior univariate analyses, therefore not included in joint model; columns reflect the model after a given block of variables had been added (i.e., before those lacking significance at P <.2 were removed).
[c] Rates represents the exponentiated beta coefficients; rates adjusted for all other variables in the column.
*P <.05, ** P <.01, *** P <.001
--- Variable excluded to create a more parsimonious model, since it lacked significance at P <0.2 level.

Table 15: Final models describing correlates of weekday consumption of three varieties of SSBs among secondary school students (n= 41829) participating in Year 2 of the COMPASS study.

Variable type	**Weekday SSB consumption [a]**			
	Composite SSB score [b]	Soft drinks	Sweetened coffees/teas	Energy drinks
	Adjusted rate [c] (95% CI)	Adjusted rate [c] (95% CI)	Adjusted rate [c] (95% CI)	Adjusted rate [c] (95% CI)
School beverage availability				
Availability of sweetened coffees/teas in school vending machines				
Unavailable	1.00	---	---	1.00
Available	1.08 (1.03-1.13) **	---	---	1.27 (1.11-1.46) ***
School neighbourhood food outlets				
Access to restaurants within 1-km buffer of school				
No	---	---	1.00	1.00
Yes	---	---	1.04 (0.99-1.08)	1.09 (0.96-1.24)

SSB = sugar-sweetened beverage
[a] Number of weekdays participants reported consuming SSBs in a typical school week (Mon.-Fri., 0-5 days).
[b] A composite score, ranging from 0-15, representing the sum of participants' weekday rates of consuming the three distinct SSB categories.
[c] Rates represents the exponentiated beta coefficients; rates adjusted for all other variables in the column, in addition to school- and student-level control variables.
*P <.05, ** P <.01, *** P <.001
--- excluded from model during univariate analyses screening or the block-wise model building process.

Supplementary material for this chapter can be found in Appendix F.

4.4 Discussion

This study examined several modifiable characteristics of the school food environment and their association with weekday SSB intake in a large cohort of Canadian youth. The study objectives parallel those of a recent COMPASS pilot study in Guatemala (Godin et al., 2017). In the present study, we

identified that many schools offer SSBs in their vending machines, consistent with previous Canadian research (Mâsse et al., 2014; Rideout et al., 2007; Seliske et al., 2013). This finding was particularly evident in Alberta. In addition, most schools had at least one restaurant and food store within its kilometer buffer, where students could purchase SSBs, mirroring the findings of other Canadian studies (Seliske et al., 2009a; Seliske et al., 2009b; Vine & Elliott, 2014). Although these characteristics reflect means of accessing less healthful beverages during school, our results largely suggest that they were not significantly associated with students' SSB intake, after controlling for student-level characteristics.

4.4.1 Interventions directed at the school environment

Ontario demonstrated significantly lower availability of most SSB categories we examined, particularly sugary soft drinks and sports drinks, compared to Alberta. This finding suggests that *P/PM 150* appears to have some positive impact on the nutritional quality of beverages available for sale in Ontario schools, compared to the voluntary policy in Alberta. However, a considerable proportion of Ontario schools offered non-policy compliant beverages in their vending machines. Further, review of the vending machine photos revealed that some, but not all, of the flavoured milks available in vending machines in Ontario were policy-compliant. For example, chocolate and strawberry milks (the flavoured drinks most often available) are permissible, though most ready-to-drink milkshake beverages (available in comparatively fewer schools) exceed the sugar and fat criteria, and thus deemed "not permitted for sale". Our finding that SSBs were available within school vending machines in both provinces, in spite of nutrition policies that recommend restricting in-school SSB availability, likely reflects the previously-identified shortcomings of these policies, including a lack of clarity, consistency, enforcement, and government resources to support policy implementation and adherence (Vine et al., 2017; Vine & Elliott, 2014). These limitations highlight the need for guidelines that are "user-friendly" and greater enforcement and support to increase compliance and thus the likelihood that these policies can improve students' dietary outcomes.

We found limited evidence of a direct association between several modifiable aspects of the school food environment on students' SSB consumption. These findings counter that of a recent review that concluded that legislative/environmental school-based interventions are effective at reducing students' SSB consumption (Vézina-Im et al., 2017). Further, the findings are quite disparate from those of the related COMPASS Guatemala study, which suggested that the high rate of SSB consumption among adolescents was encouraged, in part, by the strong presence of SSB industry within schools (Godin et al., 2017). However, the results of the present study are consistent with previous observational research in Canada and elsewhere (Lebel et al., 2016; Lien et al., 2014; Minaker et al., 2011; Park et al., 2012; van der Horst et al., 2008; Williams et al., 2014b). For example, a nationally-representative American study

revealed that, despite the ubiquity of SSB-containing school vending machines, the presence of these machines was not significantly associated with students' SSB intake (Park et al., 2012). Likewise, a recent systematic review found little evidence linking the retail food environment around schools and students' food consumption patterns, including SSB intake (Williams et al., 2014b). These studies elucidate why interventions designed solely to decrease students' SSB access during school (i.e., in food outlets on- and off-school-property) may be limited in their ability to reduce youths' SSB consumption. Further, previous research demonstrates that when students are restricted in the foods/beverages they can access during school, they may compensate by purchasing and/or consuming more of these items in other settings (Finkelstein et al., 2004; Vecchiarelli et al., 2006; Vézina-Im et al., 2017).

This current body of literature, coupled with this study's findings, highlight the value in comprehensive school-based nutrition interventions (i.e., comprising nutrition education, parental engagement, strong school nutrition policies, built environment changes, etc.) to communicate a consistent health-reinforcing message through various means to support behaviour change (McKenna, 2010; Vecchiarelli et al., 2006; Vézina-Im et al., 2017). Comprehensive interventions that aim to modify youths' diet-related values, knowledge, and preferences (i.e., rather than simply access) are critical, since SSB intake is primarily driven by socio-cultural and intrapersonal-level (versus school-level) factors (Lebel et al., 2016; van der Horst et al., 2008). This phenomenon is also reflected in our finding that school-level differences account for a very limited (≤2%) proportion of the variability in students' rate of SSB intake. Further, our findings (e.g., the general lack of association between SSB intake and school food environment characteristics) demonstrate evidence to suggest that factors within the home and broader societal environments are likely more important correlates of adolescents' SSB intake.

4.4.2 Interventions directed at broader environments

Though the school environment is undoubtedly an important physical and social context for youth, it is likely that SSB-oriented interventions within schools are undermined by larger contexts that promote SSB consumption. Previous research demonstrates that adolescents primarily consume SSBs at home (Briefel, Wilson, & Gleason, 2009), highlighting the important influence this setting may exert on adolescents' dietary choices. Parents/guardians often are responsible for purchasing and preparing food, giving them considerable control over what foods/beverages are available at home. As such, nutrition professionals should encourage parents to model healthful eating behaviours and moderate youths' SSB access (e.g., by packing school lunches with healthy drinks, serving these drinks at home, etc.) (Briefel et al., 2009; Ezendam, Evans, Stigler, Brug, & Oenema, 2010; van Ansem, van Lenthe, Schrijvers, Rodenburg, & van de Mheen, 2014). Given the importance of the home environment in shaping youth health behaviours

(Lindsay, Sussner, Kim, & Gortmaker, 2006), interventions focused on this context may be well-poised to effectively moderate adolescents' SSB consumption.

The ubiquity of SSBs in adolescents' everyday lives likely explains, in part, the lack of association we detected between SSB consumption and the school food environment (Minaker et al., 2011). For example, SSBs are among the most common products promoted to youth (Cairns et al., 2013), often via very youth-oriented, interactive advertising strategies (e.g., social media, "adver-gaming", etc.) (Cairns et al., 2013; Weber, Story, & Harnack, 2006). These marketing efforts have a profound influence on youths' food preferences, purchasing behaviour, and consumption patterns (Cairns et al., 2013), fueling recommendations for the federal government to ban the advertising of foods and beverages to children as a means to improve Canadians' diets (Ogilvie, 2016). The ubiquity of SSBs is also reflected in the increasing prevalence of 'food swamps' (i.e., neighbourhoods that have high geographic access to food retailers that primarily offer minimally nutritious food) in Canada (Luan, Law, & Quick, 2015; Minaker et al., 2016). Indeed, our models suggested that access to restaurants near schools was associated (though not statistically significant at $P < .05$) with a higher rate of consuming sweetened coffees/teas and energy drinks. Population-level efforts to increase access to healthy food outlets (e.g., grocery stores, which tend to offer the greatest variety of high-quality products at a good value) are a viable and potentially promising strategy to improve Canadians' dietary choices (Larson, Story, & Nelson, 2009; Minaker et al., 2016). These studies highlight the importance of non-school contexts in which adolescents are exposed to and can access SSBs, and developing interventions that are appropriate within these contexts.

4.4.3 Strengths and limitations

This study has many strengths, including a large sample size drawn from two provinces and 89 socioeconomically and geographically diverse schools. The survey captured multiple days of dietary behaviours, which is a better representation of participants' typical diets compared to methods that inquire about consumption within shorter timeframes (e.g., 24 hour recall) (Vanderlee et al., 2014). This study examined adolescents' consumption of several varieties of SSB, reflecting the diversity of products available on the market. This study also extended two recent COMPASS studies set in Canada and Guatemala (Godin et al., 2017; Godin et al., 2018). The distinctions in the findings of the present study and those of the Guatemala study highlight the role of context (i.e., given considerable differences in political and socioeconomic environments between these jurisdictions), as well as an opportunity for future research in other regions to apply similar methods to further elucidate the potential role of schools in shaping students' SSB intake and other dietary behaviours.

There are some important limitations to this study, many of which reflect the fact that COMPASS was not specifically designed to provide a detailed assessment of the beverages available within schools or students' SSB intake patterns. Our findings represent a conservative measure of in-school SSB availability, since we had limited data from cafeterias or tuck shops. The school food environment data to date has predominately focused on vending machines, as compared to cafeterias or tuck shops (likely due, in part, to the challenges our team encountered in collecting quality data from other school food outlets), representing a research gap. Measures of participants' SSB consumption are also limited due to the unit of measure used (i.e., number of days participants consumed SSB categories, as compared to volume or number of servings), and are limited to the SSB categories captured within the survey. We lacked data on students' ability to leave school campus during school breaks (i.e., if the school had a "closed campus" policy), which would have had a bearing on students' ability to purchase meals and snacks from food outlets in the school neighbourhood. This study used self-reported data, which may introduce social desirability and recall bias, resulting in participants underreporting their SSB consumption. Likewise, there was no formal criteria for data collectors to use to determine if a school had an adequate number of fountains and if they were easy to locate. As such, assessments of water fountain accessibility should be interpreted with caution. This study is also limited by the relatively small number of schools in Alberta. Since COMPASS uses a convenience sample of schools, and is therefore not provincially- or nationally-representative, it is unclear how well these schools represent others in the province, limiting our ability to assert that provincial differences in student and/or school characteristics reflect the provinces' distinct policy contexts. Further, since this study was cross-sectional, we cannot infer that the associations observed are causal. Future longitudinal studies examining the relationships between school food environment characteristics and adolescents' SSB consumption would be instrumental in confirming these findings.

4.5 Conclusions

Many COMPASS secondary schools in Alberta and Ontario offer SSBs within their vending machines, and are within walking distance of various food outlets. SSB availability in vending machines and overall SSB intake was higher in Alberta than Ontario, suggesting that mandatory nutrition policies restricting SSBs may be more effective than voluntary measures. We did not find an association between students' SSB consumption and most of the school food environment characteristics we examined; however, the significant association we identified between availability of sweetened coffees/teas and two measures of SSB consumption suggests that further investigation of these factors is warranted. Population-level interventions focusing on other contexts important to youth (e.g., the home and community environments)

are needed to complement school-based interventions, as they may be more appropriate settings for efforts to reduce adolescents' SSB consumption.

Chapter 5

Examining changes in school vending machine beverage availability and sugar-sweetened beverage intake among Canadian adolescents participating in the COMPASS study: A longitudinal assessment of provincial school nutrition policy compliance and effectiveness

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Overview

Background: School nutrition policies can encourage restrictions in SSB availability in school food outlets in order to discourage students' SSB intake. The study objectives were to examine i) changes in beverage availability in school vending machines across distinct school nutrition policy contexts; ii) changes in adolescents' SSB intake; and, iii) longitudinal associations between vending machine beverage availability and SSB intake.

Methods: This longitudinal study used three school years of data from the COMPASS study (2013/14-2015/16), representing 7679 students from 78 Canadian secondary schools and three school nutrition policy contexts (Alberta, Ontario public, and Ontario private schools). We assessed participants' intake of three SSB varieties (soft drinks, sweetened coffees/teas, and energy drinks) via a questionnaire and the availability of 10 beverage categories in schools' vending machines via the COMPASS School Environment Application. Hierarchical regression models were used to examine whether: (i) measures of time and policy group were associated with beverage availability; and, (ii) beverage availability was associated with students' SSB intake.

Results: Ontario public schools were significantly less likely than the other policy groups to serve SSBs in their vending machines, with the exception of flavoured milks. Vending machine beverage availability did not vary considerably over time. Participants' overall SSB intake remained relatively stable; reductions in soft drink intake were offset by increases in sweetened coffee/tea consumption. Relative to Ontario public schools, attending school in Alberta was associated with more frequent energy drink intake and overall SSB intake whereas attending an Ontario private school was associated with less frequent soft drink intake, with no differences in overall SSB intake. Few beverage availability variables were significantly associated with participants' SSB intake.

Conclusions: Provincial school nutrition policies, particularly Ontario's mandatory *P/PM 150*, appear to support restrictions in the availability of SSBs in school vending machines, which was stable over time. SSB intake was significantly lower in Ontario public and private schools, although we did not detect a direct association between SSB consumption and availability. The findings provide support for mandatory school nutrition policies, as well as the need for comprehensive school- and broader population-level efforts to reduce SSB intake.

Keywords: school nutrition policy; sugar-sweetened beverages; Canada; adolescents; schools; vending machines; longitudinal study; dietary assessment.

5.1 Background

Adolescents represents an important target for prevention efforts to reduce SSB consumption. SSBs are a category of beverages that contain added sugars, including 'regular' soft drinks, fruit drinks, sports drinks, energy drinks, and sweetened coffees/teas. Adolescents are the largest consumers of SSBs in Canada (Jones et al., 2017), and many Canadian youth report daily SSB consumption (Garriguet, 2008; Lo et al., 2008; Vanderlee, Manske, Murnaghan, Hanning, & Hammond, 2014). Frequent SSB consumption is associated with an increased risk of overweight/obesity (Hu & Malik, 2010; Malik et al., 2010; Te Morenga et al., 2013), lower intake of vitamins and nutrients (Frary, Johnson, & Wang, 2004; Vartanian, Schwartz, & Brownell, 2007), and cardiovascular disease (Ambrosini et al., 2013; Bremer, Auinger, & Byrd, 2010). SSB consumption remains high as youth progress through adolescence and increases among some subgroups (e.g., males) (Ambrosini et al., 2013; Nelson, Neumark-Sztainer, Hannan, & Story, 2009), which is concerning since youths' dietary habits often persist into adulthood (Craigie, Lake, Kelly, Adamson, & Mathers, 2011).

Schools represent a feasible and practical setting for initiatives to improve adolescents' dietary behaviours, given their population coverage, the amount of time youth spend in school, and the fact that Canadian youth generally eat at least one meal and/or snack during school hours. Further, school-level differences account for a small, though significant proportion of the variation in adolescents' SSB consumption (Godin, Chaurasia, Hammond, & Leatherdale, 2018; Lebel et al., 2016), suggesting that school characteristics may influence students' SSB intake.

Provincial school nutrition policies exist across Canada (Godin, Kirkpatrick, Hanning, Stapleton, & Leatherdale, 2017), and indicate what foods/beverages are appropriate in schools. For instance, the 2012 *ANGCY* offers voluntary recommendations for schools, including to avoid selling sugar-sweetened and artificially-sweetened beverages (Government of Alberta, 2012). Ontario's 2011 *P/PM 150* includes mandatory guidelines prohibiting the sale of many SSBs in publicly-funded secondary schools, such as <100% juice drinks, sports drinks, and "other" beverages (e.g., soft drinks) containing >40 calories or caffeine (Ontario Ministry of Education, 2016). Since Ontario private schools are not provincial government-regulated, they are not obliged to comply with *P/PM 150*.

Despite the provincial school nutrition policies' consistent recommendation to restrict sale of SSBs, research has shown that SSBs are often still available in Canadian schools' food outlets (Mâsse & de Niet, 2013; Mâsse, de Niet-Fitzgerald, Watts, Naylor, & Saewyc, 2014; Orava, Manske, & Hanning, 2016; Vine et al., 2017). Vine et al. identified that most public secondary schools in Alberta and Ontario were non-compliant with their respective provincial school nutrition policies, and that compliance

decreased with time due to a lack of enforcement (Vine et al., 2017). This study also identified that a greater proportion of schools in Alberta contained non-compliant beverages than compared to schools in Ontario (Vine et al., 2017), while a related study reported that students in Alberta have significantly more frequent SSB consumption compared to their Ontario counterpart (Godin et al., 2018).

It is plausible that greater in-school SSBs availability encourages students to consume these products, particularly given the positive association between students' purchases from school food outlets and their SSB intake (Godin et al., 2018). However, there is mixed evidence linking school characteristics to students' SSB consumption; some research identifies that in-school SSB availability predicts students' SSB consumption (Mâsse et al., 2014), while other studies suggest that the association between these factors is limited (Lien et al., 2014; Minaker et al., 2011; van der Horst et al., 2008).

There are several research gaps that warrant investigation. First, few studies have assessed beverage availability within school food outlets longitudinally. Though Vine et al. examined school vending machine contents over time (Vine et al., 2017), they reported their findings as binary measures of policy compliance (i.e., compliant versus non-compliant), which was defined differently across provinces. Given the wide range of SSBs on the market, measuring compliance as a binary outcome provides a limited account of the availability of particular SSB types, which vary in their nutritional quality. Examining the in-school availability of specific beverages types would enable a more direct comparison between jurisdictions. Second, few studies have examined how beverage availability in school food outlets influences students' SSB intake. Third, despite important distinctions in provincial school nutrition policies, there have been relatively few cross-provincial examinations of school food environment characteristics and their impact on students' dietary outcomes.

The primary objective of this study was to examine how beverage availability in school vending machines changes over time across three groups of secondary schools that represent distinct policy contexts (Alberta, Ontario public, and Ontario private schools). Secondary objectives were to examine how students' weekday intake of three types of SSBs (soft drinks, sweetened coffees/teas, and energy drinks) vary over time across these policy groups, and identify longitudinal associations between SSB intake and vending machine beverage availability. The general hypothesis was that, with time, students' SSB intake and SSB availability within school vending machines increase, reflecting decreased compliance with provincial school nutrition policies.

5.2 Methods

COMPASS is an ongoing (2012-2021) longitudinal cohort study designed to collect hierarchical data annually from a sample of adolescents attending Canadian secondary schools. This study used data from Year 2 (2013/14), Year 3 (2014/15), and Year 4 (2015/16) of COMPASS. Given the conception of COMPASS in 2012/13, these three school years of data represent the post-*ANGCY* and *P/PM* 150 policy implementation period and are termed Waves 1-3 herein.

5.2.1 Sample

Both school- and student-level eligibility criteria were used to generate the sample for this study. Between Waves 1-3, 91 schools participated in at least one year of COMPASS. Each school was assigned a unique identifier, which were used to link the school samples across waves. The final school sample for this study included 78 schools that had complete data on all school-level measures in Waves 1-3. These schools represented three policy groups: Alberta – *ANGCY* (n=9), Ontario public schools – *P/PM 150* (n=64), and Ontario private schools – control (n=5). All Albertan schools were public; however, the *ANGCY* does not distinguish between publicly- versus privately-funded schools.

Within these 78 schools, there were 8894 students that participated in COMPASS for all three waves. As described elsewhere (Qian, Battista, Bredin, Brown, & Leatherdale, 2015), unique self-generated identification codes were used to link student-level data sets across the three waves. Reasons for non-linkage included students graduating or being newly admitted to school within Waves 1-3, students transferring schools, being on spare or otherwise absent during data collections, dropping out of school, or inaccurate data provided on the data linkage measures. Participants missing data on outcome and/or control variables (i.e., SSB intake and socio-demographic characteristics) in any of the waves were excluded from analyses (n=1215, 13.7%), except those missing BMI data. The final sample comprised 7679 student participants from Alberta (n=497), Ontario public schools (n=6674), and Ontario private schools (n=508).

5.2.2 Data sources

All student-level data were collected through a paper-based questionnaire comprising questions on many health, social, and academic outcomes. The questionnaire previously underwent, and performed well in, validity and reliability testing (Leatherdale, Laxer, & Faulkner, 2014; Leatherdale & Laxer, 2013). All students present during the data collection were able to complete the questionnaire during class, enabling collection of whole-school samples.

School-level data were collected through the Co-SEA and the DMTI built environment resource. The Co-SEA is a mobile application containing a series of questions adapted from two previously validated audit tools designed to efficiently measure schools' food and physical activity environments (Jones et al., 2010; van der Horst et al., 2008). The Co-SEA also allows data collectors to store photos of built environment features, and include notes within the application, representing supplementary sources of direct observation data. The Co-SEA was tested in a convenience sample of schools and refined prior to being used in the COMPASS study. The DMTI provides data on the type, location, and number of various points of interest within various circular buffers surrounding schools. Further detail on these data sources is available elsewhere (CanMap RouteLogistics & Enhanced Points of Interest, 2015; Leatherdale, Bredin, & Blashill, 2014).

5.2.3 SSB consumption measures

The method used to derive the outcome variables was consistent with that of previous COMPASS studies of adolescents' SSB consumption (Godin et al., 2017; Godin et al., 2018). Participants were asked to indicate the number of days during a usual school week (0-5 days) that they consume each of the following SSB categories: (i) "sugar-sweetened beverages (soda pop, Kool-Aid, Gatorade, etc.)"; (ii) "high-energy drinks (Red Bull, Monster, Rock Star, etc.)"; and, (iii) "coffee or tea with sugar (cappuccino, Frappuccino, iced-tea, iced-coffees, etc.)". This first SSB category (i.e., containing soda, fruit drinks, and sports drinks) is referred to as "soft drinks" herein. Participants were advised not to include diet drinks when reporting their soft drink intake.

We used participants' responses to these questions to derive our four study outcomes related to rate of SSB consumption: (i) number of weekdays participants reported consuming each of soft drinks, (ii) sweetened coffee/teas, and (iii) energy drinks, in addition to a composite weekday SSB score. The first three outcome variables reflect distinct beverage categories, with possible values ranging from 0-5 days. For the fourth outcome variable, we assessed participants' intake of all three SSB categories captured on the questionnaire through a composite SSB score. We calculated this composite score by summing participants' weekday consumption (in days) of each category. Possible values for this score ranged from 0 (indicating no consumption of any beverage category on any day) to 15 (indicating use of all three SSB categories every weekday). This score was intended to reflect a more comprehensive measure of participants' total SSB consumption, in addition to their consumption of discrete SSB categories.

5.2.4 Vending machine beverage availability measures

We used the Co-SEA data to assess the availability of ten beverage categories (e.g., sugar-containing carbonated soft drinks, 100% juices, water, plain white milk, etc.) within schools' vending machines. For

each vending machine, data collectors counted the number of distinct (i.e., in size, flavour, cost, etc.) products within each category, irrespective of the number of slots these products occupied. For example, a vending machine containing several slots of small and large cartons of each of chocolate and strawberry milk, was counted as having four types of flavoured milk (i.e., two flavours*two sizes). Likewise, a vending machine containing cans and bottles of regular (i.e., non-diet) Pepsi, Coca-Cola, and Sprite would be counted as having six sugar-containing carbonated soft drinks (i.e., three flavours*two sizes) available. For schools with numerous beverage vending machines, we summed the number of products within each beverage category across the machines.

5.2.5 Control variables

We included both student- and school-level control variables in our analyses. Student-level control variables were gender, grade, ethnicity, weight status [i.e., BMI (kg/m2) category based on reported height and weight, and World Health Organizations classifications, adjusted for age and sex (World Health Organization, 2015b)], personal weekly spending money, truancy, and weight goal. We defined these variables in a manner that is consistent with previous COMPASS studies (Godin et al., 2018).

School-level control variables were policy group, geographic location, school neighbourhood median household income, presence of a school cafeteria, presence of a school tuck shop (i.e., store that typically has snacks available for sale), and presence of three types of food outlets within the school neighbourhood. Geographic location categories were consistent with Statistics Canada's definitions along the urban-rural continuum (Statistics Canada, 2015). School neighbourhood median household income was derived from the 2011 National Health Survey (Statistics Canada, 2013), and corresponded to schools' postal code.

We accounted for the presence of school cafeterias and tuck shops and various food outlets in the school neighbourhood as control variables, since these outlets represent other locations where students can potentially purchase SSBs. We considered access to these outlets as binary (i.e., 'not present' versus '1+ present). We used the Co-SEA data to assess the presence of school cafeterias and tuck shops, and the DMTI data to examine the presence of restaurants, variety stores, and food stores (i.e., grocery stores and miscellaneous food stores) within a 1-km circular buffer of schools. This buffer represents a distance that individuals can walk in 10-15 min. (e.g., during travel to/from school or during breaks) (Apparicio et al., 2007; Austin et al., 2005; Pikora et al., 2002).

5.2.6 Analyses

We conducted various descriptive statistics to characterize the student and school samples, including assessments of changes in vending machine beverage availability and students' SSB-related measures across waves, stratified by policy group. We used Chi square analyses, Kruskal-Wallis tests, and Fisher's Exact Tests to examine differences across policy groups at Wave 1 (2013/14) across categorical, non-normally distributed continuous variables, and categorical variables with small cell counts, respectively.

We used Generalized Estimating Equations to develop hierarchical regression models to assess predictors of schools' vending machine beverage availability (ten models; one per each beverage category) and participants' SSB consumption (four models; one per each of the SSB consumption measures).

The models of vending machine beverage availability only contained school-level covariates, including policy group and wave (the two explanatory variables of interest), as well as geographic location, school neighbourhood median household income, and the three neighbourhood food outlet accessibility variables. We included the neighbourhood food outlet variables since we suspected that these external food outlets may compete with in-school food outlets, thus their presence may influence the product offering within the school. We modeled availability of each beverage category as a binary outcome (i.e., '0 drinks available' versus '1+ drinks available'), due to concerns of small cell counts and for ease of interpretation.

The models of participants' SSB consumption accounted for the repeated nature of the COMPASS (i.e., temporal measures of the outcome variable at the student level, and spatial at the school level), and examined the association between each of the four SSB outcomes and the binary vending machine beverage availability variables. We developed a separate model for each outcome using a two-step process. First, we ran a series of univariate analyses to identify if each potential explanatory variable was independently associated with the outcome. Variables that were not statistically significantly ($P > .2$) in these univariate models at this screening stage were excluded from investigation in subsequent joint models. Second, all significant vending machine beverage availability variables from this screening stage (i.e., the vending machine beverages block of variables) were included in joint, multivariate Poisson regression models. These models included wave and all student- and school-level control variables.

We ran two additional series of models for each SSB consumption outcome variable to identify whether the addition of 'policy group' attenuated the effect of the vending machine beverage variables. One series of models contained the policy group effect (i.e., the policy group block) and all control variables, while

the other contained both the vending machine beverages and policy group blocks, in addition to all control variables. We performed all analyses using SAS version 9.4 (SAS Institute, Cary NC).

5.3 Results

School characteristics and beverage availability within vending machines at baseline

Table 16 shows the school sample characteristics at Wave 1, stratified by policy group. Overall, the sample was diverse, reflecting varied geographic and socioeconomic areas. Nearly all schools (96.2%) had at least one beverage vending machine. Most schools (85.9%) had 1+ 100% fruit juice available in the vending machines, making it the most commonly available beverage, followed by water (73.1%) and diet carbonated soft drinks (71.8%). Relatively few schools had sugar-containing sports drinks (14.1%), sugar-containing carbonated soft drinks (18.0%), and diet sports drinks (20.5%) available for sale.

Schools within the three policy groups differed significantly at Wave 1 with respect to their vending machine availability of water, 100% fruit juice, and three SSBs types: sugar-containing soft drinks (carbonated and non-carbonated) and sports drinks (Table 16). Specifically, with the exception of flavoured milk availability (which was similar across the three policy groups), SSB availability was considerably lower in Ontario public schools. For example, nearly all (98.4%) of Ontario public schools had zero sugar-containing sports drinks available in their vending machines, compared to 33.3% and 20.0% of Alberta schools and Ontario private schools, respectively.

Table 16: Characteristics of participating COMPASS secondary schools (n=78) at Wave 1 (2013/14) within three policy groups: Alberta (n=9), Ontario – Public (n=64), and Ontario – Private (n=5).

Characteristic	**Total** n (%)	**Alberta** n (%)	**Ontario – Public** n (%)	**Ontario – Private** n (%)	**p value** [a]
Socio-demographic					
Location					<0.001
Rural or small population centre	35 (44.9)	9 (100.0)	26 (40.6)	0 (0.0)	
Medium urban population centre	13 (16.7)	0 (0.0)	13 (20.3)	0 (0.0)	
Large urban population centre	30 (38.4)	0 (0.0)	25 (39.1)	5 (100.0)	
Neighbourhood median income					0.089
$25000 - 50000	7 (9.0)	0 (0.0)	6 (9.4)	1 (20.0)	
$50001-75000	51 (65.4)	4 (44.4)	45 (70.3)	2 (40.0)	
$75000 +	20 (25.6)	5 (55.6)	13 (20.3)	2 (40.0)	
Food outlets present within the school					
Cafeteria					0.003
Not present	5 (6.4)	2 (22.2)	1 (1.6)	2 (40.0)	
1+ present	73 (93.6)	7 (77.8)	63 (98.4)	3 (60.0)	
Tuck shop					0.036
Not present	69 (88.5)	7 (77.8)	59 (92.2)	3 (60.0)	
1+ present	9 (11.5)	2 (22.2)	5 (7.8)	2 (40.0)	

Beverage vending machines					0.682
No machines present	3 (3.8)	0 (0.0)	3 (4.7)	0 (0.0)	
1 machine present	8 (10.3)	1 (11.1)	6 (9.4)	1 (20.0)	
2 machines present	24 (30.8)	3 (33.3)	21 (32.8)	0 (0.0)	
3+ machines present	43 (55.1)	5 (55.6)	34 (53.1)	4 (80.0)	
Food outlets present within 1-km buffer of schools					
Restaurants					0.398
Not present	10 (12.8)	0 (0.0)	9 (14.1)	1 (20.0)	
1+ present	68 (87.2)	9 (100.0)	55 (85.9)	4 (80.0)	
Variety stores					0.086
Not present	45 (57.7)	8 (88.9)	35 (54.7)	2 (40.0)	
1+ present	33 (42.3)	1 (11.1)	39 (45.3)	3 (60.0)	
Food stores					0.204
Not present	15 (19.2)	0 (0.0)	15 (23.4)	0 (0.0)	
1+ present	63 (80.8)	9 (100.0)	49 (76.6)	9 (100.0)	
Contents of beverage vending machines [b]					
SSBs					
Sugar-containing carbonated soft drinks (e.g., non-diet Coca-Cola, non-diet Sprite, etc.)					<0.001
0 drinks available	64 (82.0)	5 (55.6)	59 (92.2)	0 (0.0)	
1 drink available	5 (6.4)	0 (0.0)	5 (7.8)	0 (0.0)	
2 drinks available	3 (3.9)	1 (11.1)	0 (0.0)	2 (40.0)	
3+ drinks available	6 (7.7)	3 (33.3)	0 (0.0)	3 (60.0)	
Sugar-containing non-carbonated soft drinks (e.g., non-diet lemonade, fruit drinks, iced tea, etc.)					<0.001
0 drinks available	36 (46.1)	0 (0.0)	36 (56.2)	0 (0.0)	
1 drink available	3 (3.9)	1 (11.1)	1 (1.6)	1 (20.0)	
2 drinks available	11 (14.1)	1 (11.1)	9 (14.1)	1 (20.0)	
3+ drinks available	28 (35.9)	7 (77.8)	18 (28.1)	3 (60.0)	
Sugar-containing sports drinks (e.g., Gatorade, PowerAde, etc.)					<0.001
0 drinks available	67 (85.9)	3 (33.3)	63 (98.4)	1 (20.0)	
1 drink available	3 (3.8)	2 (22.2)	0 (0.0)	1 (20.0)	
2 drinks available	2 (2.6)	1 (11.2)	0 (0.0)	1 (20.0)	
3+ drinks available	6 (7.7)	3 (33.3)	1 (1.6)	2 (40.0)	
Flavoured milk (e.g., strawberry, chocolate milk)					0.625
0 drinks available	42 (53.8)	6 (66.7)	33 (51.6)	3 (60.0)	
1 drink available	9 (11.5)	1 (11.1)	8 (12.5)	0 (0.0)	
2 drinks available	3 (3.9)	1 (11.1)	2 (3.1)	0 (0.0)	
3+ drinks available	24 (30.8)	1 (11.1)	21 (32.8)	2 (40.0)	
Non-SSBs					
Diet carbonated soft drinks (e.g., Diet Coke, Coke Zero, Sprite Zero, etc.)					0.244
0 drinks available	22 (28.2)	3 (33.4)	19 (29.7)	0 (0.0)	
1 drink available	8 (10.3)	1 (11.1)	5 (7.8)	2 (40.0)	
2 drinks available	8 (10.3)	1 (11.1)	6 (9.4)	1 (20.0)	
3+ drinks available	40 (51.2)	4 (44.4)	34 (53.1)	2 (40.0)	
Diet non-carbonated soft drinks (e.g., diet lemonade, Fresca, diet iced tea, etc.)					0.285
0 drinks available	40 (51.3)	6 (66.7)	31 (48.5)	3 (60.0)	
1 drink available	11 (14.1)	2 (22.2)	7 (10.9)	2 (40.0)	
2 drinks available	10 (12.8)	0 (0.0)	10 (15.6)	0 (0.0)	
3+ drinks available	17 (21.8)	1 (11.1)	16 (25.0)	0 (0.0)	
Diet sports drinks (e.g., G2, Powerade Zero, etc.)					0.126
0 drinks available	62 (79.5)	6 (66.7)	53 (82.8)	3 (60.0)	
1 drink available	4 (5.1)	1 (11.1)	2 (3.1)	1 (20.0)	
2 drinks available	4 (5.1)	0 (0.0)	3 (4.7)	1 (20.0)	
3+ drinks available	8 (10.3)	2 (22.2)	6 (9.4)	0 (0.0)	

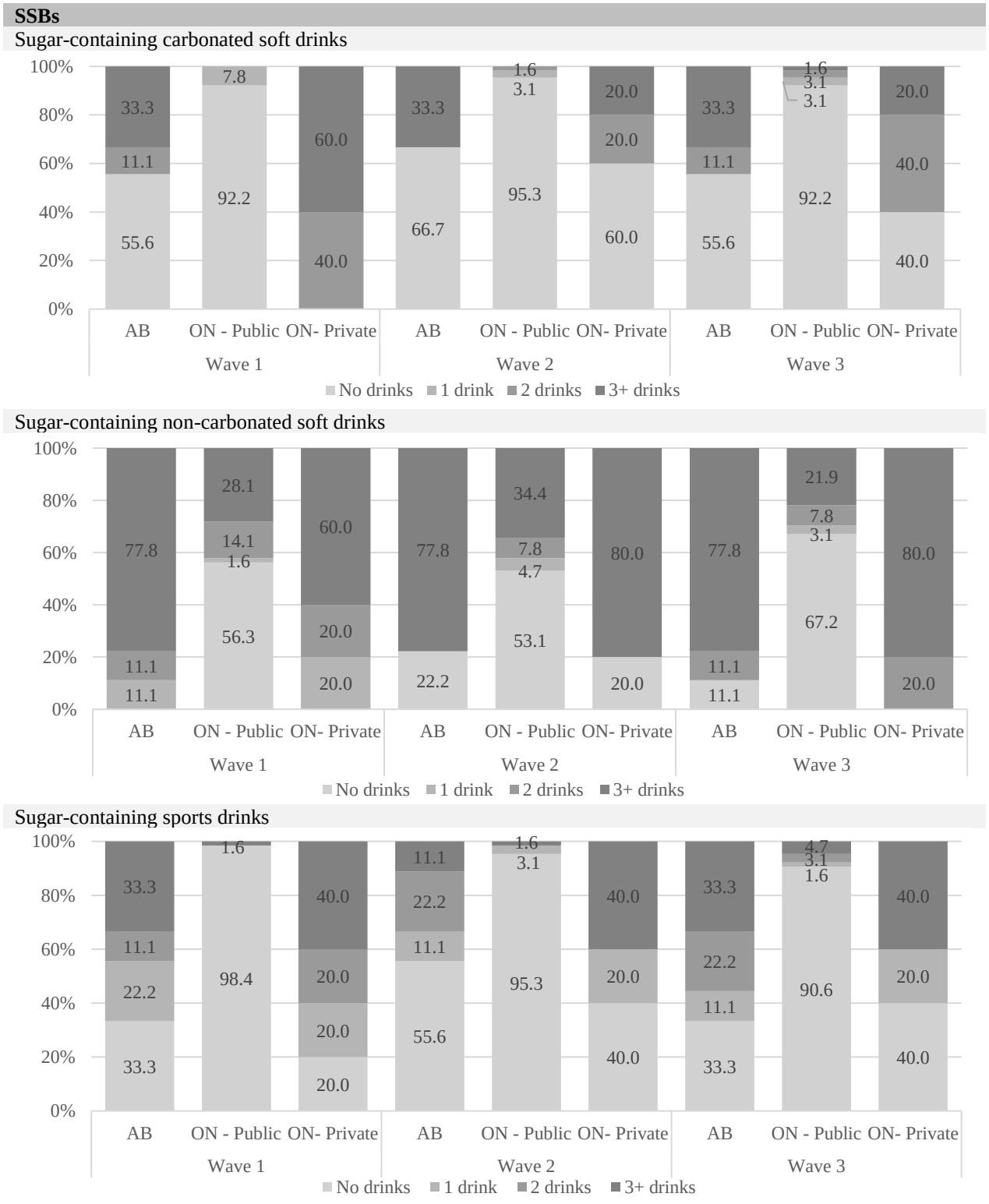
Plain white milk					0.851
0 drinks available	58 (74.4)	8 (88.9)	46 (71.9)	4 (80.0)	
1 drink available	4 (5.1)	0 (0.0)	4 (6.2)	0 (0.0)	
2 drinks available	10 (12.8)	1 (11.1)	9 (14.1)	0 (0.0)	
3+ drinks available	6 (7.7)	0 (0.0)	5 (7.8)	1 (20.0)	
100% fruit juice					0.033
0 drinks available	11 (14.1)	1 (11.2)	9 (14.1)	1 (20.0)	
1 drink available	2 (2.6)	0 (0.0)	0 (0.0)	2 (40.0)	
2 drinks available	32 (41.0)	4 (44.4)	27 (42.2)	1 (20.0)	
3+ drinks available	33 (42.3)	4 (44.4)	28 (43.7)	1 (20.0)	
Water					0.011
0 drinks available	21 (26.9)	0 (0.0)	21 (32.8)	0 (0.0)	
1 drink available	19 (24.4)	4 (44.4)	12 (18.7)	3 (60.0)	
2 drinks available	23 (29.5)	5 (55.6)	17 (26.6)	1 (20.0)	
3+ drinks available	15 (19.2)	0 (0.0)	14 (21.9)	1 (20.0)	

SSB = sugar-sweetened beverage
[a] Fisher's Exact Test used to examine differences by policy group.
[b] Schools without beverage vending machines (n=4) were coded as having '0 drinks available' within each beverage category.
Note: percentages rounded to sum to 100%.

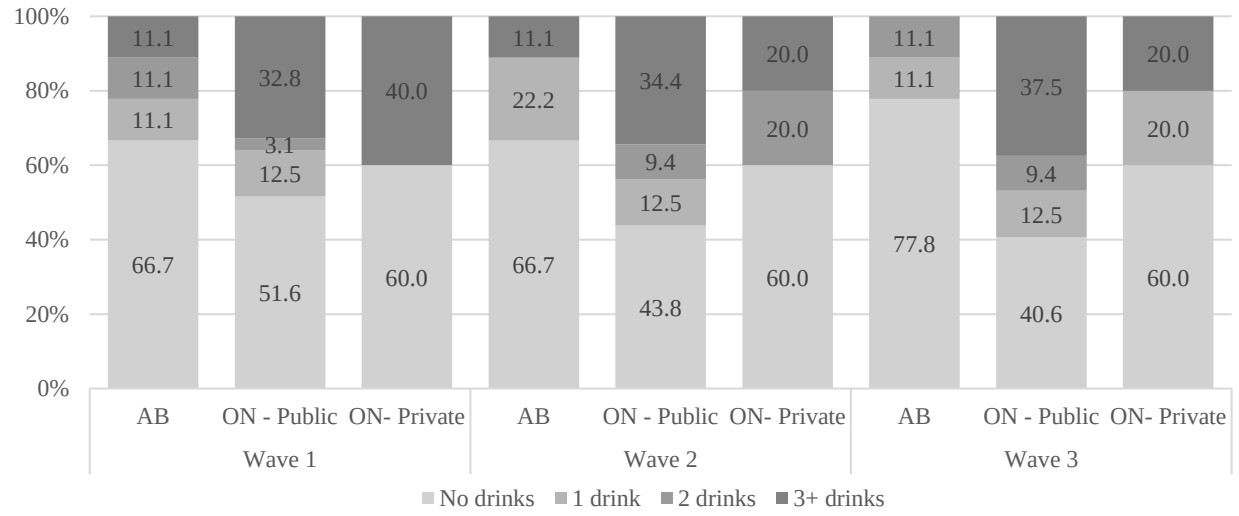
5.3.1 Changes in beverages available for sale within school vending machines

Figure 5 shows changes in the availability of various beverage categories within schools' vending machines in the different policy groups. Within Ontario public schools, vending machine beverage availability was generally stable over time. For example, the proportion of Ontario public schools without any sugar-containing carbonated soft drinks, diet carbonated soft drinks, diet sports drinks, and plain white milk fluctuated by less than 5% over time. There was a steady increase in the proportion of Ontario public schools offering 1+ flavoured milk, from 48.4% in Wave 1 to 59.4% in Wave 3. Conversely, the proportion of schools with bottled water available consistently decreased, from 67.2% in Wave 1 to 59.4% in Wave 3. The changes in beverage availability in Alberta and Ontario private school vending machines were more pronounced. For example, in Alberta the proportion of schools offering diet non-carbonated soft drinks (e.g., diet iced tea, diet lemonade, etc.) increased markedly, from 33.3% in Wave 1 to 88.9% in Wave 3. The availability of sugar-containing carbonated soft drinks fluctuated considerably in Ontario private schools, from 100% of schools having 1+ drink in Wave 1 to 40% in Wave 2 and 60% in Wave 3.

Figure 5: Changes in beverages availability in vending machines within participating COMPASS secondary schools (n=78) within three policy groups: Alberta (n=9), Ontario – Public (n=64), and Ontario – Private (n=5).

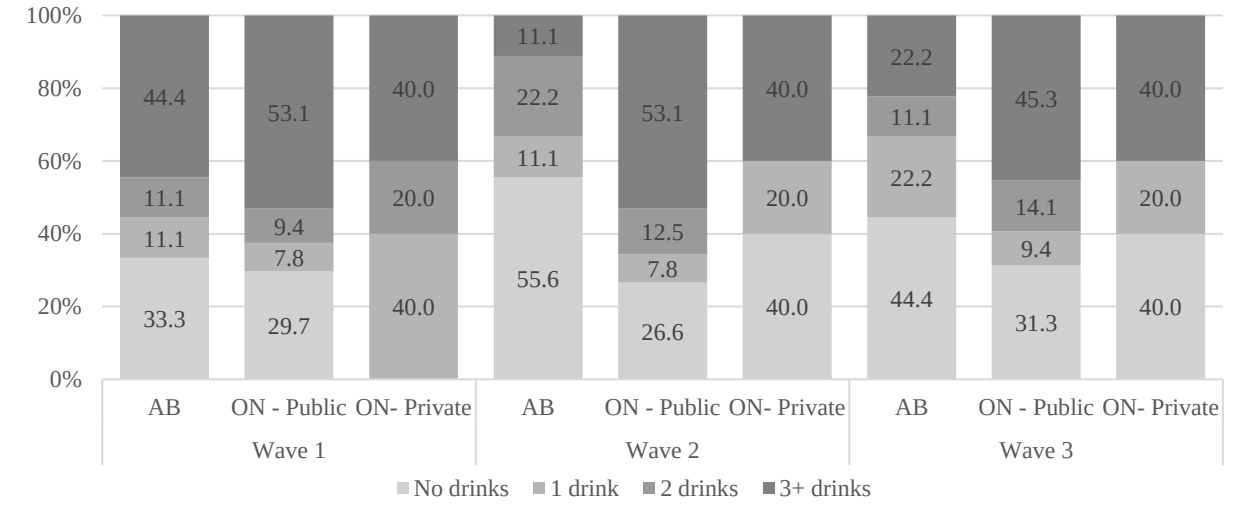


Flavoured milk

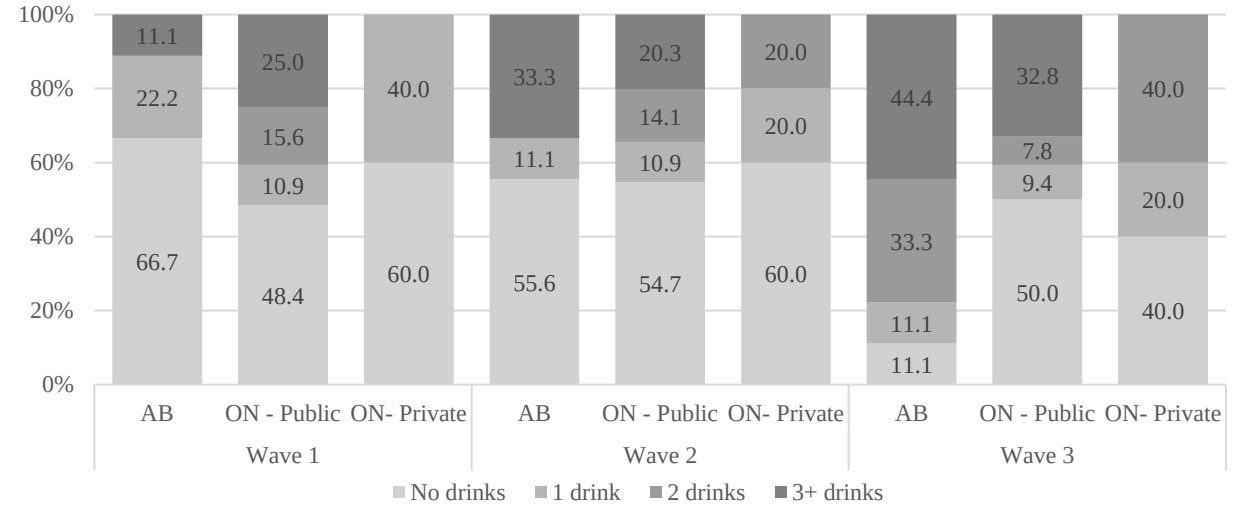


Non-SSBs

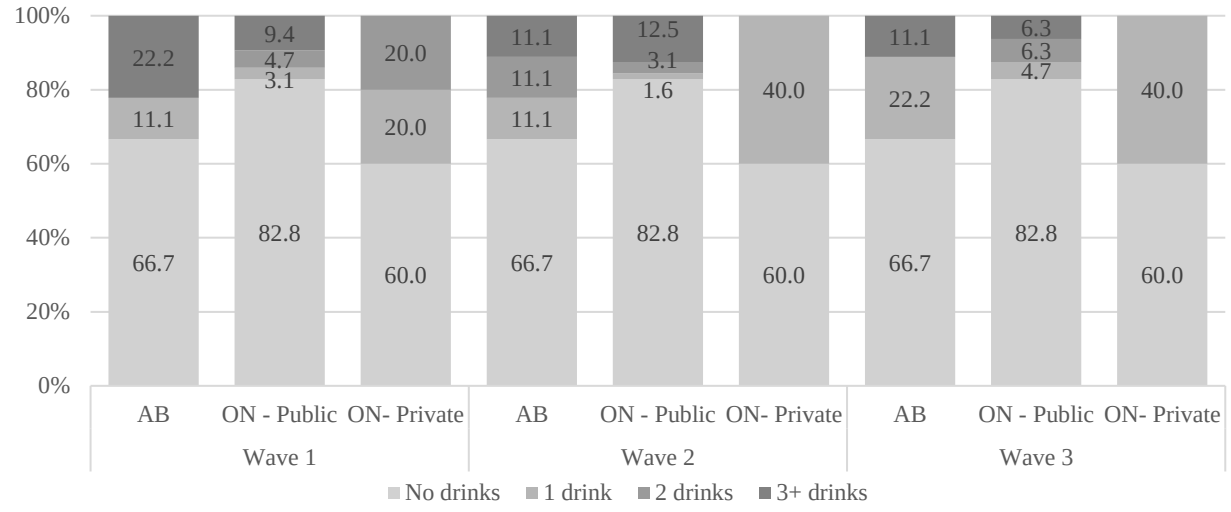
Diet carbonated soft drinks



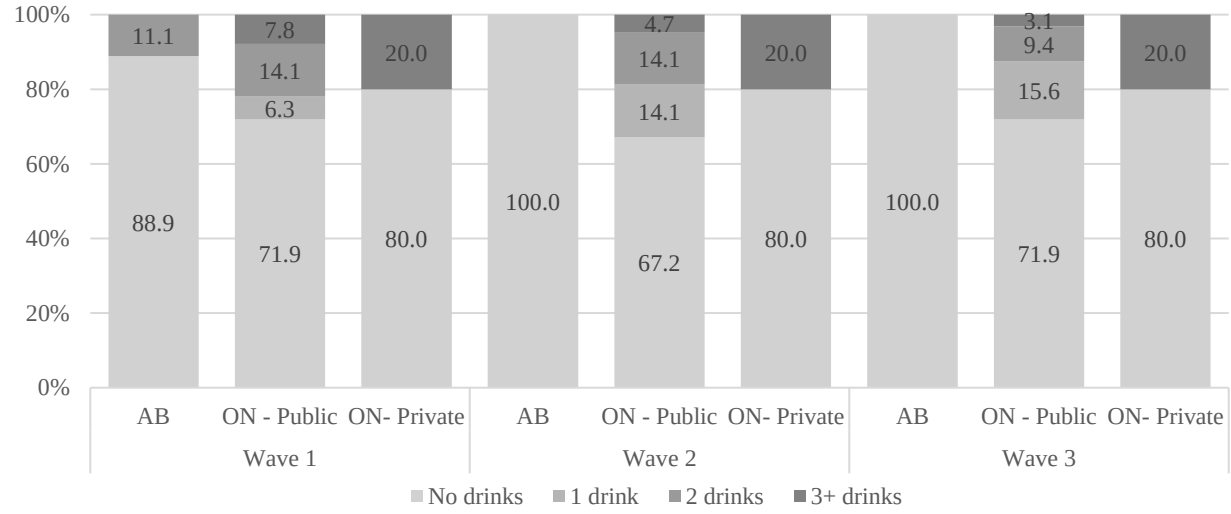
Diet non-carbonated soft drinks



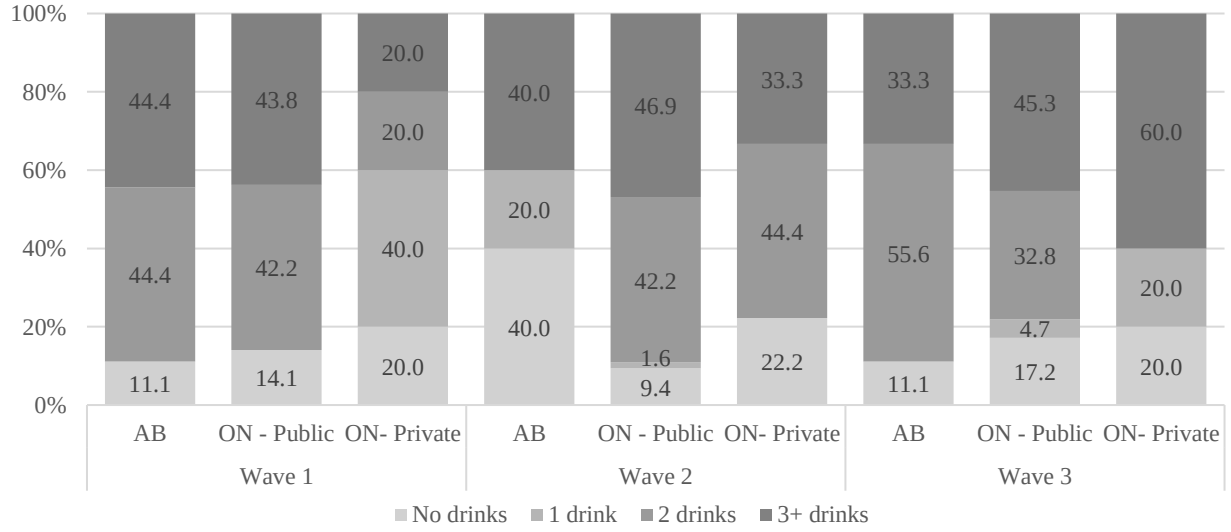
Diet sports drinks

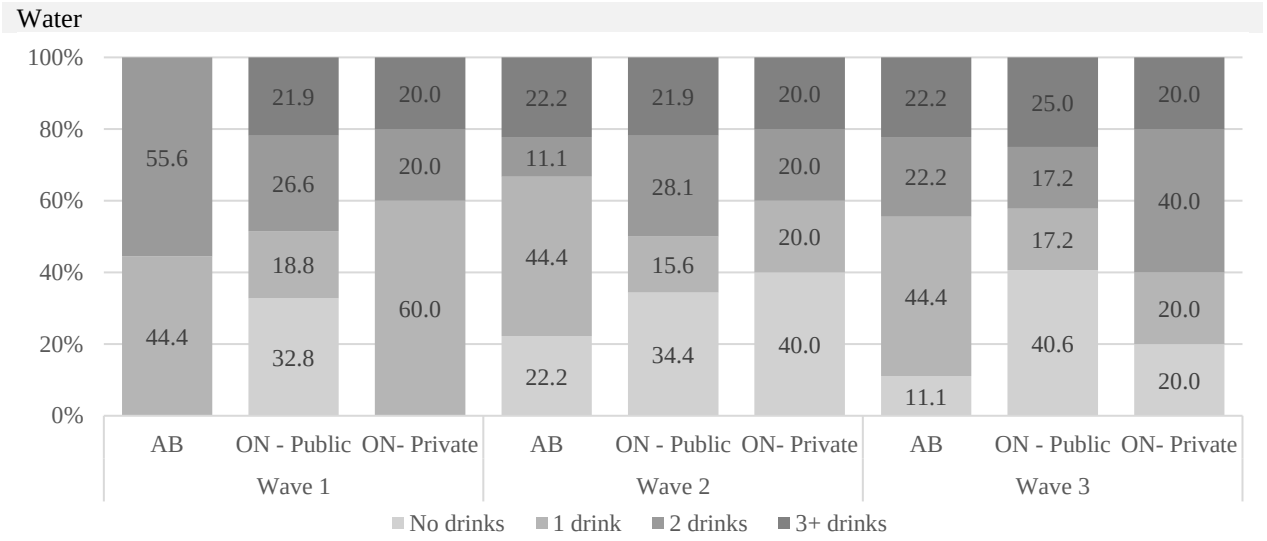


Plain white milk



100% fruit juice





Ontario public schools generally had a higher proportion of diet drinks available within vending machines compared to their sugar-containing beverage equivalent, while the other policy groups exhibited the opposite trend. For example, at Wave 1, 17.2% and 1.6% of Ontario public schools offered diet sports drinks and sugar-containing sports drinks, respectively, whereas 33.3% and 66.7% of Alberta schools offered diet sports drinks and sugar-containing sports drinks, respectively. With the exception of flavoured milks, SSB availability was lowest in vending machines in Ontario public schools across all waves and generally highest among Ontario private schools.

5.3.2 Participants' socio-demographic characteristics and SSB consumption at baseline

Table 17 shows student participants' socio-demographic characteristics and SSB intake measures at Wave 1. Since the sample included individuals that attended secondary school across Waves 1-3, nearly all participants (97.4%) were in Grades 9 or 10 at Wave 1. Most participants were female (53.5%), white (77.9%) and had a healthy weight (57.8%). Participants reported consuming soft drinks most frequently (mean 1.73 weekdays) and energy drinks least frequently (mean 0.15 weekdays). There were significant differences in participants' SSB intake measures across policy groups. Albertan participants reported a greater rate of SSB consumption across all four outcome measures compared to those in Ontario.

Table 17: Characteristics of COMPASS secondary school students (n=7679) from Alberta (n=497), Ontario – Public (n=6674), and Ontario – Private (n=508) schools at Wave 1 (2013/14).

Characteristic	**Total**	**Alberta**	**Ontario - Public**	**Ontario - Private**	
Socio-demographic and behavioural	n (%)	n (%)	n (%)	n (%)	p value [a]
Gender					<0.001
Female	4110 (53.5)	292 (58.8)	3642 (54.6)	176 (34.7)	
Male	3569 (46.5)	205 (41.2)	3032 (45.4)	332 (65.3)	
Grade					<0.001
9	4138 (53.8)	158 (31.8)	3717 (55.7)	263 (51.8)	
10	3346 (43.6)	334 (67.2)	2773 (41.6)	239 (47.0)	
11	191 (2.5)	5 (1.0)	181 (2.7)	5 (1.0)	
12	4 (0.1)	0 (0.0)	3 (0.0)	1 (0.2)	
Ethnicity					<0.001
White	5983 (77.9)	385 (77.5)	5245 (78.6)	353 (69.5)	
Aboriginal	143 (1.9)	42 (8.4)	101 (1.5)	22 (4.3)	
Asian	429 (5.6)	18 (3.6)	358 (5.4)	53 (10.4)	
Black	226 (2.9)	4 (0.8)	200 (3.0)	0 (0.0)	
Latin	109 (1.4)	2 (0.4)	99 (1.5)	8 (1.6)	
Other	789 (10.3)	46 (9.3)	671 (10.0)	72 (14.2)	
Weekly spending money					<0.001
$0	1625 (21.2)	85 (17.1)	1436 (21.5)	104 (20.5)	
$1-$20	2978 (38.8)	129 (26.0)	2659 (39.9)	190 (37.4)	
$21-$100	1607 (20.9)	126 (25.3)	1360 (20.4)	121 (23.8)	
>$100	412 (5.4)	54 (10.9)	342 (5.1)	16 (3.1)	
I don't know/missing	1057 (13.7)	103 (20.7)	877 (13.1)	77 (15.2)	
Weight status					<0.001
Underweight	107 (1.4)	6 (1.2)	91 (1.4)	10 (2.0)	
Healthy weight	4437 (57.8)	268 (53.9)	3826 (57.3)	343 (67.5)	
Overweight	1045 (13.6)	73 (14.7)	900 (13.5)	72 (14.2)	
Obese	429 (5.6)	35 (7.1)	382 (5.7)	12 (2.3)	
Missing	1661 (21.6)	115 (23.1)	1475 (22.1)	71 (14.0)	
Truancy					<0.001
Skipped 0 classes in last four weeks	6730 (87.6)	400 (80.5)	5864 (87.9)	466 (91.7)	
Skipped 1+ classes in last four weeks	949 (12.4)	97 (19.5)	810 (12.1)	42 (8.3)	
Weight goal					<0.001
Not trying to do anything about weight	1851 (24.1)	129 (26.0)	1599 (24.0)	123 (24.2)	
Gain weight	1094 (14.3)	55 (11.0)	930 (13.9)	109 (21.5)	
Lose weight	3136 (40.8)	224 (45.1)	2732 (40.9)	180 (35.4)	
Stay the same weight	1598 (20.8)	89 (17.9)	1413 (21.2)	96 (18.9)	
Weekday SSB consumption [b]	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	p value [c]
Freq. of consuming soft drinks	1.73 ± 1.70	1.92 ± 1.74	1.73 ± 1.70	1.64 ± 1.58	0.029
Freq. of consuming sweetened coffees/teas	1.15 ± 1.58	1.30 ± 1.63	1.14 ± 1.57	1.11 ± 1.60	0.021
Freq. of consuming energy drinks	0.15 ± 0.60	0.34 ± 0.92	0.14 ± 0.59	0.07 ± 0.38	<0.001
Composite SSB score [d]	3.03 ± 2.65	3.57 ± 2.92	3.00 ± 2.64	2.83 ± 2.43	<0.001

SSB = sugar-sweetened beverage

[a] Chi square analyses used to examine differences by policy group.

[b] Number of days in a typical school week (Mon.-Fri., 0-5 days).

[c] Kruskal-Wallis test used to examine differences by policy group.

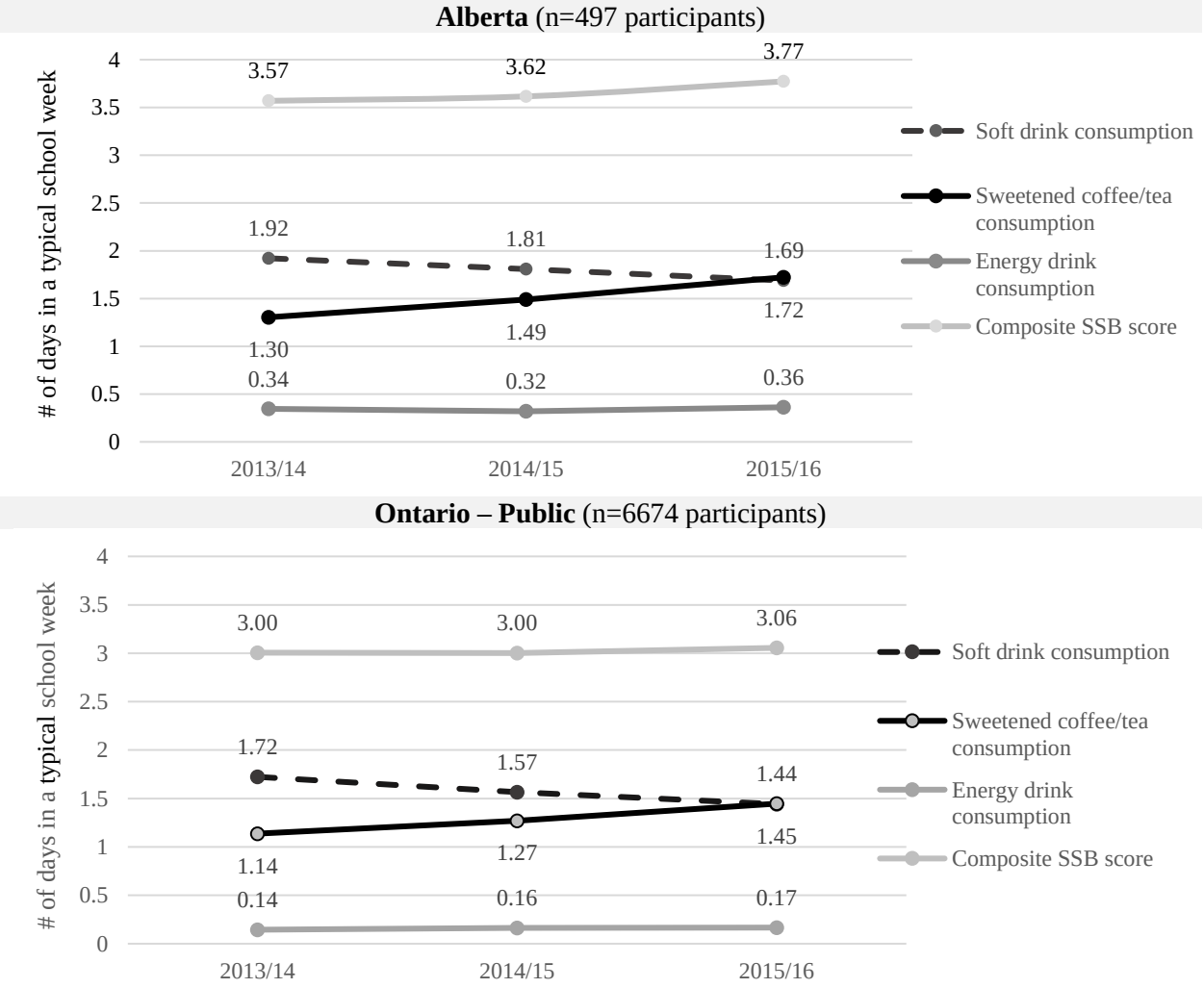
[d] A composite score, ranging from 0-15, representing the sum of participants' weekday rates of consuming the three distinct SSB categories.

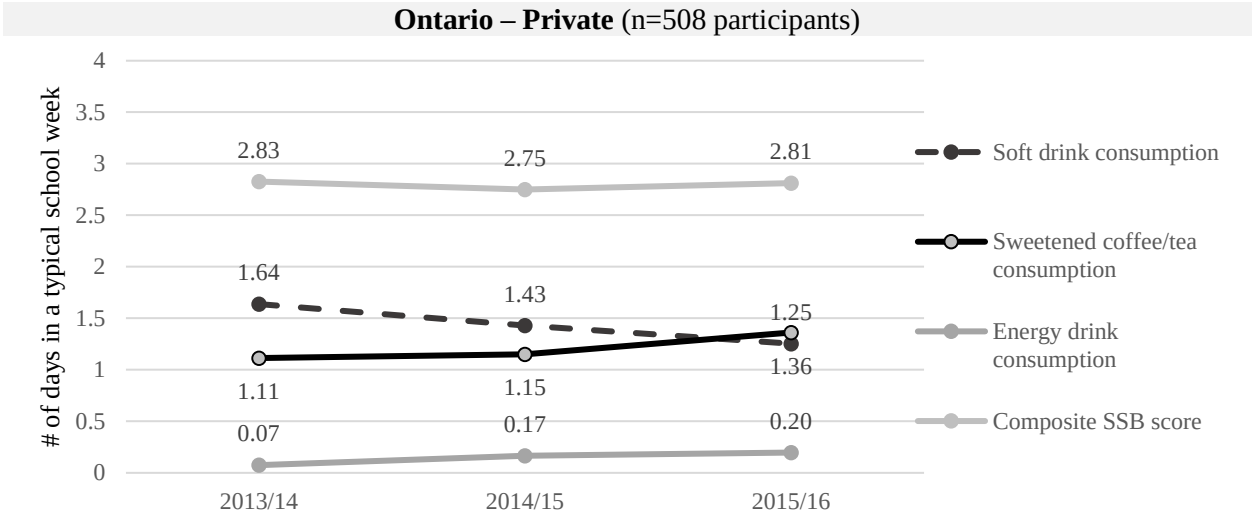
Note: percentages rounded to sum to 100%.

5.3.3 Changes in participants' rate of SSB consumption

The direction of change in participants' weekday rate of SSB consumption across Waves 1-3 was comparable across policy groups (Figure 6); participants' rate of soft drink consumption decreased while their rate of sweetened coffee/tea consumption increased. Participants' rate of energy drink consumption and composite SSB score remained fairly steady, showing relatively smaller increases over time. Across all four outcome measures and time points, participants in Alberta reported a higher rate of SSB intake than their Ontario counterparts. Ontario public school students reported more frequent SSB consumption at all time points compared to private school students, with the exception of energy drink intake, which was higher among private school students in Waves 2-3.

Figure 6: Changes between Waves 1-3 (2013/14-2015/16) in SSB consumption-related measures among COMPASS participants attending schools within three policy groups: Alberta (n=9 schools), Ontario – Public (n=64 schools), and Ontario – Private (n=5 schools). [a]





[a] Plotted values represent mean rate of the SSB consumption measure among participants in each policy group at each wave of data.

5.3.4 Modeling predictors of beverage availability

Table 18 displays the associations between school-level characteristics and vending machine availability of each of the ten beverage categories. The effect of policy group was significantly (P <.05) associated with the availability of sugar-containing soft drinks (carbonated and non-carbonated) and sports drinks; these SSBs were considerably more available in Alberta and Ontario private schools, relative to Ontario public schools, after adjusting for control variables. The models demonstrated that beverage availability generally did not vary significantly over time; however, with each wave of data, the odds of sugar-containing non-carbonated soft drinks being available in schools' vending machines decreased significantly (P <.01).

5.3.5 Modeling predictors of SSB intake

Few of the ten measures of SSB availability were significantly associated (P <.20) with the four SSB consumption-related outcomes in the univariate analyses, and thus few were retained for inclusion in the joint multivariate models (Table 19).

Table 18: Odds ratios for school characteristics associated with availability vs. non-availability of several beverage categories in school vending machines in secondary schools (n= 78) representing three policy groups in Alberta and Ontario that participated in Waves 1-3 (2013/14-2015/16) of the COMPASS study.

Characteristic	Beverage categories Adjusted odds ratio [a] (95% CI)									
	Sugar-containing carbonated soft drinks	Sugar-containing non-carbonated soft drinks	Sugar-containing sports drinks	Flavoured milk	Diet carbonated soft drinks	Diet non-carbonated soft drinks	Diet sports drinks	Plain white milk	100% fruit juice	Water
Policy group										
Ontario – Public	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Ontario – Private	28.03 (5.44-144.39) ***	26.00 (2.82-239.77) **	111.14 (10.69-1155.51) ***	0.50 (0.08-3.34)	0.45 (0.10-2.07)	0.61 (0.07-5.35)	13.75 (1.97-96.20) **	0.81 (0.09-7.03)	0.19 (0.01-2.51)	1.00 (0.11-8.85)
Alberta	16.81 (2.54-111.11) **	6.25 (1.12-34.90) *	10.18 (2.39-43.38) **	0.43 (0.11-1.67)	1.02 (0.27-3.81)	1.10 (0.32-3.74)	0.98 (0.16-5.89)	0.20 (0.02-2.08)	2.09 (0.48-9.05)	2.90 (0.48-17.34)
Wave [b]	0.86 (0.54-1.36)	0.77 (0.64-0.92) **	1.37 (0.82-2.29)	1.17 (0.96-1.42)	0.88 (0.71-1.11)	1.14 (0.91-1.43)	0.95 (0.77-1.18)	0.98 (0.73-1.31)	0.92 (0.62-1.35)	0.81 (0.69-0.95)

[a] Odds adjusted for all other variables in the column, in addition to geographic location, school neighbourhood median income, and the presence of restaurants, variety stores, and food stores within schools' 1-km circular buffer.

[b] Wave was treated as a continuous variable, where Wave 1= 0, Wave 2=1, and Wave 3=2.

*P <.05, **P <.01, ***P <.001

--- Variable not included in model due to small cell count.

Table 19: Univariate analyses for vending machine beverage availability variables in relation to students' weekday consumption of SSBs among secondary school students (n=7679) in Alberta and Ontario participating in Waves 1-3 (2013/14-2015/16) of the COMPASS study.

Variable	Weekday SSB consumption [a] Rate [b] (95% CI)			
	Composite SSB score [c]	Soft drink	Sweetened coffees/teas	Energy drinks
SSBs				
Sugar-containing carbonated soft drinks (e.g., non-diet Coca-Cola, non-diet Sprite, etc.)				
0 drinks available	REF	REF	REF	REF
1+ drinks available	1.01 (0.97-1.05)	1.00 (0.94-1.06)	1.03 (0.95-1.11)	0.99 (0.81-1.21)
Sugar-containing non-carbonated soft drinks (e.g., non-diet lemonade, fruit drinks, iced tea, etc.)				
0 drinks available	REF	REF	REF	REF
1+ drinks available	1.01 (0.98-1.04)	**1.05 (1.01-1.10) ***	0.97 (0.91-1.03)	1.04 (0.89-1.21)
Sugar-containing sports drinks (e.g., Gatorade, PowerAde, etc.)				
0 drinks available	REF	REF	REF	REF
1+ drinks available	**1.03 (0.99-1.07)**	0.98 (0.91-1.06)	**1.06 (0.97-1.15)**	1.21 (0.89-1.63)
Flavoured milk (e.g., strawberry, chocolate milk)				
0 drinks available	REF	REF	REF	REF
1+ drinks available	**0.97 (0.94-1.01)**	**0.94 (0.89-0.99) ***	1.03 (0.97-1.09)	**0.96 (0.73-1.00)**
Non-SSBs				
Diet carbonated soft drinks (e.g., Diet Coke, Coke Zero, Sprite Zero, etc.)				
0 drinks available	REF	REF	REF	REF
1+ drinks available	0.98 (0.95-1.02)	0.99 (0.93-1.06)	0.98 (0.91-1.05)	0.91 (0.76-1.08)
Diet non-carbonated soft drinks (e.g., diet lemonade, Vitaminwater Zero, diet iced tea, etc.)				
0 drinks available	REF	REF	REF	REF
1+ drinks available	1.00 (0.98-1.03)	0.99 (0.94-1.04)	1.01 (0.95-1.07)	**1.10 (0.96-1.25)**
Diet sports drinks (e.g., G2, Powerade Zero, etc.)				
0 drinks available	REF	REF	REF	REF
1+ drinks available	**1.03 (0.99-1.09)**	1.02 (0.94-1.11)	1.03 (0.95-1.11)	1.10 (0.85-1.43)
Plain white milk				
0 drinks available	REF	REF	REF	REF
1+ drinks available	**0.97 (0.94-1.01)**	0.99 (0.93-1.06)	**0.95 (0.90-1.01)**	**0.89 (0.75-1.05)**

100% fruit juice				
0 drinks available	REF	REF	REF	REF
1+ drinks available	1.02 (0.97-1.07)	1.02 (0.94-1.10)	1.02 (0.93-1.11)	1.01 (0.84-1.21)
Water				
0 drinks available	REF	REF	REF	REF
1+ drinks available	**1.03 (0.99-1.07)**	**1.07 (1.01-1.13) ***	1.00 (0.93-1.07)	0.98 (0.83-1.16)

SSB = sugar-sweetened beverage

[a] Number of weekdays participants reported consuming SSBs in a typical school week (Mon.-Fri., 0-5 days).

[b] Rates represents the exponentiated beta coefficients; bold values are statistically significant ($P < .20$).

[c] A composite score, ranging from 0-15, representing the sum of participants' weekday rates of consuming the three distinct SSB categories.

*$P < .05$, **$P < .01$, ***$P < .001$

When comparing the three series of multivariate models developed (i.e., vending machine beverage availability block only, policy group block only, and both blocks together), it was clear that the interpretation and significance of variables of interest did not differ across the series of models for each outcome. Table 20 displays the four multivariate models that contained both the vending machine beverage availability and policy group blocks. Controlling for all other variables, there were significant (P <.05) differences in participants' SSB consumption outcomes between Ontario public schools (the reference group) and the other policy groups in three of the four models. Specifically, relative to the Ontario public school students, attending school in Alberta was associated with a higher composite SSB score and rate of energy drink consumption, whereas attending an Ontario private school was associated with less frequent soft drink intake. The effect of wave was significant across models and suggested that, after controlling for all other variables, participants' rate of SSB consumption decreases as they progress through secondary school, with the exception of sweetened coffees/teas, which participants consumed more often with time. Few of the beverage availability variables retained their significance in the models. The availability of bottled water was significantly (P <.001) associated with a higher rate of soft drink consumption and composite SSB score.

Supplementary material for this chapter can be found in Appendix G.

Table 20: Final multivariate models describing correlates of weekday consumption of three varieties of SSBs among secondary school students (n= 7679) in Alberta and Ontario participating in Waves 1-3 (2013/14-2015/16) of the COMPASS study.

Variable	**Weekday SSB consumption** [a] Rate [b] (95% CI)			
	Composite SSB score [c]	Soft drink	Sweetened coffees/teas	Energy drinks
Policy group				
Ontario – Public	REF	REF	REF	REF
Ontario – Private	0.96 (0.90-1.03)	0.92 (0.86-0.99) *	0.97 (0.88-1.06)	1.01 (0.63-1.61)
Alberta	1.11 (1.00-1.24) *	1.09 (0.98-1.20)	1.06 (0.91-1.23)	1.40 (1.08-1.83) *
Wave	0.96 (0.95-0.98) ***	0.89 (0.88-0.91) ***	1.06 (1.04-1.09) ***	0.90 (0.84-0.97) **
SSBs				
Sugar-containing carbonated soft drinks (e.g., non-diet Coca-Cola, non-diet Sprite, etc.)				
0 drinks available	---	---	---	---
1+ drinks available	---	---	---	---
Sugar-containing non-carbonated soft drinks (e.g., non-diet lemonade, fruit drinks, iced tea, etc.)				
0 drinks available	---	REF	---	---
1+ drinks available	---	0.97 (0.93-1.01)	---	---
Sugar-containing sports drinks (e.g., Gatorade, PowerAde, etc.)				
0 drinks available	REF	---	REF	---
1+ drinks available	0.98 (0.92-1.04)	---	1.02 (0.94-1.12)	---
Flavoured milk (e.g., strawberry, chocolate milk)				
0 drinks available	REF	REF	---	REF
1+ drinks available	1.00 (0.96-1.04)	0.98 (0.94-1.03)	---	0.94 (0.78-1.14)
Non-SSBs				
Diet carbonated soft drinks (e.g., Diet Coke, Coke Zero, Sprite Zero, etc.)				
0 drinks available	---	---	---	---
1+ drinks available	---	---	---	---
Diet non-carbonated soft drinks (e.g., diet lemonade, Vitaminwater Zero, diet iced tea, etc.)				

0 drinks available	---	---	---	REF
1+ drinks available	---	---	---	0.97 (0.84-1.12)
Diet sports drinks (e.g., G2, Powerade Zero, etc.)				
0 drinks available	REF	---	---	---
1+ drinks available	0.98 (0.93-1.04)	---	---	---
Plain white milk				
0 drinks available	REF	---	REF	REF
1+ drinks available	0.99 (0.95-1.03)	---	1.00 (0.95-1.05)	1.01 (0.82-1.24)
100% fruit juice				
0 drinks available	---	---	---	---
1+ drinks available	---	---	---	---
Water				
0 drinks available	REF	REF	---	---
1+ drinks available	1.07 (1.03-1.12) ***	1.08 (1.03-1.13) **	---	---

SSB = sugar-sweetened beverage

[a] Number of weekdays participants reported consuming SSBs in a typical school week (Mon.-Fri., 0-5 days).

[b] Rates represents the exponentiated beta coefficients; rates adjusted for all other variables in the column, in addition to student- and school-level control variables.

[c] A composite score, ranging from 0-15, representing the sum of participants' weekday rates of consuming the three distinct SSB categories.

--- excluded from model during univariate analyses screening.

*P <.05, **P <.01, ***P <.001

5.4 Discussion

This study examined temporal changes in the contents of the beverage vending machines within secondary schools in Alberta and Ontario and students' rate of days of SSB consumption, in order to assess the implementation and impact of distinct school nutrition policies in these two Canadian provinces.

5.4.1 Beverage availability in secondary schools

Most SSB categories we examined were less available in school vending machines in Ontario public schools compared to Alberta, suggesting that *P/PM 150* is having a more positive impact on the quality of beverages available for sale in schools relative to *ANGCY*. The exception to this was flavoured milks, which were more available in Ontario public schools than the other policy groups and increased in availability with time. Although flavoured milks often contain a high quantity of added sugar, some differentiate these beverages from other SSBs, since they are also a source of calcium and protein. Further, flavoured milks are generally permitted for sale within Ontario public secondary schools, since flavoured low-fat milk and milk-based beverages are considered 'sell-most' items within *P/PM 150*, provided they contain ≤28g sugar/serving (Ontario Ministry of Education, 2016). Our observation that SSBs were often markedly less available in vending machines in Albertan schools compared to Ontario private schools provides some evidence that, even with its voluntary nature, *ANGCY* may support restrictions in the in-school sale of SSBs. Overall, our findings are consistent with previous Canadian research that suggests that provincial school nutrition policies can effectively limit SSB availability in schools (Watts, Mâsse, & Naylor, 2014).

Other notable policy group differences included a greater availability of diet beverages and lower availability of bottled water in Ontario public schools. There is no consensus on the acceptability of the non-nutritive sweeteners found in many diet drinks. For example, there are conflicting recommendations across Canadian school food guidelines regarding artificially-sweetened products; some guidelines indicate that artificial sweeteners are acceptable, others state they should be avoided (e.g., *ANGCY*), while others do not mention these sweeteners at all (e.g., *P/PM 150*) (Godin et al., 2017). Recent reviews indicate that there is a lack of strong evidence for a casual association between artificial sweetener use and adverse health effects (Brown, BANATE, & Rother, 2010; Shankar, Ahuja, & Sriram, 2013). The decreased availability of bottled water in Ontario vending machines may reflect environmental movements to limit use of plastic bottled water in favour of water fountains in schools (e.g., "Ban the Bottle" campaigns underway in schools globally) (Ban the Bottle, 2017). Previous research has identified unintended consequences of these initiatives in some settings, including significant increases in the

number of plastic bottles being shipped to schools (thereby entering the waste stream) and greater consumption of less healthy bottled beverages among students (Berman & Johnson, 2015). This does not, however, elucidate our finding that the availability of bottled water was associated with a higher composite SSB score and rate of soft drink intake among participants, which was contrary to expectations. We are unaware of previous research that has identified similar associations, although it is unlikely that the association is causal. We suspect that the associations may be more of a reflection of vending machines purchasing, in that students who make frequent purchases from vending machines generally purchase water from school vending machines (i.e., since we identified that bottled water are highly available in these food outlets) and may purchase other beverages from vending machines in other settings

Although Ontario public schools had a significantly lower availability of most SSBs in their vending machines compared to the other policy groups, the presence of these products reflects non-compliance with *P/PM 150*, as noted in previous studies (Orava et al., 2016; Vine et al., 2017). Reasons for non-compliance with school food policies include school stakeholders' perceptions of lower revenue generation, time and resource constraints, higher priced policy compliant foods (Vine, Elliott, & Raine, 2014), as well as ambiguities within policy recommendations, a lack of support with implementation, and limited policy monitoring (Godin et al., 2017; Valaitis, Hanning, & Orava, 2016; Vine et al., 2017). Greater enforcement and additional supports to help school stakeholders to understand and implement the policies as intended would likely increase policy compliance. However, our finding that 90+% of Ontario public schools had no sugar-containing carbonated soft drinks and sports drinks available in their vending machines over three school years is a positive result, and demonstrates schools' clear efforts to adhere to *P/PM 150*. There is further encouragement in our finding that SSB availability did not shift significantly over the study period, which disproved our hypothesis that policy adherence would decrease with time.

5.4.2 Changes in adolescents' SSB consumption over time

Across all three policy groups, participants' overall SSB consumption remained fairly stable as they progressed through secondary school, although their intake of certain SSB categories shifted. Notably, sweetened coffees/teas displaced soft drinks as the most frequently consumed SSB among participants. Many varieties of sweetened coffees/teas (e.g., speciality coffees drinks) contain as much or more sugar than sodas (Huang, Dumanovsky, Silver, Nonas, & Bassett, 2009) and considerably more caffeine (Mitchell, Knight, Hockenberry, Teplansky, & Hartman, 2014), which is concerning since recent estimates of adolescents' caffeine consumption exceed Health Canada's recommendations for this age group (Mitchell et al., 2014). Adolescents' caffeinated beverage consumption has increased significantly over recent decades (Branum, Rossen, & Schoendorf, 2014), mirroring increases in the per capital sales

volume for sweetened coffee/teas in Canada (Jones et al., 2017). A recent Canadian study identified various reasons for adolescents' consumption of caffeinated beverages, including parental and peer role modeling, a desire to feel/appear more mature, energy provision, and to remain alert for academic or social activities (Turton, Piché, & Battram, 2016). Future research should continue to monitor trends in adolescents' SSB intake, and examine the specific products youth consume, the sources of these beverages, and their associated health effects.

5.4.3 Provincial school nutrition policy impact

This study did not detect a significant association between beverage availability in school vending machines and adolescents' SSB intake. The lack of identified association may reflect methodological limitations of this study (e.g., the examination of only one type of school food outlet, conservative measures of SSB intake, etc.), as opposed to ineffectiveness of provincial school nutrition policies. Indeed, findings from a recent systematic review (Vézina-Im et al., 2017) and previous Canadian evaluation studies (Fung, McIsaac, Kuhle, Kirk, & Veugelers, 2013; Mullally et al., 2010) identify that school nutrition policies can have a favourable impact on students' dietary behaviours. However, our results are consistent with previous research in Canada and elsewhere that report that features of the school food environment have a limited impact on students' dietary outcomes (Lebel et al., 2016; Lien et al., 2014; Minaker et al., 2011; Park, Blanck, Sherry, Brener, & O'Toole, 2012; van der Horst et al., 2008).

There are several reasons why, even with perfect school-level compliance, school nutrition policies may be limited in their ability to moderate adolescents' SSB intake. Vine et al. found that following *P/PM 150*, schools noted an increase in students leaving school to purchase meals/snacks at neighbouring food outlets (Vine & Elliott, 2014; Vine et al., 2014). A recent COMPASS study identified that students reported purchasing snacks from school vending machines an average of 0.3 days in a typical school week, which was considerably less often than the number of days they made purchases from fast-food places/restaurants, and convenience food outlets off-school property (Godin et al., 2018). Indeed, when students are restricted in the foods/beverages they can access during school, they may compensate by consuming more of these items in other settings (Finkelstein, French, Variyam, & Haines, 2004; Vecchiarelli, Takayanagi, & Neumann, 2006; Vézina-Im et al., 2017). Further, previous research identifies that SSB intake is primarily driven by socio-cultural and intrapersonal-level (versus school-level) factors (Lebel et al., 2016; van der Horst et al., 2008), which is reflected in the very limited (≤2%) proportion of the variability in students' rate of SSB intake accounted for by school-level differences (Godin et al., 2018). These findings underscore the value in comprehensive school-based nutrition interventions (e.g., comprising nutrition education, initiatives to improve students' food skills, school

nutrition policies, built environment changes, etc.), as well as broader population-level efforts (e.g., taxation of sugary drinks, marketing restrictions, etc.), to communicate a consistent health-reinforcing message through various channels to support behaviour change (McKenna, 2010; Vecchiarelli et al., 2006; Vézina-Im et al., 2017).

5.4.4 Study limitations

This study has important limitations, some of which reflect the fact that the COMPASS study was not specifically designed to provide a detailed assessment of the beverages available for sale within schools or students' SSB consumption patterns. We only assessed beverage availability within school vending machines, as data on beverages for sale within school cafeterias or tuck shops were not consistently available. These data were unavailable due to cafeterias and tuck shops being closed during data collections, and since COMPASS researchers were often denied permission to enter and/or photograph school cafeterias, particularly those operated by external private companies. Measures of SSB consumption likely underestimate participants' true SSB intake due to the unit of measure used (i.e., as compared to volume or number of servings of SSBs consumed) and since certain SSBs (e.g., flavoured milks) are not captured on the questionnaire. Further, there was imperfect alignment between of SSB outcome measures and vending machine drink categories. For example, the "sugar-containing non-carbonated soft drink" category comprised both soft drinks (e.g., <100% fruit drinks) and sweetened coffees/teas (e.g., iced tea). This study is also limited by the relatively small number Albertan and Ontario private schools, which reflect the fact that most Canadian schools are publicly-funded and COMPASS' inception in Ontario. Finally, this study lacks data pre-implementation of provincial school nutrition policies in Alberta and Ontario, precluding the ability to examine changes in beverage availability and/or students' rate of SSB intake as a direct result of policy implementation. However, given the forthcoming release of the new *Canada's Food Guide* (i.e., Canada's national food guidelines, which were last revised in 2007) in 2018/19 and the fact that many school food guidelines are largely based on the *Food Guide* (Godin et al., 2017), it is likely that the provinces will make corresponding revisions to their school nutrition policies in the coming years. As such, there is a unique opportunity to use COMPASS data to examine the impact of future policy changes on the availability of school foods/beverages and students' dietary outcomes, using the present study as a model.

5.5 Conclusions

The mandatory nutrition policy implemented in Ontario public schools is associated with a substantially lower availability of SSBs in secondary school vending machines, compared to the voluntary policies in Alberta and Ontario private schools. Although implementation of the mandatory policy in Ontario public

schools was not perfect—particularly with respect to sugar-containing non-carbonated soft drinks (i.e., primarily fruit drinks and iced teas) —adherence to the policy was generally high and did not decrease over time. SSB consumption was significantly lower in Ontario public and private schools, although the current study did not detect a direct association between consumption and SSB availability. Overall, the findings provide support for mandatory versus voluntary school nutrition policies, as well as the need for comprehensive school- and broader population-level efforts that address other factors that influence adolescents' dietary choices (e.g., individuals' diet-related values, knowledge, attitudes, and food skills), in addition to the accessibility of unhealthy versus healthy food and beverages.

Chapter 6
General Discussion

6.1 Overview

The frequent consumption of SSBs among Canadian adolescents represents an important public health concern, given the numerous adverse health outcomes associated with high SSB consumption. Provincial school nutrition policies have emerged as one population-level strategy to promote healthy dietary choices among Canadian youth. Some evaluations of these policies have identified that they can contribute to measurable improvements in Canadian youths' dietary choices. However, other research highlights key limitations of these policies related to their adoption in Canadian schools and their ability to significantly improve measures of students' dietary behaviours, including adolescents' SSB intake.

While efforts to improve adolescents' dietary choices through school nutrition policies and other school-based initiatives are important, there exists a broad range of contextual factors outside of schools that influence individuals' dietary patterns. According to socioecological model of health, these levels of influence range from proximal (e.g., intrapersonal and interpersonal factors) to distal (e.g., community factors and public policy). The relationships between these levels of influence are dynamic and complex; no single factor acts on individuals' behaviour in isolation. School-based interventions, and evaluations of these interventions, must account for the ability for these initiatives to be supported and/or undermined by influences within other environments (e.g., the home, community, media, and larger regulatory contexts).

This dissertation examined the role of the school context in influencing Canadian adolescents' SSB consumption in Alberta and Ontario using data from the COMPASS study. The main objectives were to (i) characterize Canadian adolescents' SSB consumption patterns; (ii) describe school food environment characteristics in Canadian secondary schools; (iii) describe what these characteristics communicate about school-level compliance with provincial school nutrition policies; (iv) identify associations between school food environment characteristics and measures of students' SSB intake; and, (v) identify potentially promising settings and/or strategies for future population-level initiatives to reduce adolescents' SSB intake. This dissertation's key findings, public health and policy implications, and directions for future research are presented below.

6.2 Summary of key findings

Chapter 4 examined how several food purchasing behaviors (i.e., sources of meals or snacks) are associated with adolescents' SSB consumption, and whether these associations vary by province. The food purchasing behaviours examined reflected both temporal (e.g., weekend versus weekday) and spatial

(e.g., home, school, and broader community) contexts. The diversity of these food purchasing behaviours enabled an examination of the relative importance of behaviours situated within the school compared to those outside of the school, as they relate to students' SSB intake. The study hypothesis was that the magnitude of association between SSB intake and purchases from school food outlets would be greater among adolescents in Alberta compared to Ontario, as a possible reflection of their voluntary versus mandatory provincial school nutrition policies.

Chapter 4 identified that most of the food purchasing behaviours were significantly and positively associated with greater rates of SSB consumption. An exception to this was eating a home-packed lunch on weekdays, which was consistently protective against SSB intake. Meal or snack purchases on weekends (versus weekdays) and from food outlets off-school property (versus on-school property) had a greater association with SSB consumption. There has been a limited investigation of differences in adolescents' dietary behaviours on weekends versus weekdays in previous research; however, this finding likely reflects differences in the physical and social contexts in which adolescents spend their time in these two periods. These results highlight the contributions of home and community contexts (i.e., where many youth spend time when they are not in school) to adolescents' SSB intake.

However, this study also signaled the potential importance of the school context since school-level variation across students' SSB intake (though modest) was statistically significant across all SSB-related outcomes, and purchasing meals/snacks from school cafeterias and vending machines was associated with higher rates of SSB intake. Two earlier Canadian studies reported similar associations (Jones et al., 2015; Woodruff et al., 2010), although these studies did not examine students' snack or weekend purchasing behaviours. Although neither these two studies nor Chapter 4 assessed the availability of SSBs in school food outlets, it is plausible that these associations reflect the presence of SSBs in schools, since previous research has identified that many Canadian secondary schools have less healthful beverages available for sale (Orava, Manske, & Hanning, 2016; Vine et al., 2017).

The research identified a significantly higher rate of SSB intake among Albertan participants and a number of interesting (though not consistently significant) interaction effects between province and various food purchasing behaviours, providing evidence that students' rate of SSB intake may be related to the effect of 'province'. There have been limited inter-jurisdictional assessments of adolescents' SSB intake in Canada. One recent study identified significant differences in adolescents' SSB consumption in three diverse regions in two provinces, although the researchers did not explore the potential contribution of school policies or programs to students' beverage intake (Vanderlee, et al, 2014). Overall, this study provided rationale for further exploration of school characteristics that may be relevant to students' SSB

consumption and an assessment of how these characteristics reflect differences in school nutrition policies in Alberta and Ontario.

Chapter 5 provided a scoping assessment of several characteristics of the secondary school food environment in Alberta and Ontario, provincial differences across these school characteristics, as well as whether these characteristics are associated with students' SSB consumption rate. The school food environment characteristics examined included in-school beverage availability (i.e., via vending machines and water fountains) and the presence of food outlets in the school neighbourhood. The overall hypothesis was that greater access to SSBs within the school food environment would be positively associated with adolescents' SSB intake, and that SSB availability would be greater in Albertan schools, given the voluntary nature of their provincial school nutrition policy.

Chapter 5 identified that participants had access to several potential sources of SSBs during their time in school. Most schools were within walking distance of one or more external food outlets. All or nearly all schools in both provinces had at least one beverage vending machine, and a considerable proportion of schools stocked various types of SSBs in these machines. These findings are consistent with previous Canadian research (Seliske et al., 2009a; Seliske et al., 2009b; Olstad, Downs, Raine, Berry, & McCargar, 2011; Olstad, Lieffers, Raine, & McCargar, 2011; Orava et al., 2016; Vine et al., 2017). Cross-provincial examinations in Chapter 5 demonstrated that these beverages were significantly less available in Ontario schools, suggesting that *P/PM 150* is more effective than the *ANGCY* at restricting SSB availability in school vending machines. Vine and colleagues (2017) reported similar findings in their assessment of secondary school vending machines in these two provinces; however, they reported binary measures of school nutrition policy compliance (i.e., the proportion of vending machines that contained only policy-compliant beverages). These finding supports the dissertation study hypothesis that the voluntary nature of the Albertan policy would result in greater availability of noncompliant beverages relative to Ontario.

The availability of sweetened coffees/teas in school vending machines and access to restaurants within school's 1-km buffer were associated with increased SSB intake in three of the final models. However, overall there were few significant associations detected between the school food environment characteristics assessed and students' SSB intake. This result may reflect a methodological limitations of the study, namely related to the conservative SSB intake measure and examination of SSB availability in school vending machines exclusively versus in other food outlets in schools or on school property. These methods characteristics likely underestimate both the outcomes and exposures of interest, making it more difficult to detect an association between them. However, much the research that has reported significant associations between school food environment characteristics and students' SSB intake was conducted

with children (versus adolescents). Since children lack the independence that often accompanies adolescence (e.g., children are more likely to be barred from leaving school property during breaks, accompanied by their parents on their journey to/from school, etc.), they may be more sensitive to influences within the school food environment than older youth. Indeed, Rovner and colleagues (2011) identified that elementary school students' dietary choices were influenced positively or negatively by school vending machines (depending on what products were available), yet was no similar association was apparent among secondary school students.

In any case, the findings of Chapter 5 lend support to comprehensive school-based approaches to efforts to improve students' dietary choices, which aim to modify youths' diet-related values, knowledge, and preferences, in addition to their in-school access to nutritious food and beverages (i.e., via school nutrition standards). Given the numerous opportunities for adolescents' to purchase or otherwise obtain SSBs from a variety of settings, it is likely that strategies that primarily seek to limit in the in-school accessibility of SSBs (versus also addressing these other factors that influence dietary choices) are limited in their ability to support reductions in adolescents' overall SSB intake. The study findings, consistent with those of Chapter 4, also pointed to the importance of the non-school contexts in which adolescents spend their time (e.g., the home and community contexts) on moderating their SSB intake, and the related implications for intervention efforts.

Chapter 6 extended the two cross-sectional studies described in Chapters 4 and 5 by adopting a longitudinal design, spanning three school years, to examine changes in product availability within secondary schools' beverage vending machines, changes in students' weekday intake of SSBs over time, and the associations between these measures of beverage availability and SSB intake. An additional novel component of this chapter was the separation of public versus private schools within the Ontario subsample, resulting in three "policy groups": 'Alberta – *ANGCY'*; 'Ontario public schools – *P/PM 150'*; and, 'Ontario private schools – control'. The general hypothesis was that students' SSB intake would increase with time, paralleling modest increases in SSB availability within school vending machines in Alberta and Ontario public schools (i.e., reflecting decreased compliance with their respective provincial school nutrition policies). In light of the findings of Chapter 5, it was hypothesized that vending machines beverage availability would not emerge as an important predictor of adolescents'' SSB intake.

The findings of Chapter 6 demonstrated that, with the exception of flavoured milks, Ontario public schools had a lower availability of SSBs in their vending machines across all time points, compared to schools in Alberta and Ontario private schools. These results are congruent with those of Chapter 5 and earlier research that has specifically advocated for mandatory nutrition standards as a means of reducing

youths' access to SSBs (Olstad, 2014). The relatively higher availability of flavoured milks in vending machines in Ontario public schools likely reflects (i) the fact that most flavoured milks are *P/PM 150* compliant (i.e., provided they meet certain sugar, calcium and fat criteria); (ii) schools desire to provide beverage options that students enjoy/are likely to purchase (beyond policy non-compliant drinks like sodas); and (iii) the belief that these drinks are healthy since they contain protein and calcium. Indeed, previous research has considered flavoured milk products as distinct from other SSBs, since their high calcium content is beneficial to healthy growth and development among youth (Johnson, Bruemmer, Lund, Evens, & Mar, 2009).

While the descriptive analyses demonstrated pronounced shifts in beverage availability over time within the Alberta and Ontario private school groups, the models largely suggested that time did not have a significant bearing on beverage availability, which is consistent with previous work investigating school vending machine offerings in Ontario secondary schools (Orava et al., 2016). This chapter also highlighted some clear successes of provincial school nutrition policies with respect to beverage availability, particularly within Ontario public schools, as well as some challenges with implementation. Across all three policy groups, participants' rate of soft drinks consumption decreased markedly as they progressed through secondary school while their intake of sweetened coffees/teas increased; other SSB outcome measures remained fairly stable. These findings are contrary to the most recent publicly-available nationally-representative CCHS data that suggest that SSB intake increase as youth get older (Garriguet, 2008), but consistent with more recent Canadian research (Vanderlee et al., 2014)**.** Like in Chapters 3 and 4, across all time points and measures, Albertans reported the greatest frequency of SSBs intake. Consistent with Chapter 5, there was limited evidence that vending machine beverage availability was significantly associated with students' SSB consumption, again highlighting the limitations of efforts to curb adolescents' SSB intake by reducing their access to SSBs during school.

As a whole, this dissertation enhances our current understanding of Canadian adolescents' SSB intake patterns, the Canadian secondary school food environment, and the successes and shortcomings of school nutrition policies. This work signals the need for continued efforts to reduce adolescents' SSB intake. This dissertation illustrates that the school food environment represents a source of SSBs for Canadian adolescents, since most schools are nearby external food outlets and many schools have SSBs available for sale within school vending machines. However, this research highlights that schools are one of many contexts that influences adolescents' dietary behaviours, and suggests that efforts to limit the in-school availability of SSBs in vending machines have a limited impact on adolescents' SSB intake. This research signals the need for school-based interventions to be supported by complementary population-level initiatives that encourage healthy dietary choices among Canadian adolescents.

6.3 Overall strengths of the dissertation

This dissertation research addressed numerous important gaps in the literature, which have direct implications for interventions designed to decrease adolescents' SSB intake. First, this work provides new insights on the adolescents' consumption of several categories of SSBs, including differences in intake between weekdays and weekends, how SSB consumption varies as adolescents progress through secondary school, and jurisdictional differences in SSB consumption. There has been limited investigation of these factors in previous research in Canada or internationally, since many studies of this nature have focused on individual SSB types (e.g., energy drinks or sodas only), captured a single day's worth of dietary intake, and relied on cross-sectional data. Secondly, this dissertation provides rich data characterizing the school food environment in a large and diverse sample of secondary schools in two Canadian provinces, and describing how students engaged with the school food environment through weekday meal and snack purchases. Schools are a common setting for interventions to improve youths' dietary behaviours, although few studies to date have assessed characteristics of the school food environment and examined their association with students' SSB intake, particularly among Canadian adolescents. Finally, this work investigated how provincial school nutrition policies can influence the availability of beverages available in school vending machines and the impact this has on students' SSB consumption over time. Historically, there have been few longitudinal evaluations of provincial school nutrition policies in secondary schools and no known longitudinal examinations of how these policies can impact students' dietary behaviours in Canada. Further, this is the first known research to include cross-provincial examinations of school nutrition policy implementation and effectiveness at improving youths' dietary behaviour, enabling identification of the strengths and weaknesses of these policies. These insights can inform and strengthen future iterations of these provincial school nutrition policies.

This dissertation research is strengthened by the quasi-experimental design of the COMPASS host study, which was intended to evaluate a variety of population health initiatives as they naturally unfold within the large inter-jurisdictional school sample over several school years. The availability and use of longitudinal data on three distinct policy (i.e., intervention) groups within two provinces represents a major strength of this research (Ramanathan, Allison, Faulkner, & Dwyer, 2008), given the aim of assessing provincial school nutrition policies' implementation and impact on SSB intake. Further, while more controlled study designs are limited in their ability to make inferences on interventions' effectiveness in real-world contexts (International Agency for Research on Cancer, 2008), quasi-experimental studies are associated with high external validity. This quality is further complemented by COMPASS' large, heterogeneous longitudinal school sample, which enabled the examination of how differences across several school characteristics influence students' SSB intake over time.

This dissertation is strengthened by its foundation in the socioecological model of health, which served as the framework for the manuscripts' analyses and discussion, including recommendations for future interventions to improve youths' SSB consumption. Ecological models of health represent an established framework for developing a more nuanced understanding of complex social and public health challenges, as well as appropriate and comprehensive strategies to address them to promote population health (Richard, Gauvin, & Raine, 2011). In recent decades, public health researchers have applied ecological models of health to assess contributors to a wide range of health outcomes and risk behaviours, including those related to physical activity, fruit and vegetable consumption, aging, and early child development (Richard et al., 2011); however, there have been limited examinations of SSB consumption using this well-established framework. Using the socioecological model of health as a theoretical framework in this dissertation research enabled identification of the important social and context drivers of Canadian adolescents' SSB consumption, which has direct implications for future intervention efforts.

Finally, this dissertation offers a timely examination of the adolescents' SSB consumption and school food environment in two Canadian provinces, which is particularly valuable in light of forthcoming changes to national food and nutrition policy. In particular, Canada's revised national food guidelines are set for release later in 2018, and their release is likely to motivate subsequent amendments to provincial school nutrition policies, since many of these policies cite the *Food Guide* as a chief resource (Godin, Kirkpatrick, Hanning, Stapleton, & Leatherdale, 2017). The dissertation results represent important baseline data, enabling future pre-/post- assessments of the impact these policy changes have on both school food environment characteristics and students' SSB intake and food purchasing behaviours.

6.4 Overall limitations of the dissertation

6.4.1 Limitations of the study design

The direct contextual measures examined were limited to those within the school food environment (i.e., school food outlets, school water fountains, and food outlets within the school neighbourhood). This research did not include measures of SSB availability or accessibility within home or larger community contexts (e.g., recreational centres, home neighbourhood food outlets, etc.) since these data were not assessed within the COMPASS host study. The omission of these data is a limitation given that (i) the home and community contexts are important levels of influence within socioecological models of health, (ii) Study 1 identified evidence that adolescents' SSB consumption was a greater reflection of non-school contexts; and (iii) previous literature confirms that home and community characteristics are associated with adolescents' SSB intake. Working within the constraints of the host study, several measures of adolescents' self-reported meal/snack sources (i.e., indirect measures reflecting potential sources of SSBs)

were included in Chapter 4, allowing an assessment of the importance of home and community contexts. However, an in-depth investigation of home and community traits and their association with adolescents' SSB intake was beyond the scope of this dissertation.

This dissertation is limited by the lack of school or student data prior to implementation of *P/PM 150* in 2011 or the release of the latest iteration of the *ANGCY* in 2012. Both of these events took place prior to the conception of the COMPASS host study, preventing true pre-/post-comparisons of the policies' effects on the types of beverages available within school food outlets, as well as students' SSB consumption. A lack of true baseline data is common in natural experiments that seek to evaluate the impact of public health policies (Ramanathan et al., 2008), since researchers do not have control over intervention timing and due to the incongruence between the pace at which policies develop and the considerable time and resource requirements for conducting large-scale rigorous evaluations of baseline characteristics. In the context of this dissertation research, the lack of pre-policy implementation data makes it impossible to discern if the observed differences in school food environment characteristics and students' dietary behaviours between policy groups are an artefact of distinct starting points, versus strictly a reflection of policy adherence and effectiveness. However, the purpose of COMPASS was not to evaluate *P/PM 150* and/or *ANGCY*, although the study is well-poised to assess future iterations of these and other provincial school nutrition policies across Canada, using this dissertation as a model.

6.4.2 Limitations of the dissertation school-level measures

Assessments of school nutrition policy adherence were further limited by the focus on beverage availability within school vending machines. Consequently, this dissertation research provides a conservative measure of total in-school beverage availability, particularly since certain SSBs/beverage formats (e.g., cappuccinos, hot chocolates, open containers, fountain drinks, etc.) are not typically available in vending machines, but may be served in other food outlets. Though the COMPASS host study does capture data on features of school cafeterias and tuck shops, these data were not consistently available or collected in a consistent manner. The primary reason for these data being unavailable related to data collectors not having access to these in-school food outlets, either because these outlets were closed during data collections or school food providers forbade data collectors for entering and/or photographing the premises. For example, the scheduling of school data collections in the afternoon invariably precluded the ability to access cafeterias that only operate during lunch. These issues did not affect assessments of schools' vending machines, since these school food outlets can be accessed throughout the school day and are not monitored by school food provider staff. The lack of consistency in the assessments of cafeterias and tuck shops reflects the scale and variation in these school food outlets, which make them difficult to capture in their entirety, as well as the limited direction within the Co-SEA

on what aspects of these outlets data collectors should photograph or note. Since several individuals conduct the COMPASS school data collections each year and access the application on different devices, the quality, number, and content of the photographs vary considerably. There is far less variation in the vending machine photographs, as they are comparatively smaller and simpler food outlets. However, the focus on vending machines likely yielded a more conservative measure of overall SSB availability in schools (i.e., a primary exposure of interest), which may have reduced the ability for the study analyses to detect an association between vending machine beverage availability and students' SSB intake.

6.4.3 Limitations of the dissertation student-level measures

The limitations to the dissertation's student-level measures reflect the fact that the COMPASS study was not explicitly intended to provide a comprehensive assessment of adolescents' beverage intake patterns. Instead, the COMPASS measures were designed to capture a breadth of information on several student-level social, health, and academic outcomes and behaviours. Given concerns of participant burden (i.e., both among the students writing the questionnaire and schools that host the COMPASS researchers and allow data collections to take place during class time), the student questionnaire was developed to include a very selective series of questions within each domain, including dietary behaviours.

This desire for brevity is apparent within the measures of beverage consumption and food purchasing behaviours. These measures capture frequency of each behaviour in terms of number of days, as opposed to occasion (e.g., ranging from never to several times each day) or, in the case of beverage intake, the amount consumed (e.g., number of servings/products). As such, those who engage in a given behaviour once daily would report the same response to the corresponding survey question as those who engage in the same behaviour several times daily. Overall, the dietary measures used in this dissertation are conservative and likely do not capture the true heterogeneity that exists in adolescents' behaviour. More robust dietary measures (e.g., multiple dietary recalls) would provide a better representation of participants' regular dietary patterns, but are not compatible with a large longitudinal study like COMPASS that collects data from each school once annually. Indeed, the measures used in this dissertation represent the best available data within the COMPASS host study.

The unit of measure of 'days' across the beverage intake questions on the COMPASS survey posed additional challenges for developing a meaningful composite measure of SSB consumption. Since there is a fixed number of days within a week/school week, individuals' responses to the three questions on their consumption of distinct SSB categories could not simply be summed to represent their total SSB intake in that period; invariably, many of these sums would exceed the denominator, in terms of number of days. Thus, a composite SSB score, ranging on a scale from 0-21 in Chapter 4 (i.e., which considered weekly

SSB consumption) and 0-15 for Chapters 5 and 6 (i.e., which considered weekday SSB consumption) was developed to represent participants' overall SSB intake. This and the other measures of participants' SSB consumption have not been subjected to validation or reliability testing, representing an important limitation of this dissertation research. Other studies have summed participants' self-reported frequency of consuming discrete SSB categories to represent their overall SSB intake (Ranjit, Evans, Byrd-Williams, Evans, & Hoelscher, 2010) and reported 'days' as the unit of measuring SSB intake frequency (Garnett, Rosenberg, & Morris, 2013; Smith & Holloman, 2014); however most studies assess SSB consumption as number of servings of occasions.

There are additional reasons why participants' self-reported measures SSB consumption represent conservative estimates of their true intake. Social desirability bias may have been present, and led participants to underreport their SSB consumption, particularly if they viewed these beverages as being unhealthy or social unacceptable (Thompson & Subar, 2013). However, participants completed the COMPASS questionnaire independently and were assured that their results would remain confidential, likely reducing the likelihood of this bias. Likewise, the fact that the COMPASS questionnaire assessed a variety of youth health behaviours and outcomes (i.e., it is not strictly an SSB-focused study) may have reduced participants' concerns about being judged on the basis of their responses to the SSB-related questions, encouraging honest reporting. It is more probable that recall bias was present, particularly since individuals are prone to underestimate their food and beverage intake (Gemming & Mhurchu, 2016; Thompson & Subar, 2013). However, the risk of this bias was reduced by the dietary questions asking participants to report their behaviour in a typical time period (i.e., as opposed to a certain day or week). These measures reflect participants' generic, versus specific, memories of diet. As the time between the dietary period in question and the reporting increases, participants are better able to recall generic memory than their specific memory (Thompson & Subar, 2013), which likely increases the validity of the reported measures.

Overall, the very conservative nature of the diet-related measures used in this dissertation research (i.e., due the broad unit of measure of "days" and reasons why participants may underreport the frequency of their dietary behaviours) likely contributed to the generally low magnitude of the associations between the SSB consumption measures and the covariates of interest, even when the effects were statistically significant. Future Canadian studies outside of the COMPASS research platform (which is restricted in its level of detail within dietary measures on the student questionnaire, for reasons described earlier) would be valuable for confirming the findings of this work.

Additional shortcoming of the student-level measures available through the COMPASS host study relate to the SSB categories assessed. The COMPASS survey includes questions specifically on three general SSB categories, which reflects an understanding of the variety of SSBs available on the market. However, the combination of 'sodas, fruit drinks, and sports drinks' into one category is not very informative, since consumers of these individual products types may differ across their sociodemographic and behavioural characteristics. Further, individuals (e.g., both the school food providers that stock the vending machines, as well as the students making beverage purchases) are likely to have distinct perceptions of the healthfulness and/or appeal of these products. Beverage categories that were not captured on the questionnaire, but would provide greater insights on adolescents' beverage consumption patterns, include 100% juices, milk (both flavoured and plain), and artificially-sweetened beverages. The latter beverage category may be of particular interest, given the controversy surrounding artificial sweeteners within the nutrition community (Tandel, 2011), and relative inattention in the literature to adolescents' potential substitution of SSBs for artificially-sweetened beverages.

6.5 Implications for public health

This dissertation research identified that many Canadian adolescents consume SSBs regularly and that overall days of SSB intake increases as they progress throughout secondary school. These findings signal the need for ongoing population-level interventions to reduce youths' SSB consumption. Encouragingly, participants' days of soft drink consumption steadily decreased with time. However, these reductions were largely offset by increases in their consumption of sweetened coffees/teas and (to a lesser extent) energy drinks, both of which often contain more caffeine and similar amounts of sugar as many soft drinks. The relatively low rate of energy drink consumption among participants was positive, and may reflect these products being less familiar to young adolescents, their high cost relative to other beverages, parental disapproval of energy drinks, health concerns related to these products, as well as some stores not selling energy drinks to younger adolescents (Costa, Hayley, & Miller, 2014; McCrory et al., 2017), However, the frequency at which participants reported consuming soft drinks and sweetened coffees/teas, suggests that these beverages are both widely available and appealing to youth, reflecting priority areas for future public health action to address population-level SSB consumption.

A key message from this dissertation research is that school-based efforts to reduce students' SSB consumption must be couched in a comprehensive school health approach; nutrition standards specifying what products are appropriate for sale in secondary schools are unlikely to have an impact on adolescents' SSB intake. The school characteristics assessed in this dissertation were primarily reflections of students' access to SSBs during school, and were largely not associated with adolescents' SSB intake. This finding suggests that simple restrictions to students' in-school access of unhealthy products are unlikely to

support behaviour change, and potentially counterproductive if students compensate by consuming more of those products when they are outside of the school (Finkelstein, French, Variyam, & Haines, 2004; Vecchiarelli, Takayanagi, & Neumann, 2006; Vézina-Im et al., 2017). School-based dietary interventions would likely be strengthened by also addressing other factors that influence dietary choices among adolescents, including social norms, self-efficacy to make healthy choices, outcome expectations (i.e., the physical and social outcomes of their choices), and attitudes and knowledge of healthy eating (Fitzgerald, Heary, Kelly, Nixon, & Shevlin, 2013; Lally, Bartle, & Wardle, 2011; Pearson, Ball, & Crawford, 2011; Pedersen, Grønhøj, & Thøgersen, 2015). An example of a potential intervention subcomponent is in-school food skills lessons, which have been successful in improving students' food-related preferences, attitudes, and behaviors (Hersch, Perdue, Ambroz, & Boucher, 2014). Overall, healthy school policy represents an important pillar within the comprehensive school health frameworks, but must be complemented by action in the others (i.e., teaching and learning, social and physical environments, and partnerships and services) to achieve meaningful advances in supporting students' healthy eating behaviours (Veugelers & Schwartz, 2010).

Although this dissertation was limited to assessments of certain characteristics of school food environment, the results underscore the importance of efforts to address adolescents' SSB consumption through interventions in the home and family context. Recent research identifies that, although peers exert considerable influence over youths' dietary behaviours (Salvy, De La Haye, Bowker, & Hermans, 2012), parents remain a central social influence over their adolescent children's' dietary choices (Pedersen et al., 2015; Reicks et al., 2015; van der Horst et al., 2008). Parents can support their children's healthy eating practices through modelling these practices themselves (Loth, MacLehose, Larson, Berge, & Neumark-Sztainer, 2016; Reicks et al., 2015; van der Horst et al., 2008); these actions appear to be more influential than what parents verbally encourage/discourage their children from consuming (Pedersen et al., 2015). Home meals also facilitate adolescents' healthy dietary choices, as illustrated by the positive association between frequency of family meals and adolescents' dietary quality (Larson, Neumark-Sztainer, Hannan, & Story, 2007) and the protective effect of eating a home-packed lunch on SSB intake (Godin, Chaurasia, Hammond, & Leatherdale, 2018). Parents' influence on their children's diet is also likely explained by the fact that parents are typically responsible for grocery shopping and food preparation, thereby giving them a substantial amount of control over what is available and served at home. Indeed, adolescents' perceptions of the availability of various food items at home is strongly associated with their consumption of the products (Pearson et al., 2011; Reicks et al., 2015). The clear importance of the home/family context on shaping adolescents' dietary behaviours signals the need to leverage this influence in efforts to

reduce youths' SSB intake. In the context of this dissertation, an appropriate strategy would be to increase parents' awareness of and active involvement in school-based initiatives promoting healthy eating.

While individual and family attributes are undoubtedly important, individuals' good intentions and confidence in their ability to make healthy dietary choices are severely undermined when they live in communities that are not conducive to these choices (e.g., due to low access and availability of healthy foods and beverages) (Story, Kaphingst, Robinson-O'Brien, & Glanz, 2008). While making explicit recommendations for community-based interventions is beyond the scope of this research, the socioecological model of health underscores the need for an ecological approach to population health initiatives that strive to reduce youths' SSB consumptions by addressing the numerous social and environmental factors that drive adolescents' dietary behaviours.

6.6 Implications for policy

6.6.1 School nutrition policies - nutrition standards

While this dissertation was not intended to serve as a comprehensive evaluation of Canadian school nutrition policies, provincial school nutrition standards in Alberta and Ontario were a central focus of this research. School nutrition standards like *P/PM 150* and the *ANGCY* outline what types of food and beverages should/should not be available in a particular grade level, and are one subtype of school nutrition policies (McKenna, 2010). Many of the policy implementation challenges noted throughout the dissertation would likely extend to the food served in school food outlets, and perhaps be even more apparent, given ambiguities around mixed dishes, portion sizes, and variation in preparation methods. Overall, this dissertation research demonstrates some of the key successes and limitations associated with school nutrition standards, as illustrated through beverages availability in school vending machines.

This dissertation research suggests that provincial school nutrition policies, and Ontario's mandatory *P/PM 150* in particular, have a positive impact on the quality of beverages available in secondary school vending machines. Previous studies have concluded that few Ontario schools adhere to *P/PM 150* (Orava et al., 2016; Vine et al., 2017); however, these conclusions are largely based on binary assessments of compliance (i.e., compliant versus noncompliant), which provide little indication of schools' performance in specific policy areas. This current research provides richer detail, and thus was able to demonstrate where schools are performing well and where they may need additional support. The finding that beverage availability did not shift significantly over time was consistent with previous work (Orava et al., 2016), and suggests that schools' compliance is not waning, despite a lack of formal enforcement or monitoring of *P/PM 150* – another positive result. Given the many demands placed on schools generally

and numerous potential barriers to school nutrition policy compliance in particular (Taylor et al., 2011; Vine & Elliott, 2014), it is important to acknowledge their clear efforts to comply with these policies and provide a healthy school food environment for students, as evident through assessments of school vending machines. Overall, this dissertation findings suggest that provincial school nutrition policies can effectively encourage secondary schools to restrict the in-school sale of less healthful beverages, and that these policies are most effective at achieving this objective when they are mandatory in schools.

This dissertation provides evidence that schools' noncompliance with school nutrition policies may reflect general challenges in understanding and using nutrition information, as well as a lack of user-friendly policies. Chapter 6 demonstrated that few Ontario public schools had sugar-containing carbonated soft drinks, sweetened sports drinks, or energy drinks available in their vending machines. This finding suggests that those implementing the policies inherently perceive that these drinks are not appropriate for sale within school and/or the guidelines are clear that these products should not be served; the former scenario likely applies to sodas, while the latter is likely the case for sports and energy drinks, as these drink categories are plainly defined as "not permitted for sale" under *P/PM 150*. Meanwhile, sugar-containing non-carbonated soft drinks, which are also restricted items, were available nearly half of the *P/PM 150* schools. This drink category represents a wide range of products (e.g., fruit drinks, iced teas, flavoured waters, etc.) that are perhaps more ambiguous in their healthfulness compared to other SSBs and are permitted within schools if they satisfy particular nutritional conditions (e.g., they are caffeine-free and meet specific energy cut-offs). Given what is known about the considerable challenges individuals face with interpreting nutrition labels (Campos, Doxey, & Hammond, 2011) and school stakeholders' self-reported limited knowledge in how to interpret school nutrition guidelines (Downs et al., 2012), it is feasible that the presence of certain SSBs in schools signals school stakeholders' confusion or ignorance, rather than disregard, of the guidelines. Policy adherence would likely increase with greater clarity or simplicity in the guidelines, improvements to front-of-package food and beverage labels, and ongoing resources to support schools' understanding of and ability to comply with the policy.

A key finding of this research was that availability of SSBs in school vending machines was not meaningfully associated with students' days of consuming these products. This result may reflect students' limited use of school vending machines in general (Godin et al., 2018), students compensating for this in-school restriction by consuming more SSBs in other settings (Finkelstein et al., 2004; Vecchiarelli et al., 2006; Vézina-Im et al., 2017), bringing more of these restricted items into school from home or other food outlets (Cullen, Watson, & Zakeri, 2008), and/or diet-related attitudes and values being more important drivers of behaviour than in-school product availability. This result should not be interpreted as a signal that schools should not be restricted in the products available for sale through their

food outlets; rather, this finding suggests that even strong, well-applied school nutrition standards are insufficient to drive meaningful reductions in adolescents' SSB intake, particularly in the context of numerous other environmental and social factors that promote SSB consumption. As such, additional comprehensive school-based nutrition initiatives and broader food and nutrition policies are needed to address various individual, interpersonal, and ecological factors that influence adolescents' dietary choices to support positive behaviour change.

6.6.2 Opportunities for leveraging Canadian school nutrition polices

Beyond nutrition standards that dictate the food and beverage appropriate for sale within schools, there are other subtypes of school nutrition policies that may be leveraged to discourage adolescents' SSB intake, including those that regulate health and nutrition education, food and beverage marketing in schools, and students' access to neighbouring food outlets (McKenna, 2010). A review of these initiatives identified some evidence to support behaviour-focused nutrition education (i.e., which addresses factors that motivate youth to change what they eat and encourage them to develop healthy food skills and dietary behaviours), especially when combined with food services and other initiatives (McKenna, 2010), suggesting that these implemented and evaluated on an ongoing basis within Canadian schools.

Another means of supporting youths' healthy dietary choices outside of the school context may be the broadening of school nutrition policies to include other youth-oriented settings. This strategy is evident within Alberta, since the *ANGCY* is intended for application within childcare facilities, schools, recreational facilities, and community centres, to "ensure that children and youth are able to access healthy food choices wherever they go" (Government of Alberta, 2012). Though some evaluations of *ANGCY* identified that the guidelines were well-received in non-school settings (Nikolopoulos, Farmer, Berry, McCargar, & Mager, 2015; Olstad, Raine, & McCargar, 2012), others reported poor awareness, adoption, and/or implementation of the guidelines (Olstad, Downs, Raine, Berry, & McCargar, 2011; Olstad, Lieffers, Raine, & McCargar, 2011). Researchers identified facility-level barriers to voluntary adoption of the guidelines (e.g., concerns about profit, ease of healthy food preparation, and consumer feedback), and proposed that a mandated policy approach would represent a more efficacious means of improving the food environment (Olstad et al., 2011; Olstad et al., 2012). The experience in Alberta with *ANGCY* highlights the challenges associated with scaling up existing provincial school nutrition policies to non-school settings, provides further evidence in support of mandatory policies, and identifies that policy buy-in from stakeholders outside of schools is possible.

There is also an opportunity to extend existing policies to moderate the types of food and beverages allowed in the school, from all sources. Since provincial school nutrition policies only apply to what

products are offered by the school (i.e., available for sale and/or provided via school nutrition programs), they cannot prevent students from bringing restricted items in from home or purchased from a neighbouring school food outlet. Previous research identifies that restriction in the in-school availability of unhealthy, desirable foods are often proceeded by students bringing more of these restricted items into school from home or other food outlets (Cullen et al., 2008). This challenge may be circumvented by a policy forbidding any SSBs within schools, similar to policies that ban nut or nut-alternative spreads and other products, although no known studies have assessed such a policy.

There is a high probability that jurisdictions across Canada will update their school nutrition policies in the coming few years, since Health Canada's *Food Guide*, which serves as the foundation for many school nutrition guidelines in Canada (Godin et al., 2017), is slated to be revised in 2018. Based on a report highlighting the findings from the national public consultation process (Ipsos Public Affairs Canada, 2017), it is likely that the revised *Food Guide* will provide additional information around sugary drinks in particular, as well as more guidance on general eating behaviours and practices. It is hoped that these changes to the *Food Guide* would subsequently spark parallel changes to school nutrition policies, namely the broadening of recommendations beyond school food standards (i.e., to include strategies for improving students' diet-related attitudes and knowledge) and greater clarity and consistency in messages around beverages that are appropriate for schools.

6.6.3 Food and nutrition policies beyond the school setting

This research lends support to other food and nutrition-related policies that are currently proposed in Canada that extend well beyond the scope of the school environment. Specific recommendations for policy action outside of schools cannot be made, given the dissertation's focus on the school context. However, the dissertation findings, as well as supporting literature (Briefel, Wilson, & Gleason, 2009; Lebel et al., 2016; van der Horst et al., 2008) suggest that adolescents' SSB intake is influenced to a great extent by non-school environments. As such, school-level interventions must be complemented by broader environmental action that support individuals in adopting healthy dietary choices. The 2016 Senate report recommended marketing restrictions and SSB taxation as two policy initiatives within a broader national campaign to promote healthy weights among Canadians (Ogilvie, 2016).

Calls for restrictions of food and beverage marketing are fueled by strong evidence that marketing has a strong, direct effect on youths' food preferences, knowledge, purchases, and consumption patterns (Cairns, Angus, Hastings, & Caraher, 2013). SSBs are among the most common products promoted to children and adolescents, and these promotions are increasingly taking the form of creative and interactive digital media that appeal to youth (Cairns et al., 2013). Marketing efforts also influence social

norms related to SSBs, and contribute to youths' overestimations of peer SSB intake, which in turn predicts SSB consumption among adolescents (Perkins et al., 2010). Since 1980 Quebec has banned all commercial advertising directed at children through its *Consumer Protection Act*, which appears to have had positive effects on individuals' dietary choices (Dhar & Baylis, 2011). Although there are numerous regulatory challenges, as well as social and legal barriers associated with food/beverage marketing restrictions (Harris, Pomeranz, Lobstein, & Brownell, 2009), this type of legislation is currently in review in Canada's House of Commons, and Health Canada recently sought feedback from Canadians on their proposed approach to restricting the marketing of unhealthy food and beverages to children aged 16 or younger (Health Canada, 2017).

SSB taxation is another policy option for decreasing population-level SSB intake. Recent review evidence identifies that these taxes have yielded positive impacts on individuals' dietary behaviours and prevalence of obesity in the jurisdictions where they have been applied (Escobar et al., 2013; Niebylski, Redburn, Duhaney, & Campbell, 2015). A recent Canadian simulation study estimated that a 20% *ad valorem* tax applied to sugary drinks would decrease population-level SSB intake, contributing to considerable reductions in cases of overweight and obesity and their obesity-mediated diseases over 25 years, as well as significant health care savings (Jones et al., 2017). This evidence suggests that SSB taxation and marketing restrictions may be two promising policy interventions that would complement future and existing school-based efforts to decrease adolescents' SSB consumption and improve their dietary behaviours more generally.

6.7 Directions for future research

Future research is required to validate and build upon the findings of this dissertation, particularly investigations of Canadian adolescents' beverage intake patterns and school-based initiatives to promote healthy dietary behaviours among youth. Further, there are unique opportunities within the COMPASS host study to complement and extend this dissertation research.

There is a need to better understand Canadian adolescents' SSB consumption patterns, including what specific products they drink, in what quantity, where and when they obtain and consume these beverages, and the various factors that drive these behaviours. The overwhelming majority of the research on individuals' dietary consumption (including this dissertation) has relied on self-report measures, which are associated with some important limitations, as described earlier. However, recent advances in methods of dietary assessment (e.g., wearable cameras, image-based methods, etc.) provide an opportunity for more objective measurements of dietary measures without relying on self-report (Gemming & Mhurchu, 2016; Rollo et al., 2016). These methods have been applied to understand youths' dietary behaviours and

aspects of the food environment in other contexts, particularly in New Zealand (Chambers et al., 2017; Gemming, Doherty, Utter, Shields, & Mhurchu, 2015; Signal et al., 2017). These methods have not been widely used in Canada, representing a viable opportunity for future research. Other potential means of assessing Canadian youths' beverage intake patterns include multiple dietary recalls or analysis of school sales data. The latter method could provide interesting insights on how adoption of school nutrition standard (or other school food and nutrition-related initiatives) may impact revenue generated from school food outlets, as well as students' dietary choices. Studies employing a qualitative or mixed methods design would be well-poised to provide a rich understanding of adolescents' dietary behaviours, attitudes, and knowledge that may promote or discourage their SSB intake.

There would be great value in further examination of the Canadian school food environment, particularly in the context of school nutrition policies. As described in the literature review in Chapter 2, much of the existing research in this area is derived from a select few provinces and often from a small sample of schools. Given the clear differences in geographic, political, and sociodemographic characteristics of Canada's provinces/territories and wide variation in school nutrition guidelines across the country (Godin et al., 2017), there is likely considerable heterogeneity in the features of school food environment and their potential role in promoting or discouraging healthy eating patterns among youth that has yet to be richly explored. Given the relatively scant evidence base for various components of school nutrition policies (McKenna, 2010), there is a need for ongoing evaluation of new and existing food and nutrition initiatives in schools to develop a sense of promising practices in this area.

Future research of the Canadian school food environment must identify solutions to some of the data collection challenges noted in this research related to the existence of exclusive contracts between schools and external private school food service companies. These challenges were most apparent in school cafeterias, where COMPASS data collectors were occasionally barred from entering by the food service staff and/or were asked by staff to refrain from taking photos. Presently, there are no regulations that require school service providers to cooperate with third-party evaluations of the quality of the school food environment (e.g., compliance with provincial school nutrition policies). Such regulations or other agreements would increase transparency and accountability, help to improve relationships between school food service providers, school administration, and researchers, and ultimately enable a better understanding of the school food environment and its impact on students' dietary behaviours.

Future evaluations of provincial school nutrition policies should probe deeper into contextual factors that may support or hinder their implementation and corresponding impact on students' dietary behaviours. Such inquiry would likely generate information on promising practices, as well potential as unintended

consequences of these policies. For example, it would be identify whether the effectiveness of school nutrition policies differs in schools that have adopted a closed-campus policy (thus barring students from visiting neighbouring food outlets during breaks) compared to those without this policy. Since school nutrition policies have the potential to influence a variety of diet-related outcomes, researchers are encouraged to use diverse indicators in future outcome evaluations of these policies, including those that represent students' dietary choices and practices, and their food/nutrition-related knowledge, skills, beliefs, and values.

This dissertation provided evidence that contexts outside of the school environment (e.g., the home and/or community contexts) may be more important contributors to adolescents' SSB consumption than the school context, underscoring the importance of further research set in these settings. Future research should investigate the potential mechanisms through which these contexts influence SSB intake and other dietary behaviours. For example, it would be insightful to identify the extent to which adolescents are exposed to SSBs in their daily lives (e.g., through marketing activities, through their availability at home, etc.), and the corresponding impact this exposure has on behaviour. This evidence would be valuable in informing future population-level interventions designed to reduce adolescents' SSB intake, including those described in this dissertation.

Finally, there is considerable opportunity to use data from the COMPASS research platform to build on this dissertation. Since its inception, COMPASS has expanded to represent four Canadian provinces and one territory. This dissertation research could serve as a model for future examinations of the associations between school food environment characteristics, food and nutrition policies, and students' SSB intake in these other jurisdictions. For example, future research could explore the impact of Quebec's marketing ban on adolescents' SSB consumption by identifying provincial differences in SSB intake, potentially controlling for screen time (i.e., since television and the internet are channels for marketing initiatives). Since the 2016/17 school year, COMPASS investigators have explicitly asked schools about the challenges they face with respect to school nutrition policy compliance, some of the other healthy eating-related programming they offer (e.g., cooking lessons, school gardens, trips to farmers' markets, etc.), and if they adopted a closed campus policy. These topics represent areas with direct implications on school nutrition policy and larger school-based food and nutrition initiatives.

6.8 Conclusions

Many Canadian adolescents consume SSBs on a regular basis. Their consumption of these beverages appears to increase modestly as they progress through secondary school, posing potential health risks. Adolescents' SSB consumption is associated with their purchasing from school food outlets, suggesting

that adolescents' intake of these beverages may reflect their availability in school. However, this dissertation research identified a greater association between adolescents' SSB intake and their behaviours when they are outside of school (e.g., their weekend food purchasing behaviours, their meal and snack purchases from non-school food outlets). A closer look at the school food environment in secondary schools across Alberta and Ontario demonstrated that adolescents have considerable access to SSBs during their time in school, both from the presence of various food outlets in the school neighbourhood and the availability of SSBs within school vending machines. Availability of most types of SSBs was significantly lower in schools in Ontario, suggesting that *P/PM 150*, the province's mandatory school nutrition policy is having a positive effect on the quality of beverages available for sale in school. Assessing the contents of beverage machines over time demonstrated that schools' compliance with school nutrition policies did not falter, despite a lack of formal monitoring of these polices. While these results are positive, the availability of SSBs in school vending machines was consistently not associated with students' SSB intake. These findings may be due to adolescents' relatively limited use of school vending machines, since they make more frequent snack/meal purchases from the school cafeteria and food outlets off school property. However, it is more probable that these results reflect shortcomings of initiatives centred on reducing in-school availability of SSBs without considering factors beyond availability that influence dietary choices (e.g., food and nutrition-related knowledge, attitudes, social norms, etc.) or the widespread availability of these beverages outside of the school context. School-based initiatives to improve students' dietary behaviours, including through reductions in the SSB intake, should be embedded within a comprehensive school health framework. These initiatives must also be supported by complementary interventions to support healthy dietary choices in other contexts, such as at home or in the community, to achieve meaningful reductions in adolescents' SSB intake at the population-level.

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Chapter 1

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Appendix A

Excerpts from the *Alberta Nutrition Guidelines for Children and Youth* (2012)

School facilities…

…can provide healthy foods	… can enhance access to safe, nutritious foods	… can create environments that support healthy food choices	Grade level of school
Recommendations:			
• Use Canada's Food Guide (meals = foods from 4 food groups, snacks = foods from 2 food groups).	• Healthier food choices are competitively priced relative to less nutritious foods.	• Provide appropriate time and space to eat.	• Elementary schools, 100% of the foods available are from the Choose Most Often category.
• Individual portion sizes from Canada's Food Guide.	• Affordable healthy meal choices should be a priority over affordable healthy snacks.	• Healthy food choices are plentiful and visible.	• Junior high schools, 60% of the foods available are from the Choose Most Often and 40% of the foods available are from the Choose Sometimes category.
• Stock vending machines with appropriate-sized packages/ containers.	• All vending machines should contain healthy food options.	• Place healthier food and beverage choices where they can be seen.	• High schools, 50% of the foods available are from the Choose Most Often and 50% of the foods available are from the Choose Sometimes category.
• Offer only small portion sizes of less healthy options (where these foods are permitted).	• Healthy food choices should be available and clearly visible on special food days and at special functions.	• Food choices should reinforce healthy eating concepts taught in school.	• Multi-level schools, such as K – 12 schools, 100% of the foods from the Choose Most Often category.
	• The frequency of special food days should be defined in school policies.	• Fundraising activities are consistent with healthy eating concepts taught in school.	• When permitted, offer only small portion sizes of Choose Least Often options.
	• Monitor students who operate microwaves /other appliances		
	• Meal-time supervisors are familiar with guidelines for supporting children with allergies.		
	• Supervisors are aware of school policies of how to respond to an adverse food reaction or choking.		

Remember to:

Read food labels and follow the criteria requirements for Choose Most Often and Choose Sometimes food and beverage choices.

Beverages

The guidelines encourage facilities and organizations to consider the following when choosing beverages:

1. Promote the consumption of water to quench thirst and provide adequate hydration. Provide water fountains that are clean, accessible and in good working condition.
2. Provide access to refrigerated milk, fortified soy beverages and 100% vegetable and fruit juices.
3. Avoid beverages such as pop, iced tea, sports drinks,[a] diet beverages, fruit punches, fruit drinks, fruit 'ades' (lemonade), and flavoured and vitamin/mineral enhanced waters. These beverages have low or no nutritional value. Provision of caffeinated and artificially sweetened beverages (such as tea, coffee, juice, pop and energy drinks) to children and youth should be avoided.[b]

[a] Eliminate the sale of all sports drinks in school settings except when provided by the school's coach to student athletes participating in sports programs involving vigorous activity of more than one hour in duration.[2]

[b] Caffeine can cause children to become excited, restless, irritable and unable to sleep. Caffeine can also make it difficult for children to concentrate. The longterm use of artificial sweeteners in foods and beverages consumed by children and youth has not been assessed.

Beverages

Nutrition Facts

Drink	Sugar in teaspoons	source of ...
1% milk (250 mL or 1 cup)	3 tsp	Calcium, vitamins A, D, riboflavin and B12, protein
Chocolate milk (250 mL or 1 cup)	5 tsp	Calcium, vitamins A, D, riboflavin and B12, protein
Flavoured soy beverage fortified with Calcium and Vitamin D (250 mL or 1 cup)	6 tsp	Calcium, vitamins A, D, riboflavin and B12, protein
100% orange juice, unsweetened (250 mL or 1 cup)	7 tsp	Vitamin C, folic acid and potassium
Regular pop, 1 can (355 mL or 1.5 cups)	10 tsp	High in sugar only
Ice slush* (500 mL or 2 cups)	12 tsp	High in sugar only
Sport drinks* (591 mL or 2 ½ cups)	13 tsp	High in sugar only
Large fountain pop (1.9 L or 7 ⅔ cups)	52 tsp	High in sugar only

*The amount of sugar in slushes, beverages and sport drinks vary depending on retailer.

Symbols: ≥ greater than or equal to ≤ less than or equal to
< less than > greater than

CFGS = Canada Food Guide Serving

B. Schools

Schools can provide a consistent healthy eating message for students by ensuring access to nutritious foods, and by teaching and modeling healthy eating behaviours. Classroom nutrition education should be reinforced by making healthy food options available in school cafeterias, vending machines, stores or canteens, and at special events. Other food-related issues that arise in schools include fundraising with food, food safety, allergies, pricing, role modeling, and the meal-time environment. The following suggestions may be helpful to school administrators, teachers, and other school staff. Parents, other caregivers and/or community groups may also find some of these suggestions useful.

i) Schools can provide healthy foods

What we know:

- Healthy eating supports optimal child health, growth, and intellectual development.
- Portion sizes for many foods are unreasonably large and exceed requirements. Children and youth eat more when they are served larger portion sizes.
- Drinking sweetened beverages replaces healthier choices such as milk, vegetables and fruit which contain nutrients that build healthy bones and teeth.

Recommendations:

- **Use *Eating Well with Canada's Food Guide* to ensure meals contain foods from at least four food groups, and snacks contain foods from two food groups.**
- **Individual portion sizes should be consistent with *Eating Well with Canada's Food Guide*.**
- **Stock vending machines with appropriate portion sized packages/containers.**
- **Offer only small portion sizes of Choose Least Often options (when these foods are permitted).**

Taking action:

- School food policies can be established to determine the types and amounts of foods that can be served or sold in the school, based on available food services.
- Ensure contract(s) with food and beverage suppliers specify the types and quantities of foods that can be offered in the school.
- Offer healthy food options in meal combinations such as baked potato wedges instead of deep fried french fries.
- Healthy beverage choices include water, milk (skim, 1%, 2%), fortified soy beverages, and 100% fruit/vegetable juices.

- Develop standard serving sizes that match the portion sizes in *Eating Well with Canada's Food Guide*. Ensure serving utensils match the serving sizes.
- Offer only small portion sizes of less healthy options if served during special events or food days. Examples include Halloween-sized treats, or small portion sizes of sugary beverages (less than or equal to 200 mL).
- Develop re-usable daily/weekly/monthly menus.
- When planning menus, consider the facilities (space), staff (time, skill level), and equipment (ovens, stoves) required to prepare each item.
- Develop a file of healthy recipes.
- Evaluate how many servings from *Eating Well with Canada's Food Guide* each recipe provides. This will greatly simplify and speed up the process of developing menus that meet Canada's Food Guide recommendations. Calculate the cost to prepare each recipe. This will help to manage and predict meal costs.
- See menu planning pages 63 and 64.

Water is recommended as the first option to quench thirst and satisfy hydration.

ii) Schools can enhance access to safe, nutritious foods

What we know:

- Taste and price influences student food purchases.
- The Rocky View Schools found creative ways to effectively and proactively negotiate with vendors in order to comply with established nutrition standards for competitive foods sold in their schools. www.rockyview.ab.ca
- Ottawa Public Health and Ventrex Vending Services demonstrated that selling healthier snacks can be profitable, www.opha.on.ca.
- Food availability and accessibility are important predictors of food intake in children and youth.
- Children reduce their consumption of fruit, some vegetables, and milk, and consume more sweetened beverages and high fat vegetables when they enter middle school and gain access to student snack bars.
- Moving healthy foods, such as vegetables and fruit to the start of the cafeteria line makes them more visible and more likely to be chosen.
- The incidence of severe food allergies is increasing. Examples are nut and fish allergies.

Recommendations:

- **Ensure that healthier food choices are competitively priced relative to less nutritious foods.**
- **If pricing and affordability are a challenge, affordable healthy meal choices should be a priority over affordable healthy snacks.**
- **All vending machines should contain healthy food options.**
- **Healthy food choices should be available and clearly visible on special food days and at special functions.**
- **The frequency of special food days should be defined in school policies.**
- **Students who operate microwaves or other appliances in schools should be monitored appropriately.**
- **Ensure meal-time supervisors are familiar with guidelines for supporting children with allergies.**
- **Ensure meal-time supervisors are aware of school policies of how to respond when a child has an adverse food reaction.**

Taking action:

- Identify vendors, farmers and businesses that can provide Alberta-grown produce or other healthful products at affordable prices. Check out Alberta Agriculture and Rural Development at www.agric.gov.ab.ca.
- Schools can combine their resources and purchase healthy foods in bulk quantities.
- Promote sales of only healthy food items.
- Charge less for healthy foods and more for non-healthy foods.
- Develop school policies to guide the types of food offered on special food days, on fieldtrips, and during class parties. Ensure healthy food options are available.
- Invite parents to share healthy food ideas.
- Emphasize and promote cleanliness at meal times.
- Ensure school policies address food allergies and special dietary concerns. The goal of these policies should be to ensure a healthy environment for all children, and to protect children with food allergies from exposure to potential allergens.
- Provide education to ensure students understand the dangers some foods may pose to the health of their classmates.

iii) Schools can create environments that support healthy food choices

What we know:

- Schools offer an ideal setting to promote healthy eating behaviours in children and adolescents.
- Knowledge of healthy eating does not necessarily translate to better food choices unless the environment supports it too.
- The nutrition education students receive in the classroom may not match the messages conveyed in other school settings.
- The food-related behaviours of students change in response to changes in the school food environment.
- School nutrition policies are associated with changes in students' nutritional knowledge and behaviours.
- Children eat less if they are eager to go out and play.
- Students should be given a minimum of 20 minutes to eat.
- If students feel they need to eat quickly, they often choose to skip lunch or purchase foods from vending machines/snack bars.
- Increasing the variety and appeal of healthy options may encourage students to purchase them more often.
- Children who purchase lunch at school have a 39% increased risk of being overweight (Veugelers and Fitzgerald, 2005)

Recommendations:

- **Provide appropriate time and space to eat.**
- **Healthy food choices should be plentiful and visible.**
- **Place healthier food and beverage choices where they can be seen.**
- **Ensure that food choices reinforce healthy eating concepts taught in the classroom.**
- **Fundraising activities should be consistent with healthy eating concepts taught in the classroom.**
- **Include staff, parents and students in the decision making.**

Taking action:

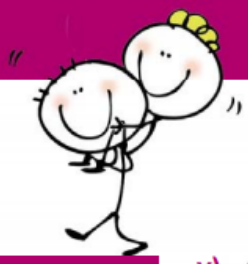
- Develop school policies to address food choices, time for eating, seating availability, socializing opportunities, and additional time for play (either before or after the meal).
- Schedule lunches so that recreation time does not compete with mealtimes.
- Allow students to have water bottles at their desks to encourage them to drink more water throughout the day.
- Market healthier food choices with positive sign associations such as a message displayed where milk is sold, "milk builds strong bones and teeth!"
- Display posters and sample plates depicting healthy meals that include foods from four different food groups.

- Suggestions for fundraising:
  - Use non-food items (cookbooks, day timers, raffle tickets for theme baskets, first aid kits, coupon books) or activities (walk-a-thons and talent shows).
  - Use nutritious food items, in appropriate portion sizes (plain popcorn, 100% juices, vegetables and fruit).
- Use non-food items for rewards such as extra gym or recess, free time at the end of class, stickers and school supplies.
- Staff, teachers, volunteers, visitors and parents can be healthy eating role models by packing healthy lunches and snacks.
- Serve healthy foods at staff social activities.

iv) Grade level of school

What we know:

- Children require different levels of support for decision making at different ages.
  - In the youngest children, good decision making is encouraged by ensuring that all available choices would be good choices.
  - As children mature, it is important that they learn how to identify and make good choices on their own. Schools should offer a balance between recognizing the need for young people to learn and practise good decision making, and modeling good lifestyle choices.
  - Note that the majority of foods available to students at all levels should be healthy, however older students can be given the opportunity for greater independence in decision making.



Recommendations:

- **In elementary schools, 100% of the foods available for regular consumption should be foods from the Choose Most Often food category.**
- **In junior high schools, 100% of the foods available to choose from for regular consumption, should be foods from the Choose Most Often (60% of the food options) and Choose Sometimes (40% of the food options) food categories.**
- **In high schools, 100% of the foods available to choose from for regular consumption, should be foods from the Choose Most Often (50% of the food options) and Choose Sometimes (50% of the food options) food categories.**
- **Where permitted offer only small portion sizes of Choose Least Often options.**
- **Multi-level schools should adhere to the most conservative recommendation.**

Water is recommended as the first option to quench thirst and satisfy hydration

v) Additional Implementation Strategies

Who to Involve:

- Schools can create their own food and nutrition policy teams that include staff, parents and students.
- Allowing students to have input into food and beverage choices may encourage greater acceptance of, and adherence to healthy food policies in schools.
- Make sure food services or stores around the school are aware that school food policies exist. Encourage nearby food establishments to support these policies by offering healthier food items.

Promotion:

- Teachers and student councils can work together on marketing campaigns that promote healthy food choices.
- Newsletters can be an effective way to communicate healthy eating campaigns.

Making Changes:

- Do not try to make too many changes at once, instead, focus on one or two changes at a time.
- Develop a transition plan to allow time for students, parents and other key stakeholders to learn about, and adapt to changes.

Appendix B

Excerpts from Ontario's *School Food and Beverage Policy – Policy/program Memorandum no. 150* (2010)

Ontario

Ministry of Education

Policy/Program Memorandum No. 150

Date of Issue: October 4, 2010

Effective: Until revoked or modified

Subject: SCHOOL FOOD AND BEVERAGE POLICY

Application: Directors of Education
Supervisory Officers and Secretary-Treasurers of School Authorities
Principals of Elementary Schools
Principals of Secondary Schools
Principals of Provincial and Demonstration Schools

Reference: This memorandum replaces Policy/Program Memorandum No. 150, January 15, 2010.

INTRODUCTION

The Ontario government is committed to making schools healthier places for students in order to establish the conditions needed to realize the potential of all students. A healthy school environment enhances student learning and success, and enhances students' social and emotional well-being. Schools have an important role to play in helping students lead healthier lives, including teaching students the skills to make healthy choices and reinforcing those lessons through school practices.

The purpose of this memorandum is to set out nutrition standards for food and beverages sold in publicly funded elementary and secondary schools in Ontario.

APPLICATION

School boards[1] are required to ensure that all food and beverages sold on school premises for school purposes meet the requirements of this memorandum, including the nutrition standards set out in the Appendix to this memorandum, by September 1, 2011. The nutrition standards apply to all food and beverages sold in all venues (e.g., cafeterias, vending machines, tuck shops), through all programs (e.g., catered lunch programs), and at all events (e.g., bake sales, sports events).

The standards do not apply to food and beverages that are:

- offered in schools to students at no cost;
- brought from home or purchased off school premises and are not for resale in schools;
- available for purchase during field trips off school premises;
- sold in schools for non-school purposes (e.g., sold by an outside organization that is using the gymnasium after school hours for a non-school–related event);

1. In this memorandum, *school board(s)* and *board(s)* refer to district school boards and school authorities.

- sold for fundraising activities that occur off school premises;
- sold in staff rooms.

LEGISLATIVE AUTHORITY

Paragraphs 29.3 and 29.4 of subsection 8(1) of the Education Act provide the Minister of Education with the authority to establish a policy with respect to nutrition standards for food and beverages and for any ingredient contained in food and beverages provided on school premises or in connection with a school-related activity, and to require school boards to comply with the policy.

RATIONALE FOR A SCHOOL FOOD AND BEVERAGE POLICY

The school food and beverage policy contributes to improved education and health outcomes for all students. Research shows that "health and education success are intertwined: schools cannot achieve their primary mission of education if students are not healthy"[2] and that "healthy eating patterns in childhood and adolescence promote optimal childhood health, growth, and intellectual development".[3]

The school environment profoundly influences students' attitudes, preferences, and behaviours. Research also shows that when nutritionally inadequate food and beverages are available and promoted at school every day, even along with healthier food and beverages, it becomes increasingly difficult for students to have a healthy diet.[4]

The implementation of the school food and beverage policy in Ontario's publicly funded schools will contribute to reducing students' risk of developing serious, chronic diseases, such as heart disease, type 2 diabetes, and certain types of cancer.

The school food and beverage policy constitutes a comprehensive approach to the sale of food and beverages in schools province-wide. The implementation of this policy is another important step in creating healthier schools in Ontario.[5] It also reinforces the knowledge, skills, and attitudes regarding healthy eating that are developed through the various subjects and disciplines in the Ontario curriculum.

2. M. M. Storey, M. S. Nanney, and M. B. Schwartz, "Schools and Obesity Prevention: Creating School Environments and Policies to Promote Healthy Eating and Physical Activity", *The Milbank Quarterly*, 87(1), (2009), p. 72.

3. Centers for Disease Control and Prevention, *Guidelines for School Health Programs to Promote Lifelong Healthy Eating*, MMWR 1996;45 (No. RR-9), p. 1.

4. Dietitians of Canada, "School Food and Nutrition Recommendations for Ontario Ministry of Education Regarding Snacks and Beverages Dispensed by Vending Machines", p. 3, published with Ontario Ministry of Education, Policy/Program Memorandum No. 135, "Healthy Foods and Beverages in Elementary School Vending Machines", October 20, 2004.

5. For further information, see Foundations for a Healthy School, at www.ontario.ca/healthyschools.

NUTRITION STANDARDS

The nutrition standards embody the principles of healthy eating outlined in Canada's Food Guide, and are intended to ensure that the food and beverages sold in schools contribute to students' healthy growth and development. The nutrition standards for food and beverages are set out within the following two sections:

Nutrition Standards for Food. Food is divided into "Vegetables and Fruit", "Grain Products", "Milk and Alternatives", and "Meat and Alternatives", following Canada's Food Guide. There are also "Mixed Dishes", for products that contain more than one major ingredient (e.g., pizza, pasta, soup, salads, and sandwiches), and "Miscellaneous Items", for items that are to be used in limited amounts (e.g., condiments, sauces, dips, oils, dressings) and for confectionery, which is not permitted for sale (e.g., candy, chocolate).

Nutrition Standards for Beverages. Standards for beverages are provided separately for elementary schools and secondary schools.

The above two sections outline nutrition criteria[6] that food and beverages must meet in order to be sold in schools. The nutrition criteria are provided in the following categories:

Sell Most (≥ 80%). Products in this category are the healthiest options and generally have higher levels of essential nutrients and lower amounts of fat, sugar, and/or sodium. They must make up *at least 80 per cent* of all food choices[7] that are available for sale in all venues, through all programs, and at all events. The same requirement applies to beverage choices.[8]

Sell Less (≤ 20%). Products in this category may have slightly higher amounts of fat, sugar, and/or sodium than food and beverages in the "Sell Most" category. They must make up *no more than 20 per cent* of all food choices that are available for sale in all venues, through all programs, and at all events. The same requirement applies to beverage choices.

Not Permitted for Sale. Products in this category generally contain few or no essential nutrients and/or contain high amounts of fat, sugar, and/or sodium (e.g., deep-fried and other fried foods, confectionery). Food and beverages in this category may not be sold in schools.

Often a type of food or beverage (e.g., bread, meat, cheese) will fit in all three of the above categories, depending on its nutritional value. To determine whether a specific product may be sold in schools, it is

6. The nutrition criteria are based on scientific research, on the Canadian Food Inspection Agency's *Guide to Labelling and Advertising* (http://www.inspection.gc.ca/english/fssa/labeti/guide/toce.shtml), on a cross-jurisdiction scan, and on market research on available food and beverage products.

7. The following are examples of food choices: a bran muffin is one food choice and a banana muffin is another food choice; an apple is one food choice and an orange is another food choice.

8. The following are examples of beverage choices: plain milk is one beverage choice and chocolate milk is another beverage choice; orange juice is one beverage choice and apple juice is another beverage choice.

necessary to read the information on the food label – particularly the Nutrition Facts table and the ingredient list – and compare this information with the nutrition criteria.

Food should always be prepared in a healthy way – that is, using cooking methods that require little or no added fat or sodium, such as baking, barbequing, boiling, broiling, grilling, microwaving, poaching, roasting, steaming, or stir-frying.

EXEMPTION FOR SPECIAL-EVENT DAYS

The school principal may designate up to ten days (or fewer, as determined by the school board) during the school year as special-event days on which food and beverages sold in schools would be exempt from the nutrition standards outlined in this memorandum. The school principal must consult with the school council prior to designating a day as a special-event day. School principals are encouraged to consult with their students in making these decisions.

Notwithstanding this exemption, on special-event days, schools are encouraged to sell food and beverages that meet the nutrition standards set out in this memorandum.

ADDITIONAL REQUIREMENTS

The following requirements must also be met:

- School boards must comply with Ontario Regulation 200/08, "Trans Fat Standards", and any other applicable regulations made under the Education Act.
- Principals must take into consideration strategies developed under the school board's policy on anaphylaxis to reduce the risk of exposure to anaphylactic causative agents.
- Food and beverages must be prepared, served, and stored in accordance with Regulation 562, "Food Premises", as amended, made under the Health Protection and Promotion Act.
- School boards must ensure that students have access to drinking water during the school day.
- The diversity of students and staff must be taken into consideration in order to accommodate religious and/or cultural needs.

PRACTICES FOR CONSIDERATION

Boards and schools should take into consideration the following when food or beverages are sold or provided in schools:

- Offer, when available and where possible, food and beverages that are produced in Ontario.
- Be environmentally aware (e.g., reduce food waste, reuse containers, recycle food scraps).
- Avoid offering food or beverages as a reward or an incentive for good behaviour, achievement, or participation.

IMPLEMENTATION AND MONITORING

Any existing school board policies or guidelines related to food and beverages sold in schools must be in accordance with this memorandum. The ministry recognizes that there may be differences in approaches and implementation at the local level. School boards and schools are encouraged to continue to work with students, parents, school staff, community members, public health professionals, and food service providers to ensure that appropriate strategies are in place to implement this memorandum.

School boards are encouraged to consult with their board of health to implement the nutrition standards. Under Ontario Public Health Standards, 2008, boards of health have a mandate to work with school boards and schools on healthy eating in schools.

School boards are responsible for monitoring the implementation of this memorandum.

At the end of the 2010–11 school year, school boards will be required to attest that they will be in full compliance with this memorandum on September 1, 2011.

For more information on support that is available to assist with implementation, see www.ontario.ca/healthyschools.

Beverages – Secondary Schools

Compare the nutrition criteria below with the Nutrition Facts table and ingredient list on the food label.			
	Sell Most (≥ 80%)	**Sell Less (≤ 20%)**	**Not Permitted for Sale**
	Nutrition Criteria	**Nutrition Criteria**	**Nutrition Criteria**
Water	Plain		
Milk* and Milk-Based Beverages (Plain or Flavoured)	Fat: ≤ 2% M.F.** or ≤ 5g **and** Sugar: ≤ 28g **and** Calcium: ≥ 25% DV***		Fat: > 2% M.F. or > 5g **or** Sugar: > 28g **or** Calcium: < 25% DV
Yogurt Drinks	Fat: ≤ 3.25% M.F. or ≤ 3g		Fat: > 3.25% M.F. or > 3g
Soy/Milk Alternative Beverages (Plain or Flavoured)	Fortified with calcium and vitamin D		Unfortified
Juices or Blends: Vegetable or Fruit	100% juice, pulp, or purée **and** Unsweetened/No sugar added		< 100% juice, pulp, or purée **or** Sugar in the ingredient list
Hot Chocolate	Fat: ≤ 2% M.F. or ≤ 5g **and** Sugar: ≤ 28g **and** Calcium: ≥ 25% DV		Fat: > 2% M.F. or > 5g **or** Sugar: > 28g **or** Calcium: < 25% DV
Coffee and Tea		Decaffeinated	Caffeinated
Iced Tea		Calories: ≤ 40 **and** Decaffeinated	Calories: > 40 **or** Caffeinated
Energy Drinks			All Energy Drinks
Sports Drinks			All Sports Drinks
Other Beverages (e.g., soft drinks; flavoured water; "juice-ades", such as lemonade, limeade)		Calories: ≤ 40 **and** Caffeine-free	Calories: > 40 **or** with caffeine

*Milk can be sold in containers that hold multiple servings.
**M.F. = Milk Fat. The amount can be found on the front of the food label.
***DV = Daily Value.

Appendix C

COMPASS Student Questionnaire

- **This is NOT a test**. All of your answers will be kept **confidential**. No one, not even your parents or teachers, will ever know what you answered. So, please be honest when you answer the questions.
- Mark only **one option per question** unless the instructions tell you to do something else.
- Choose the option that is the **closest** to what you think/feel is true for you.

Please, use a pencil to complete this questionnaire

Please mark all your answers with full, dark marks like this: ○ ● ○ ○

START HERE

Please read each sentence below carefully. Write the correct letter, number, or word on the line and then fill in the corresponding circle.

The first letter of your **middle** name (if you have more than one middle name use your first middle name; if you don't have a middle name use "Z"):____	The name of the month in which you were born: ________	The **last** letter of your full **last** name: ___	The **second** letter of your full **first** name: ___	The **first** initial of your **mother's** first name (think about the mother you see the most):___
Ⓐ Ⓙ Ⓢ	① January	Ⓐ Ⓙ Ⓢ	Ⓐ Ⓙ Ⓢ	Ⓐ Ⓙ Ⓢ
Ⓑ Ⓚ Ⓣ	② February	Ⓑ Ⓚ Ⓣ	Ⓑ Ⓚ Ⓣ	Ⓑ Ⓚ Ⓣ
Ⓒ Ⓛ Ⓤ	③ March	Ⓒ Ⓛ Ⓤ	Ⓒ Ⓛ Ⓤ	Ⓒ Ⓛ Ⓤ
Ⓓ Ⓜ Ⓥ	④ April	Ⓓ Ⓜ Ⓥ	Ⓓ Ⓜ Ⓥ	Ⓓ Ⓜ Ⓥ
Ⓔ Ⓝ Ⓦ	⑤ May	Ⓔ Ⓝ Ⓦ	Ⓔ Ⓝ Ⓦ	Ⓔ Ⓝ Ⓦ
Ⓕ Ⓞ Ⓧ	⑥ June	Ⓕ Ⓞ Ⓧ	Ⓕ Ⓞ Ⓧ	Ⓕ Ⓞ Ⓧ
Ⓖ Ⓟ Ⓨ	⑦ July	Ⓖ Ⓟ Ⓨ	Ⓖ Ⓟ Ⓨ	Ⓖ Ⓟ Ⓨ
Ⓗ Ⓠ Ⓩ	⑧ August	Ⓗ Ⓠ Ⓩ	Ⓗ Ⓠ Ⓩ	Ⓗ Ⓠ Ⓩ
Ⓘ Ⓡ	⑨ September	Ⓘ Ⓡ	Ⓘ Ⓡ	Ⓘ Ⓡ
	⑩ October			
	⑪ November			
	⑫ December			

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About You

1. What grade are you in?

- ○ Grade 9
- ○ Grade 10
- ○ Grade 11
- ○ Grade 12

2. How old are you today?

- ○ 13 years or younger
- ○ 14 years
- ○ 15 years
- ○ 16 years
- ○ 17 years
- ○ 18 years or older

3. Are you female or male?

- ○ Female
- ○ Male

4. How would you describe yourself? *(Mark all that apply)*

- ○ White
- ○ Black
- ○ Asian
- ○ Aboriginal (First Nations, Métis, Inuit)
- ○ Latin American/Hispanic
- ○ Other _____

5. About how much money do you usually get <u>each week</u> to spend on yourself or to save?
(Remember to include all money from allowances and jobs like baby-sitting, delivering papers, etc.)

- ○ Zero
- ○ $1 to $5
- ○ $6 to $10
- ○ $11 to $20
- ○ $21 to $40
- ○ $41 to $100
- ○ More than $100
- ○ I do not know how much money I get each week

6. How do you <u>usually</u> travel to and from school? *(If you use two or more modes of travel, choose the one that you spend most <u>time</u> doing)*

<u>To school</u>	<u>From school</u>
○ By car (as a passenger)	○ By car (as a passenger)
○ By car (as a driver)	○ By car (as a driver)
○ By school bus	○ By school bus
○ By public bus, subway, or streetcar	○ By public bus, subway, or streetcar
○ By walking	○ By walking
○ By bicycling	○ By bicycling
○ Other_____	○ Other_____

7. Did you attend <u>this</u> school last year?

- ○ Yes, I attended the same school last year
- ○ No, I was at another school last year

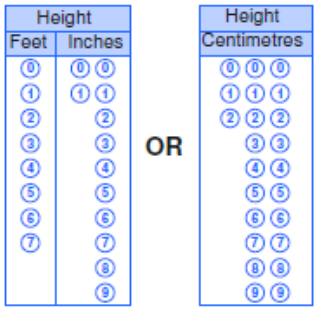
8. **How tall are you without your shoes on?** (Please write your height in feet and inches **OR** in centimetres, and then fill in the appropriate numbers for your height.)

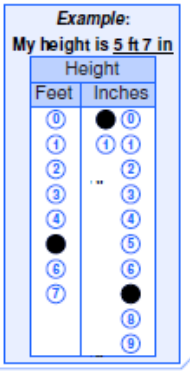
○ I do not know how tall I am

"My height is ____feet, _____inches"

OR

"My height is _____ centimetres"





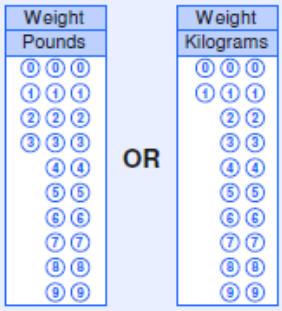
9. **How much do you weigh without your shoes on?** (Please write your weight in pounds **OR** in kilograms, and then fill in the appropriate numbers for your weight.)

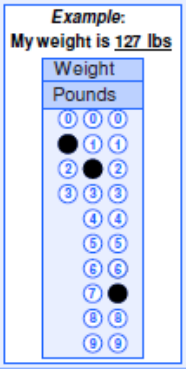
○ I do not know how much I weigh

"My weight is _____ pounds"

OR

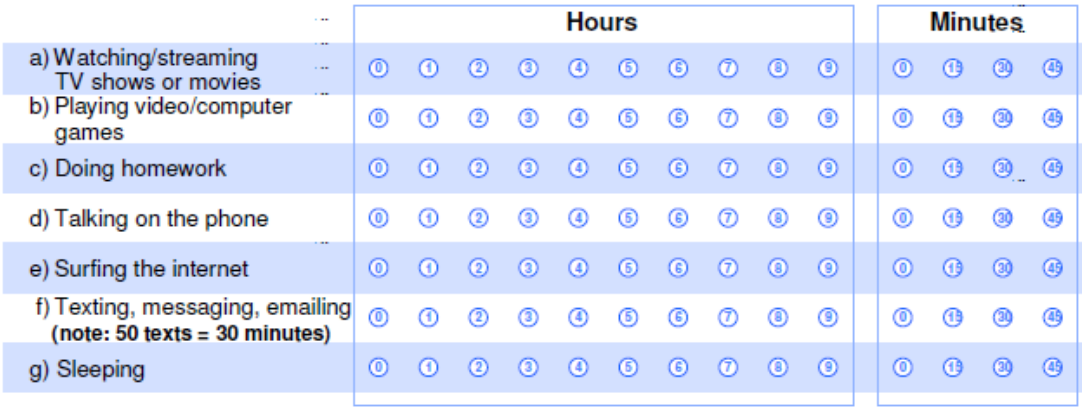
"My weight is _____ kilograms"





10. **How much time per day do you *usually* spend doing the following activities?**

For example: If you spend about 3 hours watching TV each day, you will need to fill in the 3 hour circle, and the 0 minute circle as shown below:



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Physical Activity

HARD physical activities include jogging, team sports, fast dancing, jump-rope, and any other physical activities that increase your heart rate and make you breathe hard and sweat.

MODERATE physical activities include lower intensity activities such as walking, biking to school, and recreational swimming.

11. Mark how many minutes of HARD physical activity you did on each of the last 7 days. This includes physical activity during physical education class, lunch, after school, evenings, and spare time.

	Hours					Minutes				
Monday	○	○	○	○	○	○	○	○	○	
Tuesday	○	○	○	○	○	○	○	○	○	
Wednesday	○	○	○	○	○	○	○	○	○	
Thursday	○	○	○	○	○	○	○	○	○	
Friday	○	○	○	○	○	○	○	○	○	
Saturday	○	○	○	○	○	○	○	○	○	
Sunday	○	○	○	○	○	○	○	○	○	

For example: If you did 45 minutes of hard physical activity on Monday, you will need to fill in the 0 hour circle and the 45 minute circle, as shown below:

	Hours					Minutes				
Monday	●	○	○	○	○	○	○	○	●	

12. Mark how many minutes of MODERATE physical activity you did on each of the last 7 days. This includes physical activity during physical education class, lunch, after school, evenings, and spare time. Do not include time spent doing hard physical activities.

	Hours					Minutes				
Monday	○	○	○	○	○	○	○	○	○	
Tuesday	○	○	○	○	○	○	○	○	○	
Wednesday	○	○	○	○	○	○	○	○	○	
Thursday	○	○	○	○	○	○	○	○	○	
Friday	○	○	○	○	○	○	○	○	○	
Saturday	○	○	○	○	○	○	○	○	○	
Sunday	○	○	○	○	○	○	○	○	○	

For example: If you did 1 hour and 30 minutes of moderate physical activity on Monday, you will need to fill in the 1 hour circle and the 30 minute circle, as shown below:

	Hours					Minutes				
Monday	○	●	○	○	○	○	○	●	○	

13. Were the last 7 days a typical week in terms of the amount of physical activity that you usually do?

- ○ Yes
- ○ No, I was *more* active in the last 7 days
- ○ No, I was *less* active in the last 7 days

14. Your closest friends are the friends you like to spend the most time with. How many of your closest friends are physically active?

- ○ None
- ○ 1 friend
- ○ 2 friends
- ○ 3 friends
- ○ 4 friends
- ○ 5 or more friends

15. Are you taking a physical education class at school this year?

- ○ **Yes**, I am taking one **this term**
- ○ **Yes**, I will be taking one or have taken one this school year, **but not this term**.
- ○ **No**, I am not taking a physical education class at school this year

16. **Do you participate in before-school, noon hour, or after-school physical activities organized by your school?** *(e.g., intramurals, non-competitive clubs)*

- ○ Yes
- ○ No
- ○ None offered at my school

17. **Do you participate in competitive school sports teams that compete against other schools?** *(e.g., junior varsity or varsity sports)*

- ○ Yes
- ○ No
- ○ None offered at my school

18. **Do you participate in league or team sports outside of school?**

- ○ Yes
- ○ No
- ○ There are none available where I live

19. **On how many days in the last 7 days did you do exercises to strengthen or tone your muscles?** *(e.g., push-ups, sit-ups, or weight-training)*

- ○ 0 days
- ○ 1 day
- ○ 2 days
- ○ 3 days
- ○ 4 days
- ○ 5 days
- ○ 6 days
- ○ 7 days

20. **How do <u>you</u> describe your weight?**

- ○ Very underweight
- ○ Slightly underweight
- ○ About the right weight
- ○ Slightly overweight
- ○ Very overweight

21. **Which of the following are you trying to do about your weight?**

- ○ **Lose** weight
- ○ **Gain** weight
- ○ **Stay** the same weight
- ○ I am **not trying to do anything** about my weight

22. **How much do your parents, step-parents, or guardians encourage you to be physically active?**

- ○ Strongly encourage
- ○ Encourage
- ○ Do not encourage or discourage
- ○ Discourage
- ○ Strongly discourage

23. **How much do your parents, step-parents, or guardians support you in being physically active?** *(e.g., driving you to team games, buying you sporting equipment)*

- ○ Very supportive
- ○ Supportive
- ○ Unsupportive
- ○ Very unsupportive

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Healthy Eating

24. If you do not eat breakfast every day, why do you skip breakfast? *(Mark all that apply)*

- ○ I eat breakfast every day
- ○ I don't have time for breakfast
- ○ The bus comes too early
- ○ I sleep in
- ○ I'm not hungry in the morning
- ○ I feel sick when I eat breakfast
- ○ I'm trying to lose weight
- ○ There is nothing to eat at home
- ○ Other _____

25. In a *usual* school week *(Monday to Friday)*, on how many days do you do the following?

	None	1 day	2 days	3 days	4 days	5 days
a) Eat breakfast	○	○	○	○	○	○
b) Eat breakfast provided to you **as part of a school program**	○	○	○	○	○	○
c) Eat lunch at school - lunch packed and brought from home	○	○	○	○	○	○
d) Eat lunch at school - lunch purchased in the cafeteria	○	○	○	○	○	○
e) Eat lunch purchased at a fast food place or restaurant	○	○	○	○	○	○
f) Eat snacks purchased from a vending machine **in your school**	○	○	○	○	○	○
g) Eat snacks purchased from a vending machine, corner store, snack bar, or canteen **off school property**	○	○	○	○	○	○
h) Drink sugar-sweetened beverages (soda pop, Kool-Aid, Gatorade, etc.) Do not include diet/sugar-free drinks	○	○	○	○	○	○
i) Drink high-energy drinks (Red Bull, Monster, Rock Star, etc.)	○	○	○	○	○	○
j) Drink coffee or tea **with sugar** (include cappuccino, frappuccino, iced-tea, iced-coffees, etc.)	○	○	○	○	○	○
k) Drink coffee or tea **without sugar**	○	○	○	○	○	○

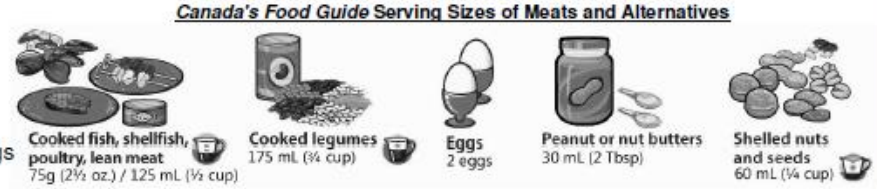
26. On a *usual* weekend *(Saturday and Sunday)*, on how many days do you do the following?

	None	1 day	2 days
a) Eat breakfast	○	○	○
b) Eat lunch	○	○	○
c) Eat foods purchased at a fast food place or restaurant	○	○	○
d) Eat snacks purchased from a vending machine, corner store, snack bar, or canteen	○	○	○
e) Drink sugar-sweetened beverages (soda pop, Kool-Aid, Gatorade, etc.) Do not include diet/sugar-free drinks	○	○	○
f) Drink high energy drinks (Red Bull, Monster, Rock Star, etc.)	○	○	○
g) Drink coffee or tea **with sugar** (include cappuccino, frappuccino, iced-tea, iced-coffees, etc.)	○	○	○
h) Drink coffee or tea **without sugar**	○	○	○

27. **YESTERDAY**, *from the time you woke up until the time you went to bed*, **how many servings of meats and alternatives did you have?** *One 'Food Guide' serving of meat and alternatives includes cooked fish, chicken, beef, pork, or game meat, eggs, nuts or seeds, peanut butter or nut butters, legumes (beans), and tofu.*

- ○ None
- ○ 1 serving
- ○ 2 servings
- ○ 3 servings
- ○ 4 servings
- ○ 5 or more servings

***Canada's Food Guide* Serving Sizes of Meats and Alternatives**



28. **YESTERDAY**, *from the time you woke up until the time you went to bed*, **how many servings of vegetables and fruits did you have?** *One 'Food Guide' serving of vegetables and fruit includes pieces of fresh vegetable or fruit, salad or raw leafy greens, cooked leafy green vegetables, dried or canned or frozen fruit, and 100% fruit or vegetable juice.*

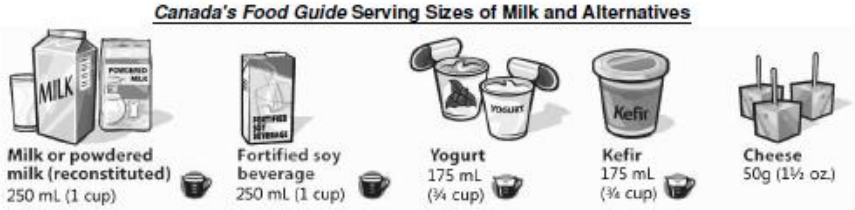
- ○ None
- ○ 1 serving
- ○ 2 servings
- ○ 3 servings
- ○ 4 servings
- ○ 5 servings
- ○ 6 servings
- ○ 7 servings
- ○ 8 servings
- ○ 9 or more servings

***Canada's Food Guide* Serving Sizes of Vegetables and Fruits**

29. **YESTERDAY**, *from the time you woke up until the time you went to bed*, **how many servings of milk and alternatives did you have?** *One 'Food Guide' serving of milk or milk alternatives includes milk, fortified soy beverage, reconstituted powdered milk, canned (evaporated) milk, yogurt or kefir (another type of cultured milk product), and cheese.*

- ○ None
- ○ 1 serving
- ○ 2 servings
- ○ 3 servings
- ○ 4 servings
- ○ 5 servings
- ○ 6 or more servings

***Canada's Food Guide* Serving Sizes of Milk and Alternatives**



30. **YESTERDAY**, *from the time you woke up until the time you went to bed*, **how many servings of grain products did you have?** *One 'Food Guide' serving of grain products includes bread, bagels, flatbread such as tortilla, pita, cooked rice or pasta, and cold cereal.*

- ○ None
- ○ 1 serving
- ○ 2 servings
- ○ 3 servings
- ○ 4 servings
- ○ 5 servings
- ○ 6 servings
- ○ 7 servings
- ○ 8 servings
- ○ 9 or more servings

***Canada's Food Guide* Serving Sizes of Grain Products**

Your Experience with Smoking

31. Have you ever tried cigarette smoking, even just a few puffs?

- ○ Yes
- ○ No

32. How old were you when you first tried smoking cigarettes, even just a few puffs?

- ○ I have never done this
- ○ I do not know

- ○ 8 years or younger
- ○ 9 years
- ○ 10 years
- ○ 11 years
- ○ 12 years
- ○ 13 years
- ○ 14 years
- ○ 15 years
- ○ 16 years
- ○ 17 years
- ○ 18 years or older

33. Do you think in the future you might try smoking cigarettes?

- ○ Definitely yes
- ○ Probably yes
- ○ Probably not
- ○ Definitely not

34. If one of your best friends were to offer you a cigarette, would you smoke it?

- ○ Definitely yes
- ○ Probably yes
- ○ Probably not
- ○ Definitely not

35. At any time during the next year do you think you will smoke a cigarette?

- ○ Definitely yes
- ○ Probably yes
- ○ Probably not
- ○ Definitely not

36. Do you think it would be difficult or easy for you to get cigarettes if you wanted to smoke?

- ○ Difficult
- ○ Easy
- ○ I do not know

37. Have you ever smoked a whole cigarette?

- ○ Yes
- ○ No

38. Have you ever smoked 100 or more whole cigarettes in your life?

- ○ Yes
- ○ No

○○○○○○○○○○○○○○○○○○○○○○○○ [serial]

39. Have you ever smoked every day for at least 7 days in a row?

- ○ Yes
- ○ No

40. On how many of the last 30 days did you smoke one or more cigarettes?

- ○ None
- ○ 1 day
- ○ 2 to 3 days
- ○ 4 to 5 days
- ○ 6 to 10 days
- ○ 11 to 20 days
- ○ 21 to 29 days
- ○ 30 days *(every day)*

41. Thinking back over the last 30 days, on the days that you smoked, how many cigarettes did you usually smoke each day?

- ○ None
- ○ A few puffs to one whole cigarette
- ○ 2 to 3 cigarettes
- ○ 4 to 5 cigarettes
- ○ 6 to 10 cigarettes
- ○ 11 to 20 cigarettes
- ○ 21 to 29 cigarettes
- ○ 30 or more cigarettes

42. Your closest friends are the friends you like to spend the most time with. How many of your closest friends smoke cigarettes?

- ○ None
- ○ 1 friend
- ○ 2 friends
- ○ 3 friends
- ○ 4 friends
- ○ 5 or more friends

43. Have you ever tried to quit smoking cigarettes?

- ○ I have never smoked
- ○ I have only smoked a few times
- ○ I have never tried to quit
- ○ I have tried to quit once
- ○ I have tried to quit 2 or 3 times
- ○ I have tried to quit 4 or 5 times
- ○ I have tried to quit 6 or more times

44. In the last 30 days, did you use any of the following? *(Mark all that apply)*

- ○ Pipe tobacco
- ○ Cigarillos or little cigars (*plain or flavoured*)
- ○ Cigars (not including cigarillos or little cigars, *plain or flavoured*)
- ○ Roll-your-own cigarettes (tobacco only)
- ○ Loose tobacco mixed with marijuana
- ○ E-cigarettes (electronic cigarettes that look like cigarettes/cigars, but produce vapour instead of smoke)
- ○ Smokeless tobacco (chewing tobacco, pinch, snuff, or snus)
- ○ Nicotine patches, nicotine gum, nicotine lozenges, or nicotine inhalers
- ○ Hookah (water-pipe) to smoke tobacco
- ○ Hookah (water-pipe) to smoke herbal sheesha/shisha
- ○ Blunt wraps (a sheet or tube made of tobacco used to roll cigarette tobacco)
- ○ I have not used any of these things in the last 30 days

Alcohol and Marijuana Use

*Please remember that we will keep your answers **completely confidential**.*

A **DRINK** means: 1 regular sized bottle, can, or draft of beer; 1 glass of wine; 1 bottle of cooler; 1 shot of liquor (rum, whiskey, etc); or 1 mixed drink (1 shot of liquor with pop, juice, energy drink).

45. In the last 12 months, how often did you have a drink of alcohol that was more than just a sip?

- ○ I have never drunk alcohol
- ○ I did not drink alcohol in the last 12 months
- ○ I have only had a sip of alcohol
- ○ Less than once a month
- ○ Once a month
- ○ 2 or 3 times a month
- ○ Once a week
- ○ 2 or 3 times a week
- ○ 4 to 6 times a week
- ○ Every day

46. How old were you when you first had a drink of alcohol that was more than just a sip?

- ○ I have never drunk alcohol
- ○ I have only had a sip of alcohol
- ○ I do not know

- ○ 8 years or younger
- ○ 9 years
- ○ 10 years
- ○ 11 years
- ○ 12 years
- ○ 13 years
- ○ 14 years
- ○ 15 years
- ○ 16 years
- ○ 17 years
- ○ 18 years or older

47. In the last 12 months, how often did you have 5 drinks of alcohol or more on one occasion?

- ○ I have never done this
- ○ I did not have 5 or more drinks on one occasion in the last 12 months
- ○ Less than once a month
- ○ Once a month
- ○ 2 to 3 times a month
- ○ Once a week
- ○ 2 to 5 times a week
- ○ Daily or almost daily

48. In the last 12 months, have you had alcohol mixed or pre-mixed with an energy drink (such as Red Bull, Rock Star, Monster, or another brand)?

- ○ I have never done this
- ○ I did not do this in the last 12 months
- ○ Yes
- ○ I do not know

49. In the last 12 months, how often did you use marijuana or cannabis? (a joint, pot, weed, hash)

- ○ I have never used marijuana
- ○ I have used marijuana but not in the last 12 months
- ○ Less than once a month
- ○ Once a month
- ○ 2 or 3 times a month
- ○ Once a week
- ○ 2 or 3 times a week
- ○ 4 to 6 times a week
- ○ Every day

50. How old were you when you first used marijuana or cannabis?

- ○ I have never used marijuana
- ○ I do not know

- ○ 8 years or younger
- ○ 9 years
- ○ 10 years
- ○ 11 years
- ○ 12 years
- ○ 13 years
- ○ 14 years
- ○ 15 years
- ○ 16 years
- ○ 17 years
- ○ 18 years or older

51. Do you think it would be difficult or easy for you to get marijuana if you wanted some?

- ○ Difficult
- ○ Easy
- ○ I do not know

○○○○○○○○○○○○○○○○○○○○○○○○ [serial]

Your School and You

52. How strongly do you agree or disagree with each of the following statements?

	Strongly Agree	Agree	Disagree	Strongly Disagree
a) I feel close to people at my school.	○	○	○	○
b) I feel I am part of my school.	○	○	○	○
c) I am happy to be at my school.	○	○	○	○
d) I feel the teachers at my school treat me fairly.	○	○	○	○
e) I feel safe in my school.	○	○	○	○
f) Getting good grades is important to me.	○	○	○	○

53. In the last 30 days, in what ways were you bullied by other students? *(Mark all that apply)*

- ○ I have not been bullied in the last 30 days
- ○ Physical attacks (e.g., getting beaten up, pushed, or kicked)
- ○ Verbal attacks (e.g., getting teased, threatened, or having rumours spread about you)
- ○ Cyber-attacks (e.g., being sent mean text messages or having rumours spread about you on the internet)
- ○ Had someone steal from you or damage your things

54. In the last 30 days, how often have you been bullied by other students?

- ○ I have not been bullied by other students in the last 30 days
- ○ Less than once a week
- ○ About once a week
- ○ 2 or 3 times a week
- ○ Daily or almost daily

55. In the last 30 days, in what ways did you bully other students? *(Mark all that apply)*

- ○ I did not bully other students in the last 30 days
- ○ Physical attacks (e.g., beat up, pushed, or kicked them)
- ○ Verbal attacks (e.g., teased, threatened, or spread rumours about them)
- ○ Cyber-attacks (e.g., sent mean text messages or spread rumours about them on the internet)
- ○ Stole from them or damaged their things

56. In the last 30 days, how often have you taken part in bullying other students?

- ○ I did not bully other students in the last 30 days
- ○ Less than once a week
- ○ About once a week
- ○ 2 or 3 times a week
- ○ Daily or almost daily

57. How supportive is your school of the following?

	Very supportive	Supportive	Unsupportive	Very unsupportive
a) Making sure there are opportunities for students to be physically active	○	○	○	○
b) Making sure students have access to healthy foods and drinks	○	○	○	○
c) Making sure no one is bullied at school	○	○	○	○
d) Giving students the support they need to resist or quit tobacco	○	○	○	○
e) Giving students the support they need to resist or quit drugs and/or alcohol	○	○	○	○

58. What academic level was your current or most recent Math course?

- ○ Applied
- ○ Academic
- ○ Other _____

59. In your current or most recent Math course, what is your approximate overall mark?
(Think about last year if you have not taken math this year)

- ○ 90% - 100%
- ○ 80% - 89%
- ○ 70% - 79%
- ○ 60% - 69%
- ○ 55% - 59%
- ○ 50% - 54%
- ○ Less than 50%

60. In your current or most recent English course, what is your approximate overall mark?
(Think about last year if you have not taken English this year)

- ○ 90% - 100%
- ○ 80% - 89%
- ○ 70% - 79%
- ○ 60% - 69%
- ○ 55% - 59%
- ○ 50% - 54%
- ○ Less than 50%

61. What is the highest level of education you would like to get? *(Choose only one)*

- ○ Some high school or less
- ○ High school diploma or graduation equivalency
- ○ College/trade/vocational certificate
- ○ University Bachelor's degree
- ○ University Master's / PhD / law school / medical school / teachers' college degree
- ○ I don't know

62. What is the highest level of education you think you will get? *(Choose only one)*

- ○ Some high school or less
- ○ High school diploma or graduation equivalency
- ○ College/trade/vocational certificate
- ○ University Bachelor's degree
- ○ University Master's / PhD / law school / medical school / teachers' college degree
- ○ I don't know

63. In the last 4 weeks, how many days of school did you miss because of your health?

- ○ 0 days
- ○ 1 or 2 days
- ○ 3 to 5 days
- ○ 6 to 10 days
- ○ 11 or more days

64. In the last 4 weeks, how many classes did you skip when you were not supposed to?

- ○ 0 classes
- ○ 1 or 2 classes
- ○ 3 to 5 classes
- ○ 6 to 10 classes
- ○ 11 to 20 classes
- ○ More than 20 classes

65. How often do you go to class without your homework complete?

- ○ Never
- ○ Seldom
- ○ Often
- ○ Usually

○○○○○○○○○○○○○○○○○○○○○○○○ [serial]

Appendix D

Excerpts of the COMPASS School Environment Application in Paper Format

Healthy Eating Observation

INSTRUCTIONS FOR STUDENT EATING AREAS

Prior to commencing observations please ensure that you have permission from the administrator or office staff to do so. The administrator may wish that a staff member accompany you as you conduct the observation. Please respond to all questions in the measure section. A photo should be taken of each facility. In the cafeteria please be sure to photograph all food menu boards, or any other information containing written food items and prices. Please DO NOT take pictures if students are using the facilities. Students CANNOT be in any photos taken. Should students be using facilities wait until they are empty. Under the photo column please record yes if a photo has been taken. Upon returning from the school data collection upload the photos for each facility and put a link in the respective "photo link(s)" column.

Component	Item	Measure(s)	Response	Photo link(s)	Additional Notes
Student Eating Areas	Cafeteria	Is there a cafeteria? (yes/no) Is food sold? (yes/no) Do the healthy food choices cost less than unhealthy options (yes/no/same) Are there healthy eating promotional materials (i.e. posters) (yes/no/same) Are there daily healthy eating specials (yes/no)			
	Tables and chairs	How many tables are there?			

		Approximately how many chairs are there per table?			
	Drinking Fountains	Are there drinking fountains? (yes/no) Are there an adequate number of fountains? (yes/no) Are they easy to find? (yes/no) Do the fountains work? (yes/no)			
	Snack bar/tuck shop	Is there a snack bar/tuck shop? (yes/no) Do the healthy food choices cost less than unhealthy options? (yes/no/same) Are there healthy eating promotional materials? (i.e. posters) (yes/no)			

INSTRUCTIONS FOR VENDING MACHINES

Prior to commencing observations please ensure that you have permission from the administrator or office staff to do so. The administrator may wish that a staff member accompany you as you conduct the observation. Please complete the following table for each vending machine located in the school. You will need one table for each machine; please be sure to bring extra copies of these tables as some schools may have several vending machines. A photo should be taken of each vending machine. The photograph should show all objects and prices in the machine. Please DO NOT take pictures if students are using the machines. Students CANNOT be in any photos taken. Should students be using the machines wait until

they are not. Under the photo column please record yes if a photo has been taken. Upon returning from the school data collection upload the photos for each facility and put a link in the respective "photo link(s)" column.

Item	Vending Machine Number	Location	Drink category (check all drinks are in the machine)	# of drinks in category	Price	Photo link(s)
Drink Vending machines			Sugar-containing Carbonated soft-drinks (e.g. Cola)			
			Sugar-containing noncarbonated soft-drinks (e.g. Iced tea)			
			Diet carbonated soft-drinks (e.g. diet-cola)			
			Diet noncarbonated soft-drinks (e.g. diet iced tea)			
			Sport drinks (e.g., Gatorade)			
			Milk (plain)			
			Chocolate/or other flavoured milk			
			100% Juice			
			Water products			
			Other _____			

Additional notes:

Appendix E

Chapter 3 Supplementary Material

This appendix includes supplementary material from the first manuscript in this dissertation: *Food purchasing behaviours and sugar-sweetened beverage consumption among Canadian secondary school students in the COMPASS study*.

Table 21 and Table 22 shows the differences between characteristics of COMPASS participants included in the study analyses (n=41299) and those that were removed from analyses due to missing data on outcome or control measures (n=3999). The former sample represents 91.1% of those who wrote the COMPASS student questionnaire in the 2013/14 school year, while the latter represents 8.9%. Notably, those who were removed from the analyses due to missing data had a significantly greater frequency of SSB consumption (across all measures), purchasing meals/snacks from food outlets on and off school property, and a lower frequency of bringing in a home-packed lunch on weekdays.

Table 21: Characteristics of participants included in the study analyses (n=41299) and of those removed from the analyses due to missing data (n=3999).

	Sample of participants included in analyses		**Sample of participants removed from analyses [a]**		***P* value [b]**
	n	%	n	%	
Gender					<.001
Female	20733	50.2	1416	35.4	
Male	20566	49.8	2146	53.6	
Grade					<.001
9	10657	25.8	1136	28.4	
10	10876	26.3	941	23.5	
11	10329	25.0	900	22.5	
12	9437	22.9	796	19.9	
Ethnicity					<.001
White	31003	75.1	2411	60.3	
Black	1498	3.6	287	7.2	
Asian	2114	5.1	189	4.7	
Aboriginal	1432	3.5	164	4.1	
Latin	765	1.9	91	2.3	
Other	4487	10.9	475	11.9	
Truancy					<.001
Skipped 0 classes in past four weeks	29406	71.2	1867	46.7	
Skipped 1+ classes in past four weeks	11893	28.8	937	23.3	
Weekly spending money					<.001
$0	6557	15.9	635	15.9	
$1-$20	11893	28.8	1018	25.5	
$21-$100	11019	26.7	959	24.0	
>$100	6621	16.0	615	15.4	
Not reported	5209	12.6	772	19.3	

Weight status					<.001
Underweight	643	1.6	46	1.2	
Healthy weight	23793	57.6	1712	42.8	
Overweight	5883	14.2	450	11.3	
Obese	2647	6.4	210	5.3	
Missing	8333	20.2	1581	39.5	
Weight intentions					<.001
Lose weight	17015	41.2	1258	31.5	
Gain weight	7444	18.0	731	18.3	
Stay the same weight	7434	18.0	572	14.3	
I am not trying to do anything about my weight	9406	22.8	747	18.7	

[a] Percentages do not sum to 100% due to participants missing data
[b] Pearson's chi-squared test used to examine sample differences.

Table 22: Food purchasing behaviours and SSB consumption among participants included in the study analyses (n=41299) and among those removed from analyses due to missing data (n=3999).

	Sample of participants included in analyses		**Sample of participants removed from analyses [a]**		
	Mean	SD	Mean	SD	*P* value [a]
# weekdays with lunch brought from home	3.01	1.97	2.64	2.06	<.001
# weekdays with lunch purchased from cafeteria	1.01	1.41	1.22	1.58	<.001
# weekdays with lunch purchased from fast food/other restaurant	0.83	1.28	1.05	1.46	<.001
# weekdays with snacks purchased from school vending machine	0.30	0.82	0.47	1.05	<.001
# weekdays with snacks purchased from off-school food outlet	0.45	0.99	0.64	1.22	<.001
# weekend days with meals purchased from fast food/other restaurant	0.54	0.60	0.60	0.64	<.001
# weekend days with snacks purchased from other food outlet	0.22	0.49	0.33	0.61	<.001
# days weekly participants report soft drink consumption	2.69	2.28	2.75	2.29	0.219
# days weekly participants report sweetened coffee/tea consumption	2.06	2.37	2.25	2.41	<.001
# days weekly participants report energy drink consumption	0.45	1.26	0.82	1.62	<.001
Weekly SSB score [b]	5.21	4.08	5.55	4.61	0.096

[a] Two-sided Wilcoxon rank sum procedure used to examine sample differences;
[b] A composite score, ranging from 0-21, representing the sum of participants' weekly rate of consuming the three distinct SSB categories.

Table 23 demonstrates participants' weekend and weekday rates of SSB consumption, stratified by province. Similar to the weekly rates of SSB consumption shown in Table 7, there are significant differences between SSB consumption measures between students in Alberta and Ontario. Participants from Alberta reported a significantly higher frequency of SSB consumption (in terms of number of days) on weekdays and weekends compared to their Ontario counterpart, with the exception of weekend soft drink intake, which was comparable between the two groups.

Table 23: Self-reported weekday and weekend rates of SSB consumption among a sample of secondary school students participating in Year 2 of the COMPASS study from Alberta (n=3300) and Ontario (n=37999), Canada.

	Total Mean ± SD	**Alberta** Mean ± SD	**Ontario** Mean ± SD	*P* value [a]
Weekday SSB consumption [b]				
Soft drinks	1.74 ± 1.73	1.94 ± 1.74	1.72 ± 1.72	<.001
Sweetened coffees/teas	1.40 ± 1.73	1.52 ± 1.73	1.39 ± 1.73	<.001
Energy drinks	0.31 ± 0.91	0.58 ± 1.23	0.28 ± 0.88	<.001
Composite SSB score [c]	3.45 ± 3.01	4.04 ± 3.32	3.40 ± 2.97	
Weekend SSB consumption [d]				
Soft drinks [d]	0.95 ± 0.78	0.96 ± 0.79	0.95 ± 0.78	0.401
Sweetened coffees/teas [d]	0.65 ± 0.79	0.69 ± 0.79	0.65 ± 0.79	0.012
Energy drinks [d]	0.15 ± 0.44	0.24 ± 0.55	0.14 ± 0.43	<.001
Composite SSB score [e]	1.75 ± 1.36	1.89 ± 1.47	1.74 ± 1.35	<.001

SSB = sugar-sweetened beverage
[a] Two-sided Wilcoxon rank sum procedure used to examine differences by province.
[b] Number of days participants report consuming SSBs in a typical school week (Mon.-Fri., 0-5 days).
[c] A composite score, ranging from 0-15, representing the sum of participants' weekday rate of consuming the three distinct SSB categories.
[d] Number of days participants report consuming SSBs in a typical weekend (Sat.-Sun., 0-2 days).
[e] A composite score, ranging from 0-6, representing the sum of participants' weekend rate of consuming the three distinct SSB categories.

Tables 24-26 provide a more detailed breakdown of participants' rate of SSB intake in a typical week, school week, and weekend, respectively.

Table 24: Self-reported number of days in a typical week participants reported SSB consumption within a sample of secondary school students participating in Year 2 of the COMPASS study from Alberta (n=3300) and Ontario (n=37999), Canada.

	Total		**Alberta**		**Ontario**	
	n	%	n	%	n	%
Soft drinks						
0 days	9413	22.79	671	20.33	8742	23.01
1 day	5827	14.11	434	13.15	5393	14.19
2 days	6644	16.09	487	14.76	6157	16.2
3 days	5579	13.51	469	14.21	5110	13.45
4 days	4129	10.00	357	10.82	3772	9.93
5 days	3386	8.20	311	9.42	3075	8.09
6 days	2255	5.46	207	6.27	2048	5.39
7 days	4066	9.85	364	11.03	3702	9.74
Sweetened coffees/teas						
0 days	18008	43.6	1297	39.3	16711	43.98
1 day	3997	9.68	350	10.61	3647	9.60
2 days	4546	11.01	366	11.09	4180	11.00
3 days	3897	9.44	338	10.24	3559	9.37
4 days	3060	7.41	290	8.79	2770	7.29
5 days	2431	5.89	224	6.79	2207	5.81
6 days	1720	4.16	147	4.45	1573	4.14
7 days	3640	8.81	288	8.73	3352	8.82
Energy drinks						
0 days	34342	83.15	2381	72.15	31961	84.11
1 day	2429	5.88	289	8.76	2140	5.63
2 days	1762	4.27	202	6.12	1560	4.11
3 days	900	2.18	130	3.94	770	2.03
4 days	596	1.44	90	2.73	506	1.33
5 days	467	1.13	71	2.15	396	1.04
6 days	275	0.67	56	1.70	219	0.58
7 days	528	1.28	81	2.45	447	1.18
Composite SSB score [a]						
0	4937	11.95	358	10.85	4579	12.05
1	3404	8.24	227	6.88	3177	8.36
2	4087	9.90	247	7.48	3840	10.11
3	3994	9.67	307	9.30	3687	9.70
4	3741	9.06	297	9.00	3444	9.06

5	3580	8.67	273	8.27	3307	8.70
6	3299	7.99	227	6.88	3072	8.08
7	4071	9.86	314	9.52	3757	9.89
8	2367	5.73	232	7.03	2135	5.62
9	1957	4.74	164	4.97	1793	4.72
10	1519	3.68	152	4.61	1367	3.60
11	1176	2.85	124	3.76	1052	2.77
12	892	2.16	85	2.58	807	2.12
13	610	1.48	72	2.18	538	1.42
14	625	1.51	61	1.85	564	1.48
15	272	0.66	35	1.06	237	0.62
16	196	0.47	39	1.18	157	0.41
17	131	0.32	24	0.73	107	0.28
18	99	0.24	13	0.39	86	0.23
19	79	0.19	13	0.39	66	0.17
20	40	0.10	12	0.36	28	0.07
21	223	0.54	24	0.73	199	0.52

SSB = sugar-sweetened beverage

[a] A composite score, ranging from 0-21, representing the sum of participants' weekly rate of consuming the three distinct SSB categories.

Table 25: Self-reported number of days in a typical school week participants reported SSB consumption within a sample of secondary school students participating in Year 2 of the COMPASS study from Alberta (n=3300) and Ontario (n=37999), Canada.

	Total		**Alberta**		**Ontario**	
	n	%	n	%	n	%
Soft drinks						
0 days	14058	34.04	948	28.73	13110	34.50
1 day	7881	19.08	616	18.67	7265	19.12
2 days	6870	16.63	578	17.52	6292	16.56
3 days	4934	11.95	465	14.09	4469	11.76
4 days	2252	5.45	225	6.82	2027	5.33
5 days	5304	12.84	468	14.18	4836	12.73
Sweetened coffees/teas						
0 days	20006	48.44	1435	43.48	18571	48.87
1 day	6040	14.63	531	16.09	5509	14.5
2 days	4879	11.81	441	13.36	4438	11.68
3 days	3829	9.27	348	10.55	3481	9.16
4 days	2029	4.91	170	5.15	1859	4.89
5 days	4516	10.93	375	11.36	4141	10.9
Energy drinks						
0 days	35291	85.45	2454	74.36	32837	86.42
1 day	2976	7.21	368	11.15	2608	6.86
2 days	1246	3.02	186	5.64	1060	2.79
3 days	718	1.74	108	3.27	610	1.61
4 days	322	0.78	65	1.97	257	0.68
5 days	746	1.81	119	3.61	627	1.65
Composite SSB score [a]						
0	7901	19.13	507	15.36	7394	19.46
1	5090	12.32	340	10.3	4750	12.50
2	5535	13.40	408	12.36	5127	13.49
3	4880	11.82	396	12.00	4484	11.8
4	3728	9.03	325	9.85	3403	8.96
5	5446	13.19	405	12.27	5041	13.27
6	2699	6.54	252	7.64	2447	6.44
7	1955	4.73	179	5.42	1776	4.67
8	1420	3.44	149	4.52	1271	3.34
9	806	1.95	102	3.09	704	1.85
10	898	2.17	92	2.79	806	2.12
11	279	0.68	37	1.12	242	0.64

12	191	0.46	34	1.03	157	0.41
13	111	0.27	20	0.61	91	0.24
14	47	0.11	11	0.33	36	0.09
15	313	0.76	43	1.30	270	0.71

SSB = sugar-sweetened beverage

[a] A composite score, ranging from 0-15, representing the sum of participants' weekday rate of consuming the three distinct SSB categories.

Table 26: Self-reported number of days in a typical weekend participants reported SSB consumption within a sample of secondary school students participating in Year 2 of the COMPASS study from Alberta (n=3300) and Ontario (n=37999), Canada.

	Total		**Alberta**		**Ontario**	
	n	%	n	%	n	%
Soft drinks						
0 days	13654	33.06	1092	33.09	12562	33.06
1 day	15951	38.62	1235	37.42	14716	38.73
2 days	11694	28.32	973	29.48	10721	28.21
Sweetened coffees/teas						
0 days	22416	54.28	1721	52.15	20695	54.46
1 day	10772	26.08	896	27.15	9876	25.99
2 days	8111	19.64	683	20.7	7428	19.55
Energy drinks						
0 days	36700	88.86	2715	82.27	33985	89.44
1 day	3120	7.55	388	11.76	2732	7.19
2 days	1479	3.58	197	5.97	1282	3.37
Composite SSB score [a]						
0	8252	19.98	664	20.12	7588	19.97
1	10695	25.90	762	23.09	9933	26.14
2	11855	28.71	872	26.42	10983	28.90
3	6017	14.57	540	16.36	5477	14.41
4	3114	7.54	289	8.76	2825	7.43
5	697	1.69	95	2.88	602	1.58
6	669	1.62	78	2.36	591	1.56

SSB = sugar-sweetened beverage

[a] A composite score, ranging from 0-6, representing the sum of participants' weekend rate of consuming the three distinct SSB categories.

Table 27 shows the results of the unconditional means models with no variables and a random intercept term (i.e., null models). The school-level variance terms were used to calculate the intra-class correlation, which represents the proportion of the total variance in the SSB-related outcome that is due to differences across schools. The table demonstrates that school-level differences account for a modest, but statistically significant, proportion of the variability in participants' weekly SSB consumption measures when controlling for individual-level variance.

Table 27: School-level variance and intra-class correlation for each weekly SSB consumption-related outcome, derived from null models.

Outcome variable	School-level variance	p value	Intra-class correlation
	Estimate (SE)		
Weekly freq. of consuming soft drinks [a]	0.097 (0.017)	<.001	1.86%
Weekly freq. of consuming sweetened coffees/teas [a]	0.047 (0.009)	<.001	0.84%
Weekly freq. of consuming energy drinks [a]	0.031 (0.005)	<.001	1.92%
Weekly composite SSB score [b]	0.261 (0.047)	<.001	1.57%

SSB, sugar-sweetened beverage
[a] Number of days in a typical week.
[b] A composite score, ranging from 0-21, representing the sum of participants' weekly rates of consuming the three distinct SSB categories.

Table 28 shows the VIFs of the food purchasing behaviour variables examined in Chapter 3. These VIFs were generated to assess risk of collinearity between the covariates.

Collinearity (also referred to as multicollinearity) exists when two or more covariates within a model are moderately or highly correlated. Collinearity is problematic because it artificially inflates the variance of regression coefficients, making the model estimates unreliable. VIFs measure how much the variance of the estimated regression coefficients are inflated as compared to when the predictor variables are not correlated. While there are no formal criteria for deciding if a VIF is large enough to affect predicted values, it is generally accepted that VIFs exceeding 4 warrant further investigation, while VIFs exceeding 10 are signs of serious collinearity. A VIF of 1 suggests that the covariates are not correlated.

Since the VIFs are all above 1 but less than 4, it demonstrates that the covariates are mildly correlated, but not to the extent that collinearity is a major concern.

Table 28: Assessing risk of collinearity across weekday and weekend food purchasing variables.

Explanatory variable	VIF
Weekday behaviours	
Freq. of eating home-packed lunch at school	1.30
Freq. of purchasing lunch from the school cafeteria	1.27
Freq. of purchasing snacks from school vending machines	1.25
Freq. of purchasing lunch in fast food places/restaurants	1.33
Freq. of purchasing snacks from convenience food outlet off-school property	1.35
Weekend behaviours	
Freq. of purchasing food from fast food places/restaurants	1.15
Freq. of purchasing snacks from convenience food outlets	1.21

Table 29 shows the models generated during the first strategy used to assess the effect of province on associations between SSB consumption outcome variables and food purchasing behaviours: stratification by province. As such, the table shows the parameter estimates for eight different models (four outcomes*two provinces). The parameter estimates appear quite comparable within the same SSB outcome measure between Alberta and Ontario models, particularly those corresponding to the weekday food purchasing behaviours, suggesting that stratification was uninformative. Following these models, the analysis proceeded to the next strategy of including 'province' as a main effect (Table 8).

Table 29: Stratified models demonstrating food purchasing behaviour-related correlates of weekly SSB consumption among secondary school students participating in the COMPASS study in Alberta (n=3300) and Ontario (n= 37999), Canada.

	Weekly SSB consumption[1] Adjusted rate[2] (95% CI)							
	Composite SSB score[3]		Soft drinks		Sweetened coffees/teas		Energy drinks	
	Alberta	Ontario	Alberta	Ontario	Alberta	Ontario	Alberta	Ontario
Weekday food purchasing behaviours[4]								
Freq. of eating lunch at school packed from home	0.97 (0.96-0.99) ***	0.98 (0.97-0.98) ***	0.98 (0.97-1.00) *	0.99 (0.99-1.00) *	0.99 (0.96-1.01)	0.98 (0.97-0.99) ***	0.89 (0.86-0.91) ***	0.91 (0.90-0.92) ***
Freq. of purchasing lunch in the school cafeteria	1.04 (1.02-1.05) ***	1.03 (1.02-1.03) ***	1.05 (1.04-1.06) ***	1.03 (1.02-1.04) ***	1.02 (1.00-1.04) *	1.02 (1.01-1.04) ***	1.05 (0.98-1.12)	1.02 (1.01-1.03) **
Freq. of purchasing lunch in a fast food place or restaurant	1.07 (1.05-1.09) ***	1.07 (1.07-1.08) ***	1.06 (1.05-1.09) ***	1.08 (1.07-1.08) ***	1.08 (1.05-1.11) ***	1.06 (1.05-1.07) ***	1.07 (1.02-1.12) **	1.08 (1.06-1.10) ***
Freq. of purchasing snacks from a vending machine in school	1.06 (1.03-1.08) ***	1.04 (1.03-1.05) ***	1.04 (1.00-1.08)	1.00 (0.99-1.02)	1.04 (1.02-1.06) ***	1.05 (1.03-1.06) ***	1.14 (1.07-1.22) ***	1.13 (1.11-1.15) ***
Freq. of purchasing snacks from a convenience food outlet off-school property	1.07 (1.04-1.10) ***	1.08 (1.07-1.09) ***	1.05 (1.03-1.07) ***	1.07 (1.06-1.08) ***	1.05 (1.00-1.09) *	1.06 (1.05-1.07) ***	1.16 (1.10-1.22) ***	1.14 (1.12-1.16) ***
Weekend food purchasing behaviours[5]								
Freq. of purchasing food from a fast food place or restaurant	1.16 (1.11-1.21) ***	1.17 (1.15-1.18) ***	1.19 (1.15-1.23) ***	1.19 (1.18-1.21) ***	1.11 (1.01-1.21) *	1.11 (1.09-1.13) ***	1.18 (1.07-1.31) **	1.22 (1.19-1.26) ***
Freq. of purchasing snacks from a convenience food outlet	1.13 (1.10-1.16) ***	1.13 (1.12-1.15) ***	1.06 (1.02-1.11) **	1.11 (1.10-1.13) ***	1.10 (1.05-1.15) ***	1.08 (1.05-1.10) ***	1.39 (1.27-1.52) ***	1.33 (1.28-1.37) ***

[1]Number of days participants report consuming SSBs in a typical week (Monday-Sunday, 0-7 days).
[2]Rates adjusted for all other variables in the column, in addition to gender, grade, ethnicity, weekly spending money, weight status, and weight goal.
[3]A composite score, ranging from 0-21, representing the sum of participants' weekly rates of consuming the three distinct SSB categories.
[4]Number of days in a typical school week (Monday-Friday, 0-5 days).
[5]Number of days in a typical weekend (Saturday-Sunday, 0-2 days).
* $P < .05$, ** $P < .01$, *** $P < .001$
--- denotes no significant effect in model(

Table 30 demonstrates the 28 interaction effects tested in the third strategy to assess the effect of province on associations between SSB consumption outcome variables and food purchasing behaviours. Only one effect (starred) is significant at $P < .05$, though four other effects (bolded) within the soft drinks model were significant at $P < .10$, and consistently suggested that the association between the food purchasing behaviour and frequency of soft drink consumption was more pronounced among students from Alberta.

Table 30: Interaction effects tested between province and food purchasing behaviours as correlates of weekly SSB consumption among secondary school students (n=41299) from Alberta and Ontario, Canada, participating in Year 2 of the COMPASS study.

	Weekly sugar-sweetened beverage consumption [a] Adjusted rate [b] (95% CI)			
	Composite SSB score [c]	Soft drinks	Sweetened coffees/teas	Energy drinks
Weekday food purchasing behaviours [d]				
Freq. of eating home-packed lunch at school * province				
Ontario	1.00	**1.00**	1.00	1.00
Alberta	0.99 (0.98-1.01)	**0.99 (0.97-1.00)**	1.01 (0.99-1.04)	0.99 (0.97-1.02)
Freq. of purchasing lunch in the school cafeteria * province				
Ontario	1.00	1.00	1.00	1.00
Alberta	1.01 (1.00-1.03)	1.02 (1.01-1.04) **	1.00 (0.98-1.02)	1.01 (0.97-1.07)
Freq. of purchasing snacks from a school vending machine * province				
Ontario	1.00	**1.00**	1.00	1.00
Alberta	1.01 (0.99-1.04)	**1.04 (1.00-1.08)**	1.00 (0.97-1.02)	0.99 (0.94-1.04)
Freq. of purchasing lunch in fast food places/restaurants * province				
Ontario	1.00	1.00	1.00	1.00
Alberta	1.00 (0.98-1.02)	0.99 (0.97-1.01)	1.01 (0.98-1.04)	0.98 (0.95-1.02)
Freq. of purchasing snacks from convenience food outlets off-school property * province				
Ontario	1.00	**1.00**	1.00	1.00
Alberta	0.99 (0.96-1.02)	**0.98 (0.96-1.00)**	0.99 (0.94-1.04)	0.99 (0.95-1.03)
Weekend food purchasing behaviours [e]				
Freq. of purchasing food from fast food places/restaurants * province				
Ontario	1.00	1.00	1.00	1.00
Alberta	0.99 (0.95-1.04)	1.00 (0.97-1.03)	1.00 (0.92-1.09)	0.94 (0.86-1.01)
Freq. of purchasing snacks from convenience food outlets * province				
Ontario	1.00	**1.00**	1.00	1.00
Alberta	0.99 (0.96-1.03)	**0.96 (0.91-1.00)**	1.01 (0.96-1.07)	0.99 (0.91-1.08)

Bolded valued $P < .10$, *$P < .05$, ** $P < .01$, *** $P < .001$

[a] Number of days participants reported consuming SSBs in a typical week (Mon.-Sun., 0-7 days).

[b] Rates adjusted for all other variables in the column, in addition to gender, grade, province, ethnicity, weekly spending money, weight status, truancy, weight goal, province, and the main effects for each of the food purchasing behaviours.

[c] A composite score, ranging from 0-21, representing the sum of participants' weekly rates of consuming the three distinct SSB categories.

[d] Number of days in a typical school week (Mon.-Fri., 0-5 days).

[e] Number of days in a typical weekend (Sat.-Sun., 0-2 days).

Appendix F

Chapter 4 Supplementary Material

This appendix includes supplementary material from the second manuscript in this dissertation: *Examining associations between school food environment characteristics and sugar-sweetened beverage consumption among Canadian secondary school students in the COMPASS study*.

Table 31 shows the VIFs of the school food environment variables examined in Chapter 4. These VIFs were generated to assess risk of collinearity between the covariates. Since the VIFs are all above 1 but less than 3, it demonstrates that the covariates are mildly correlated, but not to the extent that collinearity is a major concern.

Table 31: Assessing risk of collinearity across measures of school food environment characteristics.

Explanatory variable	VIF
Accessibility of water fountains	1.10
Availability of soft drinks in beverage vending machines	1.56
Availability of sweetened coffees/teas in beverage vending machines	1.42
Access to restaurants within 1-km buffer of school	1.79
Access to variety stores within 1-km buffer of school	1.51
Access to food stores within 1-km buffer of school	2.51

Tables 32-34 show the block-wise modelling process as applied to weekday soft drink, sweetened coffee/tea, and energy drink consumption.

Table 32: Block-wise modelling process to assess student- and school-level correlates of participants' weekday soft drink consumption (n= 41829).[a]

Characteristics	Student-level control variables	Student-level control + school beverage availability variables	Student-level control + school beverage availability + school neighbourhood variables	Student-level control + school beverage availability + school neighbourhood food outlets + school-level control variables
	Adjusted rate [b] (95% CI)	Adjusted rate [b] (95% CI)	Adjusted rate [b] (95% CI)	Adjusted rate [b] (95% CI)
Student-level control				
Gender				
Female	1.00	1.00	1.00	1.00
Male	0.78 (0.75-0.81) ***	0.78 (0.75-0.81) ***	0.78 (0.75-0.81) ***	0.78 (0.75-0.81) ***
Grade				
9	1.00	1.00	1.00	1.00
10	1.08 (1.04-1.11) ***	1.08 (1.04-1.11) ***	1.08 (1.04-1.11) ***	1.08 (1.04-1.11) ***
11	1.12 (1.07-1.16) ***	1.12 (1.07-1.16) ***	1.12 (1.07-1.16) ***	1.12 (1.07-1.16) ***
12	1.17 (1.12-1.23) ***	1.17 (1.12-1.23) ***	1.17 (1.12-1.23) ***	1.17 (1.12-1.23) **
Ethnicity				
White	1.00	1.00	1.00	1.00
Aboriginal	1.13 (1.05-1.21) ***	1.13 (1.05-1.21) ***	1.13 (1.05-1.21) ***	1.13 (1.05-1.22) ***
Asian	0.91 (0.84-0.98) *	0.91 (0.84-0.98) *	0.91 (0.84-0.98) *	0.90 (0.84-0.97) **
Black	1.13 (1.05-1.21) ***	1.13 (1.05-1.21) ***	1.13 (1.05-1.21) ***	1.13 (1.05-1.20) ***
Latin	1.02 (0.96-1.09)	1.02 (0.96-1.09)	1.02 (0.96-1.09)	1.02 (0.95-1.09)
Other	1.11 (1.07-1.16) ***	1.11 (1.07-1.16) ***	1.11 (1.07-1.16) ***	1.11 (1.06-1.15) ***
Weekly spending money				
$0	1.00	1.00	1.00	1.00
$1-$20	1.15 (1.10-1.21) ***	1.15 (1.10-1.21) ***	1.15 (1.10-1.21) ***	1.15 (1.10-1.21) ***
$21-$100	1.26 (1.20-1.31) ***	1.26 (1.20-1.31) ***	1.26 (1.20-1.31) ***	1.26 (1.20-1.31) ***
>$100	1.37 (1.30-1.43) ***	1.37 (1.30-1.43) ***	1.37 (1.30-1.43) ***	1.37 (1.31-1.43) ***
I don't know	1.13 (1.08-1.19) ***	1.13 (1.08-1.19) ***	1.13 (1.08-1.19) ***	1.13 (1.08-1.19) ***
Weight status				
Healthy weight	1.00	1.00	1.00	1.00
Underweight	1.02 (0.93-1.13)	1.02 (0.93-1.13)	1.02 (0.93-1.13)	1.02 (0.93-1.13)
Overweight	0.98 (0.95-1.01)	0.98 (0.95-1.01)	0.98 (0.95-1.01)	0.98 (0.95-1.02)
Obese	1.04 (0.99-1.10)	1.04 (0.99-1.10)	1.04 (0.99-1.10)	1.04 (0.99-1.10)
Missing	1.03 (1.00-1.06)	1.03 (1.00-1.06)	1.03 (1.00-1.06)	1.03 (1.00-1.06)
Truancy				

Skipped 0 classes in last four weeks	1.00	1.00	1.00	1.00
Skipped 1+ classes in last four weeks	1.30 (1.26-1.34) ***	1.30 (1.26-1.34) ***	1.30 (1.26-1.34) ***	1.30 (1.26-1.34) ***
Weight goal				
Not trying to do anything about weight	1.00	1.00	1.00	1.00
Gain weight	1.04 (1.00-1.09)	1.04 (1.00-1.09)	1.04 (1.00-1.09)	1.04 (1.00-1.09)
Lose weight	1.05 (1.01-1.08) **	1.05 (1.01-1.08) **	1.05 (1.01-1.08) **	1.05 (1.01-1.08) **
Stay the same weight	0.99 (0.95-1.03)	0.99 (0.95-1.03)	0.99 (0.95-1.03)	0.99 (0.95-1.03)
School-level control				
School type				
Public				1.00
Private				1.01 (0.92-1.11)
Location				
Rural or small population centre				1.00
Medium urban population centre				0.97 (0.91-1.03)
Large urban population centre				1.02 (0.97-1.07)
Neighbourhood median income				
$25000 - 50000				1.00
$50001-75000				0.93 (0.84-1.04)
$75000 +				0.95 (0.85-1.06)

[a] Table omits variables that were not significantly associated with outcome in prior univariate analyses, therefore not included in joint model; columns reflect the model after a given block of variables had been added (i.e., before those lacking significance at P <.2 were removed).
[b] Rates represents the exponentiated beta coefficients; rates adjusted for all other variables in the column.
*P <.05, ** P <.01, *** P <.001
--- Variable excluded to create a more parsimonious model, since it lacked significance at P <.2 level.

Table 33: Block-wise modelling process to assess student- and school-level correlates of participants' weekday sweetened coffee/tea consumption (n= 41829).[a]

Characteristics	Student-level control variables	Student-level control + school beverage availability variables	Student-level control + school beverage availability + school neighbourhood variables	Student-level control + school beverage availability + school neighbourhood food outlets + school-level control variables
	Adjusted rate [b] (95% CI)	Adjusted rate [b] (95% CI)	Adjusted rate [b] (95% CI)	Adjusted rate [b] (95% CI)
Student-level control				
Gender				
Female	1.00	1.00	1.00	1.00
Male	0.78 (0.75-0.81) ***	0.78 (0.75-0.81) ***	0.78 (0.75-0.81) ***	0.78 (0.75-0.81) ***
Grade				
9	1.00	1.00	1.00	1.00
10	1.08 (1.04-1.11) ***	1.08 (1.04-1.11) ***	1.08 (1.04-1.11) ***	1.08 (1.04-1.11) ***
11	1.12 (1.07-1.16) ***	1.12 (1.07-1.16) ***	1.12 (1.07-1.16) ***	1.12 (1.07-1.16) ***
12	1.17 (1.12-1.23) ***	1.17 (1.12-1.23) ***	1.17 (1.12-1.23) ***	1.17 (1.12-1.23) ***
Ethnicity				
White	1.00	1.00	1.00	1.00
Aboriginal	1.13 (1.05-1.21) **	1.13 (1.05-1.21) **	1.13 (1.05-1.21) **	1.13 (1.05-1.21) ***
Asian	0.91 (0.84-0.98) *	0.91 (0.84-0.98) *	0.91 (0.84-0.98) *	0.90 (0.84-0.97) **
Black	1.13 (1.05-1.21) ***	1.13 (1.05-1.21) ***	1.13 (1.05-1.21) ***	1.12 (1.05-1.20) ***
Latin	1.02 (0.96-1.09)	1.02 (0.96-1.09)	1.02 (0.96-1.09)	1.02 (0.95-1.09)
Other	1.11 (1.07-1.16) ***	1.11 (1.07-1.16) ***	1.11 (1.07-1.16) ***	1.11 (1.06-1.16) ***
Weekly spending money				
$0	1.00	1.00	1.00	1.00
$1-$20	1.15 (1.10-1.21) ***	1.15 (1.10-1.21) ***	1.15 (1.10-1.21) ***	1.15 (1.10-1.21) ***
$21-$100	1.26 (1.20-1.31 ***	1.26 (1.20-1.31 ***	1.26 (1.20-1.31 ***	1.26 (1.20-1.31 ***
>$100	1.37 (1.30-1.43) ***	1.37 (1.30-1.43) ***	1.37 (1.30-1.43) ***	1.37 (1.31-1.43) ***
I don't know	1.13 (1.08-1.19) ***	1.13 (1.08-1.19) ***	1.13 (1.08-1.19) ***	1.13 (1.08-1.19) ***
Weight status				
Healthy weight	1.00	1.00	1.00	1.00
Underweight	1.02 (0.93-1.13)	1.02 (0.93-1.13)	1.02 (0.93-1.13)	1.02 (0.93-1.13)
Overweight	0.98 (0.95-1.01)	0.98 (0.95-1.01)	0.98 (0.95-1.01)	0.98 (0.95-1.02)
Obese	1.04 (0.99-1.10)	1.04 (0.99-1.10)	1.04 (0.99-1.10)	1.04 (0.99-1.10)
Missing	1.03 (1.00-1.06)	1.03 (1.00-1.06)	1.03 (1.00-1.06)	1.03 (1.00-1.06)
Truancy				
Skipped 0 classes in last four weeks	1.00	1.00	1.00	1.00

Skipped 1+ classes in last four weeks	1.30 (1.26-1.34) ***	1.30 (1.26-1.34) ***	1.30 (1.26-1.34) ***	1.30 (1.26-1.34) ***
Weight goal				
Not trying to do anything about weight	1.00	1.00	1.00	1.00
Gain weight	1.04 (1.00-1.09)	1.04 (1.00-1.09)	1.04 (1.00-1.09)	1.04 (1.00-1.09)
Lose weight	1.05 (1.01-1.08) **	1.05 (1.01-1.08) **	1.05 (1.02-1.08) **	1.05 (1.01-1.08) **
Stay the same weight	0.99 (0.95-1.03)	0.99 (0.95-1.03)	0.99 (0.95-1.03)	0.99 (0.95-1.03)
School neighbourhood				
Access to restaurants within 1-km buffer of school				
No			1.00	1.04 (0.99-1.08)
Yes			1.02 (0.94-1.11)	
Access to food store within 1-km buffer of school				
No			1.00	---
Yes			1.02 (0.94-1.10)	----
School-level control				
School type				
Public				1.00
Private				1.01 (0.93-1.10)
Location				
Rural or small population centre				1.00
Medium urban population centre				0.96 (0.90-1.02)
Large urban population centre				1.02 (0.97-1.07)
Neighbourhood median income				
$25000 - 50000				1.00
$50001-75000				0.93 (0.84-1.04)
$75000 +				0.95 (0.85-1.06)

[a] Table omits variables that were not significantly associated with outcome in prior univariate analyses, therefore not included in joint model; columns reflect the model after a given block of variables had been added (i.e., before those lacking significance at P <.2 were removed).
[b] Rates represents the exponentiated beta coefficients; rates adjusted for all other variables in the column.
*P <.05, ** P <.01, *** P <.001
--- Variable excluded to create a more parsimonious model, since it lacked significance at P <.2 level.

Table 34: Block-wise modelling process to assess student- and school-level correlates of participants' weekday energy drink consumption (n= 41829).[a]

Characteristics	Student-level control variables	Student-level control + school beverage availability variables	Student-level control + school beverage availability + school neighbourhood variables	Student-level control + school beverage availability + school neighbourhood food outlets + school-level control variables
	Adjusted rate [b] (95% CI)	Adjusted rate [b] (95% CI)	Adjusted rate [b] (95% CI)	Adjusted rate [b] (95% CI)
Student-level control				
Gender				
Female	1.00	1.00	1.00	1.00
Male	1.98 (1.85-2.11) ***	1.98 (1.86-2.11) ***	1.98 (1.86-2.11) ***	2.00 (1.87-2.14) ***
Grade				
9	1.00	1.00	1.00	1.00
10	0.86 (0.79-0.94) ***	0.86 (0.79-0.93) ***	0.86 (0.79-0.93) ***	0.86 (0.79-0.94) ***
11	0.75 (0.69-0.83) ***	0.75 (0.69-0.82) ***	0.75 (0.69-0.82) ***	0.75 (0.68-0.83) ***
12	0.63 (0.57-0.68) ***	0.62 (0.57-0.68) ***	0.62 (0.57-0.68) ***	0.63 (0.57-0.69) ***
Ethnicity				
White	1.00	1.00	1.00	1.00
Aboriginal	1.63 (1.42-1.86) ***	1.62 (1.42-1.84) ***	1.61 (1.41-1.84) ***	1.57 (1.38-1.80) ***
Asian	1.02 (0.87-1.19)	1.01 (0.86-1.17)	1.01 (0.87-1.18)	1.02 (0.87-1.21)
Black	1.69 (1.47-1.93) ***	1.68 (1.47-1.92) ***	1.69 (1.48-1.94) ***	1.75 (1.52-2.01) ***
Latin	0.96 (0.79-1.17)	0.96 (0.78-1.17)	0.96 (0.78-1.18)	0.98 (0.78-1.22)
Other	1.37 (1.28-1.46) ***	1.36 (1.28-1.46) ***	1.37 (1.28-1.46) ***	1.39 (1.30-1.49) ***
Weekly spending money				
$0	1.00	1.00	1.00	1.00
$1-$20	1.17 (1.05-1.29) **	1.17 (1.05-1.30) **	1.17 (1.05-1.30) **	1.17 (1.05-1.31) **
$21-$100	1.43 (1.27-1.61) ***	1.43 (1.27-1.61) ***	1.43 (1.27-1.61) ***	1.44 (1.27-1.63) ***
>$100	1.91 (1.69-2.16) ***	1.91 (1.69-2.16) ***	1.91 (1.69-2.15) ***	1.90 (1.68-2.16) ***
I don't know	1.21 (1.07-1.37) **	1.21 (1.07-1.37) **	1.21 (1.07-1.37) **	1.22 (1.07-1.39) **
Weight status				
Healthy weight	1.00	1.00	1.00	1.00
Underweight	1.18 (0.95-1.47)	1.18 (0.94-1.46)	1.17 (0.94-1.46)	1.17 (0.93-1.48)
Overweight	1.10 (1.00-1.21) *	1.11 (1.00-1.22) *	1.11 (1.00-1.22) *	1.11 (1.00-1.22) *
Obese	1.45 (1.33-1.59) ***	1.46 (1.33-1.60) ***	1.46 (1.33-1.60) ***	1.47 (1.33-1.61) ***
Missing	1.61 (1.49-1.74) ***	1.61 (1.49-1.75) ***	1.61 (1.49-1.75) ***	1.62 (1.50-1.76) ***
Truancy				

Skipped 0 classes in last four weeks	1.00	1.00	1.00	1.00
Skipped 1+ classes in last four weeks	2.51 (2.34-2.68) ***	2.51 (2.35-2.69) ***	2.51 (2.35-2.69) ***	2.53 (2.36-2.71) ***
Weight goal				
Not trying to do anything about weight	1.00	1.00	1.00	1.00
Gain weight	1.12 (1.03-1.22) **	1.12 (1.03-1.22) **	1.12 (1.03-1.22) **	1.14 (1.04-1.24) **
Lose weight	1.06 (0.99-1.14)	1.06 (0.99-1.14)	1.06 (0.99-1.14)	1.07 (0.99-1.15)
Stay the same weight	0.99 (0.90-1.08)	0.99 (0.90-1.08)	0.99 (0.90-1.08)	0.99 (0.90-1.09)
School beverage availability				
Availability of soft drinks in school vending machines				
Unavailable		1.00	---	---
Available		1.03 (0.90-1.18)	---	---
Availability of sweetened coffees and teas in school vending machines				
Unavailable		1.00	1.00	1.00
Available		1.20 (1.02-1.43) *	1.20 (1.04-1.39) *	1.27 (1.10-1.46) **
School neighbourhood				
Access to restaurants within 1-km buffer of school				
No			1.00	1.00
Yes			1.14 (0.96-1.36)	1.10 (0.95-1.28)
Access to variety stores within 1-km buffer of school				
No			1.00	1.00
Yes			0.89 (0.78-1.02)	0.98 (0.86-1.11)
School-level control				
School type				
Public				1.00
Private				0.84 (0.64-1.10)
Location				
Rural or small population centre				1.00
Medium urban population centre				0.82 (0.71-0.94) **
Large urban population centre				0.74 (0.66-0.84) ***
Neighbourhood median income				
$25000 - 50000				1.00
$50001-75000				0.98 (0.83-1.16)
$75000 +				0.91 (0.75-1.10)

[a] Table omits variables that were not significantly associated with outcome in prior univariate analyses, therefore not included in joint model; columns reflect the model after a given block of variables had been added (i.e., before those lacking significance at P <.2 were removed).
[b] Rates represents the exponentiated beta coefficients; rates adjusted for all other variables in the column.
*P <.05, ** P <.01, *** P <.001
--- Variable excluded to create a more parsimonious model, since it lacked significance at P <.2 level.

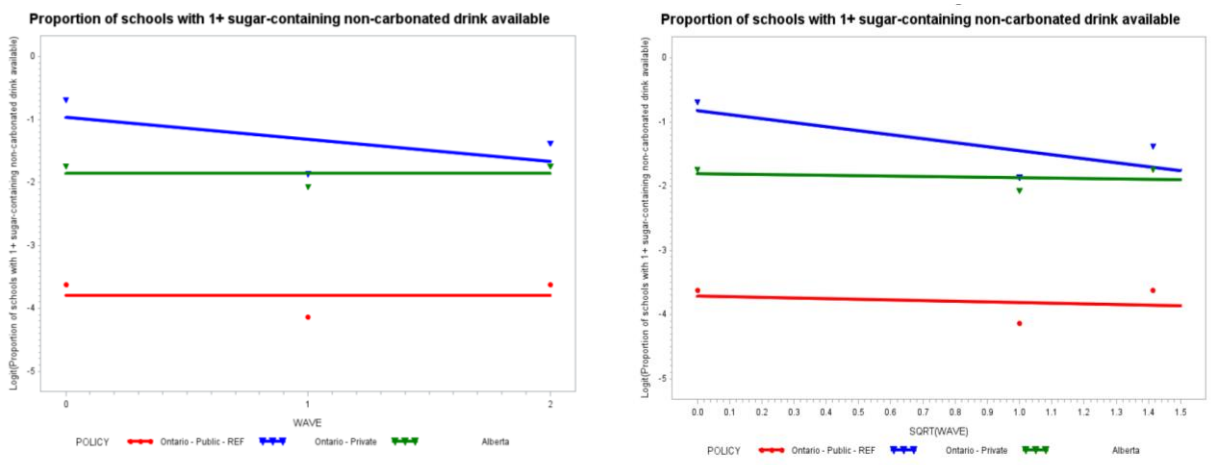
Appendix G

Chapter 5 Supplementary Material

This appendix includes supplementary material from the third manuscript in this dissertation: *Examining changes in school vending machine beverage availability and sugar-sweetened beverage intake among Canadian adolescents participating in the COMPASS study: A longitudinal assessment of provincial school nutrition policy compliance and effectiveness*.

Exploratory data analysis was used to determine the most appropriate measure of time to include as a covariate within models of vending machine beverage availability (Figure 7) and participants' SSB consumption (Figure 8). The options considered included 'wave' (i.e., 0,1, and 2), 'square-root of wave', and 'wave squared'. As shown in Figures 7 and 8, the various measures of time demonstrated a comparable association with the outcome. Thus, 'wave' was selected as the measure of time to include across all longitudinal models, since its interpretation is most straight-forward and it appears to be a good fit for the data.

Figure 7: Exploratory data analysis to assess most appropriate measure of time (i.e., between 'wave', 'square-root of wave', and 'wave squared') for models of vending machine beverage availability.



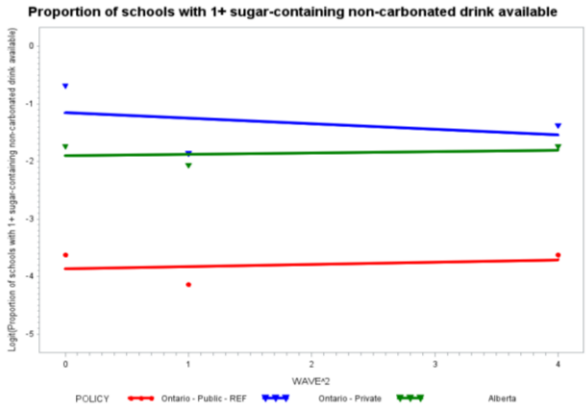
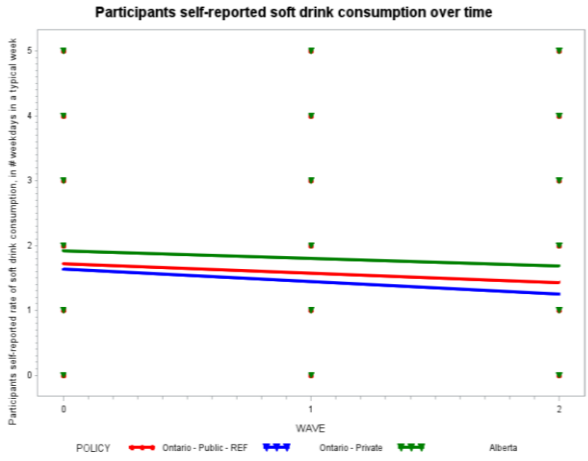
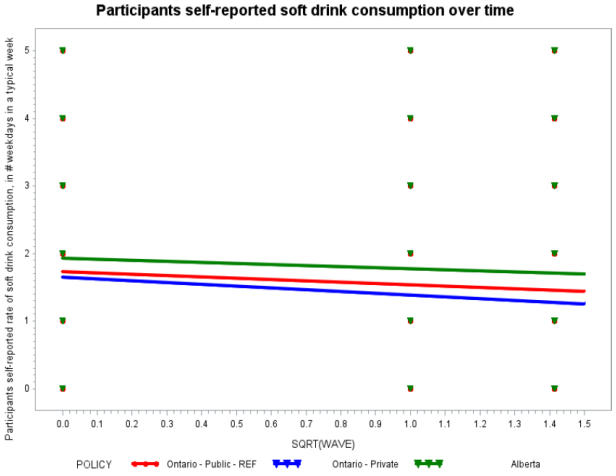


Figure 8: Exploratory data analysis to assess most appropriate measure of time (i.e., between 'wave', 'square-root of wave', and 'wave squared') for models of participants' SSB consumption measures.





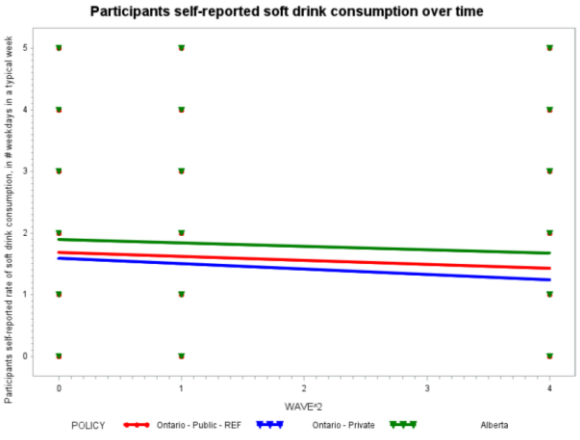


Figure 9 demonstrates changes in the numbers of days in a typical school week (Monday-Friday) in which participants reported consuming soft drinks, sweetened coffees/teas, and energy drinks over Wave 1 (2013/4), Wave 2 (2014/5), and Wave 3 (2015/6). Changes of interest include the increasing proportion of participants reporting no use of soft drinks over time (from 33.0% in Wave 1 to 38.0% in Wave 2 to 41.1% in Wave 3) and the decreasing proportion of participants reporting no use of sweetened coffees/teas over time (from 53.9% in Wave 1 to 51.5% in Wave 2 to 46.8% in Wave 3). Changes in energy drink consumption over time were less dramatic.

Recall that three series of multivariate model for each of the four SSB consumption-related variables within this chapter. The first series of models included the vending machine beverage availability variables that were retained following the univariate screening stage, in addition to the student- and school-level control variables. The model results are shown in Table 35. The second series included the policy group effect and the student- and school-level control variables. The model results are shown in Table 36. Finally, the third series contained both the beverage availability variables and policy group, plus controls. These model results were presented in Chapter 5 (Table 20).

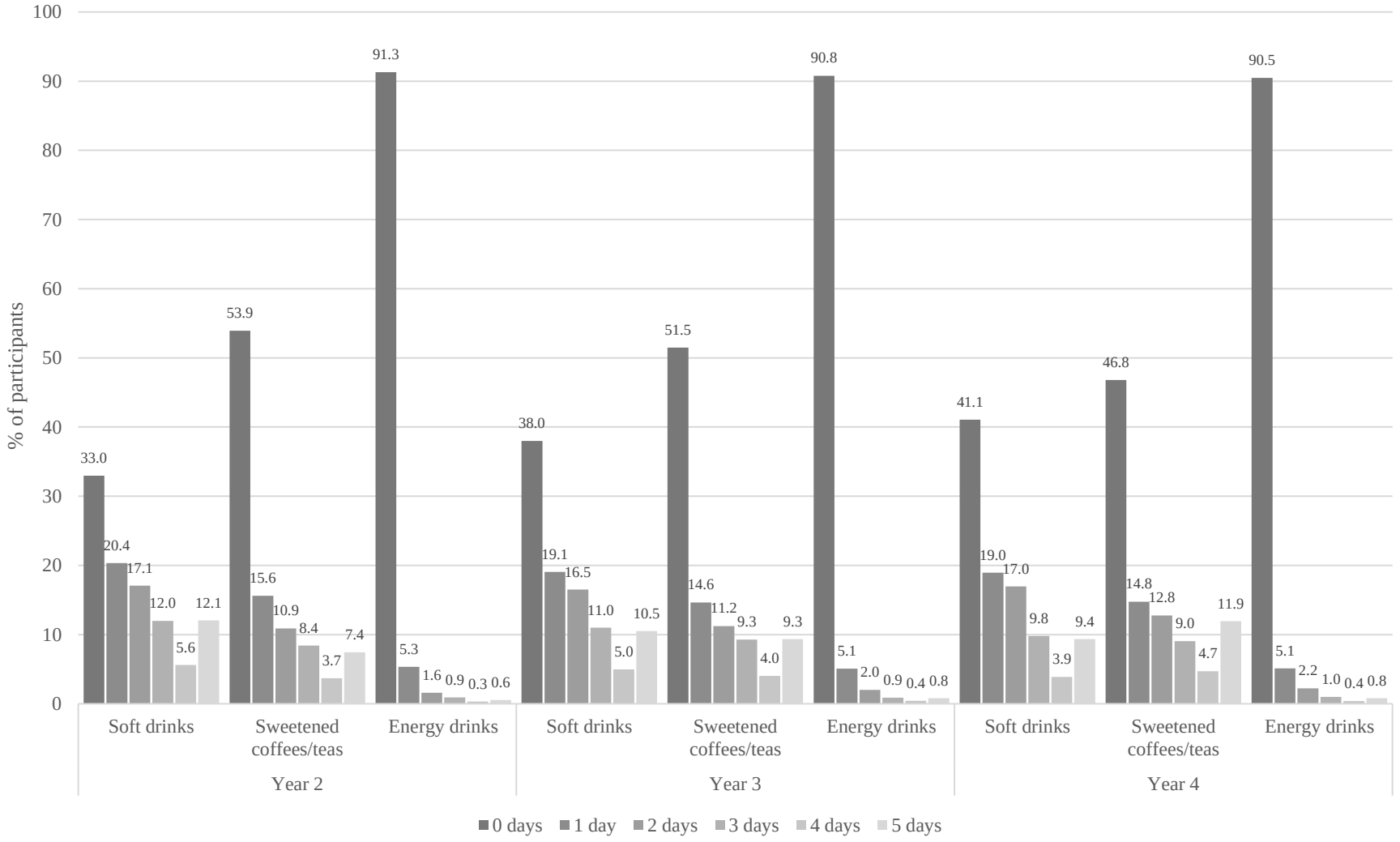


Figure 9: Changes in participants' self-reported numbers of days in a typical school week (Monday-Friday) in which they consume three categories of SSBs within a linked sample of secondary school students (n=7679) from Alberta and Ontario over Wave 1 (2013/14), Wave 2 (2014/15), and Wave 3 (2015/16).

Table 35: Multivariate models describing the associations between weekday consumption of three varieties of SSBs and both vending machine beverage availability variables and wave (i.e., measure of time) among secondary school students (n= 7679) in Alberta and Ontario participating in Waves 1-3 (2013/14-2015/16) of the COMPASS study.

Variable	Weekday SSB consumption [a] Rate [b] (95% CI)			
	Composite SSB score [c]	Soft drink	Sweetened coffees/teas	Energy drinks
Wave	0.96 (0.95-0.98) ***	0.89 (0.88-0.91) ***	1.06 (1.04-1.09) ***	0.90 (0.84-0.96) **
SSBs				
Sugar-containing carbonated soft drinks (e.g., non-diet Coca-Cola, non-diet Sprite, etc.)				
0 drinks available	---	---	---	---
1+ drinks available	---	---	---	---
Sugar-containing non-carbonated soft drinks (e.g., non-diet lemonade, fruit drinks, iced tea, etc.)				
0 drinks available	---	REF	---	---
1+ drinks available	---	0.97 (0.93-1.00)	---	---
Sugar-containing sports drinks (e.g., Gatorade, PowerAde, etc.)				
0 drinks available	REF	---	REF	---
1+ drinks available	0.99 (0.95-1.04)	---	1.03 (0.95-1.11)	---
Flavoured milk (e.g., strawberry, chocolate milk)				
0 drinks available	REF	REF	---	REF
1+ drinks available	1.00 (0.96-1.04)	0.98 (0.94-1.02)	---	0.93 (0.76-1.14)
Non-SSBs				
Diet carbonated soft drinks (e.g., Diet Coke, Coke Zero, Sprite Zero, etc.)				
0 drinks available	---	---	---	---
1+ drinks available	---	---	---	---
Diet non-carbonated soft drinks (e.g., diet lemonade, Vitaminwater Zero, diet iced tea, etc.)				
0 drinks available	---	---	---	REF
1+ drinks available	---	---	---	0.98 (0.85-1.13)
Diet sports drinks (e.g., G2, Powerade Zero, etc.)				
0 drinks available	REF	---	---	---
1+ drinks available	0.98 (0.93-1.03)	---	---	---

Plain white milk				
0 drinks available	REF	---	REF	REF
1+ drinks available	0.99 (0.95-1.03)	---	0.99 (0.95-1.04)	1.00 (0.81-1.23)
100% fruit juice				
0 drinks available	---	---	---	---
1+ drinks available	---	---	---	---
Water				
0 drinks available	REF	REF	---	---
1+ drinks available	1.07 (1.03-1.12) ***	1.08 (1.03-1.13) ***	---	---

SSB, sugar-sweetened beverage

[a] Number of weekdays participants reported consuming SSBs in a typical school week (Mon.-Fri., 0-5 days).

[b] Rates represents the exponentiated beta coefficients; rates adjusted for all other variables in the column, in addition to student- and school-level control variables.

[c] A composite score, ranging from 0-15, representing the sum of participants' weekday rates of consuming the three distinct SSB categories.

--- excluded from model during univariate analyses screening.

*P <.05, **P <.01, ***P <.001

Table 36: Multivariate models describing the associations between weekday consumption of three varieties of SSBs and both policy group and wave (i.e., measure of time) among secondary school students (n= 7679) in Alberta and Ontario participating in Waves 1-3 (2013/14-2015/16) of the COMPASS study.

Variable	Weekday SSB consumption [a] Rate [b] (95% CI)			
	Composite SSB score [c]	Soft drink	Sweetened coffees/teas	Energy drinks
Policy group				
Ontario – Public	REF	REF	REF	REF
Ontario – Private	0.95 (0.89-1.00)	0.91 (0.84-0.98) *	0.98 (0.91-1.07)	1.00 (0.61-1.64)
Alberta	1.11 (1.01-1.21) *	1.08 (0.98-1.20)	1.07 (0.93-1.23)	1.41 (1.09-1.82) **
Wave	0.96 (0.95-0.98) ***	0.89 (0.88-0.91) ***	1.06 (1.04-1.09) ***	0.90 (0.84-0.96) **

SSB, sugar-sweetened beverage

[a] Number of weekdays participants reported consuming SSBs in a typical school week (Mon.-Fri., 0-5 days).

[b] Rates represents the exponentiated beta coefficients; rates adjusted for all other variables in the column, in addition to student- and school-level control variables.

[c] A composite score, ranging from 0-15, representing the sum of participants' weekday rates of consuming the three distinct SSB categories.

*P <.05, **P <.01, ***P <.001.