Promoting Healthy Beverage Consumption Habits Among Elementary School Children: Evaluating the Healthy Kids Community Challenge 'Water Does Wonders' Interventions in London, Ontario

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Abstract

Childhood obesity is a major public health concern and has been attributed to poor diet, among other factors. Sugar-sweetened beverage (SSB) consumption, in particular, has been linked to excess weight gain in childhood, while water consumption is a protective factor. Taking advantage of the Water Does Wonders theme of the Healthy Kids Community Challenge, an initiative by the provincial government to promote water consumption, this thesis uses pre-post surveys of children aged 8-14 years to examine (a) the association between knowledge and beverage consumption habits, and (b) the effectiveness of a school-based education and environment intervention to reduce SSB and/or increase water consumption in elementary school children. Results suggest a significant positive association between knowledge and healthy beverage intake, however no discernable differences in water and SSB consumption or knowledge following the intervention were observed. Future research should explore how best to translate the knowledge-practice link into sustainable behavioural change.

Keywords

children’s health; beverage intake; water; sugar-sweetened beverages; school-based intervention; education program; environmental change; water infrastructure; Healthy Kids Community Challenge
Co-Authorship Statement

The following thesis includes two integrated articles, each of which has been or will be submitted for publication to a peer-reviewed journal. Chapter 4 appears in the exact state in which it was prepared for submission, while Chapter 5 appears in an extended state, and will be condensed prior to submission to an academic journal. Each article has been formatted to AMA citation style for the purpose of this thesis. The co-authorship details of the integrated articles are presented below.

Chapter 4: Irwin, B.R., Speechley, M., and Gilliland, J.A. Assessing the Association Between Water and Nutrition Knowledge and Beverage Consumption Habits in Children. Submitted for publication to an academic journal.

Chapter 4 was written by Bridget Irwin, with Dr. Mark Speechley and Dr. Jason Gilliland as co-authors. Bridget Irwin is the primary author of the article and performed all analyses and writing. She also assisted with the data collection. Dr. Gilliland is the principal investigator and conceived of and designed the HKCC study and developed the data collection procedures. Dr. Speechley and Dr. Gilliland were involved with the development of the analysis procedures and contributed to the editing of the article.


Chapter 5 was written by Bridget Irwin, with Dr. Mark Speechley, Dr. Jason Gilliland, Dr. Piotr Wilk, and Dr. Andrew Clark as co-authors. Bridget Irwin is the primary author of the article and performed all analyses and writing. She also assisted with the data collection. Dr. Gilliland is the principal investigator and conceived of and designed the HKCC study, and both Dr. Gilliland and Dr. Clark developed the data collection procedures. Dr. Speechley, Dr. Gilliland, Dr. Wilk, and Dr. Clark were involved with the development of the analysis procedures and contributed to the editing of the article.
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<th>Description</th>
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<tbody>
<tr>
<td>AIC</td>
<td>Akaike Information Criteria</td>
</tr>
<tr>
<td>ANCOVA</td>
<td>Analysis of Covariance</td>
</tr>
<tr>
<td>ANOVA</td>
<td>Analysis of Variance</td>
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<tr>
<td>CCHS</td>
<td>Canadian Community Health Survey</td>
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<tr>
<td>CDC</td>
<td>Centers for Disease Control and Prevention</td>
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<tr>
<td>COI</td>
<td>Conflict of Interest</td>
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<tr>
<td>CYN</td>
<td>Child and Youth Network</td>
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<tr>
<td>DAG</td>
<td>Directed Acyclic Graph</td>
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<tr>
<td>FCS</td>
<td>Fully Conditional Specification</td>
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<tr>
<td>FFQ</td>
<td>Food Frequency Questionnaire</td>
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<tr>
<td>GC</td>
<td>Growing Chefs!</td>
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<tr>
<td>GEE</td>
<td>Generalized Estimating Equation</td>
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<tr>
<td>GLM</td>
<td>Generalized Linear Model</td>
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<tr>
<td>HEAL</td>
<td>Human Environments Analysis Laboratory</td>
</tr>
<tr>
<td>ITT</td>
<td>Intention to Treat</td>
</tr>
<tr>
<td>LDCSB</td>
<td>London District Catholic School Board</td>
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<tr>
<td>LMM</td>
<td>Linear Mixed Model</td>
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<tr>
<td>MAR</td>
<td>Missing at Random</td>
</tr>
<tr>
<td>MCAR</td>
<td>Missing Completely at Random</td>
</tr>
<tr>
<td>Abbreviation</td>
<td>Definition</td>
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<td>--------------</td>
<td>------------</td>
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<tr>
<td>MI</td>
<td>Multiple Imputation</td>
</tr>
<tr>
<td>MNAR</td>
<td>Missing Not at Random</td>
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<tr>
<td>OECD</td>
<td>Organization for Economic Co-Operation and Development</td>
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<tr>
<td>PP</td>
<td>Per Protocol</td>
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<tr>
<td>QIC</td>
<td>Quasi-Likelihood Under the Independence Model Criterion</td>
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<tr>
<td>SSB</td>
<td>Sugar-Sweetened Beverage</td>
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<tr>
<td>TVDSB</td>
<td>Thames Valley District School Board</td>
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<tr>
<td>UTRCA</td>
<td>Upper Thames River Conservation Authority</td>
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<td>UWO</td>
<td>University of Western Ontario</td>
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Chapter 1

1 Introduction

This chapter introduces the thesis by providing a brief background on the current childhood obesity epidemic that has been observed worldwide, focusing specifically on the situation in Canada. It explores the consequences of and risk factors for childhood obesity and notes the role of water and sugar-sweetened beverage consumption in particular, as a rationale for undertaking this thesis. This chapter also identifies the key objectives of the thesis, as well as specific research questions and hypotheses. The chapter concludes with an overview of the remaining thesis chapters.

1.1 Research Context: Childhood Obesity as a Public Health Problem

1.1.1 The Childhood Obesity Epidemic

Obesity is the single greatest health threat facing children today\(^1\). With approximately 1 in 10 (155 million) children aged five to 17 worldwide classified as overweight or obese\(^2\), it has been described as the most serious public health crisis of the 21\(^{\text{st}}\) century, and affects children of all ethnicities, geographies, and socioeconomic statuses\(^3\). For children under five, the World Health Organization (WHO) defines overweight and obesity as weight-for-height greater than two (overweight) or three (obese) standard deviations above the WHO Child Growth Standards median\(^4\). For children aged five to 19, overweight and obesity are considered BMI-for-age greater than one (overweight) or two (obese) standard deviations above the WHO Growth Reference median\(^4\). Using these classifications, the prevalence of obesity among children and youth in Canada have nearly tripled over the past three decades, and 31.5% of five- to 17-year olds were overweight (19.8%) or obese (11.7%) as of 2011\(^5\). These rates are comparable to but slightly higher than those observed in the Organization for Economic Co-Operation and Development (OECD) member states, across which one in five children are overweight or obese\(^6\).
1.1.2 Burden of Childhood Obesity in Canada

1.1.2.1 Health Impacts

Overweight and obesity are widely known to have a number of immediate and long-term health consequences and together represent the fifth leading cause of death worldwide, with over 2.6 million deaths attributable to overweight or obesity each year\(^7\). There is strong evidence to suggest that overweight and obese individuals are at an increased risk of a variety of diseases, including type 2 diabetes, cardiovascular disease, hypertension, respiratory problems, musculoskeletal disorders, sleep apnea, and certain cancers\(^8\). These disorders, once almost exclusive to adults, are now being observed in children\(^9\). The effects of overweight and obesity can persist over the entire life course, affecting their quality of life and future morbidity and mortality. As a result, the current generation of children is the first in history to have a lower life expectancy than their parents\(^10\). Along with physical health consequences, overweight and obese children are also more likely to experience social and mental health challenges such as social isolation, discrimination, and bullying\(^11,12\). These can result in a number of psychosocial issues including low self-esteem, body image distortion, anxiety, and depression, and can affect a child’s cognitive abilities and educational attainment\(^11,12\).

1.1.2.2 Economic Impacts

The health consequences of obesity have a substantial economic burden on the health care system, accounting for approximately 4.1% of total health care expenditure, or $6 billion, in Canada in 2006 alone\(^13\). This estimate considers direct costs only; those incurred from the treatment of obesity-related conditions such as more frequent use of hospital services, physician care, and pharmaceuticals. As well, it is believed that an additional $5 billion is lost annually in indirect costs; productivity losses attributable to obesity-related disability and premature mortality\(^13\). Although the majority of these costs occur later in life, a 2014 review by Finkelstein, Graham, and Malhotra estimated that an obese child in the United States will accrue incremental lifetime direct medical costs ranging from $12,660 to $19,630 relative to a normal weight child, controlling for adult weight gain among normal weight children\(^14\). These are likely underestimates if we consider the indirect costs associated with the delayed skill acquisition and poorer cognitive abilities commonly observed in overweight and obese
Given that 24% to 90% of obese adolescents will remain obese into adulthood\textsuperscript{17}, excess weight in childhood is thought to contribute substantially to the total economic burden of overweight and obesity.

### 1.1.3 Risk Factors for Childhood Obesity

Childhood overweight and obesity are complex conditions, the causes of which are not yet fully understood. Research has identified a number of risk factors for childhood obesity, both modifiable and non-modifiable, across various levels\textsuperscript{18}.

Non-modifiable risk factors are those that influence a child’s weight status but that cannot be changed, or that are very difficult to change. These include biological factors such as genetic susceptibility and sex, socio-demographic factors such as race, income, parental education level, and parental employment status, and community factors such as urbanicity\textsuperscript{18}.

Modifiable risk factors, on the other hand, are determinants of childhood obesity that can be changed relatively easily\textsuperscript{18}. The most well-known and widely studied modifiable risk factors are behavioural factors; specifically diet and physical activity. Indeed, even with the identification of the non-modifiable determinants described above, obesity is still generally believed to be the result of individual behavioural choices that cause an upset to the energy balance in which energy intake through foods and beverages exceeds energy expended during physical activity, resulting in a surplus that culminates in weight gain\textsuperscript{19,20}. It can therefore be said that children who consume more total energy than is needed and who get less physical activity are more likely to be obese.

Both diet and physical activity, however, are themselves influenced by a number of outside factors. At the highest level are public policies, which may affect what a child eats and how much physical activity they get by imposing, for example, taxes on unhealthy foods and beverages, by offering subsidies for organized recreation activities for children, and by restricting advertising to children\textsuperscript{21,22}. Environmental determinants of diet and physical activity include the child’s food environment, such as availability of and access to healthy foods at home and at school and the proximity of fast-food outlets and convenience stores\textsuperscript{23,24}, and features of the built environment that make neighbourhoods more conducive to physical activity and active travel. The presence of sidewalks, parks, playgrounds,
recreation centres, and trees in a child’s neighbourhood, for instance, may lead to increased physical activity and thus a reduced risk of obesity, while traffic, crime, and a lack of green space may have the opposite effect\textsuperscript{24}. Interpersonally, a child’s dietary and physical activity behaviours are influenced by their parents and peers, with children tending to model those around them regarding preferences and habits\textsuperscript{20}. Finally, at the individual level, excess weight in childhood is associated with increased intake of high sugar, high fat energy-dense foods, snacking, larger portion sizes, more screen time, not getting enough sleep, sedentary behaviours, and higher consumption of sugar-sweetened beverages (SSBs)\textsuperscript{23,25}.

Although it is recognized that all of these factors, both modifiable and non-modifiable, contribute to weight gain and interact in complex ways, this thesis will focus on the role of diet-related determinants, specifically the consumption of water and sugar-sweetened beverages, which have been proposed as a protective factor and a risk factor, respectively. The mechanisms through which water and SSBs influence weight gain are explored more thoroughly in Chapter 2.

### 1.1.4 Thesis Rationale

The identification of modifiable risk factors and the development and evaluation of interventions to prevent and reduce overweight and obesity in childhood are key steps to improving the health of the Canadian population and reducing health care costs. Given the complex and multifactorial nature of the condition, which involves an interplay of individual, interpersonal, community, and public policy-level factors, comprehensive interventions are needed.

This research evaluated one such unique intervention, which targets both individual (knowledge) and environmental (availability of healthy drinking water to replace sugar-sweetened beverages) level determinants of weight status in order to promote healthy dietary behaviours. It provides insight into the role of knowledge and the built environment in fostering healthy beverage consumption habits specifically, and may inform future research, policy, and practices concerning the prevention of overweight and obesity in the child population.
1.2 Research Objectives

This thesis contributes to the growing body of literature exploring strategies for decreasing sugar-sweetened beverage and increasing water consumption during childhood. Using data generated through the Human Environments Analysis Laboratory (HEAL) as part of an evaluation of the Healthy Kids Community Challenge (HKCC) Water Does Wonders interventions in London, Ontario, this thesis aims to assess (1) the relationship between knowledge and practice, specifically as it relates to beverage intake, and (2) the effectiveness of education programs combined with environmental change at improving children’s beverage consumption habits.

To meet these objectives, this thesis will address the following research questions:

1) How does a child’s level of water and nutrition knowledge relate to their daily water and sugar-sweetened beverage consumption?

2) What is the effect of i) a nutrition education program combined with new water infrastructure, and ii) a water education program combined with new water infrastructure, compared to iii) new water infrastructure alone, on increasing water and decreasing SSB consumption in elementary school children?

It was hypothesized that children with higher water and nutrition knowledge will consume more water and fewer SSBs, and thus that children who receive an education program in addition to water infrastructure will make greater improvements in beverage intake than those who receive just water infrastructure.

It is hoped that this research will inform the development of future programs and policies to promote healthy beverage consumption habits during childhood and may be used to develop effective school-based strategies.

1.3 Thesis Format

This thesis is written in integrated article style and consists of two independent but related studies, each analyzing data collected from the HKCC Water Does Wonders study in London, Ontario. The thesis chapters are described below:
Chapter 2 uses a systematic review format to describe and summarize previous interventions to increase water consumption or decrease SSB consumption in child and adolescent populations. The review focuses particularly on the type of intervention implemented and the site of implementation, identifying patterns and best practices.

Chapter 3 describes the HKCC Water Does Wonders study in greater detail, including its design, setting, sample, data collection tools, measures, and analysis techniques.

Chapter 4 assesses the beverage consumption habits and knowledge of elementary school children aged 8 to 14 years in London, Ontario, and examines whether greater knowledge is associated with healthier beverage habits.

Chapter 5 evaluates the effectiveness of the HKCC Water Does Wonders interventions by comparing water and SSB consumption and knowledge post-intervention across the three intervention groups, controlling for pre-intervention values.

Chapter 6 summarizes and synthesizes the findings from the integrated articles and presents the research contributions, policy implications, strengths and limitations of this thesis. It concludes with a brief discussion of areas for future research.
1.4 References


6. OECD. *Obesity Update*.; 2014.


Chapter 2

2 Literature Review

2.1 Background

2.1.1 The Link Between Sugar-Sweetened Beverage Consumption and Obesity

The association between sugar-sweetened beverages (SSBs) and body weight has been well theorized, and is believed to be the result of high sugar content, low satiety, and incomplete caloric compensation\(^1\) contributing to a positive net energy balance, in which energy intake exceeds energy expenditure. Despite substantial evidence supporting these biological processes, the relationship between SSB intake and obesity itself has been more difficult to discern, with studies producing equivocal results.

In an evaluation of recent systematic reviews and meta-analyses, which are believed to represent the highest quality of evidence, a number of studies observed a positive association between SSB consumption and weight gain. Clabaugh and Neuberger, for example, concluded that there is a direct relationship between SSBs and BMI in children aged 2 to 10 years\(^2\), while Osei-Assibey et al. identified an association between body weight and SSBs in children under 8 years of age\(^3\). Similarly, Olsen and Heitmann, Woodward-Lopez et al. and Malik et al. found evidence of a positive association in all age groups\(^4-8\), and Dennis et al. in adults\(^9\). Importantly, a systematic review of recent evidence published in 2017, which updated previous reviews with new studies, observed a positive association between SSB consumption and obesity indices in both children and adults, concluding that public health efforts should aim to reduce the consumption of SSBs\(^10\).

In contrast, a handful of systematic reviews and meta-analyses report no evidence of a relationship between sugar-sweetened beverage consumption and body weight. Forshee et al., Kaiser et al., Mattes et al. and Gibson et al., for example, all failed to observe a significant association, concluding that the effect of SSBs on body weight is small and insignificant\(^11-14\), while Pérez-Morales et al., Ruxton et al., Vartanian et al., Trumbo et al.,
and Wolff et al. refrained from drawing any conclusions one way or the other, agreeing that, while compelling, the current evidence is simply too inconsistent\textsuperscript{15-19}.

The contradictory results observed in the published literature are interesting and may be explained by limitations of the studies themselves, namely conflicts of interest (COI), poor quality, and adjustments for total energy intake. Indeed, a 2013 study assessing COIs and reporting bias in studies examining the SSB-obesity relationship found that systematic reviews with financial COIs were five times more likely to conclude that there is not a positive association between SSBs and obesity\textsuperscript{20}, and this was supported by another study on the same topic\textsuperscript{21}. Given that 3 of the 4 studies that found no evidence of an association reported COIs\textsuperscript{11-13}, compared to 1 of 7 positive studies\textsuperscript{9} and 1 of 5 mixed results studies\textsuperscript{16}, it appears COIs may be responsible for some of the discrepancy in conclusions. In two systematic reviews of systematic reviews assessing how the quality of studies affects the authors’ conclusions, on the other hand, both Keller et al.\textsuperscript{22} and Weed et al.\textsuperscript{23} concluded that there was no relationship, with Keller and Bucher\textsuperscript{22} noting that the two highest quality reviews included in their study reached conflicting results.

The issue of whether or not it is appropriate to adjust for total energy intake is contested in the literature. Because SSBs are a source of calories, some authors\textsuperscript{6-8,24} claim total energy intake mediates the relationship between SSBs and obesity, and thus adjusting for it may result in the underestimation of the true effect of SSBs on body weight. Others\textsuperscript{4} argue that it is necessary to adjust for total energy intake in order to control for confounding factors. Olsen et al.\textsuperscript{4} reported that they achieved similar results regardless of whether they adjusted for total energy, suggesting that it may not be the biological mechanism underpinning the association, however Trumbo and Rivers\textsuperscript{18} found that upon stratifying their meta-analysis on the basis of whether or not the studies adjusted for total energy intake, the estimate for change in body weight was significant in those that did not adjust compared to those that did.

In considering the evidence as a whole, it appears that although there is a trend toward a direct association between SSBs and body weight, the evidence remains weak and definitive conclusions cannot be drawn. Virtually all the literature, regardless of their conclusions, emphasized the need for additional studies, particularly those of experimental and longitudinal design, in order to strengthen the body of evidence. That said, given the
biological plausibility of the association, and the urgency of the overweight and obesity epidemic, the current level of evidence should be considered sufficient to justify policy decisions and interventions targeting the association.

2.1.2 Water Consumption for Obesity Prevention

Water consumption has a wide variety of proven health benefits. Adequate hydration is necessary in order to regulate body temperature, maintain physical and mental performance, increase energy, and flush waste from the body, and is also thought to promote weight loss. Although several mechanisms have been proposed to explain this association, including a thermogenic effect causing an increase in energy expenditure, hunger suppression causing a reduction in energy intake at meals, and improved hydration causing reduced body fat, one of the most compelling is the replacement of sugar-sweetened beverages.

Several studies have explored the effect of replacing sugar-sweetened beverages with water on body weight and energy intake, and four systematic reviews on the topic have been published since 2010, largely with positive results. Daniels et al. found that replacing water in a meal with a sugar-sweetened beverage led to a significant increase in energy intake at that meal in adults\(^25\). A similar effect was not observed in children, suggesting that younger individuals may have a greater ability to compensate for caloric intake through beverages\(^25\). Similarly, Zheng et al. concluded that replacing SSBs with low calorie alternatives such as water or diet-beverages had positive effects on body weight in both children and adults\(^26\), while two reviews by Muckelbauer et al., one in children\(^27\) and one in adults\(^28\), found mixed results. Additionally, three cross-sectional studies conducted since the publication of the systematic reviews all found evidence of an association between water intake and reduced body weight\(^29-31\), one of them in children\(^31\).

These findings suggest that water consumption may be a protective factor against overweight and obesity, particularly when replacing sugar-sweetened beverages in the diet. As such, promoting water consumption as an alternative to sugar-sweetened beverages may be an effective strategy for reducing the prevalence of obesity.
2.1.3 The Beverage Consumption Habits of North American Children

The Canadian Guidelines for Healthy Eating recommends limiting intake of soft drinks, sports drinks, energy drinks, fruit drinks, and sweetened hot and cold coffee and tea drinks in favour of water, milk, fortified soy beverages, and, in moderation, 100% fruit juices. Despite these recommendations, Canadian children continue to consume high quantities of sugar-sweetened beverages. A 2011 study of beverage intake patterns of Canadian children and adolescents aged 2 to 18 years using nationally representative Canadian Community Health Survey (CCHS) data found that sugar-sweetened beverages are consumed across all age and sex groups and contribute up to 18% of total energy. This supports the findings of previous studies, which identified sugar-sweetened beverages as a top contributor of energy in Canadian adolescents’ diets, and reported increased soft drink consumption and decreased white milk consumption with age in Canadian children aged 1 to 18 years, suggesting that SSBs may be displacing milk in the diet as children begin to make their own beverage choices. Fortunately, despite these increases in SSBs, water continues to be the most or second most frequently consumed beverage among children and adolescents and approximately 70% of Canadian children drink water daily.

Although the evidence from Canada is somewhat sparse, the beverage consumption habits observed in Canadian children are similar to those of their American counterparts, where substantially more research has been conducted. Indeed, multiple nationally representative longitudinal studies from the USA have found an increase in SSB consumption among children and adolescents over the past few decades. A study comparing the beverage intake of American children aged 0 to 5 years across a 30-year period, for example, reported that at least 30% of children in this age group consumed soft drinks, and the amount of soft drinks consumed per day has increased over time. A similar study examining beverage trends in American children aged 6 to 11 years from 1989 to 2008 found that SSB intake increased over the study period, while a 2010 study of patterns of beverage intake across the lifecycle of individuals over the age of 2 years reported an increase in SSBs among children aged 2 to 18 years, as well as a decrease in milk consumption. These results align with those of previous studies, including a 2000 prospective cohort study following children from third to eighth grades, which found that the amount of soft drinks consumed as a proportion of total beverages more than tripled between grades 3 and 8, while milk and 100% juice consumption
declined\textsuperscript{39}, as well as a 2004 study of changes in beverage intake between 1977 and 2001, which observed an increase in SSB consumption and a decrease in milk consumption in children and adults over 2 years of age\textsuperscript{40}.

While there has been some evidence to suggest that the increase in SSB consumption among children may be stalling or even reversing in recent years\textsuperscript{41}, a 2013 study of American children and adults found that intake of non-traditional SSBs, particularly sports and energy drinks, has increased significantly, resulting in an overall increase in SSB consumption\textsuperscript{42}. This observation reflects the need for interventions aimed at all artificially-sweetened beverages, not just sodas and pops.

2.1.4 Factors that Influence Children’s Beverage Choices

While it is clear from the preceding section that children and adolescents are continuing to consume an excess of sugar-sweetened beverages despite recent public health campaigns, the reasons for this are poorly understood. Previous studies examining children’s beverage consumption habits have identified a number of factors that may influence their beverage choices, which can be broadly classified into three categories: intrapersonal determinants, interpersonal/social determinants, and environmental determinants\textsuperscript{43}.

2.1.4.1 Intrapersonal Factors

Intrapersonal determinants of beverage selection are individual-level factors that influence what type of beverages are consumed and include the knowledge, preferences, and habits of the child themselves\textsuperscript{43}. Children, particularly those of young age, may not be aware of the negative health impacts of consuming sugar-sweetened beverages, and thus may consume them with greater frequency. Indeed, this is often the theory behind education-based interventions to discourage SSB consumption. A qualitative study of elementary school children in London, Ontario, however, noted that the majority of those who participated in the focus groups were highly aware of the health consequences of consuming too many SSBs, and yet continued to consume them because of their preference for the flavours and tastes of the beverages\textsuperscript{44}. In several studies conducted across Canada, the USA, and the UK, children consistently cited flavor or taste as the dominant factor driving their beverage selections\textsuperscript{43–46}, and in a 2004 survey of 560 children, 96% reported that they liked or strongly
liked the taste of soft drinks\textsuperscript{45}. While it was noted that other factors, such as advertisements or peer pressure may encourage children to try new beverages, their personal preferences were what ultimately determined which beverages they would consume regularly, even overruling health concerns\textsuperscript{44}.

Along with their knowledge of the health impacts, and their preferences, children’s habits may also influence the types of beverages they select to consume. A 2015 systematic review, for example, found that children who watched more TV and had more screen time typically consumed greater amounts of sugar-sweetened beverages\textsuperscript{43}. This could be due to the tendency to snack while watching television, which itself is associated with higher SSB consumption, or to the abundance of television advertisements promoting SSBs\textsuperscript{43}. Indeed, advertising was identified as a potential influencer on beverage selection in multiple studies\textsuperscript{43,44,46}, although child focus groups noted that, while advertisements frequently drove them to try new beverages, both healthy and unhealthy, their preference for the beverage would determine whether they continued to consume it\textsuperscript{44}.

### 2.1.4.2 Interpersonal/Social Factors

In addition to their own knowledge, attitudes, and preferences, children are also influenced by those of the individuals and groups around them, and parents, teachers, caregivers, and peers are all important factors in influencing what a child will choose to drink. Parent socioeconomic status, for example, along with its proxies parental education and parental age, are strongly associated with SSB consumption, and children from lower income households or with less educated or younger parents consume more SSBs\textsuperscript{43,47,48}.

Additionally, in focus groups of elementary school children, many participants stated that their parents had power even beyond that of personal preference in determining their beverage choices\textsuperscript{44}. For younger children in particular, parents control the types of beverages purchased, as well as access to those beverages once they have been purchased, and thus govern the availability and accessibility of SSBs in the home environment\textsuperscript{44}. Parents also effectively encourage or discourage SSB consumption through their own behaviors. A number of studies have found that children whose parents regularly consume SSBs are more likely themselves to consume SSBs due to negative parental modelling\textsuperscript{43,45,48}. 
After their parents, a child’s peers are the next most important interpersonal influence, particularly during older childhood and adolescence when children become more independent. Peer pressure and the desire to fit in were cited as factors that influence beverage consumption during focus groups, and children noted that peer influence may encourage them to try new beverages.\textsuperscript{44,45}

2.1.4.3 Environmental Factors

The environment in which a child lives, plays, and attends school is also a key determinant of their beverage choices, and home, school, and neighborhood characteristics all play a role. The availability of SSBs in the home, for instance, is positively associated with the consumption of sugar-sweetened beverages\textsuperscript{43–45,48}. Similarly, children who attend schools with nutrition policies and guidelines concerning what can be sold are less likely to have access to SSB and are thus less likely to consume SSBs regularly\textsuperscript{43–45,48}. Neighborhood characteristics such as the proximity of grocery stores, convenience stores, and fast food restaurants were also found to be determinants of beverage choice in a systematic review\textsuperscript{43}, and in focus groups, children noted that it was easier to access SSBs when they were outside of the home\textsuperscript{44}.

Additionally, a study of Indigenous children in Australia, a population similar to the Indigenous in Canada, identified housing instability, urbanity, and area-level disadvantage as factors associated with SSB consumption in this group\textsuperscript{47}. The authors found that children living in isolated and remote areas were less likely to consume SSBs due to lack of access, while those living in poorer areas and urban environments were more likely\textsuperscript{47}. These findings can likely be applied to rural areas in general.

The factors that influence children’s SSB choices identified in the literature represent important areas for intervention and may be used to inform future programs and policies.

2.1.5 Purpose of this Review

Given the likely link between sugar-sweetened beverages and weight gain, the role of water consumption as a protective factor against obesity, and the persistence of high SSB consumption in Canada and around the world, this review aims to synthesize quantitative
evidence evaluating the effectiveness of interventions to improve beverage consumption habits in child and youth populations. Specifically, it seeks to determine the impact of past interventions intended to reduce sugar-sweetened beverage or increase water consumption in children and adolescents (aged 18 years and under), and to identify the intervention characteristics associated with more favourable outcomes.

A similar question was previously explored in a 2015 systematic review by Avery et al. evaluating interventions to reduce SSB consumption resulting in changes in body fatness in children. The review found that school-based interventions offer the most promise, however it was very narrow in its inclusion criteria, accepting only intervention-control trials published between 2000 and 2013, enrolling a minimum of 100 children, lasting at least six months in duration, and reporting on changes in both SSB consumption and body fatness, of which there were just eight. Given that extensive research in this area has been done since 2013, that lowering SSB and/or increasing water intake can have other beneficial effects beyond reducing body fatness, and that many relevant interventions are shorter than six months (a school term is only five months, for example), a broader review is needed.

This chapter will build on the findings of the 2015 review, while also filling its gaps. It will be useful in determining which interventions are the most effective in different contexts and could guide future public health strategies.

2.2 Methods

2.2.1 Search Strategy

A systematic review of the published literature was conducted in order to identify quantitative studies evaluating the effect of interventions to reduce sugar-sweetened beverage consumption and/or increase water consumption in children and adolescents aged 18 years and under. Relevant studies were identified from three databases, CINAHL, Medline, and Embase, using a search strategy developed with the assistance of a trained librarian. For each of the main concepts intervention, water, sugar-sweetened beverage, and children, MeSH terms and sub-headings specific to each database were identified, and a list of key words was compiled (Appendix A). Searches of the MeSH terms/subheadings or the related keywords were conducted for each concept and then combined, and database filters were applied to
eliminate all studies that were not conducted in humans, as well as non-English studies and studies not available online, for convenience sake. No restriction on publication year was made.

2.2.2 Screening Process

Figure 2.1 describes the screening process. Studies were included if i) they described an intervention, ii) the intervention aimed to reduce SSB consumption or increase water consumption as a primary or secondary objective, and iii) the intervention was targeted towards children and adolescents aged 0-18. Studies were excluded if they were not quantitative, only reported methods or baseline results, did not enroll children aged 0-18, measured SSB and/or water purchasing rather than consumption, and, where the study enrolled both child and adult populations, data was not reported separately for children and adults.

In total, 30,735 studies were retrieved from the database search. All identified studies were imported into Covidence and, after the removal of 7,775 duplicates, 22,960 records were included for screening. Screening was conducted by a single reviewer in two phases: title and abstract, and full text. An examination of the titles and abstracts resulted in the exclusion of 22,856 studies. One hundred and twelve studies progressed to full text screening, of which 48 met the inclusion criteria and were extracted. An additional nine studies were identified through hand-searching of reference lists, resulting in a final total of 57 studies, included in this review. A follow up study to Burrows et al.50 was conducted by the same researchers and on the same intervention in 201151, thus both were considered together.
2.2.3 Data Extraction

Data from all included studies were extracted using a modified form, which included the headings first author, year, country, number of subjects, mean age, study design, intervention setting, intervention duration, intervention type, effect of intervention on SSB and/or water consumption, and study conclusion. These details are summarized in Appendix B.
### 2.3 Results

#### 2.3.1 Study Characteristics

The general characteristics of the 57 studies included in this review, representing 56 unique interventions, are presented in Table 2.1. In general, randomized controlled trials were the most prevalent study design (31/56=55.4%), however non-randomized controlled trials, cross-sectional studies, and cohort studies were also common. Most studies originated from North America (26/56=46.4%) and Europe (19/56=33.9%), however South America, Asia, the Middle East, and Oceania were also represented.

Education interventions were the most frequent approach to reducing SSB or increasing water consumption, implemented in 23 studies (41.1%), followed by policy interventions in eight studies (14.3%), and environmental interventions in one study (1.8%). Twenty-two studies (39.3%) evaluated combined education and environmental interventions, while one (1.8%) evaluated a combined environmental and policy intervention and one study (1.8%) evaluated a combined education, environmental, and policy intervention. The majority of the interventions (40/56=71.4%) occurred in the school setting, compared to 13 (23.2%) in the community/home. Three interventions (5.4%) integrated both the school and community/home environments.

Sample sizes ranged from 44 to 90,730, however most studies (31/56=55.4%) enrolled between 100 and 1000 children. Of the 15 studies (26.8%) that had over 2000 participants, 40% were policy interventions, while a third of the studies were combined education and environmental interventions. Children of elementary school age (4-14 years) were the focus of 45 studies (80.4%), whereas eight (14.3%) looked at samples of high school children (15-18 years) only. Of the remaining three studies, one examined infants (0-23 months), one preschool aged children (2-3 years), and one included both elementary and high school aged children.

The duration of the interventions was unclear in several cases, however where reported, no particular length emerged as more prevalent. Ten studies (17.9%) evaluated interventions lasting between one and six months in duration, 13 (23.2%), six months to one year, 12
(21.4%), one to two years, and seven (12.5%), two to five years. Just two interventions (3.6%) were less than one month in duration, and only one (1.8%) was five years or longer.

The included studies were produced relatively consistently throughout the past decade, with 52 (92.9%) published from 2008 to the present. No studies were published prior to 2000.
Table 2.1 General Characteristics of the Included Studies (n=56)

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<thead>
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<th>Number of Articles</th>
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<td>50-99</td>
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<td>100-499</td>
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<tr>
<td>500-999</td>
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<td>&gt; 2000+</td>
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<td>Combination</td>
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2.3.2 Measuring Beverage Intake

The measurement tools used to assess children’s beverage intake were varied, making it difficult to compare across interventions. In general, most studies measured intake as a volume, such as ounces or millilitres, as a weight such as grams, as servings or portions, or as number of glasses or drinks. SSB and water intake were also commonly assessed in terms of frequency of consumption, with children reporting the number of times per day or week they consumed a particular beverage on an ordinal or ratio scale, and a handful of studies dichotomized water and/or SSB consumption into consumed/not consumed or high consumption/low consumption. Other, less common measurement techniques observed across the studies included percentage of students with positive vs negative change from baseline to follow up, propensity for consumption, prevalence of consumption, and percentage of daily kilo-calories obtained from SSBs.

Of the 56 interventions included in this review, 51 (91.1%) relied on subjective measures of beverage intake, reported by either the child themselves or their parent/guardian using questionnaires or surveys, while only five (8.9%) made use of objective measurement techniques such as direct observation.

2.3.3 Measuring Intervention Success

Thirty-four (60.7%) studies observed significant reductions in SSB intake or improvements in water intake following the intervention, while the remaining 22 (39.3%) found no significant effects. Of the non-significant results, 20 were in the expected direction and two were not. Combined education and environmental interventions appeared to have the highest rate of success, with 68.2% of studies (15/19) reporting significant improvements, compared to 52.2% of education interventions (12/23) and 50% of policy interventions (4/8). Importantly, most studies did not differentiate between statistically and clinically significant results, and improvements in many cases were small.

2.3.4 Education Interventions

Education programs emerged as the most frequently implemented strategy for changing children’s beverage consumption behaviours, and were the sole focus of 23 interventions. Of these, just over half (13/23=56.5%) occurred in the school setting, while 39.1% (9/23) were
community based. The vast majority (20/23=87.0%) targeted children of elementary school age. Education programs were diverse, generally addressing healthy beverage intake as a component of more general nutrition and physical activity lessons, and used a variety of tools to communicate their messages. These included counselling sessions, brochures, and newsletters for parents, and lessons, workshops, hands-on activities, and games for children. Education programs were typically delivered by a trained professional, such as a dietitian, nutritionist or healthcare worker, by a member of the research team, or by the child’s regular teacher. A small number of interventions included a technological component, such as a smart-phone app. Of the education interventions, exactly half yielded significant improvements in beverage consumption habits among the study participants, while the other half observed no significant effects.

2.3.5 Environmental Interventions

Environmental interventions generally consisted of changes to the built environment to make water more accessible and SSBs less accessible, for example by installing new water fountains, providing cups at water fountains, administering water filters, or distributing reusable water bottles to children. Although commonly used in combination with other strategies, environmental interventions on their own were the focus of just one study by Albalab et al.52, which evaluated the effect of delivering milk to children’s homes on displacing SSB consumption. The authors found a significant reduction in SSB intake with the provision of milk, however the intervention period was short, the sample size small, and the outcomes self-reported.

2.3.6 Policy Interventions

Policy interventions were analyzed in eight (14.3%) studies, and generally assessed children’s beverage intake before and after the implementation of a new nutrition-related policy. Such policies included mandatory provision of free drinking water during school mealtimes, soft drink taxations, standards for foods and beverages sold in schools, and the banning of sodas and/or SSBs from schools altogether. Aside from taxation, all of these policies were targeted at schools, with some implemented at the school board-level and others at the state or province-level. Policy intervention studies generally had the highest sample sizes, with all but one enrolling more than 2000 children, and seven out of eight
featured cross-sectional study designs. Half of the interventions resulted in statistically significant improvements in water and/or SSB consumption.

2.3.7 Combination Interventions

Over a third of studies (24/56=42.9%) evaluated interventions that used a combination of education, environment, and policy approaches, with the majority of these (22/24=91.7%) assessing education programs in conjunction with environmental changes. Eighteen (81.8%) of these interventions occurred in the school setting, and 68.2% resulted in positive beverage consumption improvements. Less commonly seen were interventions combining environmental changes and policy (one study; 7.1%), and interventions combining education programs, environmental changes, and policy (one study; 7.1%). No studies evaluating education and policy interventions were identified.

2.4 Discussion

2.4.1 Main Findings

The aim of this review was to identify and explore the effectiveness of interventions intended to reduce the consumption of sugar-sweetened beverages or increase the consumption of water in children and adolescents aged zero to 18. Fifty-seven studies evaluating 56 distinct interventions met the inclusion criteria, of which 34 (60.7%) observed significant reductions in SSB intake or increases in water intake post-intervention. The interventions can be broadly categorized into four types: 1) health/nutrition education programs, such as educating children about the adverse health effects of consuming SSBs; 2) environmental changes to discourage SSB or encourage water consumption, such as installing water fountains or removing soft drinks from vending machines; 3) policies relating to nutrition, such as banning the provision of SSBs at school events, and 4) combination interventions that integrate education, environmental, and policy components.

To our knowledge, this is the first review to evaluate the effects of interventions to reduce SSB and increase water consumption in child and adolescent populations without putting any restrictions on age, setting, duration, study design, or publication year. This allows for the comparison of the effectiveness of interventions in varying contexts.
2.4.2 Comparing Education, Environment, Policy, and Combination Interventions

The included studies evaluate a wide variety of diverse interventions, each occurring in different contexts and enrolling different populations. Interestingly, education programs were the most commonly employed strategy for provoking behavioural change, followed by education programs combined with environmental changes. This is likely due to the cost-effectiveness and ease of implementation of such programs, as well as their ability to reach large groups of children at once. Indeed, when delivered in the school setting, as was the case in over two-thirds (71.4%) of studies, education programs can be easily integrated into the curriculum, and can be delivered by the regular classroom teacher in many cases, while changes to the built environment, despite requiring small, short-term investments, will benefit the entire school population. In contrast, policy interventions are more difficult and time-consuming to execute and demand the support of the school board or provincial/state or federal government, depending on the level of the policy.

Although a meta-analysis was not performed due to substantial heterogeneity in measures across studies, a review of each intervention’s results suggest that education programs combined with environmental change may be the most effective at inducing meaningful changes in beverage consumption habits, with 68.2% of studies reporting increased water consumption and/or decreased SSB consumption following the interventions. This is likely due to the comprehensiveness of such interventions, with changes to the built environment reinforcing and supporting messages received from education programs. Although we would expect interventions combining all three of education, environment, and policy approaches to produce the most favorable results, only one study evaluated such an intervention. While it showed promise, with children consuming significantly fewer sugary drinks in the intervention group than the control group at follow up, more studies of this type are required before a definitive conclusion about their effectiveness can be drawn.

Education programs that target parents in addition to children may yield greater results in certain contexts, particularly when enrolling younger children who are still dependent on their parents to provide food and drinks. Smith et al.\textsuperscript{53}, for example, incorporated activities for parents into their school-based ATLAS intervention, resulting in a significantly greater decrease in SSB consumption in intervention group children compared to control group,
while Habib-Mourad et al.\textsuperscript{54} held family meetings with parents, with a reduced odds of SSB consumption observed in the intervention group at follow up. Similarly, Arvidsson et al.\textsuperscript{55} found that children who received a community-based education intervention designed to help parents promote a healthy food environment had higher quality diets at follow up, including better beverage consumption habits.

### 2.4.3 Schools as an Effective Site of Intervention Implementation

Schools were the most prevalent setting for implementing interventions to reduce sugar-sweetened beverage or increase water consumption, selected in 40 of the 56 interventions included here (71.4%). Given that children spend a significant portion of their waking hours at school and more than 94% of Ontario’s children and adolescents attend public schools\textsuperscript{56}, these institutions provide an ideal setting in which to promote health behaviours. Indeed, schools are the primary location in which children of all socioeconomic statuses congregate, making school-based health interventions a potentially effective strategy for mitigating health disparities\textsuperscript{57}. Furthermore, a link has been established between health status and educational achievement\textsuperscript{57}, making the incorporation of health promotion initiatives into the school curriculum not only feasible, but logical as well.

The nature of the school environment supports the implementation of a variety of types of health interventions, which can be combined to create comprehensive programs. Health promoting policies, for example, implemented at the school or district level, are universal and support permanent, sustainable changes, while physical changes to the built environment, such as the addition of new infrastructure, encourage and facilitate the adoption of healthy habits\textsuperscript{58}. Health promoting curriculums are easily integrated into regular science and physical education lessons and are necessary to teach children how and why healthy choices should be made\textsuperscript{58}.

Of the school-based interventions assessed in this review, 13 were education programs, seven were policies, and 20 employed combined approaches, 90% of which were education programs in conjunction with environmental changes. Just under two thirds of the interventions (24/40=60%) resulted in significant improvements in children’s beverage consumption habits, however even where non-significant, the observed effects were generally in the right direction. This suggests that schools may be an effective site for
reducing SSB and/or increasing water consumption in children, supporting the findings of Avery et al. in their 2015 review\(^49\).

### 2.4.4 Early-Middle Childhood as an Optimal Time to Induce Change

An overwhelming majority (45/56=80.4\%) of the analyzed interventions enrolled children of elementary school-age (approximately 4-14 years). This is in line with the literature, which suggests that early-middle childhood may be the optimal time in which to promote healthy nutrition, as this is when life-long dietary habits and preferences are being established, which affect future morbidity and mortality\(^59-62\).

Additionally, children in this age group are developing more autonomy and are beginning to make their own decisions. Compared to younger children, whose diets are largely restricted to the foods and beverages their parents make available to them, older children have a degree of control over what they choose to eat and drink. In upper elementary school in particular, children may have pocket money to spend and may be permitted to leave the school grounds at lunch time, affording them the opportunity to purchase unhealthy snacks and drinks without the influence of a parent or guardian. It is thus essential to instill the importance of healthy eating at this age, so that children have the knowledge and skills required to make healthy and informed decisions.

### 2.4.5 Long-Term Follow Up is Needed to Assess Sustainability

Contrary to what was expected, we found that shorter interventions lasting less than 12 months resulted in more significant improvements in beverage consumption habits than those with a duration of one year or greater (17/25=68\% vs 10/19=52.6\%). Within those shorter than 12 months, 83.3\% (10/12) of interventions less than six months reported significant changes, compared to 53.8\% (7/13) of those six to 12 months. Although these findings contradict our expectation that long-term interventions are more likely to produce sustainable behavioural changes, they likely reflect immediate, short term improvements post-intervention. These improvements may have levelled off over time, however this trend would not have been captured because of the short follow up periods of the studies. Indeed, many longer studies reported initial improvements in water and SSB consumption in the intervention compared to the control groups that were no longer apparent at a later follow
This highlights the need for longer follow up periods in order to evaluate the sustainability of any observed improvements, as well as the importance of maintenance or booster sessions to prevent children from falling back into old habits, as was discussed by Avery et al.\textsuperscript{49} and noted in multiple studies\textsuperscript{52,65–67}.

### 2.4.6 Implications for Practice

The interventions assessed in this review appear to indicate that a school-based approach encompassing both education and physical changes to the built environment could be effective at reducing sugar-sweetened beverage and/or increasing water consumption in children and adolescents of elementary and high school age. This is encouraging, as these types of interventions are easily reproducible in different settings, and there is evidence to suggest that they are effective in diverse populations.

Despite the potential to be adapted into real-world settings, however, the majority of studies did not report the necessary information for this to be easily achieved, creating a barrier for large-scale implementation of successful programs. Indeed, in a 2016 systematic review evaluating the internal and external validity of sugar-sweetened beverage interventions found that key details relating to the implementation, adoption, effectiveness, and maintenance of these programs were often missing in published studies, preventing researchers, practitioners, and policy makers from effectively translating successful interventions into practice\textsuperscript{68}. This obviates research, the primary goal of which is to evoke real-world change, impacting the greatest number of children possible.

### 2.4.7 Limitations

This review has a number of limitations that must be noted. First of all, because screening and extraction were conducted by a single reviewer only, it cannot be considered a true systematic review. Additionally, a meta-analysis could not be performed due to substantial heterogeneity in methods and outcome measures across studies, thus overall estimates of intervention effectiveness could not be obtained. This review put no restrictions on publication year, intervention setting or duration, study design, or sample size. While this allowed us to consider all interventions in a variety of contexts, it also resulted in the inclusion of studies of low quality, as well as studies using outdated data, and studies that
occurred in contexts that may not be comparable to what is experienced here in Canada, such as Chile and Lebanon. Finally, the exclusion of studies that were not available online, or that were only available in abstract form may have caused us to overlook potentially relevant studies, which could have biased our results.

2.4.8 Conclusions

Interventions to increase water and/or decrease SSB consumption in children and adolescents aged 18 years and under have been implemented in a variety of diverse settings and populations, using an assortment of strategies. Although not all of these interventions resulted in significant improvements in beverage consumption habits, programs that combined education and environmental changes, that enroll children in early-middle childhood, and that target both parents and children with education programs may be more effective in changing behaviours. Future research will need to report all aspects of the intervention design, implementation, adoption, evaluation and maintenance in detail, so that successful programs may be adapted and scaled up for use in other contexts, and should use consistent measures of beverage consumption in order to improve comparability between interventions.
2.5 References


24. Hu FB. Resolved: There is sufficient scientific evidence that decreasing sugar-sweetened beverage consumption will reduce the prevalence of obesity and obesity-related diseases. *Obes Rev.* 2013;14(8):606-619. doi:10.1111/obr.12040


58. Dilley JA. *Research Review: School-Based Health Interventions and Academic Achievement.*; 2009.


Chapter 3

3  Methods

This chapter will begin with a description of the Healthy Kids Community Challenge (HKCC) Water Does Wonders project in London, Ontario, which provided the data for this thesis. Participant recruitment and data collection procedures will be outlined and the definitions and measures of key constructs will be presented. Finally, the analytic procedures used to assess the objectives of this thesis, including the conceptualization of the models and the specific analyses performed, will be detailed. Due to the integrated article format of this thesis, some of the information described in the following sections may be repeated in subsequent chapters, however it is described here in greater detail to provide more clarity on the methods used.

3.1  Data

3.1.1  Data Source

The Healthy Kids Community Challenge is an Ontario-wide initiative led by the Ministry of Health and Long-Term Care. It provides funding, training, and social marketing tools to 45 communities across the province to promote healthy eating, physical activity, and other healthy behaviours in children. Participating communities implement programs that fit within the HKCC’s key themes, which change every nine months, approximately. The first theme, Run. Jump. Play. Everyday., encouraged daily physical activity. The second theme, Water Does Wonders, promoted water as an alternative to sugar-sweetened beverages and other unhealthy drinks. The third theme, Choose to Boost Veggies and Fruit, aimed to increase children’s fruit and vegetable intake. The fourth theme, Power Off and Play!, advocated for reduced screen time. More information on the HKCC programs can be found on the website of the Ontario Ministry of Health and Long-term Care*. This thesis analyses data collected by the Human Environment Analysis Laboratory (HEAL) through the Department of Geography at the University of Western Ontario (UWO) as part of the evaluation of the Water Does Wonders programs in London, Ontario.
The Water Does Wonders theme was developed in response to the increase in childhood obesity that has been observed nationwide, which has been linked in part to excessive consumption of sugar-sweetened beverages. The main objective of this theme was to decrease children’s SSB consumption by increasing their water consumption. London’s HKCC Water Does Wonders programs consisted of multiple interventions, which were designed and carried out by members of London’s Child and Youth Network (CYN), a partnership of over 170 diverse organizations that work together to promote child health. The CYN is responsible for overseeing HKCC programs on behalf of the city of London. Among the multiple interventions undertaken for London’s Water Does Wonders campaign, the most substantial involved providing new infrastructure, i.e. automatic water bottle filling stations, to 16 elementary schools within London. All 16 of the schools that participated in the program were meant to receive a new filling station, which dispenses cold, filtered water directly into refillable water bottles. In addition to the water bottle filling stations, a subset of schools also received one of two education interventions: the Growing Chefs! program or the Upper Thames River Conservation Authority (UTRCA) program.

Growing Chefs! is a London-based organization designed to get kids excited about nutrition and healthy eating through interactive cooking and food literacy workshops. The activities were delivered in-classroom to the whole school and happened twice during the school year. In addition to basic cooking skills, children learned the art of plating and food presentation and the importance of healthy eating.

The UTRCA program consisted of a series of activity stations designed to increase children’s knowledge of water. Topics included the water treatment system, the world’s water, water footprints, and the importance of water for our bodies. The program was initially delivered by UTRCA staff to the grade 7 students at each of the participating schools, who then taught the grade 5 students.

London’s Water Does Wonders interventions occurred throughout the 2016/2017 school year and were targeted at children in 13 priority neighbourhoods throughout the city, identified through a community needs assessment conducted by the Child and Youth Network London¹. These neighbourhoods were Argyle, Carling, East London, Glen Cairn, Hamilton
Road, Highland, Huron Heights, Medway, Southcrest, West London, Westminster, Westmount, and White Oaks, and are delineated in Figure 3.1. Compared to the city of London as a whole, priority neighbourhoods had less educated residents, lower household incomes, and more single parent households. Of the 78 elementary schools located within these neighbourhoods, 16 consented to participate in the study and self-selected based on interest into one of three groups: 1) Growing Chefs! education program plus new water infrastructure (n=5 schools); 2) UTRCA education program plus new water infrastructure (n=6 schools); 3) control group that received only new water infrastructure (n=5 schools).

Data were collected on children in grades four to eight, approximately eight to 14 years old. This age period has been identified as a key time in which dietary practices and preferences are established, laying the foundation for eating habits and thus health status later in life, and it is also the time in which children begin to develop more autonomy regarding their food choices. Additionally, previous research by the HEALab has indicated that, by grade four, children generally possess the reading and writing skills required to complete a self-administered survey. As such, this period is the ideal time in which to intervene.
Figure 3.1 Map of Priority Neighbourhoods Identified Through Community Needs Assessment
3.1.2 Recruitment Procedures

Ethics approval for the HKCC study was obtained from the Non-Medical Ethics Board of the University of Western Ontario (108328). Upon approval, two public school boards, Thames Valley District School Board (TVDSB) and London District Catholic School Board (LCDSB), were approached to participate, both of which agreed (Appendix C). Principals at each of the eligible schools were sent a letter describing the study and asking them to partake. Where the principal approved the project, beginning in September of 2016 teams of researchers visited grade four to eight classrooms and delivered short presentations, describing the study and survey process and administering letters of information and consent forms to be signed by the student’s parent or guardian (Appendix D).

Students were additionally provided with a parent survey, to be completed by the child’s parent or guardian. Students who returned their signed parent consent form by the designated day were required to sign an additional assent form on the day of the survey to confirm their interest in participating (Appendix E). Those with both a signed parent consent form and signed assent form were enrolled in the study. Students without a completed parent survey were still eligible to participate, provided they had parent consent.

3.1.3 Data Collection and Tools

Data collection for the HKCC Water Does Wonders intervention evaluation took place at two separate time points; before the interventions were implemented in October-November 2016, and then again after their completion in April-June 2017. At each time point, research teams visited the participating schools, where they gathered all students with parent consent to participate into a large space such as a library, computer lab, resource room, or gymnasium to administer the survey. Once all students were present one member of the research team provided verbal instructions. Students were reminded that they could withdraw from the study at any time, should they so choose. Researchers were on hand to answer questions related to comprehension, spelling, and process throughout the survey period, however they did not prompt students in any way. Students were provided with a complementary colour-changing pencil each time they completed a survey. Students who were absent the day of the survey were not given the opportunity to complete the survey at a later date.
The HKCC Water Does Wonders survey was designed to collect information on demographics, beverage consumption habits, food and beverage consumption frequencies, eating and drinking during the school day, beverage knowledge, and water knowledge, and was adapted from a survey developed for a previous study, described elsewhere. Five versions of the survey were created. All students were administered the same survey at baseline, consisting of 91 items under five domains: general information, drinking habits, types of food and drink consumed, eating and drinking during the school day, and beverage knowledge (Appendix F). Follow-up surveys, however, differed depending on the type of intervention received, with surveys assessing the Growing Chefs! (Appendix G) and UTRCA grade 7 (Appendix H) and 5 (Appendix I) interventions containing an additional two to three items under the domain program knowledge to assess the impact and reception of these interventions. The surveys included multiple choice, yes/no, Likert scale, and fill in the blank questions.

A version of the baseline survey was also adapted for parents/guardians, measuring basic demographics as well as the child’s eating and drinking habits, and eating and drinking during the school day to supplement information collected from the youth survey (Appendix J). The parent survey consisted of 50 items under four domains: general information, drinking habits, the types of food your child eats and drinks, and eating and drinking during the school day, and was completed once, at baseline.

### 3.2 Measures

This section will describe how each individual variable was defined and measured. The variables that were included in the statistical models are summarized in Table 3.1.
<table>
<thead>
<tr>
<th>Variable Name</th>
<th>Type of Variable</th>
<th>How Variable was Measured</th>
<th>Data Source</th>
<th>Use of Variable in Models</th>
<th>Study 1 or 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>Continuous</td>
<td>Continuous in number of years</td>
<td>Parent Survey supplemented with child survey</td>
<td>Covariate</td>
<td>Both</td>
</tr>
<tr>
<td>Sex</td>
<td>Binary</td>
<td>Nominal categorical with response options 'male', 'female', and 'other'. No respondents selected 'other'</td>
<td>Parent survey</td>
<td>Covariate</td>
<td>Both</td>
</tr>
<tr>
<td>Ethnicity</td>
<td>Binary</td>
<td>Nominal categorical with response options 'white/Caucasian', 'South Asian', 'Middle Eastern', 'Latin American', 'Aboriginal', and 'Black/African/Caribbean'. Dichotomized into 'white/Caucasian' and 'non-white/mixed-ethnicity' due to low cell counts</td>
<td>Parent survey supplemented with child survey</td>
<td>Covariate</td>
<td>Both</td>
</tr>
<tr>
<td>Household Income Level</td>
<td>Ordinal Categorical</td>
<td>Derived variable based on annual household income (reported in $10,000 ranges) and number of people in household (reported continuously in number of people)</td>
<td>Parent survey (annual household income) and child survey (number of people in household)</td>
<td>Covariate</td>
<td>Both</td>
</tr>
<tr>
<td>Maximum Household Education</td>
<td>Ordinal Categorical</td>
<td>Derived variable based on the highest level of educational attainment reported for either parent/guardian. For each parent/guardian education was assessed as an ordinal categorical variable with response options 'grade school' (specify highest grade completed), 'college/university', and graduate school</td>
<td>Parent survey</td>
<td>Covariate</td>
<td>Both</td>
</tr>
<tr>
<td>Parental Employment Status</td>
<td>Binary</td>
<td>Nominal categorical with response options 'employed full time', 'employed part-time', 'at home with children', 'unemployed', 'student', 'other'(fill in the blank), 'I prefer not to answer', and 'N/A. Assessed separately for each parent/guardian. Dichotomized into 'employed' and 'unemployed' due to low cell counts</td>
<td>Parent survey</td>
<td>Covariate</td>
<td>Both</td>
</tr>
<tr>
<td>Child Living Arrangement</td>
<td>Nominal Categorical</td>
<td>Nominal categorical with response options 'single parent/guardian household', 'two-parent/guardian household', and 'other'</td>
<td>Parent survey supplemented with child survey</td>
<td>Covariate</td>
<td>Both</td>
</tr>
<tr>
<td>Variable</td>
<td>Scale Type</td>
<td>Description</td>
<td>Sample Source</td>
<td>Variable Type</td>
<td>Both</td>
</tr>
<tr>
<td>----------------------------------------------</td>
<td>----------------</td>
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</tr>
<tr>
<td>Daily Servings of Fruits and Vegetables</td>
<td>Continuous</td>
<td>Derived variable based on the sum of the number of servings of fruits consumed/day (continuous) and the number of servings of vegetables consumed/day (continuous)</td>
<td>Child survey</td>
<td>Covariate</td>
<td>Both</td>
</tr>
<tr>
<td>Weekly Less Healthy Food Consumption Frequency</td>
<td>Continuous</td>
<td>Derived variable based on the sum of the number of times/week a respondent reported consuming sweetened breakfast cereal, cake/pie/doughnuts, potato chips, chocolate bars, pizza, French fries, hot dog, ice cream, candy, granola bars, and cookies (response categories 0-6+ for each)</td>
<td>Child survey</td>
<td>Covariate</td>
<td>Both</td>
</tr>
<tr>
<td>Daily Water Consumption</td>
<td>Continuous</td>
<td>Derived variable based on dividing the number of times/day a respondent reported consuming water (response categories 0-7+) by the number of times/day a respondent reported consuming all beverages (water, 100% fruit juice, fruit-flavoured drinks, white milk, chocolate milk, pop, diet pop, energy drinks, coffee, and tea, each with response categories 0-7+)</td>
<td>Child survey</td>
<td>Dependent Variable</td>
<td>Both</td>
</tr>
<tr>
<td>Daily SSB Consumption</td>
<td>Continuous</td>
<td>Derived variable based on dividing the number of times/day a respondent reported consuming an SSB (fruit-flavoured drinks, chocolate milk, pop, and energy drinks with response categories 0-7+) by the number of times/day a respondent reported consuming all beverages (water, 100% fruit juice, fruit-flavoured drinks, white milk, chocolate milk, pop, diet pop, energy drinks, coffee, and tea, each with response categories 0-7+)</td>
<td>Child survey</td>
<td>Dependent Variable</td>
<td>Both</td>
</tr>
<tr>
<td>Frequency of Refillable Water Bottle Use</td>
<td>Ordinal categorical</td>
<td>Ordinal categorical variable measured on a 5-point Likert scale with response categories 'never', 'rarely', 'sometimes', 'usually', and 'always'</td>
<td>Child survey</td>
<td>Covariate</td>
<td>Both</td>
</tr>
<tr>
<td>Participation in a School Milk Program</td>
<td>Binary</td>
<td>Nominal categorical variable with response categories 'yes', 'no', and 'my school does not have a milk program'. Dichotomized into 'yes' and 'no' due to low cell counts, with 'my school does not have a milk program' considered 'no'</td>
<td>Child survey</td>
<td>Covariate</td>
<td>Both</td>
</tr>
<tr>
<td>Permission to</td>
<td>Binary</td>
<td>Binary variable with response categories</td>
<td>Child survey</td>
<td>Covariate</td>
<td>Both</td>
</tr>
</tbody>
</table>
3.2.1 Independent and Dependent Variables

3.2.1.1 Water Consumption

Water consumption was one of two primary dependent variables analyzed in this thesis and was measured as the number of times per day a child reported consuming water using a food-frequency questionnaire (FFQ), with response categories ranging from zero to seven or more. Although water is commonly measured as a volume, such as mL/day, this study opted to use instance frequencies instead because some studies have suggested that children of this age may have difficulties estimating volumes and portion sizes\(^9-12\), making instances a suitable choice for assessing beverage intake in this population. Indeed, instances have been used to quantify dietary intake in similar studies in child populations in the past\(^4-8\). To account for potential differences in children’s interpretation of the ‘times per day’ measurement, however, for analysis water consumption frequency was divided by the total beverage consumption frequency reported by each child to obtain standardized proportions. For example, if a child reported consuming water four times per day and their total beverage consumption frequency was 16 instances, 25% of their total daily beverage consumption
would be attributable to water. Water consumption was considered a continuous variable, and it was assumed that observations did not generally cluster around the upper or lower bounds, but rather fell within the 20%-80% range.

### 3.2.1.2 SSB Consumption

SSB consumption was the second of two primary dependent variables analyzed in this thesis and was an aggregate variable, derived from summing the number of times per day a child reported consuming regular pop, fruit-flavored drinks (including sports drinks), energy drinks, and chocolate milk (each ranging from zero to seven or more for a total SSB frequency possible range of 0-28+). Although there is some debate as to whether sweetened milks and milk alternatives should be considered SSBs, due to the high number of important nutrients they contain, we opted to include them for the purpose of this analysis based a report published by the Dietitians of Canada and using the definition of sugar-sweetened beverage defined by the Centre for Disease Control and Prevention (CDC).

Conversely, while sweetened coffee and tea drinks are also considered SSBs under the CDC definition, they were not included in this analysis because the nature of the survey did not allow respondents to specify whether or not the tea and coffee beverages they consumed contained added sugar. Additionally, despite the fact that 100% fruit juices are high in sugar and have a similar effect to SSBs on the body, they were excluded from the analysis because their sugar is naturally occurring. Diet beverages were also excluded from the SSB classification based on the Dietitians of Canada report.

Like water consumption, for analysis purposes SSB consumption frequency was divided by the total beverage consumption frequency reported by each child to generate the percentage of total beverage consumption frequency attributable to SSBs. Again, SSB consumption was considered a continuous variable, and it was assumed that observations did not generally cluster around the upper or lower bounds, but rather fell within the 20%-80% range.

### 3.2.1.3 Water and Nutrition Knowledge

Water and nutrition knowledge score, both separate and combined, were the primary independent variable(s) investigated in Chapter 4, and combined knowledge score was also used as a dependent variable when evaluating the intervention effects in Chapter 5.
Nutrition knowledge was measured by summing the scores of 36 individual questions assessing children’s knowledge of the sugar, caffeine, and water content of various foods and beverages, evaluated using a self-administered survey. Examples of questions included: “from the list below, choose the beverages that are high in sugar and/or high in caffeine” (100% apple juice, black/green tea, cappuccino, chocolate milk, Coca-Cola, coffee, fruit punch, Nestea iced tea, peach drink, Red Bull energy drink, Rock Star energy drink, Sprite, SunnyD, water, white milk); and “check the fruit or vegetable that has the most water from each pairing” (cucumber or carrots, apple or peach, carrots or tomatoes, cucumber or beans, strawberries or pears, spinach or corn). The minimum possible score children could achieve was zero and the maximum was 36.

Water knowledge was measured by summing the scores of eight individual questions assessing children’s knowledge of the water treatment system, health benefits of water, and the world’s water, evaluated using a self-administered survey. Examples of questions included: “where does the water from your tap come from?” (ground water, Lake Ontario & Erie, Lake Huron & Erie, Thames River, I don’t know); “how much water do we need to drink each day?” (3-4 cups, 5-6 cups, 7-8 cups, 9-10 cups); “can you name one way that your tap water is treated?”; “can you list 2 ways to conserve water at home or at school?”; “true or false, bottled water is better than tap water”; “true or false, water is an unlimited resource”; and “true or false, we have enough water in Canada for everyone, forever”. The minimum possible score a child could achieve was zero and the maximum was eight.

Total nutrition and water knowledge was determined by summing the scores of the nutrition and water knowledge subscale scores. The minimum score that could be achieved was zero and the maximum was 44. For analysis purposes, all knowledge variables were converted to percentages and treated as continuous, and it was assumed that observations did not generally cluster around the upper or lower bounds, but rather fell within the 20%-80% range.

3.2.1.4 Intervention Group

Intervention group was the primary independent variable used in Chapter 5 and was a nominal categorical variable created by the researchers to indicate which intervention a child received. Categories included control (water bottle filling station only), Growing Chefs! plus water bottle filling station, and UTRCA plus water bottle filling station.
3.2.2 Socio-Demographic Variables

3.2.2.1 Age

Age in years was assessed in both the youth and parent surveys. Parent-reported age was used preferentially for analysis. Where parent-reported age was missing, child-reported age was substituted. Age was considered a continuous variable.

3.2.2.2 Sex

Child sex was assessed using the parent survey, with parents reporting whether their child was male, female, or other. Because no parent reported their child as ‘other’, in the analysis, sex was a binary variable.

3.2.2.3 Ethnicity

Ethnicity was assessed in both the parent and youth surveys and was a nominal categorical variable, with response options including white/Caucasian, South Asian, East Asian, Middle Eastern, Latin American, Aboriginal, and Black/African/Caribbean. Respondents were instructed to select one or two primary ethnic backgrounds. Parent-reported ethnicity was used preferentially for analysis. Where parent-reported ethnicity was missing, child-reported ethnicity was substituted. For analysis purposes, ethnicity was dichotomized into white/Caucasian and non-white/mixed-ethnicity due to low cell counts.

3.2.2.4 Highest Parental Education Level

The highest level of education obtained by any member of the household was assessed using the parent survey. Respondents were asked to select the highest level of education they had completed from the options grade school (specify grade one-13), college/university, graduate school, and n/a. Where applicable, the respondent was also asked to select the highest level of education the child’s second parent or guardian had completed. The maximum education level obtained by either parent/guardian was used in the analyses and was considered an ordinal categorical variable.
3.2.2.5 Household Income Level

Household income level was calculated based on parent-reported household income (categorized into $10,000 ranges) and child-reported number of people in the household, and was classified into four categories based on the methods used to derive the Total Household Income variable of the Canadian Community Health Survey, as described in the Derived Variable Specifications. Families were considered low income if their total income was less than $15,000 for a household of one to two people, less than $20,000 for a household of three to four people, and less than $30,000 for a household of five or more people. Families were considered lower middle income if their total income was $15,000 to $29,999 for a household of one to two people, $20,000 to $39,999 for a household of three to four people, and $30,000 to $59,999 for a household of five or more people. Families were considered upper middle income if their total income was $30,000 to $59,999 for a household of one to two people, $40,000-$79,999 for a family of three to four people, and $60,000-$79,999 for a household of five or more people. Families were considered high income if their total income was above $60,000 for a household of one to two people, or above $80,000 for a household of five or more people.

Where the household income or household size information was missing, or where the parent respondent selected the ‘don’t know’ or ‘prefer not to answer’ response options for income, household income level was coded as missing. Due to the high amount of missing data in this variable (34.02%), missing income was included as its own category in all analyses so as not to bias results. As such, this variable was not imputed during the multiple imputation phase.

3.2.2.6 Child Living Arrangements

Child living arrangement was assessed in both the parent and youth surveys, and was a nominal categorical variable, with response options including single-parent/guardian household, two-parent-guardian household, and other. Parent-reported living arrangement was used preferentially for analysis. Where parent-reported living arrangement was missing, child-reported living arrangement was substituted.
3.2.2.7 Parental Employment Status

Parental employment status was reported in the parent survey and was a nominal categorical variable. Respondents were asked to select the response that best described a) their current work status; and b) the second parent/guardian’s current work status (if applicable), with response options including employed-full time, employed part-time, at home with children, unemployed, student, other (fill in the blank), prefer not to answer, and N/A. For analysis purposes, parent employment status was dichotomized into employed or unemployed for each parent/guardian, with the responses employed full-time, employed part-time, self-employed, contract worker, maternity leave, and employed seasonally considered employed, and unemployed, at home with children, student, retired, and disability considered unemployed.

3.2.3 Dietary Variables

3.2.3.1 Less Healthy Food Consumption

Less healthy food consumption was an aggregate variable derived from summing the number of times a child consumed sweetened breakfast cereal, cake/pie/doughnuts, potato chips, chocolate bars, pizza, French fries, hot dogs, ice cream, candy, granola bars, and cookies per week, as reported in the youth survey. Each response option ranged from zero to six or more times per week, for a total less healthy food consumption frequency possible range of zero to 66 or more times per week. Less healthy food consumption was considered a continuous variable.

3.2.3.2 Fruit and Vegetable Consumption

Fruit and vegetable consumption was assessed using the youth survey and was an aggregate variable derived from summing the number of servings of fruits and vegetables a child reported consuming in a typical day. Response options ranged from none to four or more servings per day, for a total fruit and vegetable consumption range of zero to eight or more servings per day. Children were provided with examples of what constitutes a serving in order to facilitate accurate reporting. For example, a serving of fruit was described as a piece of fresh fruit, like an apple, while a serving of vegetables was described as a carrot or other
fresh vegetable, or a small bowl of green salad. Fruit and vegetable consumption was considered a continuous variable.

3.2.4 Behavioural Variables

3.2.4.1 Refillable Water Bottle Use

Frequency of refillable water bottle use was assessed on a five-point Likert scale using the youth survey and was an ordinal categorical variable, with response options including never, rarely, sometimes, usually, and always.

3.2.4.2 Participation in a School Milk Program

Participation in a school milk program was assessed using the youth survey and was a nominal categorical variable, with response options including yes, no, and my school does not have a milk program. For analysis, responses were dichotomized into yes and no, with my school does not have a milk program responses considered as no.

3.2.4.3 Permission to Leave School Grounds at Lunch Time

Permission to leave schools grounds was assessed using the youth survey and was a binary variable. Response options included yes and no.

3.3 Model Conceptualization

This section will explain how the models used to assess the objectives of each integrated article were developed, and why each variable was included.

3.3.1 Directed Acyclic Graphs

In epidemiology, confounding occurs when a variable is associated both with the exposure of interest and with the outcome, but is not a mediator between them\textsuperscript{16}. Failing to consider a potential confounder may lead to an over or underestimation of the true association between the exposure and the outcome, which can result in biased conclusions\textsuperscript{17}. In order to obtain unbiased estimates of the association between the exposure and outcome, it is thus necessary to identify and adjust for confounders in the data analysis\textsuperscript{16}. Directed acyclic graphs (DAGs) may be useful in determining which confounders to adjust for. DAGs are causal diagrams that provide a visual representation of confounding that can aid in variable selection\textsuperscript{16}. DAGs
illustrating the relationship between knowledge and beverage consumption (Figure 3.2), intervention group and beverage consumption (Figure 3.3), and intervention group and knowledge (Figure 3.4) are presented below. These DAGs are not meant to include an exhaustive list of the factors that influence the outcomes of interest, but rather serve as an aid to identify key variables that were collected using the parent and/or youth survey, and that, when adjusted for, could provide a less biased estimate of the associations.

For Chapter 4 these variables were age, sex, race/ethnicity, and maximum household education, as illustrated in Figure 3.2. For Chapter 5 age was the sole confounder identified in the relationship between both intervention group and beverage consumption habits and intervention group and knowledge, as illustrated in Figure 3.3 and Figure 3.4. In addition to these confounders, a number of other socio-demographic, dietary, and behavioural variables believed to be associated with beverage consumption or knowledge were included in the models. These variables included parent employment status, household income level, child living arrangements, eating habits, permission to leave school grounds at lunch time, participation in a school milk program, and frequency of refillable water bottle use. Justification for including these confounders and covariates is provided below.
Figure 3.2 DAG for Relationship Between Knowledge and Beverage Consumption
Figure 3.3 DAG for Relationship Between Intervention Group and Beverage Consumption
Figure 3.4 DAG for Relationship Between Intervention Group and Knowledge
3.3.2 Variable Justifications

3.3.2.1 Confounders

Age is a well-established determinant of children’s beverage habits, with older children generally consuming more plain water than younger children\textsuperscript{18}, as well as more sugar-sweetened beverages\textsuperscript{19,20}. This could be because older children consume a higher volume of beverages overall compared to younger children, however it has been found that SSBs make up a greater proportion of children’s daily beverage consumption as their age increases\textsuperscript{21}. Older age is also associated with greater knowledge, due simply to the fact that older children have had more education. Additionally, because the UTRCA intervention was grade-specific, a child’s age was a factor in determining whether or not they received the program.

Multiple studies have found evidence to suggest that beverage consumption habits differ for males and females, with males consuming more SSBs\textsuperscript{19,22–26}. This could be because males consume a greater volume of beverages overall, however, and it has been found that males also consume more plain water than females\textsuperscript{18}. Similarly, sex differences in general knowledge have been observed, and a recent systematic review and meta-analysis found that, in high school students, males had slightly higher knowledge than females\textsuperscript{27}.

Racial differences in beverage consumption have also been established, and a number of studies have found that racial minorities consume more SSBs than their white peers\textsuperscript{28–33}, while Caucasian children consume more water\textsuperscript{34}. Given that racial minorities have higher rates of obesity\textsuperscript{35,36}, this could be representative of overall diet quality, which may be poorer in racial minorities due to lower household income or parental education\textsuperscript{37,38}. Additionally, some differences in reading and math skills between young children of different races has been observed\textsuperscript{39}, and it is therefore plausible that racial/ethnic differences in knowledge exist as well.

Children who come from more highly educated households may consume more water and less SSBs due to increased parental knowledge about the effects of consuming these beverages, which may translate to better parent-modelling of healthy beverage behaviours and reduced availability of SSBs in the home. In line with this theory, Hafekost et al. found that children living in a household with a lower level of parent education had a higher odds
of SSB consumption\textsuperscript{19}, while Beck et al. observed that having a parent with more than a high school degree was associated with a lower odds of consuming SSBs than having parents with a high school degree or less\textsuperscript{29}. Furthermore, children with more educated parents have been found to achieve better educational attainment themselves\textsuperscript{40,41}, and parental education has been identified as one of the strongest predictors of a child’s success in school\textsuperscript{42}.

### 3.3.2.2 Covariates

Parent employment status may influence a child’s water and SSB intake in two contradictory ways. On one hand, households with two parents or guardians who work full time are more likely to be higher income and more educated, both of which are associated with higher water and lower SSB consumption. On the other hand, when both parents/guardians work full time there is less time to devote to cooking and preparing healthy meals, which could drive these families to consume more fast food and, by association, SSBs. Indeed a study found that an increasing proportion of children’s food is prepared and consumed away from home as the number of two working parent household has increased\textsuperscript{43}.

Several studies have found that tap water consumption increases with income\textsuperscript{18,34}, and a systematic review of determinants of sugar-sweetened beverage consumption in young children concluded that lower parental socioeconomic status is associated with higher SSB consumption\textsuperscript{44}. Children with a higher household income can thus be expected to consume more water and less SSBs.

Children who live in a two-parent household may have different beverage consumption habits than those who live in a single-parent household and split their time, either equally or unequally, between two homes. This could be the function of reduced household income, reduced motor vehicle ownership, more time constraints on parents (limiting their ability to cook healthy food), and other such factors that usually affect children with separated parents and have been theorized to influence diet quality and water intake.

Eating habits, including fruit and vegetable consumption and less healthy food intake, are often correlated with beverage consumption habits, and those who consume more SSBs generally consume more less healthy food and fast food\textsuperscript{22,26}. These children also consume fewer servings of fruits\textsuperscript{19} and vegetables\textsuperscript{24}. Additionally, an association between nutrition
knowledge and dietary habits has been identified in youth populations, with increased knowledge correlated with a healthier diet\textsuperscript{45}.

Children who are allowed to leave the school grounds at lunch time without being accompanied by a parent or guardian have greater access to SSBs and other unhealthy foods than those who are not. These children are typically older and are able to make their own spending decisions, likely resulting in lower daily water intake due to displacement by SSBs.

Although the effect of milk provision on water intake has not itself been studied, a number of researchers have explored the opposite; that is, the effect of water provision on milk intake. These studies have reached differing conclusions, with one finding that the provision of water at meal times did not significantly displace milk consumption\textsuperscript{46}, and another observing a small and temporary but significant decline in milk taking at lunch with the provision of drinking water\textsuperscript{47}. Similarly, the effect of providing milk on SSB intake has not been studied, however multiple studies have found that sugar-sweetened beverages displace milk in children’s diets\textsuperscript{48,49}. Given these findings, it is theoretically possible that children who participate in their school’s milk program will consume less water and/or less SSBs due to beverage displacement caused by increased milk consumption.

The relationship between using a refillable water bottle and total water intake has not been studied in the existing literature, however it is likely that individuals who keep a bottle of water with them at all times will end up consuming more than those who have to go to the fountain or fill up a cup every time they want a drink. Furthermore, research has found that some youth are concerned about the safety and cleanliness of tap and fountain water, which may discourage them from consuming water from these sources\textsuperscript{50}, thus lowering their overall intake and driving them to consume different beverages to compensate, including SSBs.

\section*{3.4 Analytic Procedures}

This section describes the analytic procedures used in each of the integrated articles, including the strategy for handling missing data and the statistical analyses.
3.4.1 Missing Data

Missing data in this study was the result of survey non-response and, with the exception of household income level, was assumed to be missing at random (MAR). Data that are missing at random can be predicted by other variables in the dataset, however the probability of missingness does not depend on the missing values themselves\(^{51}\). This is in contrast to data that are missing completely at random (MCAR), which cannot be predicted by the other variables in the dataset or the unobserved value of the missing variable itself, and data that are missing not at random (MNAR), which can be predicted by the unobserved value of the missing variable\(^{51}\). Household income level was thought to be MNAR because individuals with very high incomes have been found to be more likely to not report their income than those with lower, more moderate incomes\(^{51}\). Analyzing only the complete cases will not result in biased effect estimates if the data are MCAR, although it may increase standard errors, however, if the data are MAR or MNAR, complete case analysis may produce bias\(^{51}\).

As such, the following steps were used to fill in missing values:

1) Wherever possible, missing data were supplemented using the youth or parent survey. For example, age, ethnicity, and living arrangements were assessed in both the youth and parent surveys, and, while the parent-reported information was used preferentially due to increased accuracy, where missing, youth-reported data was used. This was considered acceptable, as kappa statistics were calculated to assess the agreement between parent and child-reported information and were found to be almost perfect (kappa statistic 0.81-1.00) for age and sex, moderate (kappa statistic 0.41-0.60) for living arrangements, and fair (kappa statistic 0.21-0.40) for ethnicity. Dietary and behavioural variables, however, were not consistent between the parent and child surveys, and thus even though food and beverage intake was assessed in both surveys, child-reported data was not substituted with parent-reported data where missing.

2) Values that remained missing following supplementation were imputed using chained equations, also known as fully conditional specification (FCS) multiple imputation, with arbitrary missing data patterns in SAS 9.4\(^{52}\). Multiple imputation (MI) is a common and effective strategy for dealing with missing data and involves...
the use of regression equations to fill in missing information based on the distribution of the observed data\textsuperscript{51,52}. Multiple datasets are created using this technique and analyses are performed on each one separately, and then pooled to obtain overall estimates, variances, and confidence intervals\textsuperscript{51,52}. MI is appropriate for data that are MCAR or MAR, however it cannot be used for data that are MNAR. As such, household income level was not imputed, and missing values were included as a separate category in all analyses.

FCS multiple imputation uses a separate conditional distribution for each imputed variable and is appropriate when imputing several variables of different types (i.e. continuous, binary, ordered or unordered categorical)\textsuperscript{52}. Discriminant function for non-ordered variables and logistic regression for ordered variables were used to impute binary and categorical variables, while predictive mean matching was used for continuous variables, as it generates imputed values that are consistent with observed values\textsuperscript{51}.

Although historically, three to five imputed datasets were considered sufficient\textsuperscript{53}, SAS’s guide on multiple imputation suggests a larger number, on the basis that more imputations will yield more stable estimates of coefficients and variances\textsuperscript{51}. White et al. have proposed the rule that the number of imputed datasets should be approximately equal to the percentage of incomplete cases\textsuperscript{52,54}. Based on this guideline, 50 imputed datasets were created for the analysis for Chapter 4, and 40 were created for the analysis for Chapter 5.

Imputation diagnostics were performed through visual inspection of the trace plots, as described in SAS’s guide on multiple imputation\textsuperscript{51}. Additionally, summary statistics of observed versus imputed data were calculated and are presented in tables 3.2 and 3.3. Built-in imputation diagnostic features are not currently available in SAS\textsuperscript{55}, and thus more thorough diagnostics were not performed. Sensitivity analyses using only non-imputed data were conducted for each objective and similar results were found.
### Table 3.2 Summary Statistics of the Observed and Imputed Data for the Continuous Variables in the Analysis Models

<table>
<thead>
<tr>
<th>Variable</th>
<th>Number Missing</th>
<th>Mean</th>
<th>SD</th>
<th>Min</th>
<th>Max</th>
<th>Mean</th>
<th>SD</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
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<td>10.56</td>
<td>1.39</td>
<td>8</td>
<td>14</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
</tr>
<tr>
<td>Daily Servings of Fruits and Vegetables</td>
<td>24</td>
<td>4.39</td>
<td>1.99</td>
<td>0</td>
<td>8</td>
<td>4.33</td>
<td>1.98</td>
<td>0</td>
<td>8</td>
</tr>
<tr>
<td>Weekly Less Healthy Food Consumption Frequency</td>
<td>10</td>
<td>15.66</td>
<td>10.08</td>
<td>0</td>
<td>65</td>
<td>15.63</td>
<td>9.53</td>
<td>0</td>
<td>65</td>
</tr>
<tr>
<td>Daily Proportion of Water Consumption at Baseline</td>
<td>15</td>
<td>39.66</td>
<td>19.48</td>
<td>0</td>
<td>100</td>
<td>36.72</td>
<td>19.7</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>Daily Proportion of Water Consumption at Follow Up</td>
<td>9</td>
<td>40.3</td>
<td>18.68</td>
<td>0</td>
<td>100</td>
<td>34.49</td>
<td>16.68</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>Daily Proportion of SSB Consumption at Baseline</td>
<td>12</td>
<td>21.98</td>
<td>17.22</td>
<td>0</td>
<td>100</td>
<td>19.74</td>
<td>17.17</td>
<td>0</td>
<td>100</td>
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<td>Daily Proportion of SSB Consumption at Follow Up</td>
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<td>21.65</td>
<td>16.85</td>
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<td>100</td>
<td>17.06</td>
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<td>0</td>
<td>65</td>
</tr>
<tr>
<td>Total Knowledge Score at Baseline</td>
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<td>66.48</td>
<td>14.86</td>
<td>0</td>
<td>95.45</td>
<td>59.56</td>
<td>15.81</td>
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<td>88.64</td>
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<td>Total Knowledge Score at Follow Up</td>
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<td>70.3</td>
<td>14.02</td>
<td>15.91</td>
<td>93.18</td>
<td>/</td>
<td>/</td>
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</tbody>
</table>
Table 3.3 Summary Statistics of the Imputed Data for the Categorical Variables in the Analysis Models

<table>
<thead>
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<th>Variable</th>
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<th>Observed Percent</th>
<th>Imputed Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
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<tr>
<td>Male</td>
<td></td>
<td>43.88</td>
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<tr>
<td>Female</td>
<td></td>
<td>56.12</td>
<td>50.63</td>
</tr>
<tr>
<td>Ethnicity</td>
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<td></td>
</tr>
<tr>
<td>White/Caucasian</td>
<td></td>
<td>64.12</td>
<td></td>
</tr>
<tr>
<td>Non-White/Mixed</td>
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<td>35.88</td>
<td></td>
</tr>
<tr>
<td>Maximum Household Education</td>
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<td>17.69</td>
</tr>
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<td>71.05</td>
<td>73.08</td>
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<td>College/University</td>
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<td>17.24</td>
<td>9.23</td>
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<td>Income Level</td>
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<tr>
<td>Low</td>
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<tr>
<td>Low-Middle</td>
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<td>11.28</td>
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</tr>
<tr>
<td>Middle-High</td>
<td></td>
<td>14.18</td>
<td></td>
</tr>
<tr>
<td>High</td>
<td></td>
<td>33.19</td>
<td></td>
</tr>
<tr>
<td>Child Living Arrangements</td>
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</tr>
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<td>Single Parent</td>
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<td>Other</td>
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<td>Mother's Employment Status</td>
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<td>Employed</td>
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<td>Unemployed</td>
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<td>Father's Employment Status</td>
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<tr>
<td>Employed</td>
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<tr>
<td>Unemployed</td>
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<tr>
<td>Frequency of Refillable Water Bottle Use</td>
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<tr>
<td>Never</td>
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<tr>
<td>Rarely</td>
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<td>Sometimes</td>
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<td>Usually</td>
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<tr>
<td>Always</td>
<td></td>
<td>32.29</td>
<td>27.20</td>
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<tr>
<td>Participation in School Milk Program</td>
<td>17</td>
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<td></td>
</tr>
<tr>
<td>Yes</td>
<td></td>
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<td>17.79</td>
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<tr>
<td>No</td>
<td></td>
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<td>82.21</td>
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<td>Permission to Leave School at Lunch</td>
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<td>Yes</td>
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<td></td>
<td>82.51</td>
<td>83.75</td>
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</table>
3.4.2 Statistical Analyses

The following section describes the specific analyses used in each study. Data cleaning was performed using SPSS 24, while all other statistical analyses were conducted using SAS 9.4.

3.4.2.1 Analyses for Chapter 4

3.4.2.1.1 Preliminary Analyses

Written parental consent was obtained for 1,504 (36.8%) of eligible children. Of these, 1099 completed the baseline youth survey. One school (n=26) withdrew from the study following baseline data collection and was excluded from the analysis, resulting in a final sample of 16 schools encompassing 1,478 children. Children were included in the analysis for Chapter 4 if they met the following inclusion criteria: a) had a completed youth survey, and b) had a completed parent/guardian survey. In total, 1049 children, representing 25.67% of eligible children and 85.08% of children who completed a baseline youth survey met these criteria and were included in the analysis. Wilcoxon Mann-Whitney and t-tests for continuous variables and chi-square, Fisher’s exact, and Monte Carlo simulation tests for categorical variables were used to test for differences between children who met these criteria and those who didn’t, and based on the results, it was concluded that selection bias was unlikely.

Descriptive statistics were calculated to summarize the characteristics of the sample at baseline. For the main exposure and outcomes of interest (knowledge and water and SSB consumption), and for the continuous covariates (age, daily servings of fruits and vegetables, and weekly less healthy food consumption frequency) means and standard deviations were calculated. For the categorical covariates (sex, race/ethnicity, household income level, maximum household education, parental employment status, living situation, frequency of refillable water bottle use, participation in a school milk program, and permission to leave the school grounds at lunch) frequencies and percentages were reported.

3.4.2.1.2 Multivariable Regression Analyses

The primary objective of Chapter 4 was to assess the association between water and nutrition knowledge scores and water and SSB consumption among elementary school children in London, Ontario. This was achieved using hierarchical multivariable linear regression.
Due to the sampling strategy used in the HKCC study, children were clustered within schools. Because of this, children who attended the same school may be more similar than those who attended different schools, and thus the observations cannot be considered statistically independent. If the clustering is not taken into account in the analysis, the standard errors may be underestimated, which will increase the probability of Type I error. As such, generalized estimating equations (GEEs) were used in this analysis in order to account for clustering at the school-level using PROC GENMOD. GEEs are an extension of generalized linear models (GLMs) and modify the estimation procedures under the assumption of correlation among the outcomes without changing the underlying model. The use of GEEs assumes that responses are correlated or clustered, that errors are correlated, and that the covariance structure is specified. Using GEE procedures results in some gain in efficiency compared to the use of robust standard errors alone, particularly when clusters are of varying sizes, as we have here, and are also robust to misspecifications of the covariance structure.

Confounders and covariates were entered into the model hierarchically in three blocks. Hierarchical linear regression is a statistical technique used to assess how the addition of variables affects the predictive power of the model. Similar variables are entered into the model in blocks based on theory. For Chapter 4, variables were entered in the following three blocks: 1) socio-demographic variables including sex, age, race/ethnicity, maximum household education, household income level, parent employment status, and child living arrangements; 2) dietary variables including weekly less healthy food consumption and daily servings of fruits and vegetables; and 3) behavioural factors including frequency of refillable water bottle use, participation in a school milk program, and permission to leave the school grounds at lunch time. After each block of variables was entered, the association between knowledge and beverage consumption was re-evaluated.

The models were compared through visual inspection of the Quasi-likelihood under the Independence Model Criterion (QIC) values after each block was added. Analogous to Akaike’s Information Criterion (AIC), which is used to compare models fit with likelihood-based methods, QICs inform model selection, with smaller values indicating a better fit.
3.4.2.2 Analyses for Chapter 5

3.4.2.2.1 Preliminary Analyses

Children were included in the analyses for Chapter 5 if they met the following inclusion criteria: a) had a completed parent survey; b) had a completed baseline youth survey; and c) had a completed follow-up youth survey. In total, 931 children met these inclusion criteria, representing an 88.8% retention rate from baseline.

Wilcoxon Mann-Whitney and t-tests tests for continuous variables and chi-square, Fisher’s exact and Monte Carlo simulations tests for categorical variables were used to test for differences between children who were lost to follow up and those who were retained. Children who were lost to follow up were more likely to be visible minorities and to live in a single parent household, however they did not differ from children who were retained in any other way.

Descriptive statistics were calculated to summarize the characteristics of the sample at baseline by intervention group. For the main outcomes of interest (knowledge and water and SSB consumption), and for the continuous covariates (age, daily servings of fruits and vegetables, and weekly less healthy food consumption frequency) means and standard deviations were calculated. For the categorical covariates (sex, race/ethnicity, household income level, maximum household education, parental employment status, living situation, frequency of refillable water bottle use, participation in a school milk program, and permission to leave the school grounds at lunch) frequencies and percentages were reported. One-way ANOVA tests for continuous variables and Kruskal-Wallis tests for categorical variables were used to assess differences in baseline characteristics between children in each intervention group. Small but significant differences in age, parental education level, weekly less healthy food consumption frequency, and knowledge score at baseline were observed between the three intervention groups, however they were otherwise comparable.

3.4.2.2.2 Multivariable Linear Mixed Regression Analyses

The primary objective of Chapter 5 was to evaluate the effectiveness of the HKCC Water Does Wonders interventions at increasing children’s water consumption and decreasing their
SSB consumption. The impact of the programs on total knowledge score was also assessed. This was achieved using multivariable linear mixed model ANCOVAs using PROC MIXED.

Linear mixed models (LMMs) are an extension of linear regression and are appropriate when analyzing clustered or nested data, which cannot be assumed to be independent\textsuperscript{58}. As was discussed previously, children who participated in the HKCC study were clustered within schools, with those who attended the same school potentially more similar than those who attended different schools. Each level of this clustering can introduce additional variation and correlation and may therefore cause the standard errors to be underestimated if not accounted for in the analysis, increasing the probability of Type 1 error\textsuperscript{58}. LMMs use covariance parameters to account for clustering.

Mixed models allow for both fixed and random effects to be included in the model. Fixed effects are known explanatory variables that remain constant across individuals and may include age, sex, and ethnicity. These factors have a fixed effect on the outcome of interest and are assumed not to change over time\textsuperscript{58}. Random effects, on the other hand, are unknown random variables that are believed to affect the variability of the data. Random factors vary in effect on the outcome across clusters, and thus cannot be assumed to be constant\textsuperscript{57}. In this analysis we included two random effects terms: one for the intercept and one for the slope of the baseline value of the outcome of interest. An unstructured covariance structure was selected, as it is the most flexible and imposes the fewest restrictions\textsuperscript{58}. Mixed models assume that data is clustered or nested, that there is a linear relationship between the exposure and outcome variable, that there is constant variance among the errors, that the errors are independent, and that the errors are normally distributed\textsuperscript{56}.

Due to the pretest-posttest control group design of this study, analysis of covariance (ANCOVA) was used to assess differences in outcome between intervention group. ANCOVA models use the posttest outcome value as the dependent variable and include the pretest value as a covariate in the model\textsuperscript{59}. This is in contrast to the CHANGE method, in which the difference between post- and pretest values is used as the dependent variable\textsuperscript{58}. ANOVA was selected over CHANGE for this analysis because the intervention groups were comparable at baseline, and because this method accounts for varying baseline values,
ensuring that any posttest differences in the outcome are truly the result of the intervention and not pretest differences between the groups.\textsuperscript{59}

Three models were run, the first with water consumption as the outcome, the second with SSB consumption as the outcome, and the third with knowledge as the outcome. To maintain consistency with Chapter 4, socio-demographic (age, sex, ethnicity, household income level, parental work status, maximum household education, child living arrangements), dietary (daily servings of fruits and vegetables, weekly less healthy food consumption frequency), and behavioural (frequency of refillable water bottle use, participation in a school milk program, permission to leave school at lunch) variables were included in the models as control variables.

Because the HKCC Water Does Wonders study was a natural experiment, the researchers had no control over which schools received which intervention, nor over whether or not protocols were followed, and three of the 16 schools ultimately did not receive their automatic water bottle filling station until after follow-up data collection had been completed. In order to account for this, analyses included both intention to treat (ITT) analysis, where all students are analyzed in the groups to which they were allocated, regardless of whether or not they actually got the water bottle filling station (n=931), and per protocol (PP) analysis, where only the students who actually received the water bottle filling station are analyzed (n=621). For the purpose of this thesis, the results of the ITT analyzed are given preference, as ITT preserves sample sizes compared to PP, as well as eliminates bias and better represents the real life situation.\textsuperscript{60}

### 3.5 Conclusion

Due to the integrated article format of this thesis, the methods used in each article could not be discussed at length in the studies themselves. As such, the purpose of this chapter was to present a more detailed description of the design, recruitment, data collection, and measurement tools employed in the HKCC Water Does Wonders study, and to provide a rationale for the analyses used in each of the following articles. The background information presented here should provide a greater clarification of how the thesis objectives were addressed and will facilitate a deeper understanding of the studies.
3.6 References


10. Matheson DM, Hanson KA, Mcdonald TE, Robinson TN. Validity of children’s food


56. Vach W. *Regression Models as a Tool in Medical Research,* Boca Raton, FL: CRC


Chapter 4

4 Assessing the Relationship Between Water and Nutrition Knowledge and Beverage Consumption Habits in Children

4.1 Abstract

*Objective:* To examine the relationship between knowledge and beverage consumption habits among children.

*Design:* Cross-sectional analysis. Linear regression was used to identify socio-demographic, dietary, and behavioural determinants of beverage consumption and knowledge, and to describe the relationships between children’s knowledge and water and sugar-sweetened beverage consumption.

*Settings:* Seventeen elementary schools in London, Ontario.

*Subjects:* A total of 1049 children aged 8-14 years.

*Results:* Knowledge scores were low overall. Children with higher knowledge scores consumed significantly fewer SSBs ($\beta = -0.33; 95\% \text{ CI } -0.49, -0.18; p < 0.0001$), and significantly more water ($\beta = 0.34; 95\% \text{ CI } 0.16, 0.52; p = 0.0002$). More frequent refillable water bottle use, lower less healthy food consumption, lower fruit and vegetable consumption, female sex, higher parental education, two-parent households, and not participating in a milk program were associated with higher water consumption. Male sex, higher less healthy food consumption, single parent households, lower parental education, participating in a milk program, less frequent refillable water bottle use, and permission to leave school grounds at lunch were associated with higher SSB consumption. Water was the most frequently consumed beverage, however 79% of respondents reported consuming an SSB at least once daily and 50% reported consuming an SSB 3 or more times a day.

*Conclusions:* Elementary school children have relatively low nutrition and water knowledge and consume SSBs frequently. Higher knowledge is associated with increased water consumption and reduced SSB consumption. Interventions to increase knowledge may be effective at improving children’s beverage consumption habits.

*Keywords:* children’s health, beverage intake, water, sugar-sweetened beverages, water knowledge, nutrition knowledge, multivariate analysis
4.2 Introduction

Childhood obesity has emerged as a major public health concern of the 21st century. In Canada alone, the prevalence of overweight and obesity has doubled in the past 40 years, now affecting roughly 30% of children aged 5-17 years\textsuperscript{1,2}. There is strong evidence to suggest that overweight and obese children are at an increased risk of a number of non-communicable diseases and socio-psychological issues including cardiovascular disease, type 2 diabetes, hypertension, and depression\textsuperscript{3}. These complications follow a child throughout their life course, affecting adult morbidity and mortality\textsuperscript{4}.

Children’s beverage consumption habits have been linked to the rising levels of overweight and obesity observed globally\textsuperscript{5-10}. According to the Academy of Nutrition and Dietetics, children require approximately 6 to 8 cups of total water each day to maintain sufficient hydration\textsuperscript{11} and healthy bodyweights\textsuperscript{12}. Nationwide survey data, however, suggests that few American children are consuming enough water\textsuperscript{13,14}. Similarly, findings from the Canadian Community Health Survey (CCHS) demonstrate that just 60% of children’s beverage intake consists of healthy drinks such as water, milk, and 100% fruit juice, with sugar-sweetened beverages (SSBs), including pop, fruit-flavoured drinks, sports drinks, and energy drinks, thought to make up the majority of the difference\textsuperscript{15}. These beverages account for approximately 44% of daily sugar intake for Canadian children and adolescents, contributing a substantial proportion of daily calories\textsuperscript{1,16}, and there is moderate quality evidence linking their consumption to excess weight gain in children\textsuperscript{5,6,8,9,17,18}. Given these findings, it is not surprising that sugar-sweetened beverage consumption has been identified as a key risk factor for being overweight or obese\textsuperscript{7}, and recent systematic reviews suggest that reducing SSB intake in young children and/or replacing SSBs with water, a calorie and sugar-free alternative, is an effective strategy for reducing obesity\textsuperscript{6,10}.

Most water and SSB interventions can be categorized into three types: 1) health/nutrition education programs, such as educating children about the adverse health effects of consuming SSBs; 2) environmental changes to discourage SSB or encourage water consumption, such as installing water fountains or removing soft drinks from vending machines; and 3) policies relating to nutrition, such as banning the provision of SSBs at school events. Although these approaches are often used in combination, a review of the
published literature reveals that education programs are the most common, particularly when targeting child populations\(^{19}\). Education interventions aim to positively influence behaviour through improving knowledge and it is believed that by providing children with the information and skills they require to make healthy and balanced food choices, they will automatically begin to incorporate this into their everyday lives, fostering healthy habits\(^{20,21,30–33,22–29}\). It is particularly important to establish healthy dietary habits in childhood, as behaviours formed during this period tend to persist into adulthood and thereby affect long-term health status\(^{34–37}\).

While an association between health-related knowledge and behaviour has been demonstrated in other contexts, there is mixed evidence concerning the effectiveness of nutrition education programs at altering dietary habits. A number of studies have assessed the relationship between nutrition knowledge and dietary intake, with the majority finding a weak positive association\(^{38}\); however, only a few have focused on child populations\(^{39–44}\) and just one of these included beverages\(^{40}\). That study identified a negative association between children’s nutrition knowledge and sugary drink consumption; however, it was conducted in a restrictive sample of children and adolescents living in rural Sicily and thus may not be generalizable to other populations\(^{40}\).

Given these gaps, the purpose of this study was to describe the beverage consumption habits and knowledge of elementary school children aged eight to 14 years in London, Ontario, and to assess whether greater knowledge is associated with healthier beverage habits. The results will inform the design of future SSB and water education-based interventions targeted towards children.

### 4.3 Methods

#### 4.3.1 Setting and Participants

The Water Does Wonders project occurred in the city of London, Ontario throughout the 2016/2017 school year and targeted children in 13 priority neighbourhoods, as identified by a community needs assessment conducted through the Child and Youth Network\(^ {45}\). Compared to the city of London as a whole, priority neighbourhoods were more likely to contain households that had lower incomes, lower levels of educational attainment, and were headed
by single parents\textsuperscript{45}. Of the 78 elementary schools in these neighbourhoods, 19 agreed to participate in the study; of these 16 were included in the analyses. Data were collected from children in grades four to eight, who were approximately eight to 14 years old. All children were required to have written parental consent, as well as provide personal assent in order to participate.

4.3.2 Data Collection Tools

Data collection for this study took place in October-November 2016. Teams of research assistants, volunteers, and graduate students from the Human Environments Analysis Laboratory (HEAL) at Western University administered surveys to participating students. The research teams provided verbal instructions and while they were available to answer questions related to comprehension, spelling, and process throughout the survey period, they did not prompt students in any way. Students were provided with a complimentary colour-changing pencil upon completing the survey. Students who were absent the day of the survey were not given the opportunity to complete the survey at a later date.

The youth survey consisted of 91 items under five domains including demographics, beverage consumption habits, food and beverage consumption frequencies, eating and drinking during the school day, and nutrition and water knowledge. Response options included multiple choice, yes/no, Likert scale, and fill-in-the-blank questions. A parental/guardian version of the survey consisting of 50 items under four domains measuring basic demographics, the child’s eating and drinking habits, and eating and drinking during the school day was used to supplement information collected from the youth survey.

4.3.3 Outcome Measures

Dietary habits were assessed using a food-frequency questionnaire (FFQ), adapted from a survey developed for a previous study, described elsewhere\textsuperscript{46}.

4.3.3.1 Water Consumption

Water consumption was measured as the number of times per day a child reported consuming water, with response categories ranging from zero to seven or more. In order to account for potential differences in children’s interpretation of ‘times per day’, for analysis water
consumption frequency was divided by the total beverage consumption frequency reported by each child to obtain standardized proportions. For example, if a child reported consuming water 6 times per day and their total beverage intake frequency was 18 instances, 33.33% of their total daily beverage consumption would be attributable to water.

### 4.3.3.2 SSB Consumption

Sugar-sweetened beverage (SSB) consumption was an aggregate variable, derived from summing the number of times per day a child reported consuming regular pop, fruit-flavoured drinks (including sports drinks), energy drinks, and chocolate milk, each ranging from zero to seven or more for a total SSB frequency possible range of zero to 28+. Although there is some debate as to whether sweetened milks and milk alternatives should be considered SSBs due to the high number of essential nutrients they contain, we included them in our analysis based on a report published by the Dietitians of Canada\textsuperscript{47} and using the definition of sugar-sweetened beverage defined by the Centre for Disease Control and Prevention\textsuperscript{48}. Conversely, while sweetened coffee and tea drinks are considered SSBs under the CDC definition, they were not included in this analysis because the nature of the survey did not allow respondents to specify whether or not the tea and coffee beverages they consumed contained added sugar. Additionally, despite the fact that 100% fruit juices are high in sugar and have a similar effect to SSBs on the body\textsuperscript{49}, they were excluded from the analysis because their sugar is naturally occurring. Diet beverages were also excluded. As with water consumption, for analysis SSB consumption frequency was divided by total beverage consumption frequency to generate the percentage of overall reported beverage consumption frequency attributable to SSBs.

### 4.3.3.3 Water and Nutrition Knowledge

Nutrition knowledge was measured by summing the scores of 36 individual questions assessing children’s knowledge of the sugar, caffeine, and water content of various foods and beverages. Examples include: “from the list below, choose the beverages that are high in sugar and/or high in caffeine” (100% apple juice, black/green tea, cappuccino, chocolate milk, Coca-Cola, coffee, fruit punch, Nestea iced tea, peach drink, Red Bull energy drink, Rock Star energy drink, Sprite, SunnyD, water, white milk); and “check the fruit or vegetable that has the most water from each pairing” (cucumber or carrots, apple or peach, carrots or
tomatoes, cucumber or beans, strawberries or pears, spinach or corn). The minimum possible score a child could achieve was zero and the maximum was 36.

Water knowledge was measured by summing the scores of eight individual questions assessing children’s knowledge of the water treatment system, health benefits of water, and the world’s water. Examples include: “where does the water from your tap come from?” (ground water; Lake Ontario & Erie; Lake Huron & Erie; Thames River; I don’t know); “how much water do we need to drink each day?” (3-4 cups, 5-6 cups, 7-8 cups, 9-10 cups); “can you name one way that your tap water is treated?”; “can you list 2 ways to conserve water at home or at school?”; “true or false, bottled water is better than tap water”; “true or false, water is an unlimited resource”; and “true or false, we have enough water in Canada for everyone, forever”. The minimum possible score a child could achieve was zero and the maximum was eight.

Total knowledge was determined by summing the scores of the nutrition and water knowledge subscale scores. The minimum score that could be achieved was zero and the maximum was 44. For analysis purposes, knowledge scores were treated as continuous.

4.3.4 Covariates

Socio-demographic characteristics including sex (male/female), age, race (white/non-white), living arrangement (single parent household/two parent household/other), parent education (high school or less/college or university/graduate school), parent employment status (employed/unemployed), and household income level (low/low-middle/high-middle/high) were determined using self-administered surveys completed by both the parent and child. Income level classifications were made based on reported annual household income and number of people in the household using methods described in the Canadian Community Health Survey Derived Variable Specifications50. Parent-reported data was used wherever possible, due to increased likelihood of accuracy, however where missing, child-reported data was substituted.

Dietary intake including daily servings of fruits and vegetables and weekly less healthy food consumption frequency was assessed using the FFQ component of the youth survey. Less healthy food consumption was an aggregate variable, derived from summing the number of
times per week a child reported consuming sweetened breakfast cereal, cake/pie/doughnuts, potato chips, chocolate bars, pizza, French fries, hot dogs, ice cream, candy, granola bars, and cookies, each ranging from zero to six or more for a total less healthy food frequency possible range of zero to 66+. Information on drinking habits such as frequency of use of a refillable water (never/rarely/sometimes/usually/always), milk program participation (yes/no), and permission to leave school grounds at lunch time (yes/no) was also collected using the youth survey.

4.3.5 Data Analysis

Data cleaning was performed using SPSS 24, while all other statistical analyses were conducted using SAS 9.4.

Written parental consent was obtained for 1,504 (36.8%) of 4,086 eligible children, of which 1099 completed the youth survey. Among the remaining study participants, 24 children did not have a corresponding parent survey and were excluded from the analysis due to a lack of socio-demographic information. Wilcoxon Mann-Whitney tests, t-tests, chi-square tests, Fisher’s exact tests, and Monte Carlo estimation simulations with 40,000 simulations revealed no significant differences between children with a parent survey and children without, however, indicating that selection bias on this variable is unlikely. The final number of analyzed subjects was 1049 parent-child dyads, representing 25.67% of eligible children and 85.08% of children who completed surveys.

Fully conditional specification (FCS) multiple imputation with arbitrary missing data patterns was performed to impute values using SAS 9.4. Fifty imputed datasets were created, based on the guideline that the number of imputations should be approximately equal to the percentage of incomplete cases. In our sample, just 58.7% of participants had complete data for all variables of interest and missing data among the imputed variables ranged from 0.5% (total knowledge score) to 27.6% (father’s employment status). Approximately 33.9% of subjects were missing data on household income level, however this variable was not imputed due to the high probability that it was not missing at random. Variables included in the imputation model were all of those included in the final analysis, as well as a number of auxiliary variables that were correlated with or predicted missing variables.
Descriptive statistics including means and frequencies were used to describe the characteristics of the sample, as well as participants’ beverage consumption habits and water and nutrition knowledge. Hierarchical multivariable regression models with generalized estimating equations (GEEs) to account for clustering at the school level were used to assess the relationship between knowledge and water and SSB consumption, controlling for potential confounders, and to determine which variables were most predictive of knowledge, and water and SSB consumption frequency.

Model 1 adjusted for socio-demographic characteristics including sex, age, ethnicity, household income level, maximum household education, living arrangements, and parental employment status. Model 2 added the dietary variables unhealthy food consumption frequency and daily servings of fruits and vegetables. Model 3 added behavioural factors including frequency of refillable water bottle use, participation in a school milk program, and permission to leave school grounds at lunch time. These variables were selected based on the literature as well as theoretical plausibility and are hypothesized to affect children’s water and/or SSB consumption. Unadjusted and adjusted results are presented. P-values <0.05 were considered statistically significant. A sensitivity analysis using only non-imputed data was performed. No multi-collinearity between covariates was identified.

4.4 Results

4.4.1 Characteristics of the Sample

Sample demographics, dietary habits, and nutrition/water knowledge are presented in Tables 1-3. The mean age of respondents was 10.6 (SD 1.4) years, and 56.7% were female. The majority of participants were Caucasian (62.7%), lived in two-parent households (78.6%), and had college/university educated parents (88.1%). 74.4% of mothers and 93.6% of fathers were employed, and 32.3% of households were classified as high income, compared to 8.1% classified as low income.
Table 4.1 Demographic Characteristics of the Sample

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Mean / Frequency (%)</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (Mean)</td>
<td>10.56</td>
<td>1.39</td>
</tr>
<tr>
<td>Grade (Frequency (%))</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>227 (23.02%)</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>240 (24.34%)</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>194 (19.68%)</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>189 (19.17%)</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>136 (13.79%)</td>
<td></td>
</tr>
<tr>
<td>Sex (Frequency (%))</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>449 (43.26%)</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>589 (56.74%)</td>
<td></td>
</tr>
<tr>
<td>Race/Ethnicity (Frequency (%))</td>
<td></td>
<td></td>
</tr>
<tr>
<td>White/Caucasian</td>
<td>658 (62.73%)</td>
<td></td>
</tr>
<tr>
<td>Visible Minority/Mixed Race</td>
<td>391 (37.27%)</td>
<td></td>
</tr>
<tr>
<td>Household Income Level (Frequency (%))</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>85 (8.10%)</td>
<td></td>
</tr>
<tr>
<td>Low-Middle</td>
<td>121 (11.53%)</td>
<td></td>
</tr>
<tr>
<td>High-Middle</td>
<td>148 (14.11%)</td>
<td></td>
</tr>
<tr>
<td>High</td>
<td>339 (32.32%)</td>
<td></td>
</tr>
<tr>
<td>Missing</td>
<td>356 (33.94%)</td>
<td></td>
</tr>
<tr>
<td>Maximum Household Education (Frequency (%))</td>
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<td></td>
</tr>
<tr>
<td>High School or Less</td>
<td>121 (11.89%)</td>
<td></td>
</tr>
<tr>
<td>College/University</td>
<td>720 (70.73%)</td>
<td></td>
</tr>
<tr>
<td>Graduate School</td>
<td>177 (17.39%)</td>
<td></td>
</tr>
<tr>
<td>Mother’s Employment Status (Frequency (%))</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Employed</td>
<td>700 (74.39%)</td>
<td></td>
</tr>
<tr>
<td>Unemployed</td>
<td>241 (25.61%)</td>
<td></td>
</tr>
<tr>
<td>Father’s Employment Status (Frequency (%))</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Employed</td>
<td>711 (93.55%)</td>
<td></td>
</tr>
<tr>
<td>Unemployed</td>
<td>49 (6.45%)</td>
<td></td>
</tr>
<tr>
<td>Child Living Arrangement (Frequency (%))</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single Parent/Guardian Household</td>
<td>218 (21.06%)</td>
<td></td>
</tr>
<tr>
<td>Two Parent/Guardian Household</td>
<td>813 (78.55%)</td>
<td></td>
</tr>
<tr>
<td>Other Arrangement</td>
<td>4 (0.39%)</td>
<td></td>
</tr>
</tbody>
</table>
Table 4.2 Dietary Behaviours of the Sample

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Mean / Frequency (%)</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of Water Consumed at Home (Frequency (%))</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tap</td>
<td>395 (37.65%)</td>
<td></td>
</tr>
<tr>
<td>Barrel</td>
<td>42 (4.0%)</td>
<td></td>
</tr>
<tr>
<td>Bottle</td>
<td>268 (25.55%)</td>
<td></td>
</tr>
<tr>
<td>Filtered</td>
<td>434 (41.37%)</td>
<td></td>
</tr>
<tr>
<td>Use of a Refillable Water Bottle (Frequency (%))</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>722 (91.51%)</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>67 (8.49%)</td>
<td></td>
</tr>
<tr>
<td>Frequency of Refillable Water Bottle Use (Frequency (%))</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Never</td>
<td>31 (3.06%)</td>
<td></td>
</tr>
<tr>
<td>Rarely</td>
<td>70 (6.92%)</td>
<td></td>
</tr>
<tr>
<td>Sometimes</td>
<td>239 (23.62%)</td>
<td></td>
</tr>
<tr>
<td>Usually</td>
<td>337 (33.30%)</td>
<td></td>
</tr>
<tr>
<td>Always</td>
<td>335 (33.10%)</td>
<td></td>
</tr>
<tr>
<td>Family Use of a Refillable Water Bottle (Frequency (%))</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>865 (83.66%)</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>169 (16.34%)</td>
<td></td>
</tr>
<tr>
<td>Use of a Refillable Water Bottle at School (Frequency (%))</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>870 (84.80%)</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>156 (15.20%)</td>
<td></td>
</tr>
<tr>
<td>Type of Beverage Consumed During PA (Frequency (%))</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water</td>
<td>908 (86.56%)</td>
<td></td>
</tr>
<tr>
<td>100% Juice</td>
<td>57 (5.43%)</td>
<td></td>
</tr>
<tr>
<td>Energy Drinks</td>
<td>20 (1.91%)</td>
<td></td>
</tr>
<tr>
<td>Sports Drinks</td>
<td>175 (16.68%)</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>21 (2.0%)</td>
<td></td>
</tr>
<tr>
<td>Daily Servings of Fruits and Vegetables (Mean)</td>
<td>4.39</td>
<td>2.00</td>
</tr>
<tr>
<td>Times Less Healthy Food Consumed/Week (Mean)</td>
<td>15.52</td>
<td>10.06</td>
</tr>
<tr>
<td>Times Beverages Consumed/Day (Mean)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water</td>
<td>5.13</td>
<td>1.93</td>
</tr>
<tr>
<td>Sugar-Sweetened Beverages</td>
<td>3.92</td>
<td>4.31</td>
</tr>
<tr>
<td>100% Juice</td>
<td>1.86</td>
<td>1.84</td>
</tr>
<tr>
<td>White Milk</td>
<td>2.90</td>
<td>2.43</td>
</tr>
<tr>
<td>Diet Pop</td>
<td>0.37</td>
<td>0.99</td>
</tr>
<tr>
<td>Coffee</td>
<td>0.25</td>
<td>0.86</td>
</tr>
<tr>
<td>Tea</td>
<td>0.98</td>
<td>1.66</td>
</tr>
<tr>
<td>Percentage of Total Daily Beverage Consumption Attributable to Water (Mean)</td>
<td>39.77</td>
<td>19.61</td>
</tr>
<tr>
<td>Percentage of Total Daily Beverage Consumption Attributable to SSBs (Mean)</td>
<td>22.03</td>
<td>17.11</td>
</tr>
<tr>
<td>Beverages Allowed to Bring to School (Frequency (%))</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water</td>
<td>978 (93.23%)</td>
<td></td>
</tr>
<tr>
<td>Juice</td>
<td>472 (45.0%)</td>
<td></td>
</tr>
<tr>
<td>Fruit-Flavoured Drinks</td>
<td>276 (26.31%)</td>
<td></td>
</tr>
<tr>
<td>Milk</td>
<td>332 (31.65%)</td>
<td></td>
</tr>
<tr>
<td>Pop</td>
<td>145 (13.82%)</td>
<td></td>
</tr>
<tr>
<td>Participation in School Milk Program (Frequency (%))</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>149 (14.45%)</td>
<td></td>
</tr>
<tr>
<td>No/Do Not Have</td>
<td>882 (85.55%)</td>
<td></td>
</tr>
<tr>
<td>Allowed to Leave School at Lunch (Frequency (%))</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>149 (18.33%)</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>842 (81.67%)</td>
<td></td>
</tr>
</tbody>
</table>
Table 4.3 Water and Nutrition Knowledge of the Sample

<table>
<thead>
<tr>
<th>Question</th>
<th>Frequency Correct (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beverage Sugar Content (Frequency Correct (%))</td>
<td></td>
</tr>
<tr>
<td>100% Apple Juice</td>
<td>547 (53.42%)</td>
</tr>
<tr>
<td>Tea</td>
<td>724 (77.19%)</td>
</tr>
<tr>
<td>Cappuccino</td>
<td>285 (31.42%)</td>
</tr>
<tr>
<td>Chocolate Milk</td>
<td>762 (75.00%)</td>
</tr>
<tr>
<td>Coca-Cola</td>
<td>946 (94.13%)</td>
</tr>
<tr>
<td>Coffee</td>
<td>458 (51.35%)</td>
</tr>
<tr>
<td>Fruit Punch</td>
<td>904 (88.45%)</td>
</tr>
<tr>
<td>Iced Tea</td>
<td>832 (82.70%)</td>
</tr>
<tr>
<td>Peach Drink</td>
<td>752 (74.02%)</td>
</tr>
<tr>
<td>Red Bull</td>
<td>837 (86.11%)</td>
</tr>
<tr>
<td>Rock Star</td>
<td>858 (87.55%)</td>
</tr>
<tr>
<td>Sprite</td>
<td>936 (91.85%)</td>
</tr>
<tr>
<td>SunnyD</td>
<td>798 (79.09%)</td>
</tr>
<tr>
<td>Water</td>
<td>972 (95.76%)</td>
</tr>
<tr>
<td>Milk</td>
<td>909 (90.18%)</td>
</tr>
<tr>
<td>Beverage Caffeine Content (Frequency Correct (%))</td>
<td></td>
</tr>
<tr>
<td>100% Apple Juice</td>
<td>854 (95.42%)</td>
</tr>
<tr>
<td>Tea</td>
<td>537 (55.71%)</td>
</tr>
<tr>
<td>Cappuccino</td>
<td>893 (89.39%)</td>
</tr>
<tr>
<td>Chocolate Milk</td>
<td>811 (91.64%)</td>
</tr>
<tr>
<td>Coca-Cola</td>
<td>612 (66.31%)</td>
</tr>
<tr>
<td>Coffee</td>
<td>904 (90.49%)</td>
</tr>
<tr>
<td>Fruit Punch</td>
<td>819 (91.92%)</td>
</tr>
<tr>
<td>Iced Tea</td>
<td>630 (69.69%)</td>
</tr>
<tr>
<td>Peach Drink</td>
<td>795 (90.24%)</td>
</tr>
<tr>
<td>Red Bull</td>
<td>728 (76.63%)</td>
</tr>
<tr>
<td>Rock Star</td>
<td>678 (72.51%)</td>
</tr>
<tr>
<td>Sprite</td>
<td>643 (71.05%)</td>
</tr>
<tr>
<td>SunnyD</td>
<td>787 (88.33%)</td>
</tr>
<tr>
<td>Water</td>
<td>861 (94.51%)</td>
</tr>
<tr>
<td>Milk</td>
<td>857 (93.76%)</td>
</tr>
<tr>
<td>Fruit and Vegetable Water Content (Frequency Correct (%))</td>
<td></td>
</tr>
<tr>
<td>Cucumber vs Carrots</td>
<td>908 (92.00%)</td>
</tr>
<tr>
<td>Apples vs Peaches</td>
<td>539 (55.06%)</td>
</tr>
<tr>
<td>Carrots vs Tomatoes</td>
<td>881 (89.26%)</td>
</tr>
<tr>
<td>Cucumber vs Beans</td>
<td>882 (90.18%)</td>
</tr>
<tr>
<td>Strawberries vs Pears</td>
<td>667 (69.55%)</td>
</tr>
<tr>
<td>Spinach vs Corn</td>
<td>329 (34.24%)</td>
</tr>
<tr>
<td>Where does Your Tap Water Come From? (Frequency Correct (%))</td>
<td>68 (6.64%)</td>
</tr>
<tr>
<td>How Much Water Should You Drink Each Day? (Frequency Correct (%))</td>
<td>542 (52.67%)</td>
</tr>
<tr>
<td>How is Tap Water Treated? (Frequency Correct (%))</td>
<td>50 (5.37%)</td>
</tr>
<tr>
<td>Water Conservation (Frequency Correct (%))</td>
<td></td>
</tr>
<tr>
<td>Correctly Named 1 Way</td>
<td>278 (26.50%)</td>
</tr>
<tr>
<td>Correctly Named 2 Ways</td>
<td>231 (22.02%)</td>
</tr>
<tr>
<td>Correctly Named 0 Ways</td>
<td>306 (29.17%)</td>
</tr>
<tr>
<td>Is Bottled or Tap Water Better? (Frequency Correct (%))</td>
<td>541 (52.42%)</td>
</tr>
<tr>
<td>Is Water Unlimited? (Frequency Correct (%))</td>
<td>662 (64.15%)</td>
</tr>
<tr>
<td>Is There Enough Water in Canada? (Frequency Correct (%))</td>
<td>699 (67.60%)</td>
</tr>
<tr>
<td>Nutrition Knowledge Score (Mean ± SD)</td>
<td>25.99 ± 5.81 (72%)</td>
</tr>
<tr>
<td>Water Knowledge Score (Mean ± SD)</td>
<td>3.22 ± 1.63 (40%)</td>
</tr>
<tr>
<td>Total Knowledge Score (Mean ± SD)</td>
<td>29.20 ± 6.53 (66%)</td>
</tr>
</tbody>
</table>
4.4.2 Beverage Consumption and Dietary Intake

Participants self-reported consuming water a mean of 5.1 (sd 1.9) times per day, accounting for approximately 39.8% (sd 19.6%) of their total daily beverage intake, and sugar-sweetened beverages a mean of 3.9 (sd 4.3) times per day, accounting for approximately 22.0% (sd 17.1%) of their total daily beverage intake. About four out of five (79.4%) youth reported consuming an SSB at least once per day, and half (49.6%) reported consuming an SSB 3 or more times per day. Comparatively, 98.3% of students reported consuming water at least once per day, and 86.4% reported consuming water three or more times per day. On average, participants consumed 4.4 (SD 2.0) servings of fruit and vegetables per day, with approximately 29.6% meeting Canada’s Food Guide recommendation of six or more servings per day. Less healthy foods were consumed a mean of 15.5 (SD 10.1) times per week, or about 2.2 times per day.

Over one-third (37.7%) of children reported consuming tap water at home, and 91.5% reported using a refillable water bottle in their everyday life. Additionally, 84.8% used a refillable water bottle at school, and 83.7% said their family members used refillable water bottles. Water was the most frequently consumed beverage during physical activity, selected by 86.6% of respondents, and also the most common beverage brought to school, reported by 93.2%. Just 14.5% of respondents participated in their school’s milk program. Fewer than 1 in 5 (18.3%) were allowed to leave the school grounds at lunch time.

4.4.3 Water and Nutrition Knowledge

The mean total knowledge score was 29.2 (SD 6.5) out of a possible 44 points (approximately 66.4%), with mean subscale scores of 26.0 (SD 5.8) out of 36 for nutrition knowledge (approximately 72.2%) and 3.2 (SD 1.6) out of eight for water knowledge (approximately 40%). Table 3 presents the proportion of students who responded correctly to each question. Children generally scored well on the questions related to nutritional aspects of different foods and beverages; however, knowledge of water, including its health benefits, conservation, and treatment, was lacking. Just 6.5% of respondents knew the origin of their tap water, and only 28% could name two ways to conserve water. Furthermore, just over half
(51.6%) of children knew how many cups of water they should consume in a day, and almost half (48.4%) believed bottled water to be superior to tap water.

### 4.4.4 Relationship Between Water and Nutrition Knowledge and Beverage Consumption Habits

The relationship between children’s beverage consumption and water and nutrition knowledge is presented in Table 4. Higher total knowledge scores, along with higher water and nutrition subscale scores, were associated with significantly higher water and lower SSB consumption in both crude and adjusted analyses.

A one-point increase in total knowledge score was associated with a 0.34% (95% CI 0.16, 0.52; p=0.0002) increase in total daily beverage consumption attributable to water and a 0.33% (95% CI -0.49, -0.18; p<0.0001) decrease in total daily beverage consumption attributable to SSBs, adjusting for socio-demographic, dietary, and behavioural factors. In looking at water and nutrition knowledge subscales separately, a one point increase in water knowledge was associated with a 1.12% (95% CI 0.39, 1.85; p=0.0026) increase in total daily beverage consumption attributable to water and a 1.41% (95% CI -2.03, -0.79; p<0.0001) decrease in total daily beverage consumption attributable to SSBs, while a one point increase in nutrition knowledge was associated with a 0.32% (95% CI 0.12, 0.52; p=0.0015) increase in total daily beverage consumption attributable to water and a 0.29% (95% CI -0.46, -0.12; p=0.0008) decrease in total daily beverage consumption attributable to SSBs, adjusting for socio-demographic, dietary, and behavioural factors.
Table 4.4 Relationship Between Knowledge Score and Percentage of Water and SSB Consumption

<table>
<thead>
<tr>
<th></th>
<th>Percentage of Total Beverage Consumption Frequency</th>
<th>Percentage of Total Beverage Consumption Frequency</th>
<th>Unadjusted</th>
<th>95% CI</th>
<th>P</th>
<th>Model 1</th>
<th>95% CI</th>
<th>P</th>
<th>Model 2</th>
<th>95% CI</th>
<th>P</th>
<th>Model 3</th>
<th>95% CI</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total Knowledge Score</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Unadjusted</td>
<td>0.56</td>
<td>0.39, 0.74</td>
<td>&lt;0.0001</td>
<td>-0.56</td>
<td>-0.72, -0.40</td>
<td>&lt;0.0001</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model 1&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.51</td>
<td>0.32, 0.70</td>
<td>&lt;0.0001</td>
<td>-0.50</td>
<td>-0.67, -0.34</td>
<td>&lt;0.0001</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model 2&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.37</td>
<td>0.19, 0.56</td>
<td>&lt;0.0001</td>
<td>-0.37</td>
<td>-0.52, -0.21</td>
<td>&lt;0.0001</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Model 3&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.34</td>
<td>0.16, 0.52</td>
<td>0.0002</td>
<td>-0.33</td>
<td>-0.49, -0.18</td>
<td>&lt;0.0001</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Water Knowledge Score</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>Unadjusted</td>
<td>1.90</td>
<td>1.17, 2.62</td>
<td>&lt;0.0001</td>
<td>-2.12</td>
<td>-2.75, -1.49</td>
<td>&lt;0.0001</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model 1&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.64</td>
<td>0.87, 2.41</td>
<td>&lt;0.0001</td>
<td>-1.88</td>
<td>-2.55, -1.22</td>
<td>&lt;0.0001</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model 2&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.11</td>
<td>0.37, 1.85</td>
<td>0.0031</td>
<td>-1.36</td>
<td>-1.99, -0.74</td>
<td>&lt;0.0001</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model 3&lt;sup&gt;c&lt;/sup&gt;</td>
<td>1.12</td>
<td>0.39, 1.85</td>
<td>0.0026</td>
<td>-1.41</td>
<td>-2.03, -0.79</td>
<td>&lt;0.0001</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Nutrition Knowledge Score</strong></td>
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<td></td>
<td></td>
<td></td>
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<td></td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>Unadjusted</td>
<td>0.56</td>
<td>0.35, 0.76</td>
<td>&lt;0.0001</td>
<td>-0.53</td>
<td>-0.71, -0.36</td>
<td>&lt;0.0001</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model 1&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.49</td>
<td>0.28, 0.70</td>
<td>&lt;0.0001</td>
<td>-0.46</td>
<td>-0.64, -0.28</td>
<td>&lt;0.0001</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model 2&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.36</td>
<td>0.16, 0.56</td>
<td>0.0004</td>
<td>-0.33</td>
<td>-0.51, -0.16</td>
<td>0.0001</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model 3&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.32</td>
<td>0.12, 0.52</td>
<td>0.0015</td>
<td>-0.29</td>
<td>-0.46, -0.12</td>
<td>0.0008</td>
<td></td>
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<td></td>
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<td></td>
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<td></td>
</tr>
</tbody>
</table>

SSBs, sugar-sweetened beverages
<br>β, standardized regression coefficient
<sup>a</sup> Model 1 adjusted for sex, age, ethnicity, household income level, maximum household education, living arrangements, and parental work status
<sup>b</sup> Model 2 added daily servings of fruits and vegetables and weekly less healthy food consumption frequency
<sup>c</sup> Model 3 added participation in school milk program, permission to leave school grounds at lunch, and frequency of refillable water bottle use
† SSBs include fruit-flavoured drinks, regular pop, energy drinks, and chocolate milk

### 4.4.5 Determinants of Water and SSB Consumption and Knowledge

Tables 5-7 present the associations between water and SSB consumption and knowledge and various socio-demographic, dietary and behavioural factors. Older age, higher household income level, and more educated parents/guardians were associated with higher total knowledge scores.

Higher water consumption was associated with being female, having a more educated parent/guardian, living in a two-parent/guardian household, consuming less healthy food less frequently, consuming fewer servings of fruits and vegetables, not participating in a school
milk program, and using a refillable water bottle more frequently.

Higher sugar-sweetened beverage consumption was associated with being male, having a less educated parent/guardian, consuming less healthy food more frequently, living in a single parent/guardian household, participating in a school milk program, using a refillable water bottle less frequently, and being allowed to leave the school grounds at lunch time.
<table>
<thead>
<tr>
<th>Socio-Demographic Factors</th>
<th>Crude</th>
<th>Adjusted</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>β</td>
<td>95% CI</td>
</tr>
<tr>
<td>Age</td>
<td>0.66</td>
<td>-0.20, 1.52</td>
</tr>
<tr>
<td>Sex (ref=female)</td>
<td>5.42</td>
<td>3.03, 7.82</td>
</tr>
<tr>
<td>Ethnicity (ref=Caucasian)</td>
<td>0.99</td>
<td>-1.47, 3.45</td>
</tr>
<tr>
<td>Household Income (ref=high)</td>
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</tr>
<tr>
<td>Low</td>
<td>-5.10</td>
<td>-9.75, -0.44</td>
</tr>
<tr>
<td>Low-Middle</td>
<td>-3.16</td>
<td>-7.22, 0.91</td>
</tr>
<tr>
<td>High-Middle</td>
<td>-5.57</td>
<td>-9.37, -1.78</td>
</tr>
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<td>Missing</td>
<td>-1.73</td>
<td>-4.64, 1.19</td>
</tr>
<tr>
<td>Parental Education (ref=college/university)</td>
<td>0.0003 ***</td>
<td>0.0003 ***</td>
</tr>
<tr>
<td>High School or Less</td>
<td>-5.27</td>
<td>-9.00, -1.55</td>
</tr>
<tr>
<td>Graduate School</td>
<td>3.20</td>
<td>-0.003, 6.41</td>
</tr>
<tr>
<td>Mother's Employment Status (ref=employed)</td>
<td>-0.48</td>
<td>-3.26, 2.29</td>
</tr>
<tr>
<td>Father's Employment Status (ref=employed)</td>
<td>2.04</td>
<td>-3.05, 7.13</td>
</tr>
<tr>
<td>Living Arrangements (ref=two-parent household)</td>
<td>0.0002 ***</td>
<td>0.0002 ***</td>
</tr>
<tr>
<td>Single Parent Household</td>
<td>-5.88</td>
<td>-8.81, -2.95</td>
</tr>
<tr>
<td>Other</td>
<td>-6.51</td>
<td>-25.65, 12.63</td>
</tr>
</tbody>
</table>

**Dietary Factors**
- Daily Servings of Fruits and Vegetables
  - Weekly Less Healthy Food Consumption
    - Frequency†
      -Never: -4.51, -7.88, -1.13 | 0.0088*** | -4.03, -7.15, -0.92 | 0.0087***
      -Rarely: -3.48, -6.57, -0.39 | 0.0271† | -2.93, -5.58, 0.24 | 0.0609
      -Sometimes: -4.15, -7.39, -0.91 | 0.0008 † | -3.25, -6.29, -0.21 |
      -Usually: 0.60, -2.36, 3.56 | 0.26 | -2.48, 3.00 |

β, standardized regression coefficient
Ref, reference category
* p<0.05, ** p<0.01, *** p<0.001
† Less healthy food includes sweetened cereal, cake/pie/doughnuts, potato chips, chocolate bars, pizza, French fries, hot dogs, ice cream, candy, granola bars, and cookies
<table>
<thead>
<tr>
<th>Socio-Demographic Factors</th>
<th>Crude β</th>
<th>95% CI</th>
<th>P</th>
<th>Adjusted β</th>
<th>95% CI</th>
<th>P</th>
</tr>
</thead>
<tbody>
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<td>Age</td>
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<td>-1.64</td>
<td>-0.15</td>
<td>0.0189*</td>
<td>-0.70</td>
<td>-1.39</td>
</tr>
<tr>
<td>Sex (ref=female)</td>
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<td>-7.73</td>
<td>-3.58</td>
<td>&lt;0.0001***</td>
<td>3.72</td>
<td>1.79</td>
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<tr>
<td>Ethnicity (ref=Caucasian)</td>
<td>-0.80</td>
<td>-2.95</td>
<td>1.35</td>
<td>0.4652</td>
<td>-0.48</td>
<td>-2.66</td>
</tr>
<tr>
<td>Household Income (ref=high)</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>2.25</td>
<td>-1.81</td>
<td>6.30</td>
<td>0.2759</td>
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</tr>
<tr>
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<td>0.93</td>
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<tr>
<td>High-Middle</td>
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<td>1.65</td>
<td>8.26</td>
<td></td>
<td>2.17</td>
<td>1.52</td>
</tr>
<tr>
<td>Missing</td>
<td>1.76</td>
<td>-0.78</td>
<td>4.31</td>
<td></td>
<td>0.94</td>
<td>1.52</td>
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<tr>
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<tr>
<td>High School or Less</td>
<td>4.64</td>
<td>1.36</td>
<td>7.92</td>
<td>2.19</td>
<td>-0.89</td>
<td>5.27</td>
</tr>
<tr>
<td>Graduate School</td>
<td>-2.82</td>
<td>-5.61</td>
<td>-0.03</td>
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<td>-4.43</td>
<td>0.71</td>
</tr>
<tr>
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<tr>
<td>Father's Employment Status (ref=employed)</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Living Arrangements (ref=two-parent household)</td>
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<td></td>
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<td></td>
<td></td>
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<tr>
<td>Single Parent Household</td>
<td>4.67</td>
<td>2.13</td>
<td>7.22</td>
<td>2.65</td>
<td>0.19</td>
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<tr>
<td>Other</td>
<td>-2.65</td>
<td>-19.25</td>
<td>13.96</td>
<td>-4.61</td>
<td>-19.68</td>
<td>10.47</td>
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<td>Dietary Factors</td>
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</tr>
<tr>
<td>Daily Servings of Fruits and Vegetables</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weekly Less Healthy Food Consumption</td>
<td>-0.60</td>
<td>-1.14</td>
<td>-0.07</td>
<td>0.0263*</td>
<td>-0.24</td>
<td>-0.73</td>
</tr>
<tr>
<td>Frequency†</td>
<td>0.66</td>
<td>0.56</td>
<td>0.76</td>
<td>&lt;0.0001***</td>
<td>0.61</td>
<td>-0.52</td>
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<tr>
<td>Behavioural Factors</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Participation in School Milk Program (ref=no)</td>
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<td></td>
</tr>
<tr>
<td>Permission to Leave School at Lunch (ref=no)</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Frequency of Water Bottle Use (ref=always)</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Never</td>
<td>6.11</td>
<td>1.35</td>
<td>10.87</td>
<td>5.07</td>
<td>0.73</td>
<td>9.41</td>
</tr>
<tr>
<td>Rarely</td>
<td>4.89</td>
<td>0.49</td>
<td>9.28</td>
<td>2.85</td>
<td>-1.20</td>
<td>6.90</td>
</tr>
<tr>
<td>Sometimes</td>
<td>3.46</td>
<td>0.64</td>
<td>6.29</td>
<td>1.59</td>
<td>-1.01</td>
<td>4.19</td>
</tr>
<tr>
<td>Usually</td>
<td>0.61</td>
<td>-1.97</td>
<td>3.18</td>
<td>0.26</td>
<td>-2.07</td>
<td>2.59</td>
</tr>
</tbody>
</table>

β, standardized regression coefficient
Ref, reference category
*p<0.05, **p<0.01, ***p<0.001
† Less healthy food includes sweetened cereal, cake/pie/doughnuts, potato chips, chocolate bars, pizza, French fries, hot dogs, ice cream, candy, granola bars, and cookies

Table 4.6 Predictors of SSB Consumption
### Table 4.7 Predictors of Total Knowledge Score

<table>
<thead>
<tr>
<th>Socio-Demographic Factors</th>
<th>Crude</th>
<th>Adjusted</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>β</td>
<td>95% CI</td>
</tr>
<tr>
<td><strong>Age</strong></td>
<td>1.53</td>
<td>1.26, 1.80</td>
</tr>
<tr>
<td><strong>Sex (ref=female)</strong></td>
<td>-0.36</td>
<td>-1.16, 0.44</td>
</tr>
<tr>
<td><strong>Ethnicity (ref=Caucasian)</strong></td>
<td>-0.57</td>
<td>-1.39, 0.24</td>
</tr>
<tr>
<td><strong>Household Income (ref=high)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Low</strong></td>
<td>-2.88</td>
<td>-4.41, -1.35</td>
</tr>
<tr>
<td><strong>Low-Middle</strong></td>
<td>-2.48</td>
<td>-3.82, -1.14</td>
</tr>
<tr>
<td><strong>High-Middle</strong></td>
<td>-0.80</td>
<td>-2.04, 0.45</td>
</tr>
<tr>
<td><strong>Missing</strong></td>
<td>-0.32</td>
<td>-1.28, 0.64</td>
</tr>
<tr>
<td><strong>Parental Education (ref=college/university)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>High School or Less</strong></td>
<td>-2.74</td>
<td>-3.98, -1.50</td>
</tr>
<tr>
<td><strong>Graduate School</strong></td>
<td>0.82</td>
<td>-0.24, 1.88</td>
</tr>
<tr>
<td><strong>Mother's Employment Status (ref=employed)</strong></td>
<td>-1.10</td>
<td>-2.04, -0.17</td>
</tr>
<tr>
<td><strong>Father's Employment Status (ref=employed)</strong></td>
<td>-0.88</td>
<td>-2.61, 0.85</td>
</tr>
<tr>
<td><strong>Living Arrangements (ref=two-parent household)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Single Parent Household</strong></td>
<td>-0.99</td>
<td>-1.96, -0.01</td>
</tr>
<tr>
<td><strong>Other</strong></td>
<td>2.02</td>
<td>-4.38, 8.42</td>
</tr>
</tbody>
</table>

β, standardized regression coefficient
Ref, reference category
*p<0.05, **p<0.01, ***p<0.001
4.4.6 Sensitivity Analysis

Sensitivity analyses were performed for all outcomes using non-imputed data only. The results of this complete case analysis are presented in Table 8. Although the effect estimates were less precise they were similar in size and direction, and all associations remained significant, except for that between water knowledge score and percentage of total daily beverage consumption attributable to water ($\beta=0.30$; 95% CI $0.50, 2.67$; $p=0.0599$).

### Table 4.8 Sensitivity Analysis Using Non-Imputed Data (Complete Case Analysis)

<table>
<thead>
<tr>
<th></th>
<th>Percentage of Total Beverage Consumption Frequency Attributable to Water</th>
<th>Percentage of Total Beverage Consumption Frequency Attributable to SSBs†</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$\beta$</td>
<td>95% CI</td>
</tr>
<tr>
<td><strong>Total Knowledge Score</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unadjusted</td>
<td>0.55</td>
<td>0.36, 0.74</td>
</tr>
<tr>
<td>Model 1*</td>
<td>0.49</td>
<td>0.24, 0.74</td>
</tr>
<tr>
<td>Model 2**</td>
<td>0.36</td>
<td>0.13, 0.60</td>
</tr>
<tr>
<td>Model 3***</td>
<td>0.34</td>
<td>0.06, 0.61</td>
</tr>
<tr>
<td><strong>Water Knowledge Score</strong></td>
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<td></td>
</tr>
<tr>
<td>Unadjusted</td>
<td>1.87</td>
<td>0.97, 2.78</td>
</tr>
<tr>
<td>Model 1*</td>
<td>1.91</td>
<td>0.76, 0.43</td>
</tr>
<tr>
<td>Model 2**</td>
<td>1.34</td>
<td>0.06, 2.63</td>
</tr>
<tr>
<td>Model 3***</td>
<td>1.31</td>
<td>-0.50, 2.67</td>
</tr>
<tr>
<td><strong>Nutrition Knowledge Score</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unadjusted</td>
<td>0.55</td>
<td>0.32, 0.77</td>
</tr>
<tr>
<td>Model 1*</td>
<td>0.44</td>
<td>0.18, 0.70</td>
</tr>
<tr>
<td>Model 2**</td>
<td>0.33</td>
<td>0.07, 0.58</td>
</tr>
<tr>
<td>Model 3***</td>
<td>0.30</td>
<td>0.01, 0.59</td>
</tr>
</tbody>
</table>

$\beta$, standardized regression coefficient
SSBs, sugar-sweetened beverages
* Model 1 adjusts for the socio-demographic characteristics sex, age, ethnicity, household income level, maximum household education level, child living arrangements, and parental employment status
** Model 2 adds daily servings of fruits and vegetables, and weekly less healthy food consumption frequency
*** Model 3 adds participation in a school milk program, permission to leave school grounds at lunch time, and frequency of refillable water bottle use
† SSBs include fruit-flavoured drinks, regular pop, energy drinks, and chocolate milk
4.5 Discussion

This study described the beverage consumption habits of a sample of elementary school children in London, Ontario, and examined the association between knowledge and water and SSB intake. As far as we know, this is the first study to specifically evaluate the relationship between knowledge and beverage consumption.

4.5.1 Knowledge is a Determinant of Beverage Consumption Habits

Our results indicate that knowledge is a significant predictor of beverage consumption habits, with higher scoring children consuming a higher proportion of water and a lower proportion of SSBs than their lower scoring peers. This association remained significant when nutrition and water knowledge sub-scores were analyzed separately. These findings are consistent with the previous research investigating the association between knowledge and dietary intake in this population, which identified a weak positive correlation overall. A survey performed in Iceland among 11-year-old children, for example, found that knowledge was a significant determinant of fruit and vegetable consumption\textsuperscript{41}, while a Japanese study identified a strong association between nutrition knowledge and vegetable intake in elementary school children\textsuperscript{39}. A positive correlation between nutrition knowledge and eating behaviour was additionally observed in American children, particularly as they increased in age\textsuperscript{42}, and a study of Sicilian children found that nutrition knowledge was negatively associated with a number of unhealthy foods including sugary drinks\textsuperscript{40}.

These findings are also supported by a qualitative study examining the perceptions and determinants of SSBs consumption in London elementary school children, in which participants identified improving knowledge as a necessary strategy to help reduce their intake of sugary drinks\textsuperscript{53}. Children specifically noted the need for hands on and engaging educational programs, and believed that education should be incorporated into the curriculum as early as possible\textsuperscript{53}.

4.5.2 Water and Nutrition Knowledge is Limited

Our results also provide valuable insights into the gaps in knowledge that exist within this population, which can be used to develop more effective interventions. For example, although we observed a significant association between knowledge and practice, knowledge
in our sample was relatively low overall, with children scoring an average of 66% in total and 72% and 40% on the nutrition and water subscales respectively. Indeed, an evaluation of the survey results demonstrated that children had very little knowledge of the water treatment system or water conservation, and almost half were unaware of the amount of water they should consume in a day.

Even more concerning, a lack of knowledge about the safety of tap water was identified, and the belief that bottled water was superior to tap was widespread. Although London’s tap water is of high quality and is rigorously monitored\textsuperscript{54}, these findings are in line with the existing literature, which has identified negative perceptions of tap water among North American children and adolescents pertaining to taste and cleanliness\textsuperscript{55,56}, and may explain the low number of children reporting consuming tap water at home in our study. Given that larger point estimates were observed for water knowledge than nutrition knowledge, suggesting that water knowledge may have a greater influence on drinking behaviours than nutrition knowledge, future education programs to improve children’s drinking habits must incorporate lessons on water specifically and should attempt to dispel negative attitudes and beliefs about tap water in order to achieve the best possible results.

4.5.3 Children have Poor Dietary Habits Overall

Corresponding with the low levels of knowledge observed, children in our sample consumed relatively low proportions of water, accounting for approximately 39.8% of their total daily beverage intake, and high proportions of SSBs, accounting for approximately 22.0% of their total daily beverage intake. This substantially exceeds the guidelines set by the American Heart Association, which has recommended that children consume no more than 8 ounces of SSBs per week\textsuperscript{57}, approximately 1.7-2.25% of the total daily fluid intake recommendations. These findings, however, are in agreement with other studies of SSB intake in Canadian children and adolescents, which have also observed an over-consumption of these beverages\textsuperscript{15,58,59}. A survey of youth from three Canadian cities, for instance, found that 80% of respondents consumed at least one SSB per day, and 44% consumed three or more\textsuperscript{60}. This is comparable to our sample, of which 79.4% reported consuming an SSB at least once per day, and half 49.6% reported consuming an SSB three or more times per day.
In addition to knowledge, we identified several independent predictors of more frequent SSB consumption which can potentially be used to identify individuals who may benefit most from interventions. These included male sex, more frequent unhealthy food consumption, living in a single parent household, having less educated parents, participating in a school milk program, using a refillable water bottle less frequently, and having permission to leave school grounds at lunch time. Independent predictors of more frequent water consumption included female sex, having more educated parents, living in a two-parent household, consuming unhealthy food less frequently, having fewer daily servings of fruits and vegetables, not participating in a school milk program, and using a refillable water bottle more frequently. These factors are in line with those examined in previous research, with the exception of the observed association between more frequent water consumption and fewer servings of fruits and vegetables. While this seems counterintuitive, with water and fruit and vegetable intake both markers of a healthy diet, children who consume more fruits and vegetables may get more of their daily water requirements through foods, which may translate to drinking less overall to compensate.

Along with poor beverage consumption habits, we also observed suboptimal diet quality in this sample. Just under 30% of children met Canada’s Food Guide recommendation of six or more servings of fruits and vegetables per day, and less healthy foods such as candy, pizza, and cake were consumed more than twice a day, on average. This is in line with previous studies of children’s diets. For example, an examination of 2004 CCHS data indicated that 65% of nine to 13-year-old children did not meet the recommended servings of fruits and vegetables\textsuperscript{61}, while another study found that just 26% of Canadians met the minimum daily fruit and vegetable servings for their age-sex group, and that in adolescents and teens, this number dropped to less than 20%\textsuperscript{62}.

4.5.4 Implications for Policy and Practice

Our results support the continued implementation of education programs as a potentially effective strategy for reducing SSB consumption and/or increasing water consumption in child and adolescent populations. This is encouraging, as education interventions are cost-effective and easy to implement, compared to environmental and policy interventions, and are also highly reproducible, with successful programs being adaptable for different
populations and different settings. Given that children spend the majority of their waking hours in school, this is the ideal environment through which to deliver standardized evidence-based programs targeting healthy behaviours. Furthermore, when delivered in the school environment, education interventions are capable of reaching many children at once, and may serve as an equalizer, minimizing differences in knowledge and access to information between children of different socioeconomic statuses and backgrounds. This is particularly important as we observed that, in addition to age, household income level and parental education were significant predictors of baseline knowledge in this population.

It must be noted, however, that although we identified a statistically significant association between high knowledge scores and healthier beverage consumption habits, the observed effects were small in magnitude and thus improvements in knowledge may not translate to clinically significant improvements in behaviour. Indeed, this may explain why education-only interventions to improve beverage consumption habits are often unsuccessful long term. Further research is therefore needed to understand how to maximize the effect of education interventions in order to capitalize on the association between knowledge and behaviour.

4.5.5 Limitations

Our results should be interpreted in light of several limitations. First of all, it is important to note that, in addition to knowledge, there are a number of other factors that influence children’s food and beverage choices including taste preferences, advertising, and parental control. Given that the subjects evaluated in this study were relatively young, ranging from eight to 14 years of age, parental control was likely a major determinant of dietary intake in those children who are restricted to what is available to them at home. Indeed, a number of studies have identified the importance of parental knowledge and maternal knowledge specifically on children’s diet quality, finding that children with more knowledgeable parents had better diets. Although our study was not able to assess parental knowledge, we did measure parental education, which can be considered a proxy. We found that higher parental education was associated with a significantly higher percentage of total daily beverage consumption attributable to water and with higher total knowledge scores for children; however, no significant association with SSB intake was observed.
Secondly, the ambiguous ‘times per day’ measure of water and SSB consumption, as opposed to a standardized volume measure such as cups or mL per day, may have been interpreted differently by each child, potentially resulting in measurement error. We attempted to correct for this by converting absolute frequencies into proportions in order to standardize responses. Moreover, some studies have suggested that children may have difficulties estimating volumes and portion sizes\textsuperscript{74–77}, making instance frequencies the better choice for assessing beverage intake in this population. Indeed, instances have been used in the past in similar studies in child populations\textsuperscript{23,29,40,78,79}.

Additionally, as with most studies on children’s dietary behaviours, our study used self-reported dietary data, which is vulnerable to recall bias and may be inaccurate, especially in children. Self-reported measures can be useful in that they are more suited to assessing usual intake, however, whereas observations and other objective measures assess recent intake, and there is also no risk of children changing their behaviours because they know they are being observed when using self-reported, compared to objective measures\textsuperscript{80}.

Finally, this was a cross-sectional study. This prevents us from establishing temporality, and the direction of the relationship between knowledge and beverage consumption habits cannot be discerned.

4.6 Conclusions

In this cross-sectional study of school children in Southwestern Ontario, we provided new evidence of an association between dietary intake and knowledge. We were able to demonstrate that children with higher knowledge scores had significantly healthier beverage consumption habits; however, knowledge in our sample was low overall, which was reflected in water and SSB intake. Future interventions to increase water and/or decrease SSB consumption in young children should therefore target water and nutrition knowledge through education programs, as they may be effective at changing behaviour. Additional research is required to evaluate whether or not changes in knowledge actually yield clinically significant improvements in behaviour in practice, and should investigate the optimal characteristics of education interventions so that a framework can be developed for use in a variety of settings, populations, and contexts.
4.7 Acknowledgements

We gratefully thank the students and families that participated in this study, along with the teachers and principals at each school and the research board from the Thames Valley District School Board and the London District Catholic School Board. We would also like to acknowledge the many research assistants and volunteers from the Human Environments Analysis Laboratory who helped with data collection and entry for the HKCC project, as well as the invaluable contributions of Dr. Andrew Clark, who coordinated the project, Dr. Piotr Wilk, who assisted with the statistical techniques, and Dr. Colleen O’Connor, who provided advice concerning the nutritional aspects of this study.

4.8 Financial Support

This study was jointly funded by the Ontario Ministry of Health and Long Term Care as part of the City of London’s Healthy Kids Community Challenge, and the Children’s Health Foundation through the Children’s Health Research Institute. Additionally, the Canadian Institute of Health Research (CIHR) provided graduate student funding in the form of a Canada Graduate Scholarship (CGS-M). Funders did not have any role in the study design, data collection/analysis, writing, or publication of this study.
4.9 References


10. Ludwig DS, Peterson KE, Gortmaker SL. Relation between consumption of sugar-


18. Langlois K, Garriguet D. Sugar consumption among Canadians of all ages. *Heal*


26. Steyn NP, De Villiers A, Gwebushe N, et al. Did HealthKick, a randomised controlled trial primary school nutrition intervention improve dietary quality of children in low-


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Chapter 5

5 Promoting Healthy Beverage Consumption Habits Among Elementary School Children: Results of the Healthy Kids Community Challenge Water Does Wonders Interventions in London, Ontario

5.1 Abstract

Objectives. To determine the effectiveness of school-based interventions to increase water and decrease sugar-sweetened beverage consumption among children in grades 4-8.

Methods. Quasi-experimental non-randomized controlled trial. Children’s water and nutrition knowledge and dietary intake were measured before and after interventions (2016-2017). Intervention schools (n=11) received education programs and water bottle filling stations. Control schools (n=5) received only water stations. Multivariable linear mixed model ANCOVAs were used to compare water and SSB consumption and knowledge across intervention groups, adjusting for pre-intervention values and accounting for school-level clustering. Intention to treat and per-protocol analyses were performed.

Results. Children (n=931, mean age 10.6 years, 56% female) who received an education intervention combined with filling stations, as opposed to just filling stations, consumed more water and fewer SSBs post-intervention, and had higher water and nutrition knowledge. These findings were not statistically significant.

Conclusions. An education and environmental intervention intended to increase children’s healthy beverage consumption yielded effects in the expected direction; however, these effects were small in magnitude and non-significant.

Public Health Implications. Environmental changes, even when combined with education programs, may be insufficient to meaningfully change children’s dietary behaviours.

5.2 Introduction

Despite substantial preventive public health effort, childhood obesity remains one of the greatest threats facing children today\textsuperscript{1,2}, and now affects roughly 30\% of Canadians aged five
to 17\(^3\). Although obesity is a multifaceted issue with genetic, environmental, and behavioural factors at play, research has identified diet as a key determinant of weight status, and the role of sugar-sweetened beverages (SSBs) in particular has been the focus of extensive inquiry.

Evidence has linked the consumption of SSBs, which include regular pop, fruit-flavoured drinks, sports drinks, energy drinks, and sweetened tea, coffee, and milk drinks, to excess weight gain in childhood\(^4\)–\(^7\), which in turn is associated with adverse health outcomes such as cardiovascular disease, type 2 diabetes, and hypertension\(^8\). Data from the Canadian Community Health Survey (CCHS)\(^9\) suggest that Canadian children’s SSB consumption well exceeds the recommended maximum intake of eight ounces per week as set by the American Heart Association\(^10\), and similar trends have been observed worldwide. Consequently, reducing SSB consumption has become a global public health priority and a mass movement has emerged to curtail children’s SSB intake, and to replace SSBs with water, a calorie and sugar-free alternative.

A recent systematic review of interventions to reduce the consumption of sugar-sweetened beverages in children concluded that school-based education programs may be an effective and sustainable strategy for improving children’s beverage consumption habits\(^11\). Indeed, virtually all children attend school\(^12\), and spend a significant portion of their waking hours there, making these institutions a critical site in which to promote healthy behaviours among children of all socioeconomic statuses\(^13\). Along with education, changes to the school environment to support healthy habits may promote even greater improvements in children’s beverage intake\(^11\). In German elementary schools, for example, a significant increase in water consumption was observed among second and third-graders following a series of classroom lessons on water combined with the installation of water fountains\(^14\), while the provision of cups near water fountains at schools in Boston, along with a social marketing campaign to promote water, resulted in a significant increase in water consumption\(^15\).

The purpose of this study was to evaluate the effectiveness of a naturally-occurring school-based intervention intended to increase children’s water consumption and decrease SSB consumption by combining water and nutrition education with environmental changes to support water consumption. It was hypothesized that children who participated in an education program in addition to receiving environmental changes to their school would
consume more water and fewer SSBs post-intervention and would have higher knowledge scores than those who received only environmental changes.

5.3 Methods

5.3.1 Data Source

The Healthy Kids Community Challenge (HKCC) initiative of the Ontario Ministry of Health and Long Term Care provided funding, training, and social marketing tools to 45 communities across the province of Ontario, Canada to promote healthy eating, physical activity, and other healthy behaviours in children and youth. Participating communities implemented programs and activities that fit within the HKCC’s key themes. This study analyses data collected by the Human Environment Analysis Laboratory (HEAL) at the University of Western Ontario (UWO) as part of an evaluation of the Water Does Wonders theme interventions in London, Ontario, a city of approximately 383,000 people. The overall aim of the Water Does Wonders theme was to improve children’s beverage consumption habits.

5.3.2 Interventions

The Water Does Wonders activities in London consisted of three interventions, which were designed and implemented by London’s Child and Youth Network (CYN), a partnership of over 170 diverse organizations working together to promote child health. Each participating school received a new automatic water bottle filling station, which dispenses cold, filtered water directly into refillable water bottles. In addition, a subset of schools received one of two education interventions: The Growing Chefs! (GC) program or the Upper Thames River Conservation Authority (UTRCA) program. Growing Chefs! is a London-based organization that gets kids excited about nutrition and healthy eating through interactive cooking and food literacy workshops. The activities associated with Water Does Wonders were delivered in-classroom to the whole school and occurred twice during the school year. In addition to basic cooking skills, children learned the art of plating and food presentation and the importance of healthy eating. The Upper Thames River Conservation Authority program consisted of a series of activity stations designed to increase children’s knowledge of water. Topics included the water treatment system, the world’s water, water footprints, and the importance
of water for our bodies. The program was initially delivered by UTRCA staff to the grade 7 students at each of the participating schools, who then taught the grade 5 students.

5.3.3 Setting and Participants

The interventions occurred throughout the 2016/2017 school year and targeted grade four to eight children (approximately eight-14 years) in 13 priority neighbourhoods across the city. This age group was selected because grade four is roughly the age at which children begin to develop more autonomy regarding their food choices\textsuperscript{16}, and our previous research has indicated that, by grade four, children generally are able to complete a self-administered survey. The 13 priority neighbourhoods were identified in a community needs assessment conducted by the CYN, based on having lower levels of education, lower household incomes, and more single parent households than the city as a whole. Seventeen elementary schools within these neighbourhoods consented to participate in the study and self-selected into one of three groups: 1) GC plus water infrastructure; 2) UTRCA plus water infrastructure; and 3) water infrastructure only. All participating children were required to have written parental consent, and to provide personal assent prior to enrolling in the survey. This study was conducted in accordance with the Canadian Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans, and was approved by the UWO Non-Medical Ethics Board (108328), the Thames Valley District School Board and London District Catholic School Board.

5.3.4 Data Collection and Tools

Data collection took place at two time points - before the interventions were implemented in October-November 2016 and following their cessation in April-June 2017. At each time point, research teams from the HEAL at UWO distributed youth surveys to participating students. The research teams provided verbal instructions and, while they were available to answer questions related to comprehension, spelling, and process throughout the survey period, did not prompt students in any way.

The youth survey consisted of 91 items under five domains: General Information, Drinking Habits, Types of Food and Drink Consumed, Eating and Drinking During the School Day, and Beverage Knowledge; and included multiple choice, yes/no, Likert scale, and fill in the
blank questions. Follow-up surveys assessing the Growing Chefs! and UTRCA interventions also contained an additional two to three items under the domain Program Knowledge to assess the impact and reception of these interventions. A questionnaire version consisting of 50 items under four domains was also adapted for parents/guardians and measured basic demographics as well as the child’s eating and drinking habits, and eating and drinking during the school day to supplement information collected from the youth survey.

5.3.5 Outcome Measures

5.3.5.1 Beverage Consumption

Beverage consumption was assessed using a food-frequency questionnaire (FFQ), which asked children to record the number of times per day they consumed water, 100% fruit juice, fruit flavoured drinks (including sports drinks), white milk, chocolate milk, regular pop, diet pop, energy drinks, coffee, and tea. Response categories ranged from zero to seven or more times per day. SSB consumption was derived by summing the number of times per day the respondent reported consuming regular pop, fruit-flavoured drinks, energy drinks, and chocolate milk, resulting in a possible range of zero to 28 or more times per day.

Using the definition of a sugar-sweetened beverage as defined by the Centre for Disease Control and Prevention (CDC)\(^\text{17}\), chocolate milk was included as an SSB in the analyses, while 100% fruit juices and diet beverages were excluded. While sweetened coffee and tea drinks are considered SSBs under the CDC definition\(^\text{17}\), they were not included in this analysis because the nature of the survey did not allow respondents to specify whether or not the tea and coffee beverages they consumed contained added sugar.

To account for potential differences in children’s interpretation of the ‘times per day’ measurement, for data analysis water and SSB consumption frequency were divided by the total beverage consumption frequency reported by each child to obtain proportions.

5.3.5.2 Water and Nutrition Knowledge

Nutrition knowledge was measured by summing the scores of 36 questions assessing children’s knowledge of the sugar, caffeine, and water content of various foods and beverages. Examples of questions included: “from the list below, choose the beverages that
are high in sugar and/or high in caffeine” (100% apple juice, black/green tea, cappuccino, chocolate milk, Coca-Cola, coffee, fruit punch, Nestea iced tea, peach drink, Red Bull energy drink, Rock Star energy drink, Sprite, SunnyD, water, white milk); and “check the fruit or vegetable that has the most water from each pairing” (cucumber or carrots, apple or peach, carrots or tomatoes, cucumber or beans, strawberries or pears, spinach or corn). When summed, the minimum possible score was zero and the maximum was 36.

Water knowledge was measured with eight questions assessing children’s knowledge of the water treatment system, health benefits of water, and the world’s water. Examples of questions included: “where does the water from your tap come from?” (ground water, Lake Ontario & Erie, Lake Huron & Erie, Thames River, I don’t know); “how much water do we need to drink each day?” (3-4 cups, 5-6 cups, 7-8 cups, 9-10 cups); “can you name one way that your tap water is treated?”; “can you list 2 ways to conserve water at home or at school?”; “true or false, bottled water is better than tap water”; “true or false, water is an unlimited resource”; and “true or false, we have enough water in Canada for everyone, forever”. The minimum possible score a child could achieve was zero and the maximum was eight.

Total knowledge was determined by summing the scores of the nutrition and water knowledge subscale scores. The minimum score that could be achieved was zero and the maximum was 44. For analysis purposes, knowledge scores were converted to percentages and treated as continuous.

5.3.5.3 Other Covariates

Socio-demographic characteristics including sex (male/female), age (continuous in years), ethnicity (white/non-white), living arrangement (single parent household/two parent household/other), parent education (high school or less/college or university/graduate school), parent employment status (employed/unemployed), and household income level (low/low-middle/high-middle/high) were determined using self-administered surveys completed by both the parent and child. Income level classifications were made based on reported annual household income and number of people in the household using methods described in the Canadian Community Health Survey Derived Variable Specifications\(^\text{18}\).
Parent-reported data were used due to increased likelihood of accuracy; however, when they were missing, child-reported data was substituted.

Dietary intake including daily servings of fruits and vegetables and weekly less healthy food consumption frequency was assessed using the FFQ component of the youth survey. Less healthy food consumption was an aggregate variable, derived from summing the number of times per week a child reported consuming sweetened breakfast cereal, cake/pie/doughnuts, potato chips, chocolate bars, pizza, French fries, hot dogs, ice cream, candy, granola bars, and cookies, each ranging from 0 to 6+ for a total possible less healthy food frequency range of 0 to 66+. Information on drinking habits such as frequency of use of a refillable water (never/rarely/sometimes/usually/always), milk program participation (yes/no), and permission to leave school grounds at lunch time (yes/no) was also collected using the youth survey.

5.3.6 Data Analysis

Data cleaning was performed using SPSS 24, while all other statistical analyses were conducted using SAS 9.4. Fully conditional specification (FCS) multiple imputation with arbitrary missing data patterns was performed to impute values using SAS 9.4. Forty imputed datasets were created, based on the recommendation that the number of imputations should be approximately equal to the percentage of incomplete cases. In our sample, just 62.7% of subjects had complete data for all variables of interest, and missing data among the imputed variables ranged from 0% (age, ethnicity, nutrition knowledge score at follow up, and total knowledge score at follow up) to 25.8% (father’s employment status). Approximately 33.6% of subjects were missing data on household income level, however this variable was not imputed due to the high probability that it was not missing at random.

Descriptive statistics, including means and frequencies, were used to describe the characteristics of the sample, as well as the participants’ beverage consumption habits and knowledge. Linear mixed model ANCOVAs accounting for clustering at the school level were used to compare post-intervention beverage consumption and knowledge across the three intervention groups, adjusting for pre-intervention values, using the PROC MIXED procedure in SAS 9.4. Models additionally adjusted for socio-demographic characteristics including sex, age, ethnicity, household income level, maximum household education, living
arrangements, and parental employment status; dietary variables including unhealthy food consumption frequency and daily servings of fruits and vegetables; and behavioural factors including frequency of refillable water bottle use, participation in a school milk program, and permission to leave school grounds at lunch time. These variables were selected based on the literature as well as theoretical plausibility and are hypothesized to affect children’s water and/or SSB consumption.

Because three schools did not receive their automatic water bottle filling stations until after the follow-up survey had been completed, we performed both intention to treat (ITT) analysis, where we analyzed all children, regardless of whether or not they actually got the filling station (n=931), and per protocol (PP) analysis, where we analyzed only the children from the 13 schools that got the filling station (n=621). The results of the ITT analysis are given precedence here, as ITT is generally thought to be superior to PP in that it preserves sample sizes, eliminates bias, and better represents the real life situation\textsuperscript{21}.

Unadjusted and adjusted results are presented. P-values <0.05 were considered statistically significant. No collinearity between covariates was identified. Sensitivity analyses using only non-imputed data were conducted.

5.4 Results

Written parental consent was obtained for 1,504 (36.8%) of 4,086 eligible children, of whom 1,099 completed the baseline youth survey. One school (n=26) withdrew from the study following baseline data collection and was thus excluded from the present analysis. Among the remaining study participants, 24 children did not have a corresponding parent survey, and 118 children did not complete a follow-up survey, resulting in their exclusion. The final number of analyzed subjects was 931 parent-child dyads, representing 22.8% of eligible children and an 88.8% retention rate from baseline. Children who were lost to follow up were more likely to be visible minorities and to live in a single-parent household, however they did not differ from those who were retained in any other way.

5.4.1 Sample Characteristics

Baseline socio-demographic, dietary, and behavioural information by intervention group is presented in Table 1. Slight differences in age, parental education level, weekly less healthy
food consumption frequency, and knowledge score at baseline were observed between the three intervention groups, however they were otherwise comparable.
Table 5.1 Baseline Characteristics of the Sample by Intervention Group: London, 2016

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Total Sample (n=931)</th>
<th>Control (n=410)</th>
<th>Growing Chefs! (n=348)</th>
<th>UTRCA (n=173)</th>
<th>P-Value&lt;sup&gt;c&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (Mean ± SD)</td>
<td>10.56 ± 1.39</td>
<td>10.33 ± 1.39</td>
<td>10.64 ± 1.53</td>
<td>10.91 ± 1.20</td>
<td>&lt;0.0001&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Sex (Frequency (%))</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>405 (43.88%)</td>
<td>181 (44.69%)</td>
<td>146 (42.20%)</td>
<td>78 (45.25%)</td>
<td>0.718</td>
</tr>
<tr>
<td>Female</td>
<td>518 956.12%</td>
<td>224 (55.31%)</td>
<td>200 (57.80%)</td>
<td>94 (54.65%)</td>
<td></td>
</tr>
<tr>
<td>Race/Ethnicity (Frequency (%))</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>597 (64.12%)</td>
<td>258 (62.93%)</td>
<td>218 (62.64%)</td>
<td>121 (69.94%)</td>
<td>0.21</td>
</tr>
<tr>
<td>Non-white/Mixed</td>
<td>334 (35.88%)</td>
<td>152 (37.07%)</td>
<td>130 (37.36%)</td>
<td>52 (30.06%)</td>
<td></td>
</tr>
<tr>
<td>Household Income Level (Frequency (%))</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>72 (7.73%)</td>
<td>38 (9.27%)</td>
<td>25 (7.18%)</td>
<td>9 (5.20%)</td>
<td></td>
</tr>
<tr>
<td>Low-Middle</td>
<td>105 (11.28%)</td>
<td>53 (12.93%)</td>
<td>34 (9.77%)</td>
<td>18 (10.40%)</td>
<td></td>
</tr>
<tr>
<td>Middle-High</td>
<td>132 (14.18%)</td>
<td>66 (16.10%)</td>
<td>40 (11.49%)</td>
<td>26 (15.03%)</td>
<td></td>
</tr>
<tr>
<td>High</td>
<td>309 (33.19%)</td>
<td>123 (30.00%)</td>
<td>119 (34.20%)</td>
<td>67 (38.73%)</td>
<td></td>
</tr>
<tr>
<td>Missing</td>
<td>313 (33.62%)</td>
<td>130 (31.71%)</td>
<td>130 (37.36%)</td>
<td>53 (30.64%)</td>
<td>0.117</td>
</tr>
<tr>
<td>Maximum Household Education (Frequency (%))</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High School Diploma or Less</td>
<td>106 (11.71%)</td>
<td>49 (12.31%)</td>
<td>36 (10.56%)</td>
<td>21 (12.65%)</td>
<td></td>
</tr>
<tr>
<td>College/University</td>
<td>643 (71.05%)</td>
<td>296 (74.37%)</td>
<td>228 (66.86)</td>
<td>119 (71.69%)</td>
<td></td>
</tr>
<tr>
<td>Graduate School</td>
<td>156 (17.24%)</td>
<td>53 (13.32%)</td>
<td>77 (22.58)</td>
<td>26 (15.66%)</td>
<td>0.021&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Mother’s Employment Status (Frequency (%))</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Employed</td>
<td>629 (69.06%)</td>
<td>264 (72.33%)</td>
<td>236 (75.40%)</td>
<td>129 (80.63%)</td>
<td></td>
</tr>
<tr>
<td>Unemployed</td>
<td>209 (24.94%)</td>
<td>101 (27.67%)</td>
<td>77 (24.60%)</td>
<td>31 (19.38%)</td>
<td>0.129</td>
</tr>
<tr>
<td>Father’s Employment Status (Frequency (%))</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Employed</td>
<td>646 (93.49%)</td>
<td>282 (93.07%)</td>
<td>236 (92.19%)</td>
<td>128 (96.97%)</td>
<td></td>
</tr>
<tr>
<td>Unemployed</td>
<td>45 (6.51%)</td>
<td>21 (6.93%)</td>
<td>20 (7.81%)</td>
<td>4 (3.03%)</td>
<td>0.176</td>
</tr>
<tr>
<td>Child Living Situation (Frequency (%))</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Two Parent Household</td>
<td>733 (79.67%)</td>
<td>318 (78.52%)</td>
<td>271 (78.78%)</td>
<td>144 (84.21%)</td>
<td></td>
</tr>
<tr>
<td>Single Parent Household</td>
<td>183 (19.89%)</td>
<td>85 (20.99%)</td>
<td>71 (20.64%)</td>
<td>27 (15.79%)</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>4 (0.43%)</td>
<td>2 (0.49%)</td>
<td>2 (0.58%)</td>
<td>/</td>
<td>0.526</td>
</tr>
<tr>
<td>Frequency of Refillable Water Bottle Use (Frequency (%))</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Never</td>
<td>30 (3.34%)</td>
<td>15 (3.81%)</td>
<td>10 (2.98%)</td>
<td>5 (2.98%)</td>
<td></td>
</tr>
<tr>
<td>Rarely</td>
<td>60 (6.68%)</td>
<td>34 (8.63%)</td>
<td>16 (4.76%)</td>
<td>10 (5.95%)</td>
<td></td>
</tr>
<tr>
<td>Sometimes</td>
<td>210 (23.39%)</td>
<td>87 (22.08%)</td>
<td>89 (26.49%)</td>
<td>34 (20.24%)</td>
<td></td>
</tr>
<tr>
<td>Usually</td>
<td>308 (34.30%)</td>
<td>140 (35.53%)</td>
<td>110 (32.74%)</td>
<td>58 (34.52%)</td>
<td></td>
</tr>
<tr>
<td>Always</td>
<td>290 (32.29%)</td>
<td>118 (29.95%)</td>
<td>111 (33.04%)</td>
<td>61 (36.31%)</td>
<td>0.339</td>
</tr>
<tr>
<td>Daily Servings of Fruits and Vegetables (Mean ± SD)</td>
<td>4.93 ± 1.99</td>
<td>4.42 ± 1.98</td>
<td>4.28 ± 1.93</td>
<td>4.54 ± 2.09</td>
<td>0.379</td>
</tr>
<tr>
<td>Times Water Consumed Per Day (Mean ± SD)</td>
<td>39.66 ± 19.49</td>
<td>38.44 ± 19.14</td>
<td>41.60 ± 19.48</td>
<td>38.62 ± 20.09</td>
<td>0.054</td>
</tr>
<tr>
<td>Times SSBs Consumed Per Day (Mean ± SD)</td>
<td>21.98 ± 17.23</td>
<td>22.84 ± 16.89</td>
<td>20.65 ± 16.93</td>
<td>22.62 ± 18.51</td>
<td>0.154</td>
</tr>
<tr>
<td>Times Less Healthy Food Consumed Per Week (Mean ± SD)</td>
<td>15.66 ± 10.08</td>
<td>16.06 ± 9.40</td>
<td>13.86 ± 9.49</td>
<td>18.30 ± 11.98</td>
<td>&lt;0.0001&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Participation in School Milk Program (Frequency (%))</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>135 (14.77%)</td>
<td>67 (16.79%)</td>
<td>47 (13.70%)</td>
<td>21 (12.21%)</td>
<td>0.285</td>
</tr>
<tr>
<td>No</td>
<td>779 (85.23%)</td>
<td>332 (83.21%)</td>
<td>296 (86.30%)</td>
<td>151 (87.79%)</td>
<td></td>
</tr>
<tr>
<td>Allowed to Leave School Grounds at Lunch Time (Frequency (%))</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>160 (17.49%)</td>
<td>66 (16.46%)</td>
<td>60 (17.54%)</td>
<td>34 (19.77%)</td>
<td>0.619</td>
</tr>
<tr>
<td>No</td>
<td>755 (82.51%)</td>
<td>335 (83.54%)</td>
<td>282 (82.46%)</td>
<td>138 (80.235)</td>
<td></td>
</tr>
<tr>
<td>Total Knowledge Score (Mean ± SD)</td>
<td>29.25 ± 6.54</td>
<td>28.56 ± 6.50</td>
<td>29.66 ± 6.80</td>
<td>30.05 ± 5.98</td>
<td>0.003&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<sup>c</sup> For differences in baseline characteristics between intervention groups

* = significant at α=0.05
5.4.2 Intervention Effects

Descriptive statistics indicate that, overall, water consumption increased in the intervention groups and decreased in the control group, while SSB consumption decreased in the intervention groups and increased in the control group. Knowledge scores increased in all three groups. For all outcomes, the greatest improvements were observed in the UTRCA group, followed by the Growing Chefs! group, and then the control group.

Table 2 presents the results of the linear mixed models using ITT analysis. After adjusting for clustering and socio-demographic, dietary, and behavioural confounders, participating in the GC intervention was associated with a 2.18% (95% CI -1.43, 6.27; p=0.218) increase in the percentage of total daily beverage consumption attributable to water, while participating in the UTRCA intervention was associated with a 2.90% (95% CI -0.23, 6.03; p=0.070) increase in the percentage of total daily beverage consumption attributable to water at follow up, compared to controls. Similarly, participating in the GC intervention was associated with a -1.17% (95% CI -3.83, 1.49; p=0.387) decrease in the percentage of total daily beverage consumption attributable to SSBs, while participating in the UTRCA group was associated with a -2.56% (95% CI -5.12, 0.001; p=0.050) decrease in the percentage of total daily beverage consumption attributable to SSBs at follow up, compared to controls. The GC intervention was also associated with an increase in knowledge score of 1.57% (95% CI -1.68, 4.83; p=0.343), compared to not receiving an education intervention, while the UTRCA intervention was associated with an increase in knowledge score of 2.02% (95% CI -0.35, 4.39; p=0.095), adjusting for clustering and socio-demographic, dietary, and behavioural confounders. None of the observed effects were statistically significant, although the adjusted effect of the UTRCA intervention on SSB consumption was borderline significant.
### Table 5.2: Regression Models for Association Between Intervention Group and Beverage Consumption and Knowledge Post-Intervention Using Intention to Treat Analysis: London, 2017

<table>
<thead>
<tr>
<th></th>
<th>Model 1: Percentage of Total Beverage Consumption Frequency Attributable to Water</th>
<th>Model 2: Percentage of Total Beverage Consumption Frequency Attributable to SSBs†</th>
<th>Model 3: Knowledge Score (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>β</td>
<td>95% CI</td>
<td>P</td>
</tr>
<tr>
<td><strong>Growing Chefs!</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unadjusted</td>
<td>2.42</td>
<td>-1.43, 6.27</td>
<td>0.218</td>
</tr>
<tr>
<td>Adjusted</td>
<td>2.18</td>
<td>-1.87, 6.22</td>
<td>0.291</td>
</tr>
<tr>
<td><strong>UTRCA</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unadjusted</td>
<td>2.89</td>
<td>-0.21, 5.99</td>
<td>0.067</td>
</tr>
<tr>
<td>Adjusted</td>
<td>2.90</td>
<td>-0.23, 6.03</td>
<td>0.070</td>
</tr>
</tbody>
</table>

β, standardized regression coefficient
* = significant at α = 0.05
CI = confidence interval
† SSBs include fruit-flavoured drinks, regular pop, energy drinks, and chocolate milk

In model 1, adjusted analyses account for baseline water consumption, sex, age, ethnicity, household income level, maximum household education, living arrangements, parental work status, baseline daily servings of fruits and vegetables, baseline weekly less healthy food consumption frequency, participation in school milk program, permission to leave school grounds at lunch, and frequency of refillable water bottle use.

In model 2, adjusted analyses account for baseline SSB consumption, sex, age, ethnicity, household income level, maximum household education, living arrangements, parental work status, baseline daily servings of fruits and vegetables, baseline weekly less healthy food consumption frequency, participation in school milk program, permission to leave school grounds at lunch, and frequency of refillable water bottle use.

In model 3, adjusted analyses account for baseline knowledge score, sex, age, ethnicity, household income level, maximum household education, living arrangements, parental work status, baseline water consumption, baseline SSB consumption, baseline daily servings of fruits and vegetables, baseline weekly less healthy food consumption frequency, participation in school milk program, permission to leave school grounds at lunch, and frequency of refillable water bottle use.
5.4.3 Per Protocol Analysis

The results of the linear mixed models using per-protocol analysis are presented in Table 3. The effect of the UTRCA and control interventions on water and SSB consumption and knowledge did not change substantially when using PP compared to ITT analysis, with estimates remaining a similar magnitude and in the same direction, however this was not the case in the GC intervention group. Using per-protocol analysis, receiving the GC program in addition to a water bottle filling station was associated with a decrease in the total proportion of daily beverage consumption attributable to water of -1.19% (95% CI -6.27, 3.89; p=0.646), and an increase in the total proportion of daily beverage consumption attributable to SSBs of 1.86% (95% CI -1.93, 5.66; p=0.336. The association between the GC program and knowledge scores remained positive. Again, none of the observed effects were statistically significant.
<table>
<thead>
<tr>
<th>Model</th>
<th>Model 1: Percentage of Total Beverage Consumption Frequency Attributable to Water</th>
<th>Model 2: Percentage of Total Beverage Consumption Frequency Attributable to SSBs</th>
<th>Model 3: Knowledge Score (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(\beta)</td>
<td>95% CI</td>
<td>P</td>
</tr>
<tr>
<td><strong>Growing Chefs!</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unadjusted</td>
<td>-0.87</td>
<td>-5.69, 3.95</td>
<td>0.724</td>
</tr>
<tr>
<td>Adjusted</td>
<td>-1.19</td>
<td>-6.27, 3.89</td>
<td>0.646</td>
</tr>
<tr>
<td><strong>UTRCA</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unadjusted</td>
<td>2.91</td>
<td>-0.11, 5.93</td>
<td>0.059</td>
</tr>
<tr>
<td>Adjusted</td>
<td>2.84</td>
<td>-0.22, 5.91</td>
<td>0.069</td>
</tr>
</tbody>
</table>

\(\beta\), standardized regression coefficient
* = significant at \(\alpha=0.05\)
CI = confidence interval
† SSBs include fruit-flavoured drinks, regular pop, energy drinks, and chocolate milk

In model 1, adjusted analyses account for baseline water consumption, sex, age, ethnicity, household income level, maximum household education, living arrangements, parental work status, baseline daily servings of fruits and vegetables, baseline weekly less healthy food consumption frequency, participation in school milk program, permission to leave school grounds at lunch, and frequency of refillable water bottle use.

In model 2, adjusted analyses account for baseline SSB consumption, sex, age, ethnicity, household income level, maximum household education, living arrangements, parental work status, baseline daily servings of fruits and vegetables, baseline weekly less healthy food consumption frequency, participation in school milk program, permission to leave school grounds at lunch, and frequency of refillable water bottle use.

In model 3, adjusted analyses account for baseline knowledge score, sex, age, ethnicity, household income level, maximum household education, living arrangements, parental work status, baseline water consumption, baseline SSB consumption, baseline daily servings of fruits and vegetables, baseline weekly less healthy food consumption frequency, participation in school milk program, permission to leave school grounds at lunch, and frequency of refillable water bottle use.
5.5 Discussion

This study evaluated the effectiveness of a naturally-occurring, school-based intervention to increase water consumption and decrease SSB consumption in elementary school children using a combination of education and environmental change. To our knowledge, this study provides the first empirical evidence of the impact of a provincially-funded Healthy Kids Community Challenge Water Does Wonders intervention on promoting health in children.

Using ITT analysis, our results show a trend toward improved beverage consumption habits and knowledge following participation in the GC and UTRCA interventions, however statistical significance was not reached, and the observed effect estimates were small in magnitude. While discouraging, these results are consistent with other studies using similar education and environmental change interventions, which also observed small and non-significant changes in water or SSB consumption\(^{14,22-27}\). Taken together, these findings may indicate that education and environmental changes, even when combined, are simply not enough to evoke meaningful, sustainable changes in beverage consumption habits. This demonstrates just how difficult it is to change dietary behaviours even in children. To generate lasting behavioural change requires continuous motivation and support\(^{28}\), which may not have been achieved here with only limited-term interventions. Long-term incorporation of water and nutrition education into all-aspects of the day-to-day curriculum would potentially be more effective.

Alternatively, the lack of significant improvements in beverage consumption habits could be directly related to the lack of significant improvements in knowledge score following the interventions. Indeed, evidence of an association between dietary intake and knowledge has been demonstrated in a number of contexts, including child populations\(^{29-34}\), however our study observed just small improvements across all three groups, which were likely not enough to yield clinically significant improvements in behaviour. The lack of significant increases in knowledge score could again be because the education interventions were simply too short in duration, delivered in just one (UTRCA) or two (Growing Chefs!) days, or it could be due to the content of the programs themselves, which were developed without the input of the researchers and may not have fully aligned with the objectives of the Water Does Wonders theme.
Although the interventions did not have a significant effect on beverage consumption, the programs were generally well-received by the participants themselves. Of the children who participated in Growing Chefs!, for example, 50.58% reported learning how to cook a new food or dish, while 10.47% said they learned how to preserve food and 10.17% said they learned the art of food preservation and plating. About one-third (34.22%) claimed that they are now willing to try the healthy foods introduced through the program (e.g. stir-fry, different fruits and vegetables) where they would not have done so before, and 17.15% were willing to try cooking, baking, or preserving by themselves. Although 40.64% of children reported no change in their eating and drinking habits because of the program, 19.59% said they now eat healthier and 12.87% said they drink more water or fewer SSBs.

Children who participated in UTRCA reported learning about where our tap water comes from (20.43% of grade 7s and 19.44% of grade 5s), the water treatment system (17.35% of grade 7s and 19.44% of grade 5s), and the importance of conservation and ways to conserve water (20.41% of grade 7s and 13.89% of grade 5s) from the program. Additionally, of the grade 7 students who were selected to teach the UTRCA program to the grade 5s, the majority (69.23%) described the experience positively, using words such as “fun”, “enjoyable”, “good”, or “rewarding”. One student, for example, said that “it was nice to be leaders”, while another wrote that “it made [them] feel responsible”, suggesting that there may be benefits to peer-led education beyond increases in knowledge.

5.5.1 Public Health Implications

Education programs are one of the most common public health interventions implemented to change dietary behaviours in children and are expected to improve beverage intake by providing participants with the information and skills required to make healthy choices through increasing their knowledge. Our findings, however, suggest that short-term education programs, even when combined with environmental changes to support healthy behaviours, may not be effective at significantly improving beverage consumption in this age group. This may indicate the need for a longer education program, particularly one that is integrated into the existing school curriculum in order to ensure engagement from teachers and students alike, or it may suggest that a different approach is necessary; for example, the implementation of a school or even province-level policy to further discourage SSB
consumption, which have proven effective in other contexts\textsuperscript{35–38}. Alternatively, our findings may reflect an issue with the Water Does Wonders education interventions specifically, rather than education interventions in general, which were short in duration and did not focus directly on water or SSB consumption, the primary outcomes of interest. This lack of overlap may have limited the ability of the programs to provoke significant changes in knowledge and thus behaviour. Future interventions should therefore ensure that their educational components are designed with the goals of the program in mind and accurately reflect the outcomes of interest.

It is important to note, however, that children who received both an education program and environmental change to their school environment had better outcomes at follow up than those who received only environmental change, demonstrating the value of combining multiple strategies and the need for a comprehensive approach to behavioural change. Thus, future interventions should continue to encompass multi-level strategies and should target all factors that may influence children’s beverage consumption habits, including taste, availability in the home, and parent and peer modelling\textsuperscript{39}, in addition to knowledge and accessibility in the school, which were the focus of our interventions.

\textbf{5.5.2 Study Limitations}

This study has several limitations. First, although it is better suited to assess usual intake and prevents the occurrence of the Hawthorne effect, the use of self-reported dietary data is vulnerable to recall bias, particularly in children, and may be inaccurate compared to objective measures. Similarly, while there is some evidence to suggest that instance frequencies are the best method for assessing beverage intake in child populations due to difficulties in estimating more standard measures such as volumes and portion sizes\textsuperscript{40}, the use of the ambiguous “times per day” measure may have been interpreted differently by each child, potentially resulting in measurement error.

We also did not account for the varying amount of time between the intervention and the follow-up survey at each school, thus if the intervention effects of the education programs were only sustained short term, they may not have been fully captured. Likewise, if it took longer for the new water bottle filling station to change student drinking behaviour, the intervention effects of the stations may have been missed.
Finally, substantial deviations in protocol occurred over the course of the study and 3 schools encompassing 310 students did not receive their water bottle filling station until after data collection had been completed, resulting in contradictory findings in ITT compared to PP analyses, particularly in the GC intervention group. While this is a peril of natural experiments and was completely out of the control of the researchers, the exclusion of these students from the PP analysis resulted in a considerable reduction in sample size, which limited the power of the study to detect true effects. This type of applied research is messy and imperfect, however it is valuable for evaluating the real-world impact of policies and programs, particularly large-scale, publically-funded health interventions like we have described here, where a true RCT is impractical\textsuperscript{41}.

5.6 Conclusion

In this quasi-experimental, non-randomized controlled trial, we provided the first evaluation of the Ontario government’s Healthy Kids Community Challenge Water Does Wonders interventions at promoting healthy beverage consumption habits in children. We found that participating in the Growing Chefs! and UTRCA education programs in addition to receiving new water infrastructure, compared to new water infrastructure only, was not associated with statistically or clinically significant improvements in water and SSB intake or knowledge, although the trends in the UTRCA group were consistently in the expected direction. Given the contradictory findings of the ITT and PP analyses on the effect of the GC intervention, however, larger studies with greater adherence and more accurate measures of beverage consumption are needed in order to better understand the potential impact of education interventions combined with environmental changes to improve dietary behaviours in children.
5.7 Acknowledgements

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5.9 References


20. Bodner TE. What improves with increased missing data imputations? *Struct Equ*


Chapter 6

6 Synthesis and Conclusion

The objectives of this chapter are to summarize the research presented in this thesis, synthesize the results of the two analytic studies, and situate the findings in the context of the larger literature. The research and methodological contributions are highlighted and the limitations are noted. The chapter ends with a discussion of the implications of the findings of this thesis for policy and practice and the next steps for future research.

6.1 Summary of Studies

The overarching goal of this thesis was to contribute to the growing body of literature on strategies for promoting healthy beverage intake in children. Using two independent but complementary quantitative analyses, this thesis evaluated the Healthy Kids Community Challenge Water Does Wonders programs in London, Ontario. First, the assumed link between water and nutrition knowledge, and beverage consumption habits, was tested (Chapter 4), providing context for the subsequent examination of the effectiveness and impacts of a school-based education intervention intended to improve beverage intake through increasing knowledge, combined with environmental change (Chapter 5).

Chapter 4 sought to justify the use of education programs to change dietary behaviours in children by examining the association between water and nutrition knowledge (both separately and combined) and beverage consumption habits in children. Additionally, several socio-demographic, dietary, and behavioural correlates of water and SSB consumption and knowledge score were identified. In total, parent and youth surveys were collected from 1049 children aged eight to 14 years from 16 schools across London, Ontario. Using hierarchical multivariable linear regression models with GEEs to account for school-level clustering, higher total knowledge scores were found to be significantly associated with higher water consumption and lower SSB consumption, and this relationship remained when water and nutrition knowledge sub-scores were analyzed separately.

Along with higher knowledge, higher water consumption was also associated with being female, having a more educated parent/guardian, living in a two parent household, less
frequent less healthy food consumption, fewer daily servings of fruits and vegetables, not participating in a school milk program, and more frequent use of a refillable water bottle. Lower SSB consumption was associated with being female, having a more educated parent/guardian, living in a two parent household, less frequent less healthy food consumption, not participating in a school milk program, more frequent use of a refillable water bottle, and not being allowed to leave the school grounds at lunch time. Higher total knowledge scores were associated with older age, higher household income level, and having a more educated parent/guardian.

Despite the observed associations, a descriptive analysis revealed that among the study population, water and nutrition knowledge scores were low overall, and that this corresponded with low water consumption and high SSB consumption. The findings of this study reinforce the need for interventions targeting these behaviours, and also support the implementation of knowledge-enhancing education programs as a potentially effective strategy for improving beverage consumption habits in children.

Based on the link between knowledge and behaviour established in Chapter 4, and on the results of the literature review in Chapter 2 that identified education programs combined with environmental change as the most effective method for eliciting meaningful, sustained changes in beverage consumption, Chapter 5 evaluated as a natural experiment the effectiveness of the Healthy Kids Community Challenge Water Does Wonders program in London. Participating children received one of three interventions: 1) Growing Chefs! (a nutrition-focused education intervention) plus new water bottle filling station infrastructure; 2) UTRCA (a water-focused education intervention) plus new water bottle filling station infrastructure; or 3) control group that received new water bottle filling station infrastructure only. Using multivariable linear mixed model ANCOVAs, the water and SSB consumption and knowledge scores of 931 children from 16 elementary schools were assessed across the Growing Chefs!, UTRCA, and control groups post-intervention. Compared to the control group, intention to treat analyses revealed that the intervention groups were expected to consume more water and fewer SSBs and to have higher knowledge scores following the cessation of the interventions; however, these changes were small in magnitude and were not statistically significant. Per protocol analyses, on the other hand, indicated that the Growing
Chefs! group was expected to consume less water and more SSBs following the intervention, although again, these findings were not significant.

Given these discrepant findings, much of the discussion of Chapter 5 is centered on the limitations of the evaluation, namely that substantial deviations from protocol, which occurred when a delay prevented three schools from getting their water bottle filling stations prior to follow up data collection, greatly reducing the sample size of the Growing Chefs! group, diminishing the power of the study to detect true effects. The small effect sizes observed from the models also led us to question whether education programs in general are simply insufficient to significantly alter dietary behaviours in child populations, even when combined with environmental changes to support healthy habits, or whether the null results actually reflect an issue with our intervention specifically. Given that a misalignment occurred between the content of the education programs and the outcomes of interest of the Water Does Wonders theme, and that the education programs themselves were very short in duration, the latter seems more probable, and highlights the need for evaluations of interventions to be designed to assess the specific objectives of the interventions.

6.2 Research and Methodological Contributions

The research presented in this thesis adds a new case study to the growing body of literature on strategies for reducing SSB consumption and increasing water consumption in child populations, and provides the first evaluation of a Water Does Wonders intervention associated with the provincially-funded Healthy Kids Community Challenge. When considered together, the two studies presented in Chapters 4 and 5 of this thesis provide greater insight into the theoretical underpinnings and practical challenges of education-centered public health interventions and the effectiveness of these interventions in practice.

Individually, Chapter 4 expanded on the previous literature exploring the link between knowledge and dietary behaviour by focusing on beverage consumption specifically, as opposed to dietary intake in general; the first to our knowledge to do so. This is long overdue, given the multitude of educational interventions seeking to increase water or reduce SSB consumption that have been implemented as of late, both in Canada and internationally. The significant association observed between knowledge and beverage intake supports the findings of previous research in child populations, which also identified positive correlations
between children’s knowledge of food-related topics and their dietary behaviours\(^1\)\(^{-6}\), and is the first study of this nature conducted in the Canadian context. The results of Chapter 4 provide support and rationale for the continued investment in, and implementation of, education-based public health interventions that seek to improve behaviours through increasing knowledge. Chapter 4 also demonstrated that, despite a levelling off of childhood obesity rates in Canada in recent years, poor beverage consumption habits persist among Canadian children and adolescents, with the majority drinking too many SSBs and not enough water. These findings confirm those of other studies of SSB intake in the Canadian population, which have observed an over-consumption of sugary drinks in all age groups, including children\(^7\)\(^{-10}\), suggesting that new and effective interventions are necessary.

Chapter 5 contributes a new, Canada-specific case study to the beverage consumption intervention literature and offers the first quantitative assessment of the effectiveness and impact of a Water Does Wonders intervention associated with the Healthy Kids Community Challenge, which has been implemented in some form or another in 45 communities across Ontario. To date, quantitative evaluations of water and SSB interventions in Canada have been limited, with just three of the 56 studies identified in Chapter 2’s literature review occurring in the Canadian context\(^11\)\(^{-13}\). Given that two of these studies were strictly education interventions and enrolled fewer than 100 children in the study sample\(^11\),\(^13\), and that the third evaluated a policy intervention\(^12\), Chapter 5 fills an important gap in the literature. The findings of Chapter 5, although unique to the city of London where the interventions were implemented, are comparable to those observed in other contexts and may thus offer important information about education and environmental programs more broadly. For example, an evaluation of an intervention in German elementary schools that combined the installation of new water fountains with classroom lessons on water also found no significant reduction in soft drink or juice consumption in the intervention group compared to the control\(^14\), nor did the implementation of interactive workshops along with changes to the school cafeteria menu in Argentina\(^15\). Null findings were also observed for combined education and environmental change interventions in schools in Portugal and Romania\(^16\), Sweden\(^17\), and South Africa\(^18\). With the exception of the study by Muckelbauer et al.\(^14\), all of these interventions, our own included, incorporated healthy beverage consumption into more general obesity prevention lessons but did not focus on it directly. As such, these messages
may have been buried amidst a multitude of other information. Programs addressing water and SSB consumption specifically may therefore be needed, as trying to change too many behaviours at once may result in nothing changing at all.

Linking the discussions of Chapters 4 and 5 is the idea that statistically significant associations between knowledge and practice may not translate to clinically important improvements in beverage consumption habits with increasing knowledge. Indeed, the small effect sizes observed in Chapter 4 correspond with equally small changes in beverage consumption following the HKCC interventions in Chapter 5, and these changes were imprecise. This suggests that, even if statistical significance was reached, any improvements to beverage consumption would simply be too small in magnitude to have a meaningful effect on weight status, or health more broadly. As such, a more intensive or longer-lasting approach may be needed.

Methodologically, both Chapters 4 and 5 made use of a novel method of standardizing beverage instance frequencies across children by dividing the number of times per day each child reported consuming the beverage of interest by the total number of times they reported consuming any beverage that day to create a proportion. This allowed us to retain the benefits of instance frequency measures, namely that they are easier for children to estimate than volumes or portion sizes\textsuperscript{19-22}, while also correcting for the ambiguity of the “times per day” measure, which could have been interpreted differently by each child, and the possibility of over- and under-reporting. The result was enhanced comparability of the data across children. To our knowledge, this is the first time that such an approach has been used in research evaluating beverage intake.

### 6.3 Limitations

There are a number of limitations within this thesis that must be considered when interpreting the results. Common to both study 1 and study 2, for instance, are issues with the measurement tool, which was un-validated and relied on subjective, self-reported measures. This type of data is vulnerable to recall bias\textsuperscript{23}, particularly in children, and may thus be inaccurate. Self-reported data is not uncommon in research involving dietary behaviours. Indeed 91\% of the studies included in the literature review in Chapter 2 used subjective measures. Despite the limitations of self-reported data, these measures have their merits.
Specifically, subjective measures are more suitable than objective measures for assessing usual intake, as opposed to recent intake, and reduce the occurrence of the Hawthorne effect, wherein study subjects change their behaviour because they know they are being watched\textsuperscript{24}.

Also common to both studies was the possibility of the effect of unmeasured confounders, such as parental control and parental knowledge, taste preferences, and peer influence\textsuperscript{25}. While parental education was used as a proxy for parental knowledge, the other confounders could not be accounted for, reflecting a limitation of the survey tool. It must be noted, however, that beverage consumption and the decision to consume certain beverages over others is complex and not fully understood, influenced by a multitude of known and unknown factors. Therefore, it is not realistic to attempt to adjust for every possible confounder. Rather, we controlled for the factors that we were able to measure and that may have exerted some sort of effect on beverage consumption, based both on previous literature, and on theory.

The use of the ambiguous “times per day” measure of beverage consumption rather than a standardized volume measure such as cups or mL per day was another limitation, as it may have been interpreted differently by each child, reducing comparability and resulting in measurement error. As discussed in the previous section, however, instance frequencies are often preferable to volumes in child populations, as they are easier to estimate than volumes and portion sizes\textsuperscript{19–22}, and we attempted to correct for any error introduced by this method by converting absolute frequencies into proportions to standardize across children, the first study to our knowledge to do so.

Along with the issues common to both integrated articles, Chapter 5 also presents additional limitations, the majority of which stem from the natural experiment design of the project, which afforded the researchers less control over the study than if conducting a traditional RCT. Perhaps most important are the considerable deviations from protocol that were observed over the course of the study wherein three schools, encompassing 310 students, did not receive water bottle filling stations until after the completion of the follow-up survey. This greatly reduced the sample size of the Growing Chefs! group in particular, limiting the power of the study to detect true effects, and potentially resulting in contradictory findings using ITT compared to PP analyses.
There were also some limitations with the interventions themselves. For one thing, there was a disconnect between the content of the education programs and the objectives of the HKCC. Specifically, the goal of the Water Does Wonders theme of the Healthy Kids Community Challenge was to increase water consumption and decrease SSB consumption in children; however, the Growing Chefs! and UTRCA education interventions focused on cooking skills and nutrition, and water conservation and treatment, respectively. While water and SSB consumption were touched upon in both programs, they were not the primary focus, and thus improvements in beverage consumption were minimal compared to what could have been observed if the education programs aligned more closely with the program objectives. The provision of additional materials, such as reusable water bottles to encourage the use of the new refillable water bottle filling stations, may also have led to improved findings.

Additionally, the interventions were targeted solely at the children and did not incorporate parents or guardians in any way. This is a major limitation given that, at this age, parents still have a high degree of control over what beverages a child is served and what is available to them in the home environment. Indeed, studies by Asakura et al. and Grosso et al. indicate a high degree of correlation between parental nutrition knowledge and child dietary habits\textsuperscript{1,2}, suggesting that incorporating parents into the interventions may have resulted in larger effects. Furthermore, research has demonstrated that parent modelling is an important determinant of beverage intake, and improving parental drinking habits may therefore have led to greater improvements in children. The interventions were also very short in duration, with the Growing Chefs! program occurring on two days throughout the school year and the UTRCA program occurring on just one. Although our literature review found that shorter interventions resulted in more significant improvements in beverage consumption than longer interventions, most of the included studies were at least a month long in duration, and it is difficult to believe that any program less than that would yield any sustained changes. As such, this represents a major limitation.

Finally, in our assessment of the intervention we were unable to account for differing lengths of follow up between the intervention and the follow up survey, seasonality effects, wherein children who were surveyed in April may have consumed less water than those surveyed in June due to lower daily temperatures, or whether or not the fountains were actually used. The discrepancies in time between intervention and follow up are particularly important, as we
could not examine potential regression to pre-intervention beverage consumption frequencies following an initial spike in water intake or drop in SSB intake. Assessing the outcomes at multiple time points following the interventions could correct for this, and the need for longer follow up periods was a key finding of the literature review presented in Chapter 2.

As stated previously, the majority of the limitations with the interventions are due to the natural experiment design of the study, however the benefits of this type of research must also be acknowledged. While not true experiments, natural experiments offer a unique evaluation of the impacts of programs and policies in the real world, rather than in the highly controlled environment of an RCT, providing a potentially more accurate reflection of the actual effectiveness of these interventions\textsuperscript{26}.

### 6.4 Implications for Policy and Practice

Reducing the amount of sugar-sweetened beverages consumed by children and increasing their water consumption has been identified as necessary in the current fight against childhood obesity, and is a goal common to public health practitioners, policy makers, and parents alike. This research explored one prevailing public health strategy for improving children’s beverage consumption habits: the use of education interventions, combined with environmental changes. Findings from each of the integrated articles provide important lessons that may be used to inform the design of future interventions targeting water and SSBs in order to improve the drinking habits of Canadian children through policy and practice.

From a policy perspective, the results of the study presented in Chapter 4 reinforce the potential effectiveness of education at promoting positive behavioural change, providing evidence of a statistically significant, if small in magnitude, association between knowledge of water and nutrition topics and water and SSB intake. These findings support the integration of nutrition education policies into schools, which have been identified as an effective setting for promoting healthy eating and drinking behaviours. School-based education programs, after all, are nearly universal, with virtually all children attending school, and also afford kids the opportunity to put what they’ve learned into practice, given that they spend a significant portion of their waking hours immersed in the school environment\textsuperscript{27}. Furthermore, the development of a comprehensive, interactive, evidence-
based, and culturally and socio-economically appropriate nutrition education program may serve as an equalizer, minimizing disparities in knowledge\textsuperscript{28,29}, which were observed between children of different socio-economic statuses in Chapter 4.

Based on these benefits, incorporating nutrition education into the elementary school curriculum was a key recommendation of a recent report on food literacy in Canada\textsuperscript{30}. Published by the Conference Board of Canada in 2013, the report identified substantial gaps in children’s food and nutrition knowledge and concluded that education about nutrition should be integrated into Canadian school programs until at least grade 6\textsuperscript{30}. As of 2015, healthy eating has been one of the foci of Ontario’s Health and Physical Education curriculum, and is discussed to some degree or another in all grades from 1 to 12\textsuperscript{31,32}. There is very little academic research to date, however, exploring the content, quality, and breadth of this nutrition education curriculum, and extent to which it incorporates beverages. A beverage-specific module may therefore be needed. British Columbia, for example has had success with their \textit{Sip Smart! BC} program, an educational initiative to teach grade 4 to 6 children about the importance of healthy beverage consumption\textsuperscript{30}. The program engages students with grade-specific activities and is integrated into the Health and Career Education and Science curriculums to achieve maximum benefit\textsuperscript{33}. Efforts have been made to replicate \textit{Sip Smart!} in other contexts and the program was recently licensed for use in Ontario\textsuperscript{34}.

Chapter 5 demonstrated the importance of the food environment in influencing children’s beverage consumption behaviours. Specifically, children who received a new water bottle filling station at their school in addition to an education intervention had larger improvements in beverage consumption than those who received only a new filling station. These findings reflect the importance of easy access to healthy options at all times to support the adoption of healthy habits, and highlight the need for strict nutrition standards in schools, which dictate the types of food and beverages available. Currently, school nutrition standards are widespread throughout the developed world, however these policies vary greatly in stringency and adherence criteria\textsuperscript{35}. In Ontario, a school food and beverage policy banning the sale of fruit-flavoured drinks, energy drinks, sports drinks, and sodas in elementary schools has been in effect since 2011, however these standards do not apply to beverages brought from home\textsuperscript{36}. This is a major limitation of school nutrition policies, particularly in countries like Canada, where universal, publically funded school meal programs do not exist,
because most foods consumed in elementary schools are brought from home\textsuperscript{37}. While research on the quality of these home-packed lunches is lacking in the Canadian context, studies from the United States\textsuperscript{38,39} and United Kingdom\textsuperscript{40-42} have suggested that lunchboxes may be less nutritious than the meals provided by the school, and that children who bring lunches from home consume more unhealthy beverages\textsuperscript{38-42}. As such, there is a need to extend school nutrition standards to incorporate foods and drinks packed in lunch boxes brought from home. Some individual schools and school boards have already made progress at implementing lunchbox policies, banning certain less healthy foods including carbonated drinks from entering schools at all, but, unfortunately, these are the minority. Along with nutrition standards, school policies allowing students to keep water bottles at their desks may also promote increased water consumption throughout the day. Indeed, the results of chapter 4 indicated that children who use a refillable water bottle more frequently consume more water and less SSBs overall. Currently, individual teachers typically set the rules on water bottles at desks across Ontario\textsuperscript{43}, and may ban the practice if they feel that it causes distractions to learning, even at the expense of children’s hydration.

In addition to policies decreeing what can be sold in schools and what can be brought from home, regulations affecting the school neighbourhood may also be beneficial in promoting healthy drinking habits in children\textsuperscript{35}. In chapter 4, for example, we demonstrated that children who were allowed to leave school grounds at lunch time consumed SSBs more frequently than those who were not. This is likely because these students were able to purchase SSBs that would not otherwise have been available to them at stores or restaurants nearby. Indeed, a 2012 study demonstrated that, of 320 Canadian schools included in the research, around half had one or more convenience stores or fast food restaurants within a 1 km radius\textsuperscript{44}. Policies preventing fast food restaurants from operating within a set distance of school, therefore, may prevent students from seeking unhealthy beverages off-campus. Such policies have been implemented selectively in three municipalities in Quebec, although it is too soon to comment on their effectiveness\textsuperscript{45}. Alternatively, where regulations to the built environment are not possible, policies prohibiting students from leaving the school grounds during lunch and recess periods may also be effective\textsuperscript{35}.

Concerning practice, both chapters 4 and 5 offer important insights that can be used to inform the design and implementation of future interventions targeting beverage consumption habits
in order to maximize their uptake and impact. To begin, Chapter 4 established a number of socio-demographic, dietary, and behavioural predictors of healthy beverage consumption which may be used to identify individuals at risk, or to tailor interventions to those who need them most. Males, children from single-parent households, and children with less educated parents, for instance, consumed water less frequently and SSBs more frequently than their peers in our study, indicating the need to target interventions at these groups. Indeed, a recent review indicated that obesity prevention interventions targeting individuals who were predisposed to obesity, for example because of their socioeconomic status, were better able to demonstrate significant improvements than those targeting the general population\textsuperscript{46}.

Along with determinants of beverage intake, Chapter 4 also identified gaps in water and nutrition knowledge, which may guide the development of education program curriculums. Specifically, children in our sample were largely uninformed about water treatment, conservation, and health topics. Almost half were unaware of the daily water intake recommendations for their age group and many believed bottled water to be superior to tap, and may have been hesitant to drink from water fountains because of it. Future education interventions, therefore, must dispel misconceptions and negative attitudes about tap water, and should incorporate lessons on the importance of and health benefits associated with daily water consumption, in order to encourage more frequent consumption. This is particularly important as analyses of the water and nutrition sub-scores separately in Chapter 4 indicated that a one-percent increase in water knowledge resulted in larger improvements in water and SSB intake than a one-percent increase in nutrition knowledge.

Chapter 5 reveals important insights into the strengths and limitations of education and environmental interventions in practice, which can be used in the development of future programs. For one thing, despite the association between knowledge and beverage intake observed in Chapter 4, the lack of significant improvements following the Water Does Wonders activities in Chapter 5 potentially reflects an issue with translating the knowledge-practice link into effective, real-world interventions capable of generating sustained behavioural change, and may therefore suggest that education programs are not the most effective strategy for improving beverage intake in children. Indeed, to evoke lasting behavioural changes requires long-term support and continuous motivation\textsuperscript{47}, which is often difficult to achieve with school-based education interventions, as they are typically short in
duration. To this point, the Growing Chefs! intervention studied here took place over the course of just two days, while the UTRCA intervention occurred on one day, likely limiting the ability of these programs have any significant impacts. Given that education programs are one of the most common public health interventions for changing dietary behaviours in children, this finding is important, and indicates the need for a different approach, such as a policy intervention.

On the other hand, the null findings observed in Chapter 5 may be more indicative of a flaw with the Water Does Wonders interventions themselves, as opposed to education programs in general. As mentioned previously, for instance, the Growing Chefs! and UTRCA interventions were extremely short in duration, and furthermore, they did not focus directly on water or SSB consumption, despite these being the primary outcomes of interest of the Water Does Wonders theme. As a result, the ability of the programs to elicit any sort of significant changes in beverage consumption was hindered from their very conception. Thus, in developing future interventions targeting water and SSB consumption, thorough research and planning prior to implementation is essential, in order to ensure that the intervention and the program objectives are fully aligned. The planning process should include a variety of stakeholders such as public health practitioners, teachers, parents, and even children themselves, who are able to provide a unique perspective.

Also important for the development of future programs, the positive reception of the interventions by study participants suggests that engaging and interactive workshop-based education programs may be a beneficial addition to traditional, lecture-style education. This confirms the findings of a 2015 study comparing lecture- and experience-based learning programs for nutrition education, which recommended the use of both methods after observing greater improvements in children’s dietary behaviours with experience-based methods and greater improvements in their knowledge with lecture-based methods. As noted previously, traditional nutrition education already exists in the Ontario school curriculum, and thus additional education interventions should supplement and reinforce their messages using practical, hands-on experiences which may make the content more memorable.
Finally, Chapter 5’s finding that children who received both an education program and environmental changes to the school environment had greater improvements in both beverage consumption and knowledge than those who received only environmental changes indicates the need for comprehensive, multi-level strategies. Beverage consumption, after all, is a complex and multifaceted behaviour, influenced by a number of different factors, and therefore interventions must target determinants of beverage consumption habits at all levels in order to be successful. This can include the individual and physical environment levels, as we have targeted here, or the social or community environment in which a child exists.

6.5 Future Research

Considering the findings and limitations of the research presented in this thesis, future studies should continue to investigate the association between knowledge and practice and the effectiveness of education and environmental interventions for improving children’s beverage consumption habits. Specifically, additional research concerning whether changes in knowledge can actually yield clinically significant improvements in beverage consumption habits in practice are needed, in order to better understand the value and potential impact of education-based interventions. Future work in this field of research should also seek to establish a framework of best practices building on successful past interventions so that policy makers and practitioners are able to more easily and efficiently design and implement effective, evidence based strategies that can be used in a variety of populations and settings.

In doing this, forthcoming research must evaluate longer duration interventions using more accurate measures of beverage consumption and ensuring greater adherence to the study protocols. Ideally, this would take the form of an RCT to afford the researchers more control over the design, implementation, and evaluation of the study, providing a better understanding of the true ability of education interventions combined with environmental changes to improve dietary behaviours in children.

Finally, future studies should attempt to measure a greater variety of confounders, such as parental knowledge and peer influence, in order to obtain more accurate estimates of the associations, and should account for seasonality differences and discrepancies in time between intervention completion and follow up survey. A repeated measure study design,
evaluating children’s drinking habits at multiple time points following the interventions, may also be useful in determining the sustainability of any observed improvements.

6.6 Conclusions

The primary objective of this thesis was to investigate the potential for a school-based education and environment intervention to significantly improve children’s beverage consumption habits as a strategy for reducing childhood obesity. By examining the association between knowledge of water and nutrition topics and water and SSB consumption, the first of the two studies suggested that education interventions intended to increase knowledge may result in positive improvements in beverage consumption. Building on this finding, the second study evaluated London’s HKCC Water Does Wonders intervention, which combined nutrition and water education programs with the installation of new water bottle filling stations in elementary schools. Although this program did not yield any measurable improvements in water or SSB intake or knowledge, the observation of positive trends nevertheless indicates that important lessons may be taken from this intervention. Specifically, the results of the study highlight the need for appropriately designed, long-term, multi-level programs if any sustainable behavioural change is to be achieved. The findings from this thesis have important implications for policy makers, health practitioners, school administrators, parents, and researchers seeking to improve the state of childhood obesity through improving beverage consumption habits. The results will support the development of effective policies, programs, and practices to encourage and support children in drinking more water and fewer SSBs in order to better their overall health and well-being.
6.7 References


45. Robitaille E, Paquette M-C, Cutumisu N, Lalonde B. *The Food Environment around Public Schools and the Consumption of Junk Food for Lunch by Québec Secondary*
School Students.; 2016.


<table>
<thead>
<tr>
<th>CONCEPT</th>
<th>CINAHL</th>
<th>MEDLINE</th>
<th>EMBASE</th>
<th>KEYWORDS</th>
</tr>
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<tbody>
<tr>
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<td>Intervention* OR strategy* OR Program* OR policy OR policies OR method* OR approach* OR project* OR tactic* OR way* OR technique* OR best practice* OR advertising OR school-based OR education OR legislation</td>
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<td>WATER</td>
<td>(MH Water)</td>
<td>Drinking Water</td>
<td>Exp Drinking Water</td>
<td>Water OR drinking water</td>
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<td>MEDLINE</td>
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<td>SUGAR-SWEETENED BEVERAGE</td>
<td>(MH Carbonated beverages) OR (MH Food and Beverages) OR (MH Beverages)</td>
<td>Beverages/ OR Carbonated Beverages/</td>
<td>exp Beverage/ OR exp Sugar Intake/</td>
<td>Sugar-sweetened beverage* OR sugar-sweetened drink* OR sweetened drink* OR sweetened beverage* OR sweet drink* OR sweet beverage* OR sugary drink* OR sugary beverage* OR soft drink* OR soda OR pop OR fountain drink* OR juice OR fruit drink* OR sports drink* OR energy drink* OR carbonated beverage* OR carbonated drink*</td>
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<td>CHILDREN</td>
<td>(MH Child) OR (MH Students, Elementary) OR (MH Child, preschool) OR (MH Students, Middle School) OR (MH Students)</td>
<td>Child/ OR Child, preschool/</td>
<td>Exp child/ OR exp adolescent/ OR exp preschool child/ OR exp school child/</td>
<td>Children OR child OR kid* OR adolescent* OR youngster OR young adult* OR juvenile* OR minor* OR youth OR student*</td>
</tr>
</tbody>
</table>
Appendix B Full Characteristics of the Studies Included in the Literature Review (28 Pages)

<table>
<thead>
<tr>
<th>First Author (Year), Country</th>
<th>Total Number of Subjects, Mean Age, Intervention Setting, Study Design</th>
<th>Intervention Length</th>
<th>Intervention</th>
<th>Change in Consumption of Water/SSBs</th>
<th>Study Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Albala (2008), Chile&lt;sup&gt;52&lt;/sup&gt;</td>
<td>98, 9 years, community-based, randomized controlled trial</td>
<td>16 weeks</td>
<td>Environment. Milk was delivered to the homes of intervention-group children. They were instructed to consume 3 servings of milk and no SSBs</td>
<td>Measured as grams/day. Intervention group (n=44) SSB consumption decreased by 711.0(33.7)g. Control group (n=46) SSB consumption increased by 71.9(33.6)g. p&lt;0.0001</td>
<td>Replacing habitual consumption of SSBs with milk may be effective at reducing SSB intake and may have beneficial effects on lean body mass and growth in children</td>
</tr>
<tr>
<td>Al Khalifah (2016), Canada&lt;sup&gt;63&lt;/sup&gt;</td>
<td>81, 8.9 years, Montreal Children's Hospital, prospective cohort study</td>
<td>12 months</td>
<td>Education. Healthy Active Living (HAL) education program, which included teaching sessions and counseling tools. The program focused on 4 goals: five servings of fruits and vegetables per day, less than 2 hours screen time per day, more than one hour physical activity</td>
<td>Measured as number of drinks/day. Consumption was 0.4 (0.8) at baseline, 0.3 (0.7) at 6 months follow up, and 0.4 (0.7) at 12 months follow up. Change from baseline to 6 months was -0.15 (0.5), p&lt;0.01. Change from 6 months to 12 months was 0.1 (1.0), p=0.6</td>
<td>Short-term improvement in caloric drink consumption was observed however this was not sustained at 12 months.</td>
</tr>
<tr>
<td>Study</td>
<td>Country</td>
<td>Sample Size</td>
<td>Duration</td>
<td>Setting</td>
<td>Intervention</td>
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<tr>
<td>Angelopoulos (2010)</td>
<td>Greece</td>
<td>646, 10 years, 26 elementary schools</td>
<td>10 months (one school year)</td>
<td>Non-randomized controlled trial</td>
<td>Education + Environment. Intervention based on the theory of planned behaviour and focusing on overcoming the barriers in accessing physical activity areas, increasing the availability of fruits and vegetables, and increasing parental support for dietary and physical activity patterns</td>
</tr>
<tr>
<td>Anttonen (2011)</td>
<td>England</td>
<td>739 in 2007/647 in 2008, approximately 13 years, 12 secondary schools</td>
<td>1 academic school year</td>
<td>Cluster-randomized controlled trial</td>
<td>Education. Dietary intervention including an oral health intervention to improve the quality of tooth brushing</td>
</tr>
</tbody>
</table>
to 18.2% at school and increased from 54.3% to 56.3% at home. In the control group, the percentage of students who generally consumed water to quench their third decreased from 69.4% to 62.5% at school and from 35.0% to 29.7% at home, while the percentage who generally consumed SSBs to quench their thirst increased from 17.0% to 25.4% at school and increased from 48.0% to 53.3% at home. These findings were not statistically significant while the proportion who chose juice/soft drinks increased.

Arvidsson (2015), Multi-Country (Belgium, Cyprus, Estonia, Germany, Hungary, Italy, Spain, Sweden)\(^5\)

Education. IDEFICS study. Materials were developed and provided at the community level, with the aim of helping parents promote and encourage a healthy food environment.

Measured as propensity for water consumption. In the intervention group (n=3870) propensity for water consumption was 51.81 (0.55) at five years follow-up, while in the control group (n=3325) propensity for water consumption was 49.94 (0.78), p=0.045.

Intervention children had better diet qualities at 5 years post-intervention, suggesting the intervention may yield sustainable improvements.
<table>
<thead>
<tr>
<th>Study</th>
<th>Sample Size</th>
<th>Intervention Duration</th>
<th>Intervention Description</th>
<th>Consumption Measurement</th>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bayer (2009), Germany</td>
<td>64 kindergartens, 1340, 6.12 years</td>
<td>1 year</td>
<td>Education. TigerKids behavioural intervention, which aimed to enhance physical activity and modify food and drink habits. Intervention included information folders for teachers, materials for use in Kindergarten setting, newsletters and &quot;TippCards&quot; for parents, and a wooden train used to structure lessons in food and drink for children</td>
<td>Measured as high or low consumption of high caloric drinks, with low consumption classified as a maximum of one glass/day (200 mL).</td>
<td>Mixed results concerning the effectiveness of the intervention on beverage consumption habits. Sustainable improvements were observed in fruit and vegetable consumption.</td>
</tr>
<tr>
<td>Bogart (2014), USA</td>
<td>2997, approximately 13 years</td>
<td>5 weeks</td>
<td>Education + Environment. SNaX combined environmental changes, multimedia, encouragement and peer-led education to address obesity</td>
<td>Measured as tap water consumption frequency (everyday, a few times a week, once a week, twice a month, once a month, less than once a month, never).</td>
<td>Tap water consumption decreased in the control group but increased in the intervention group. The difference between intervention and control was statistically significant (p&lt;0.0001).</td>
</tr>
</tbody>
</table>
and post-intervention was 2.01 (2.27). In the intervention group, mean consumption pre-intervention was 2.21 (2.46) and post-intervention was 2.26 (2.44). The intervention control difference was 0.18 (0.09), p<0.05

**Bogart (2016), USA**

73 2665, 14.6 years, schools, cross-sectional

Policy. School districts required to provide free, fresh drinking water during mealtimes in food service areas. Measured as glasses consumed. Having free water available at school, compared to not having it available, was associated with a 0.67 glass increase in water consumption, p<0.05

Children in schools that provided free water consumed significantly more than those in schools where water was not available

**Burrows (2008/2011), Australia**

50,51 165/160, 8 years, community, randomized controlled trial/longitudinal analysis of a randomized controlled trial

Education. Three treatment groups: 1) PRAISE (parent centred lifestyle and dietary modification program), 2) SHARK (child-centred physical activity skills development program), 3) both programs combined

Measured as percent of daily energy obtained from sweetened drinks. All groups three groups improved their dietary intake after 6 months, and no significant difference between groups was observed/

Significant decreases in soda consumption were observed in the diet and diet + activity groups
<table>
<thead>
<tr>
<th>Reference</th>
<th>Participants</th>
<th>Duration</th>
<th>Intervention</th>
<th>Outcome 1</th>
<th>Outcome 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Campbell (2013)</td>
<td>USA 64 542, 3.8 months, community, cluster-randomized controlled trial</td>
<td>15 months</td>
<td>Education. Parents received dietitian-delivered sessions focusing on infant feeding, diet, physical activity and television viewing</td>
<td>Measured as portions of soda per day. In the diet intervention only group, soda portions decreased by 0.2 portions from baseline to 2 year follow-up, p&lt;0.05. In the activity intervention only group, soda portions decreased by an insignificant from baseline to 2 year follow-up. In the combined diet and activity intervention group, soda portions decreased by 0.3 portions, p&lt;0.05</td>
<td>At 9 months of age, intervention group children consumed significantly fewer grams of non-core drinks than control group children, and were less likely to consume non-core drinks at all. This difference was no longer observed at 20 months of age. Intervention was not sustainable.</td>
</tr>
</tbody>
</table>
Cunha (2013), Brazil\textsuperscript{74} evaluated the impact of 9 nutritional education sessions delivered by trained nutritionists over 9 months at 574, 11 years, 20 elementary schools, paired cluster-randomized controlled trial. Education. 9 nutritional education sessions delivered by trained nutritionists Measured as variation in daily frequency. For sodas (p=0.02) there was a change of -0.2 in the intervention group (N=242) and -0.08 in the control group (N=236). For juices (p=0.66) there was a change of -0.16 in the intervention group and 0.01 in the control group. Reduction in SSBs was encouraging.
Ebbeling (2012), USA
15 years, community, randomized controlled trial 1 year (additional follow up assessment at 2 years)
Education + Environment. Home delivery of non-caloric beverages, monthly motivational telephone calls with parents, and three check-in visits
Measured as servings per day. In the intervention group, SSB consumption decreased by -1.5 servings/day at 1-year follow up and by -1.3 servings/day at 2-years follow up, p<0.001. In the control group, SSB consumption decreased by -0.8 servings/day at 1-year follow up and by -0.9 servings/day at 2-years follow up, p<0.001. The difference between groups was significant at both 1 and 2-year follow up
SSB consumption was lower in the intervention group than the control group post-intervention, and remained lower a year after the cessation of the intervention

Ermetici (2013), Italy
12.5 years, 6 middle schools, non-randomized controlled study 2 school years
Education + Environment. EAT project - classroom nutrition lessons, incentives to increase physical activity and environmental school changes
Measured as times SSBs consumed per week. In the intervention group a change of -0.95 (1.86) times/week was observed from baseline to 2 year follow up, compared to a change of 0.17 (0.95) in the control group. The difference in change between the groups was -1.12 times/week, and this was statistically significant
Reduction in consumption of SSBs was observed
<table>
<thead>
<tr>
<th>Author(s)</th>
<th>Country</th>
<th>Sample Size</th>
<th>Duration</th>
<th>Objective</th>
<th>Intervention Description</th>
<th>Measure of Effect</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ezendam (2012), Netherlands</td>
<td>Netherlands</td>
<td>883</td>
<td>10 weeks</td>
<td>Education.</td>
<td>FATaintPHAT, a web-based, computer-tailored education intervention that aimed to increase physical activity, decrease sedentary behaviour, and promote healthy eating</td>
<td>Measured as whether participants were consuming more or less than 400 mL/day of SSBs. In the intervention group (n=436) 74.4% of students were consuming more than 400 mL/day at baseline, 64.3% were consuming more than 400 mL/day at 4 months, and 71.5% were consuming more than 400 mL at 2 year follow-up. In the control group (n=372) 78.1% of students were consuming more than 400 mL/day of SSBs at baseline, 75.8% were at 4 month follow-up, and 72.3% were at 2 year follow-up. At 4 months follow up, the odds of consuming more than 400 mL of SSBs/day was significantly lower, at 0.54. At 2 years follow-up, the odds were 1.00.</td>
<td>Intervention was associated with lower odds of drinking more than 400 mL of SSBs per day at 4 months follow up. Difference at 2 years follow up was not significant. The FATaintPHAT intervention was associated with positive short-term effects but these were not sustained long-term</td>
</tr>
<tr>
<td>Fiechtner (2016), USA</td>
<td>USA</td>
<td>498</td>
<td>2 years (this study)</td>
<td>Education. Practices were randomly assigned to usual care, computerized clinician evaluation effects after 1 year</td>
<td>Measured as servings per day. In the control group (n=169), SSB intake decreased by 20%, and in the intervention group (n=329), SSB intake increased by 5%.</td>
<td>No significant changes in children's SSB consumption</td>
<td></td>
</tr>
</tbody>
</table>
169

cell-assayed randomized controlled trial

decision support + family self-guided behaviour change intervention, or computerized clinician decision support + health coach intervention

0.32 (1.47) servings/day at 1-year follow up, while in the intervention group (n=320), SSB intake decreased by 0.40 (1.36) servings/day, p=0.56 between the groups was observed, though intervention children did decrease their intake more than children receiving usual care

Fletcher (2010), USA 78

11,052 fifth grade /8,344 8th grade, approximately 10/13 years, schools/comm unity, cross-sectional

Policy. Evaluation of school vending machine restriction policies and taxation of soft drink policies

Measured as consumed soda in the past week or not. In schools that had vending machine access (n=2871) 86% of 5th graders had consumed soda in the past week, compared to 84% in schools that had no vending machine access (n=7664), p=0.09. In 8th graders, 84% had consumed soda in the past week in schools with vending machine access (n=4719), compared to 83% in schools with no vending machine access (n=3073), p=0.43

No significant difference in soda consumption in grades 5 or 8 in children attending schools with vending machine access and those attending schools without vending machine access; no significant difference in soft drink consumption in children who lives in states with and without soft drink taxes

Measured as total grams of soda consumed. In states that have ever had a soft drink tax, children's mean soda
Consumption was 319.67g, compared to 312.09 in states that have never had a soft drink tax, p=0.569.

Folta (2013), USA<sup>79</sup>

458, 24 months
7.5 years, Environmental + Policy. Measures as oz./day.
10 elementary schools, Non-significant effect of intervention on SSB reduction
non-randomized controlled trial

Intervention group (N=346): 6.5 (6.0) at baseline and 7.6 (7.0) at follow-up.
Control group (N=112): 6.1 (6.3) at baseline and 5.5 (6.7) at follow up. Pre-post change = -2.00 (-3.73, -0.25, p=0.04)

Freeman (2009), Ireland<sup>80</sup>

364, 24 months
9 years, Policy. Boosting Better Measures as number of SSBs consumed per day via rubbish bags.
16 elementary schools, Control group (N=175): 20 at baseline and 10 at follow-up.
matched non-randomized controlled trial Intervention group (N=189): 12 at baseline and 29 at follow up

Intervention group was observed

Fung (2013), Canada<sup>81</sup>

10,723, Measured at 2 time points in 2003 and 2010
10.5 years, Policy. Policy that mandates standards for food and beverages preserved and sold in public schools and guidelines concerning eating practices
10 elementary schools, Non-significant increase in SSB consumption in the intervention group was observed
cross-sectional provincial study

In 2003, pre-intervention, mean SSB consumption was 0.99.
In 2011, post-intervention, mean SSB consumption was 0.62.
Unadjusted change from pre to post intervention = -0.34 (-

Findings suggest school nutrition policies have a positive influence on SSB consumption
<table>
<thead>
<tr>
<th>Study</th>
<th>Sample Size</th>
<th>Duration</th>
<th>Intervention</th>
<th>Outcome Measure</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Goldberg (2015), USA</td>
<td>482</td>
<td>7 months</td>
<td>Education. Great Taste, Less Waste intervention (GTLW), which linked healthy eating to the environment, and foods-2-choose (F2C) nutrition only campaign</td>
<td>Measured as SSB servings/day and prevalence of SSB consumption. Change in mean servings from baseline to follow up was 0.01 (0.03) in the GTLW group (n=327), -0.01 (0.07) in the F2C group (n=78), and 0.01 (0.05) in the control group (n=177), p=0.97. Change in prevalence from baseline to follow up was -2.1% in the GTLW group, -6.4% in the F2C group, and -2.3% in the control group, p=0.31</td>
<td></td>
</tr>
<tr>
<td>Gutschall (2013), USA</td>
<td>44</td>
<td>6 weeks</td>
<td>Education. Children participated in ten 60 minute nutrition education sessions, which included worksheets, games, hands-on activities, lessons, and the preparation and consumption of a snack</td>
<td>Measured as weekly servings of sweetened beverages. Mean weekly servings of SSBs at baseline was 22.3 (9.7), compared to 16.8 (7.8) at follow up, p&lt;0.001</td>
<td>Significant decreases in weekly servings of sweetened beverages were reported following the intervention</td>
</tr>
<tr>
<td>Habib-Mourad (2014), Lebanon</td>
<td>387</td>
<td>3 months</td>
<td>Education + Environment. Intervention consisted of classroom sessions, consuming soft drinks and sweetened drinks between meals or not.</td>
<td>Measured as intervention group had a reduced odds of drinking soft</td>
<td></td>
</tr>
</tbody>
</table>
randomized controlled trial

family program which involved meetings, health fairs, and information packets, and a food service intervention which targeted school shops and lunch boxes brought from home

Percentage of children consuming soft drinks between meals decreased from 25.9 to 8.5 from baseline to follow up in the intervention group (n=193) and from 39.8 to 26.3 in the control group (n=181).

Percentage of children consuming sweetened drinks decreased from 64.2 to 43.6 from baseline to follow up in the intervention group, and increased from 48.6 to 52.8 in the control group.

Measured as odds of consuming a soft drink or sweetened drink between meals. At post-intervention, the odds of consuming a soft drink between meals was 0.31, p<0.05, and the odds of consuming a sweetened drink between meals was 0.47 (not significant)

Hardy (2015), Australia

2812, 10 weeks Education. Sessions address education, skill training and motivational enhancement

Measured as frequency of SSB consumption (rarely, once a week, a few times a week, most days of the week, every day), compared to the control group.

Significant reduction in probability of consuming an SSB frequently
The probability of consuming SSBs frequently decreased from 0.73% to 0.56%, representing a change of -0.25%, p<0.001 (0.73% vs 0.56%). Children who completed more than 75% of program were more likely to have beneficial changes in SSB consumption.

### Heneman
(2008) USA
Education. Reading Across My Pyramid Curriculum, which consisted of lessons on nutrition and physician activity delivered by nutrition educators

- **N:** 62, 6.3, 4 elementary schools, cohort study
- **Duration:** 3 weeks
- **Unit of measurement:** Measured as percentage of parents reporting that their child consumes soft drinks. Pre-intervention: 79% of parents reported that their child drinks soft drinks. Post-intervention: 77% of parents reported that their child drinks soft drinks (p=0.6)

### Heo
(2016), USA
Education. HealthCorps program, which offers education programs, mentoring, clubs, fairs, festivals, etc. on mental health, healthy eating, and physical activity

- **N:** 2255, 15.73 years, 14 secondary schools, cross-sectional study
- **Duration:** 10 months (one school year)
- **Unit of measurement:** not clear. SSB and high-energy drink consumption increased by 0.04 among boys, p=0.075, and decreased by 0.05 among girls, p=0.033

### James
(2004), England
Education. Nutritional education program called Ditch the Fizz, delivered for 1 hour each term for a total of 4 sessions

- **N:** 644, 9 years, 6 elementary schools, cluster-randomized
- **Duration:** 12 months
- **Unit of measurement:** Measured as number of glasses/3 days. Control group (N=319): 1.6 (0.6) at baseline and 1.8 (0.6) at follow up. Intervention groupStatistically significant reduction in the number of carbonated drinks consumed by the
controlled trial

Kenney (2015), USA

Unknown number of children in kindergarten - grade 8, 10 schools, cluster-randomized controlled trial

3 months

Education + Environment. Grab a Cup, Fill it Up!

Involved posters highlighting water source locations and encouraging consumption to promote water's appeal and the installation of cup dispensers near water fountains to make water consumption easier

(N=325): 1.9 (0.5) at baseline and 1.3 (0.6) at follow up

Measured in ounces. In intervention schools, water consumption increased from 0.21 to 0.74 oz/student. In control schools, water consumption decreased from 0.71 to 0.65 oz/student. Percentage of children choosing to drink water at lunch increased from 5.8% to 13.1%, p<0.001

Positive effects on water consumption observed in intervention schools

Kipping (2010), England

506, 9 years, 19 schools, randomized controlled trial

Unclear. Follow up assessed 5 months later

Education. 16 lessons on nutrition, physical activity, and screen time. Teachers were trained and provided with lesson plans and resources.

Measured as proportion consuming <2 vs >2 high energy drinks. In intervention schools (n=244), the proportion of students consuming <2 high energy drinks at 5 months follow up was 33.7 compared to 36.5 in the control schools (n=262). The odds of consuming a healthy amount of SSBs in the intervention group compared to the control group was 0.85, p=0.41

No significant different in odds of consuming a healthy amount of high energy drinks at follow up

Kipping (2014), 2164, 8.5 years, (one school)

Education. The Active for Life Year 5

Measured as servings of high-energy drinks.

Servings of SSB/day were
England\textsuperscript{8} 60 elementary schools, cluster-randomized controlled trial (AFLY5), which consisted of teacher training, provision of lesson and child-parent interactive homework plans, all materials required for lessons and homework, and written materials for school newsletters and parents. Control group (N=1157): 2 (0.5) at baseline and 2.45 (1.61) at follow-up. Intervention group (N=1064): 2 (0.5) at baseline and 2.18 (1.44) at follow-up. The difference in means was -0.26 (-0.43, -0.10), $p=0.002$ higher at follow up in both the intervention and control groups but were significantly less so in the intervention group.

Klesges\textsuperscript{9} 303 girls, 9 years, 10 community centres, randomized controlled trial Education. GEMS obesity prevention program, which consisted of weekly or monthly sessions on nutrition and physical activity (intervention) or social awareness and community responsibility (control). Both programs also included monthly field trips within the community to provide interactive learning experiences. Measured as servings of water/SSBs. At 1 year follow up the intervention group was consuming -0.13 servings less of SSBs than the control group (non-significant), while at 2 years follow up the intervention group was consuming -0.19 servings less than the control group (non-significant). At 1 year follow up the intervention group was consuming 0.18 servings more of water than the control group (non-significant), while at 2 years follow up the intervention group was consuming 0.21 servings more (significant). Treatment effects were in the expected direction but were only significant for water consumption.
<table>
<thead>
<tr>
<th>Study</th>
<th>Participants</th>
<th>Duration</th>
<th>Intervention</th>
<th>Measurement</th>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Korwanch (2008), Thailand</td>
<td>234 children, 9 months</td>
<td>Education + Environment + Policy.</td>
<td>Intervention schools received a new Healthy Eating Policy, which consisted of nutritional guidelines, ensuring health snacks were available at school and at home, and encouraging nutrition through stories, songs, dance, toys, posters, rewards, and a garden project</td>
<td>Measured as mean frequencies of daily intake using the ‘rubbish bag’ method.</td>
<td>A statistically significant decrease in sugary drink consumption was observed in the intervention group but not in the control group.</td>
</tr>
<tr>
<td>Loughridge (2005), England</td>
<td>2965 children, 1 month</td>
<td>Education + Environment.</td>
<td>One school received water coolers within the cafeteria, one school received water coolers and water promotion, in which they were educated about the health benefits of drinking water and how to access it, and one school was a control</td>
<td>Measured as mL/student/day. At 3 months follow up the average volume of water consumed by children in the coolers and promotion group was about 160 mL, compared to about 60 mL in the coolers only group and about 0 mL in the control group.</td>
<td>Significantly more water was consumed by students in the water and promotion schools than students in the water only and control schools post-intervention. No significant differences in the volume of soft drinks purchased was observed.</td>
</tr>
<tr>
<td>Mantziki (2016), Portugal and Romania</td>
<td>296 children, 1 year</td>
<td>Education + Environment. Epode for the Promotion of Healthy Equity project, which developed community-based</td>
<td>Measured as median weekly soft drink intake in mL in children with highly educated mothers compared to children</td>
<td>Weekly soft drink consumption decreased among children with less educated mothers after the</td>
<td></td>
</tr>
</tbody>
</table>
interventions to increase fruit and vegetable consumption, decrease sedentary behaviour, and encourage tap water intake and adequate sleep duration with less educated mothers. High education group (N=159): median intake of 250 mL at baseline and 250 mL at follow up in Portugal and 580 mL at baseline and 580 mL at follow up in Romania. Low education group (N=138): median intake of 580 mL at baseline and 580 mL at follow up in Portugal and 1000 mL at baseline and 580 mL at follow up in Romania. This effect was not statistically significant.

Marcus (2009), Sweden 94 3135, 7 years, 10 elementary schools, cluster-randomized controlled pre-post trial. Up to 4 years, depending on grade child was in when program began. Education + Environment. Additional physical activity time was incorporated into the school day, children were not allowed to bring in handheld video games, schools offered more variety of fruits and vegetables, vegetables were served first, sugar was reduced, white bread and whole fat dairy products were substituted, newsletters were distributed to parents. Measured as healthy or unhealthy intake, with unhealthy classified as consuming sugar-containing drinks everyday or several times a week. Coefficients were not reported however no difference in drink consumption was observed between the intervention and control children, p=0.75. No significant differences in unhealthy drink consumption was observed between the intervention and control children.
Muckelbauer (2012), Germany 95
2950, 1 year
8.3 years, 32 elementary schools, cluster-randomized controlled trial
Education + Environment. Water fountains were installed, free water bottles were distributed, with children encouraged to fill their bottle each morning, and 4 45-minute lessons on water were taught in classrooms
Measured as mean glasses per day. Baseline: 1.3 (1.7) glasses of soft drinks and 1.5 (1.8) glasses of juice in the intervention group (N=1721) and 1.3 (1.7) glasses of soft drinks and 1.3 (1.6) glasses of juice in the control group (N=1469). Follow up: non-significant difference of -0.1 glasses of juice per day in the intervention group compared to the control group (p=0.5) and non-significant difference in soft drink consumption (p=0.406)

Nanney (2014), USA 96
18,881, N/A
age not reported, 37 junior and senior high schools, cohort of schools, cross sectional of students
Policy. Evaluated food and activity-related policies as they were implemented
Measured as daily glasses of sugary drinks. Daily glasses of sugary drinks were estimated to decrease by 0.08 glasses with each increase of 1 key policy, p=0.04 With each additional policy there was a statistically significant decrease in the daily glasses of sugary drinks consumed

Nystrom (2017), Sweden 97
315, 6 months
4.5 years, community-based, randomized
Education. MINISTOP mobile health program which provided parents with information and support on their
Measured as mL/day of SSBs. The difference in daily mL of SSBs from baseline to follow up was -12 (85) in the intervention group compared to the control group. Follow up children in the intervention group drank less SSBs, while children in...
smartphones. Biweekly themes were introduced, with information, advice, and strategies on how to change unhealthy behaviours.

O'Brien (2010), USA 98
80,428, N/A
age not reported,
328 middle and high schools,
pre-post cross-sectional evaluation
Education + Environment. As part of the Healthy Maine Partnerships, school health coordinators were appointed, who established health leadership teams and implemented annual work plans to address health risk behaviours. The difference in difference was statistically significant.

Ostbye (2012), USA 99
400, 8 months
Community-based, randomized controlled trial
Education + Environment. KAN-DO intervention included telephone coaching sessions and child kits with measured Child SSB intake.

In schools with a policy preventing students from buying unhealthy items before school the odds of consuming 2+ sodas per week was 0.85, p=0.022. In schools with policies preventing students from buying unhealthy items during lunch the odds of consuming 2+ sodas per week was 0.83, p=0.023. In schools with required teaching of nutrition and dietary concepts the odds of consuming 2+ sodas per week was 0.93, p<0.001.
<table>
<thead>
<tr>
<th>Study</th>
<th>Country</th>
<th>Age</th>
<th>Setting</th>
<th>Intervention</th>
<th>Measure</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Porepa (2016)</td>
<td>Canada</td>
<td>74, 11 years</td>
<td>1 elementary school, cohort study</td>
<td>Education. Kids on Kids' Health student-created magazine, distributed throughout the school. The magazine included a Drop the Pop campaign to promote a reduction in soda consumption</td>
<td>Measured as self-reported soda consumption. Before intervention: 43% reported no soda consumption, 66% reported less than 2 cups of soda per day. After intervention: 67% reported no soda consumption, 85% reported less than 2 cups of soda per day, p=0.01</td>
<td>Self-reported decrease in soda consumption was observed</td>
</tr>
<tr>
<td>Rausch Herscovi ci (2013)</td>
<td>Argentina</td>
<td>405, 9.7 years</td>
<td>6 elementary schools, randomized controlled trial</td>
<td>Education + Environment. Obesity prevention intervention that included four workshops and modifications to the school cafeteria menu</td>
<td>Measured as percentage of boys and girls that had positive vs negative change in SSB consumption. Control group: 25% of girls and 12% of boys showed a decrease. Intervention group: 27.3% of girls and 17% of boys showed a decrease</td>
<td>No significant differences in the percentage of boys and girls reporting a decrease in SSB consumption in the intervention vs control group were observed</td>
</tr>
<tr>
<td>Rogers (2013)</td>
<td>USA</td>
<td>800 parents of children aged 0-18, 11.3 years, multi-setting (schools and</td>
<td>Education + Environment. Let's go! Program consisted of a communications and messaging campaign promoting the 5-2-1-0</td>
<td>Measured as percentage of children adhering to the &lt;1 sugary beverage per day guideline. In 2007 at survey 1, 63% of children were adhering to the &lt;1 sugary beverage per day guideline</td>
<td>The % of children adhering to the &lt;1 SSB per day guideline significantly increased from</td>
<td></td>
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</tbody>
</table>
message (5 servings of fruits and vegetables, 2 hours or less of screen time, 1 hour or more of physical activity, 0 SSBs), as well as community-based interventions to promote physical activity and healthy eating, which included handouts and toolkits surveyed children adhered to the guideline, compared to 66% in 2009 at survey 2, and 69% in 2011 at survey 3, p=0.011

<table>
<thead>
<tr>
<th>Study</th>
<th>N</th>
<th>Duration</th>
<th>Intervention Details</th>
<th>Measured</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rosario (2013), Portugal</td>
<td>464</td>
<td>6 months</td>
<td>Education. Teachers attended 12 training workshops on health topics, and then delivered the learnt content to their students and developed creative and engaging classroom activities about the topics</td>
<td>Measured in grams.</td>
<td>No effect was observed on SSB consumption</td>
</tr>
<tr>
<td>Sharma (2016), USA</td>
<td>717</td>
<td>16 weeks</td>
<td>Education + Environment. “Brighter Bites” program, which combines access to fruit and vegetables with nutrition education. The program included produce distribution, recipe tasting, health education</td>
<td>Measured as estimated percent of daily kilocalories from sugar beverages. Control group (N=233): 129.9 (174.8) at baseline and 243.3 (303.8) at follow up. Intervention group (N=231): 110.1 (157.2) at baseline and 227.0 (263.6) at follow up</td>
<td>Statistically significant decrease in % of daily kilocalories from sugar-sweetened beverages was observed in the intervention group but not the control group</td>
</tr>
<tr>
<td>Sichieri (2009), Bazil</td>
<td>1140</td>
<td>7 months (one school year)</td>
<td>Education + Environment. Program delivered simple</td>
<td>Measured as mL per day. A difference of -56 mL/day of SSB consumption was significantly lower in the</td>
<td></td>
</tr>
</tbody>
</table>
messages encouraging water consumption as an alternative to SSBs using 10 1-hour sessions of classroom activities (songs, quizzes, competitions, and games) along with banners, and the distribution of water bottles. Carbonated drinks were observed between the intervention (n=435) and control (n=608) groups post-interventions, p<0.05. Singh (2009), Netherlands, 67 prevocational secondary schools, randomized controlled trial, 20 months, 1108, 12.7 years, 8. Education + Environment. Dutch Obesity Intervention in Teenagers (DOiT), which consisted of 11 biology and physical education lessons, the offering of additional physical education classes, and changes to school cafeterias (environmental components were optional). Measured as mL of SSBs/day. After 12 months, SSB consumption had decreased by -233 mL/day in boys and -271 mL/day in girls (p<0.05). After 20 months SSB consumption had decreased by -287 mL/day in boys and -249 mL/day in girls (p<0.05). The intervention resulted in significant reductions in SSB consumption in both the short and long terms.

Smith (2014), Australia, 106 361 boys, 12.7 years, 14 secondary schools, cluster-randomized controlled trial, 20 weeks. Education + Environment. ATLAS intervention, which included the provision of fitness equipment to schools, physical activity sessions, student mentoring, seminars, and an app and website. Activities for parents and teachers. Measured as glasses of SSBs per day. In the intervention group, mean SSB intake decreased from 3.9 (0.4) to 3.1 (0.41) glasses per day from baseline to 8 month follow up, representing a change of -0.8 (0.19) glasses per day, SSB intake decreased in both the intervention and control groups, however it decreased by significantly more in the intervention group.
also existed p<0.001. In the control group, mean SSB intake decreased from 3.9 (0.36) to 3.7 (0.36) glasses per day from baseline to 8 months follow up, representing a change of -0.1 (0.18) glasses per day, p=0.44

Smith (2014), USA 53
186, 15.85 years, 2 high schools, longitudinal repeated measures study
30 days "Sodabriety" intervention, which consisted of a promotional campaign featuring flyers, t-shirts, posters, and daily facts announcements. Measured as days per week SSBs were consumed. At time 1, SSBs were consumed a mean of 4.3 (0.22) days per week, compared to 2.64 (0.18) at time 2 (p<0.001), and 3.14 (0.21) at time 3 (p<0.001). Measured as number of SSBs consumed per day. At time 1, an average of 2.32 (0.23) SSBs were consumed per day, compared to 1.32 (0.14) at time 2 (p<0.001), and 1.71 (0.17) at time 3 (p=0.028). Measured as servings of water consumed per day. At time 1, an average of 4.28 (0.39) servings of water were consumed per day, compared to 5.09 (0.34) at time 2 (p=0.108), and 5.56...
**Steyn (2015), South Africa**

- **Participants**: 998, 9.9 years, 16 elementary schools in a randomized controlled trial.
- **Intervention**: Education + Environment. “HealthKick” intervention, a comprehensive, whole-school intervention that involves increased opportunities for physical activity and healthy eating.
- **Outcome Measure**: Measured as percentage of learners consuming carbonated beverages. Intervention group (N=500): 16.0% (6.65) at baseline and 31.9% (15.52) at follow up. Control group (N=498): 10.3% (9.05) at baseline and 26.1% (12.81) at follow up.

- In both the intervention and control groups, an increase of more than 10% in carbonated beverage consumption was observed. The difference between groups was not significant.

**Taber (2011), USA**

- **Participants**: 90,730, approximately 16 years, schools in 33 states.
- **Intervention**: Policy. Evaluated differences in states that prohibited less healthy food in vending machines, snack bars, concession stands, and parties.
- **Outcome Measure**: Measured as daily servings of soda. In schools with a vending machine policy compared to those without, students consumed 0.02 more servings of soda per day (not significant). In schools with a required snack bar policy compared to those without, students consumed 0.01 more servings of soda per day (not significant). In schools with a concession stand policy compared to those without, students consumed 0.09 less servings per day.

- Policy changes targeting concession stands were associated with fewer servings of soda per days, and this association was more pronounced among non-Hispanic blacks. Policy changes targeting parties were also associated with fewer servings per day.
<table>
<thead>
<tr>
<th>Study</th>
<th>Year</th>
<th>Location</th>
<th>Participants</th>
<th>Design</th>
<th>Intervention</th>
<th>Controls</th>
<th>Results</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Taber (2012), USA</td>
<td>2012</td>
<td>40 states, cross-sectional</td>
<td>6900, approximately 11-12 years, schools in 40 states</td>
<td>Schools with a parties policy compared to those without</td>
<td>Students consumed 0.07 less servings of soda per day (borderline significant)</td>
<td>Overall SSB consumption was not associated with state policy, indicating that access does not determine intake</td>
<td></td>
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<tr>
<td>Taveras (2011), USA</td>
<td>2011</td>
<td>10 pediatric primary care centres, cluster-randomised</td>
<td>475, 4.9 years,</td>
<td>Education + Environment. Practices received primary care restructuring, families received motivational interviewing and</td>
<td>Measured as servings per day. In the intervention group, children in the intervention group had a small, non-significant decrease in SSB consumption by 0.59 (0.10) servings per day</td>
<td>SSB consumption decreased by 0.5 from 5th to 8th grade, while daily SSB consumption prevalence increased by 2.3. In schools where all SSBs were banned, weekly SSB consumption prevalence increased by 2.0 from 5th to 8th grade and daily SSB consumption prevalence increased by 5.8</td>
<td></td>
<td></td>
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<tr>
<td>Study</td>
<td>Country</td>
<td>Sample Size</td>
<td>Duration</td>
<td>Design</td>
<td>Interventions</td>
<td>Outcomes</td>
<td>Results</td>
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<tr>
<td>Taylor (2007), New Zealand</td>
<td>730, 7.7 years, 7 elementary schools</td>
<td>2 years</td>
<td>Non-randomized controlled trial</td>
<td>730, 7.7 years, 7 elementary schools</td>
<td>Education + Environment. APPLE, a community-based obesity prevention program that encouraged increased physical activity, provided water filters, and games, and included science lessons</td>
<td>Measured as total servings of sweet drinks. Control group (N=346): 4.8 (4.0) servings at baseline and 6.0 (4.2) servings at follow up. Intervention group (N=384): 4.8 (4.6) servings at baseline and 4.6 (4.8) servings at follow up</td>
<td>Intervention children consumed significantly fewer sweet drinks than control children at follow up</td>
<td></td>
</tr>
<tr>
<td>Terry-McElrath (2015), USA</td>
<td>Unknown number of subjects, age unreported, 243 high schools in 42 states</td>
<td>N/A</td>
<td>Cross-sectional</td>
<td>243 high schools in 42 states</td>
<td>Policy. Evaluated differences in state and school-district level policies mandating school soda bans, school soda availability, and student soda consumption</td>
<td>Measured as number of 12-oz servings of soft drinks consumed per day, which was dichotomized into any consumption and daily consumption. A state ban was associated with a 0.025 (0.140) increase in the number of soft drinks consumed per day, p=0.86, however indirectly through availability it was associated with a 0.086 (0.034) decrease in the number of soft drinks</td>
<td>No association between state policy and overall soda consumption was observed in the whole sample, however in African American students state policies were indirectly associated with significantly lower consumption</td>
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<tr>
<td>randomized controlled trial</td>
<td>randomized controlled trial</td>
<td>from baseline to 1 year follow up, while in the control group, SSB consumption decreased by 0.33 (0.06) servings per day, p=0.15</td>
<td>reduction in SSB servings</td>
<td>from baseline to 1 year follow up, while in the control group, SSB consumption decreased by 0.33 (0.06) servings per day, p=0.15</td>
<td>education modules targeting television viewing, and fast food and SSB intake</td>
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</tbody>
</table>
consumed per day, $p=0.011$ in African American students

van de Garr (2014), Netherlands

Education + Environment. The ‘Water Campaign’, a school and community-based social marketing intervention that included promotional materials, activities, and free water bottles

Measured as parent-reported SSB servings per day. Control group (N=198): 3.05 (1.61) at baseline and 2.92 (1.34) at follow up. Intervention group (N=158): 2.74 (1.68) at baseline and 2.39 (1.28) at follow up

After one year of intervention, average SSB servings were significantly lower for children in the intervention group

van Grieken (2014), Netherlands

Education. Motivational interviewing by health care professionals to parents. Specific behaviours emphasized were 1) playing outside at least an hour a day, 2) having breakfast daily, 3) drinking no more than 2 glasses of sweet beverages, and 4) limiting TV time to no more than 2 hours a day

Measured as percentage of children drinking less than or equal to 2 sweet beverages a day. In the intervention group, the percentage increased from 32.1% to 55.2% from baseline to follow up, $p<0.0001$. In the control group, the percentage increased from 33.3% to 47.9%, $p<0.05$. The odds of consuming less than 2 sweet beverages between the intervention and control groups at follow up was 1.38 (not significant)

Significant improvements in drinking habits were observed in both the intervention and control group, however at follow up, the odds of drinking less than 2 glasses of SSBs/day were not significantly different between the two groups
Appendix C Research Ethics Approval Forms (3 Forms, Redacted)

Western University Non-Medical Research Ethics Board
NMREB Delegated Initial Approval Notice

Principal Investigator: Dr. Jason Gilliland
Department & Institution: Social Science/Geography, Western University

NMREB File Number: 108328
Study Title: Evaluating the Child & Youth Network's Comprehensive Drinking Water Infrastructure and Education in Schools Strategy

NMREB Initial Approval Date: September 12, 2016
NMREB Expiry Date: September 12, 2017

Documents Approved and/or Received for Information:

<table>
<thead>
<tr>
<th>Document Name</th>
<th>Comments</th>
<th>Version Date</th>
</tr>
</thead>
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<tr>
<td>Western University Protocol</td>
<td>Received</td>
<td>2016/09/08</td>
</tr>
<tr>
<td></td>
<td>September 9, 2016</td>
<td></td>
</tr>
<tr>
<td>Letter of Information &amp; Consent</td>
<td></td>
<td>2016/09/08</td>
</tr>
<tr>
<td>Assent</td>
<td></td>
<td>2016/09/08</td>
</tr>
<tr>
<td>Instruments</td>
<td>Youth Survey</td>
<td>2016/08/29</td>
</tr>
<tr>
<td>Instruments</td>
<td>Parent Survey</td>
<td>2016/08/30</td>
</tr>
</tbody>
</table>

The Western University Non-Medical Research Ethics Board (NMREB) has reviewed and approved the above named study, as of the NMREB Initial Approval Date noted above.

NMREB approval for this study remains valid until the NMREB Expiry Date noted above, conditional to timely submission and acceptance of NMREB Continuing Ethics Review.

The Western University NMREB operates in compliance with the Tri-Council Policy Statement Ethical Conduct for Research Involving Humans (TCPS2), the Ontario Personal Health Information Protection Act (PHIPA, 2004), and the applicable laws and regulations of Ontario.

Members of the NMREB who are named as Investigators in research studies do not participate in discussions related to, nor vote on such studies when they are presented to the REB.

The NMREB is registered with the U.S. Department of Health & Human Services under the IRB registration number IRB 00000941.

Ethics Officer, on behalf of Dr. Riley Hinson, NMREB Chair or delegated board member

Ethics Officer: Erika Bamente, Nicole Kaszuk, Grace Kelly, Katelyn Harris, Vikki Tram, Karen Gopal

[Redacted]
30 Sep 2016

Dear Dr. Clark:

Your project, entitled "Evaluating the Child & Youth Network’s Comprehensive Drinking Water Infrastructure and Education in Schools Strategy" has been approved by Research and Assessment Services at the Thames Valley District School Board. Please ensure that all members of your research team who will be assisting with data collection involving students have an up-to-date criminal record check. You may contact the schools that have been identified.

The continued willingness of our families and staff to participate in research studies is greatly enhanced by pertinent feedback of findings. It is suggested that direct feedback be provided to the school(s), staff, students, and/or families involved in the study. Please find attached the Thames Valley District School Board Study Completion Form. Once you have completed your research in our board, please complete this form and submit it to Research and Assessment Services. This form should be submitted within two years of receiving approval. If the study is not completed within two years of the date on this letter, please submit a study extension request to Dr. Sarah Folino.

All the best with your research. Please feel free to contact me if I can be of further assistance.

Sincerely,

Sarah Folino, Ph.D.
Research and Assessment Services
Thames Valley District School Board

/sd

cc: M. Deman, Superintendent of Student Achievement
Hi Andrew:

The HKCC Water Evaluation project has been approved. Please let me know if I can offer any assistance.

All the best on the project.

Terry

Terry Spencer
Research and Evaluation Officer
Board Office
Cell: [redacted]
Email: [redacted]

Website: www.ldcsb.ca

CONFIDENTIALITY NOTICE: This email and attached material are intended for the use of the individual or organization to whom they are addressed and may not be distributed, copied, or disclosed to other unauthorized persons. This material may contain confidential and/or personal information subject to the provisions of the Freedom of Information and Protection of Privacy Act, the Municipal Freedom of Information and Protection of Privacy Act, and/or the Personal Health Information Protection Act. If you receive this transmission in error, please notify me immediately and delete this message. Do not email, print, copy, distribute, or disclose this email or its contents further. Thank you for your co-operation and assistance.
Appendix D Letter of Information for Parents/Guardians (2 Pages) and Parent/Guardian Consent Form (1 Page)

Dear parent or guardian,

Dr. Jason Gilliland and his research team from Western University invite you and your child to participate in a study aimed at understanding how the implementation of water filling stations and additional water education programs may impact your child’s water consumption and knowledge. The study involves students from grades 4 through 8 at participating elementary schools across London.

What is being studied?

Our team is studying how the implementation of water filling stations in your school and additional water education programs influence your child’s water consumption and knowledge. Through the distribution of family and youth surveys, we aim to learn about your child’s eating and drinking patterns and knowledge.

What will happen in this study?

If your child agrees to participate in our project, your child will be asked to:

- **Complete Youth Survey #1.** Children in grades 4 through 8 are invited to participate in the baseline Youth Survey (September 2016). This survey primarily asks children about their eating and drinking patterns and knowledge. This survey usually takes about 15-20 minutes to fill out and will be done in their classroom at a time decided by their teacher. (Note: students not filling out the survey will be given quiet activities by their teacher to do at their desks).
- **Complete Youth Survey #2.** One week after the conclusion of the water education program (estimated as Spring 2017), we will ask your child to complete the second survey to understand the effectiveness of the implementation of water filling stations and water education programs for long term benefits of water consumption. The survey will ask the same questions and be conducted the same as youth survey #1.

As the child’s parent/guardian, you will be asked to:

- Please complete and return to school the attached consent form in the envelope provided to you if you would like your child to participate in the youth survey.
- **Complete the attached Family Survey #1.** The survey asks many of the same questions as the Youth surveys, as well as questions about your household. It usually takes about 10-15 minutes to fill out. The Parent Survey is completely voluntary – your child can still join the study themselves even if you decide not to fill out the Parent Survey; however, as the survey gives us critical information from the point of view of parents, we would really appreciate your participation.
- **Complete Family Survey #2.** One week after the conclusion of the water education program (estimated as Spring 2017), your child will bring home a second survey for you to complete to help us understand how the water fountain and education program changes your child’s water consumption and eating habits. The survey will ask the same questions as family survey #1.
Do we have to participate in this study?

Your participation in this study is completely voluntary. You and your child do not have to participate. You can each refuse to answer any survey questions, and can choose to leave the study at any time. If you or your child decide to leave the study at any time (even up to 30 days AFTER the study has been completed), any data collected from you or your child will be immediately destroyed and excluded from the analysis.

What are the benefits and risks if my child participates?

By participating in this research, students and parents will help us evaluate the effectiveness of how installing a water infrastructure and educational program improves children’s water consumption, knowledge, and behaviour. By reaching a fuller understanding of this relationship, the schools can develop a model for schools to use when installing refillable water bottle stations in the future. This will help students gain the maximum health benefit when building this infrastructure within the school.

There is little risk to your child if he/she participates in this study, but there is a slight chance that you or your child may be uncomfortable sharing details of your family, such as economic status, to the researchers. This is being minimized in the following ways. You or your child will not be personally identified or identifiable by name in any of the documents related to the study. All of the information collected in this study will be kept strictly confidential. You and your child will be assigned a unique identification code – your name will not appear on any materials or data files except for this consent form. Until the unique identification code is recorded, your consent and parent survey will be stored together to ensure the connection between surveys is maintained. Furthermore, materials and data files will ONLY be viewed by members of the research team and will be stored in a locked filing cabinet until transferred onto a password protected computer in a secure facility at the University of Western Ontario. Representatives of The University of Western Ontario’s Non-Medical Research Ethics Board may require access to your study-related records to monitor the conduct of the research. Data will be kept until the conclusion of data analysis and publications from this study are completed. The results of this study will only be presented for groups so that children will never be individually identifiable. While we do our best to protect your information there is no guarantee that we will be able to do so. If data is collected during the project which may be required to report by law, we have a duty to report. You do not waive any of the legal rights you would otherwise have as a participant in a research study.

Who do I contact if I have any other questions?

Should you have any questions or concerns about participating in this project, you can contact the Lead Investigator, Professor Clancy at the University of Western Ontario.

If you have any further questions regarding your rights as a study participant, please contact the Office of Human Research Ethics.

This letter is for you to keep. Please complete and return to school the attached consent form if you would like your child to participate in the youth surveys.
Parent / Guardian Consent Form (Grades 4-8)

Research Project: Evaluating the Child & Youth Network’s Comprehensive Drinking Water Infrastructure and Education in Schools Strategy

Principal Investigator: Dr. Jason Gilliland, PhD

To learn how the implementation of water filling stations in your school and additional water education programs influence your child(ren)’s water consumption and knowledge, we ask that you allow your child(ren) in grades 4-8 to complete two ‘youth surveys’ during class time. The surveys are coded to match the parent and youth surveys together and to keep your names unknown. Please review the Letter of Information before providing your child consent.

WE NEED YOUR PERMISSION TO HAVE YOUR CHILD FILL OUT THE SURVEY AT SCHOOL

I agree for my child ________________________________ (please print child’s full name) to fill out the two youth surveys (Fall 2016 and Spring 2017).

_________________________________________  __________________________
Parent / Guardian’s signature                        Date

_________________________________________
Teacher’s name

Completed consent forms should be returned to the school with the child who brought it home by

_________________________________________

Version: September 8, 2016
Appendix E Child Assent Form (1 Page)

Child Assent: Water Does Wonders!

Hello! We are researchers from Western University and we are doing a study in your school. We need students in Grades 4-8, like you, to help us learn about what you like to eat and drink most days.

What are we going to study?
We all know that getting lots of water can help keep us healthy! We’d like to know what you eat and drink most days. We are also interested in learning what you know about water!

What would you have to do?
If you agree to be in the study, we’d like you to fill out two short surveys (one today and one in a few months) on what you eat and drink normally and what you know about water. You will fill this out one day at school with your classmates. It takes about 10-20 minutes to finish but you can take as much time as you need.

Do you have to join this project?
No – you only join if you want to. You can also decide at any time that you would like to stop. We will never share your information with anyone else, even your parents, but you can ask to see it at any time. You can ALWAYS talk to your teacher or the researchers if you have any questions or worries.

I want to participate in this study!
If you would like to join this study, please sign below:

First and Last Name ____________________________

Sign your name ____________________________ Today’s Date __________________

Researcher’s Name ____________________________

Researcher’s signature ____________________________ Today’s Date __________________

Version Date: July 26, 2016
Youth Survey

We need your help to make our study a success. Your honest answers to the items in this survey are very important to us. This will not take too long to complete. Remember...

- We want to know what you think
- There are no right or wrong answers, and
- Everything you tell us will be kept strictly confidential (secret)

A. General Information

1. I am a □ girl □ boy □ other
2. What is your age: ____________________
3. What grade are you currently in? ____________________
4. I live at my main home with...
   □ one-parent    □ two-parents    □ other: ____________________
5. I live in...
   □ one home (sleep all nights in the same home)
   □ more than one home (please describe): ____________________
6. How many days a week do you live at your main home?
   □ 1 □ 2 □ 3 □ 4 □ 5 □ 6 □ 7
7. How many people live (including yourself) in your main home?
   □ 2 □ 3 □ 4 □ 5 □ 6 or more
8. How many children (including yourself) live in your main home?
   □ 1 □ 2 □ 3 □ 4 □ 5 or more
9. What is your primary race / ethnic background (choose 1 or 2)?
   □ White/Caucasian
   □ South Asian (e.g. East Indian, Pakistani, Sri Lankan)
   □ East Asian (e.g., China, Japan, Korea)
   □ Middle Eastern (e.g., Egypt, Iran, Lebanon)
   □ Latin American
   □ North American Indian, Metis or Inuit
   □ Black/African/Caribbean

Version: August 29, 2016
B. Drinking Habits

1. What kind of water do you usually drink at home?
   - Directly from the Tap
   - Barreled Water (e.g., Culligan)
   - Bottled Water
   - Filtrated Water (e.g., Brita, Fridge filter)

2. Do you use a refillable water bottle? □ Yes □ No
   a. If yes, how often do you use your refillable water bottle for drinking water?
      - Never
      - Rarely
      - Sometimes
      - Usually
      - Always

3. Does your family use refillable water bottles? □ Yes □ No

4. Do you use a refillable water bottle at school? □ Yes □ No

5. What do you usually drink when you are playing sports or being physically active?
   - Energy Drinks (e.g., Red Bull, Monster)
   - 100% Fruit Juice
   - Sports Drinks (e.g., Gatorade, Powerade)
   - Water
   - Other (Please specify): __________________________

C. The Types of Food You Eat & Drink

1. In a typical day, about how many servings of fruit do you eat?
   Example – 1 serving is equal to:
   - A piece of fresh fruit, like an apple
   - A small bowl of fruit salad
   □ None □ 1 □ 2 □ 3 □ 4 or more

2. In a typical day, about how many servings of vegetables do you eat?
   Example – 1 serving is equal to:
   - A carrot or other fresh vegetable (Do not count French fries, potato chips)
   - A small bowl of green salad
   - A small bowl of fresh or cooked vegetables
   □ None □ 1 □ 2 □ 3 □ 4 or more
Over the past week, how many times per week did you eat:

<table>
<thead>
<tr>
<th>Number of times per week</th>
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<th>6 or more</th>
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<tr>
<td>3. Peanut butter</td>
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<td>4. Unsweetened breakfast cereal (like Cheerios, Rice Krispies)</td>
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<td>5. Sweetened breakfast cereal (like Frosted Loops, Frosted Flakes)</td>
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<td>6. Cake, pie, or doughnuts</td>
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<td>7. Potato chips</td>
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<td>11. Hot Dog</td>
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<td>12. Ice Cream</td>
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<td>13. Candy</td>
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<td>14. Granola bar</td>
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<td>15. Cookies</td>
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</tbody>
</table>

Over the past week, how many times per day did you drink:

<table>
<thead>
<tr>
<th>Number of times per day</th>
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<th>1</th>
<th>2</th>
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<th>4</th>
<th>5</th>
<th>6</th>
<th>7 or more</th>
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<tr>
<td>16. Water</td>
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<td>17. 100% fruit juice</td>
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<td>18. Fruit-flavoured drinks (like Frutopia, Gatorade, Snapple)</td>
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<td>19. White milk</td>
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<td>20. Chocolate milk</td>
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<tr>
<td>21. Regular pop with sugar</td>
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<td>22. Diet or sugar free pop</td>
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<td>23. Energy drinks</td>
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<td>24. Coffee</td>
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<td>25. Tea</td>
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</tbody>
</table>
D. Eating & Drinking during the School Day

1. What are you allowed to bring to school as a beverage (check all that apply)?
   - Water
   - 100% Fruit Juice
   - Fruit-Flavoured drinks
   - Milk
   - Pop

2. Do you take part in your school’s milk program?
   - Yes
   - No
   - My school does not have a milk program

3. Are you allowed to leave the school grounds at lunch time?
   - Yes
   - No

During a normal school week, how many days per week do you:

<table>
<thead>
<tr>
<th>Beverage</th>
<th>High in Sugar</th>
<th>High in Caffeine</th>
</tr>
</thead>
<tbody>
<tr>
<td>100% Apple Juice</td>
<td></td>
<td></td>
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<tr>
<td>Black or Green Tea</td>
<td></td>
<td></td>
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<tr>
<td>Cappuccino</td>
<td></td>
<td></td>
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<tr>
<td>Chocolate Milk</td>
<td></td>
<td></td>
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<tr>
<td>Coca-Cola</td>
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<tr>
<td>Coffee</td>
<td></td>
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<tr>
<td>Fruit Punch</td>
<td></td>
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<tr>
<td>Nescafe Iced Tea</td>
<td></td>
<td></td>
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<tr>
<td>Peach Drink</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Red Bull Energy Drink</td>
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<tr>
<td>Rock Star Energy Drink</td>
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<tr>
<td>Sprite</td>
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<tr>
<td>SunnyD</td>
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<tr>
<td>Water</td>
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<tr>
<td>White Milk</td>
<td></td>
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</tbody>
</table>
2. Please check the fruit or vegetable that has the most water from each pairing of food.
   a) Cucumber or Carrots
   b) Apple or Peach
   c) Carrots or Tomatoes
   d) Cucumber or Beans
   e) Strawberries or Pears
   f) Spinach or Corn

3. Where does water from your tap come from?
   - Ground Water
   - Lakes Huron & Erie
   - Lake Ontario & Erie
   - Thames River
   - I don’t know

4. What percentage of the human body is made up of water?
   - 30%
   - 40%
   - 50%
   - 60%
   - 70%

5. How much water do we need to drink each day?
   - 3-4 cups
   - 5-6 cups
   - 7-8 cups
   - 9-10 cups

6. Can you name one way that your tap water is treated? ______________________________

7. Can you list 2 ways to conserve water at home or at school?
   1) ________________________________
   2) ________________________________

8. True or False, bottled water is better than tap water.
   - True
   - False

9. True or False, water is an unlimited resource.
   - True
   - False

10. True or False, we have enough water in Canada for everyone, forever.
    - True
    - False
Appendix G Additional Survey Questions to Assess Program Knowledge in the Growing Chefs! Group at Follow Up (1 Page)

E. Program Knowledge

1. Can you tell us what you have learned from Growing Chefs?*

2. Can you tell us how your eating/drinking behaviour has changed because of Growing Chefs?*

3. After being part of the Growing Chefs! program, what new things are you willing to try that you haven't liked in the past?*

* These questions are designed to assess the knowledge and behaviors that participants have acquired through the Growing Chefs! program.
Appendix H Additional Survey Questions to Assess Program Knowledge in the UTRCA Grade 7 Group at Follow Up (1 Page)

E. Program Knowledge

1. Can you tell us what you have learned from the mini-water festival?

2. What were your favourite mini-water festival activities?

3. Describe your experience teaching the grade 5 students during the mini-water festival?
Appendix I Additional Survey Questions to Assess Program Knowledge in the UTRCA Grade 5 Group at Follow Up (1 Page)

E. Program Knowledge

1. Can you tell us what you have learned from the mini-water festival?

2. What were your favourite mini-water festival activities?
Appendix J HKCC Parent/Guardian Survey (6 Pages)

Parent/Guardian Survey
We need your help to make this study a success. Your honest answers to the items in this survey are very important. This will not take too long to complete. If you have more than one child bringing home a survey – we would appreciate you filling out a survey for each child since many answers will be specific to each child.

A. General Information
1. My child is ○ Female ○ Male ○ Other
2. My child’s current age is ○ ○ ○ ○ ○ ○ ○ ○ years old.
3. What is your relationship to the child (taking part in the study)?
   ○ Mother
   ○ Father
   ○ Primary caregiver/Guardian
   ○ Other ____________
4. If your child has two parents/guardians, what is the relationship between your child (taking part in the study) and the other parent/guardian?
   ○ Mother
   ○ Father
   ○ Primary caregiver/Guardian
   ○ Other ____________
   ○ N/A
5. My child lives primarily in a:
   ○ Single-parent/guardian household
   ○ Two-parent/guardian household
   ○ Other ____________
6. My child:
   ○ lives in a single household
   ○ splits their time equally between 2 households
   ○ lives in one household but regularly visits/lives in a second household
   ○ has another household arrangement
7. How many motor vehicles in working order (car, van, truck, motorcycle) are there in your household?
   - None   - 1   - 2   - 3   - 4 or more

8. Please select the highest level of education you have completed.
   - Grade: 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
   - College/University
   - Graduate School
   - N/A

9. Please select the highest level of education the second parent/guardian has completed.
   - Grade: 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
   - College/University
   - Graduate School
   - N/A

10. Which of the following best describes your current work status?
    - Employed full-time
    - Employed part-time
    - At home with children
    - Unemployed
    - Student
    - Other
    - I prefer not to answer
    - N/A

11. Which of the following best describes the current work status of the second parent/guardian?
    - Employed full-time
    - Employed part-time
    - At home with children
    - Unemployed
    - Student
    - Other
    - I prefer not to answer
    - N/A

12. Please indicate the total income from all sources that you and other members of your household received in the last year (Jan-Dec) before taxes. The total income from all sources was:
    - Less than $20,000
    - $20,000 - $29,999
    - $30,000 - $39,999
    - $40,000 - $49,999
    - $50,000 - $59,999
    - $60,000 - $69,999
    - $70,000 - $79,999
    - $80,000 - $89,999
    - $90,000 - $99,999
    - $100,000 - $109,999
    - $110,000 - $119,999
    - $120,000 - $129,999
    - $130,000 - $139,999
    - $140,000 - $149,999
    - $150,000 or more
    - I don't know
    - I prefer not to answer
13. What is your child's primary race / ethnic background (choose 1 or 2)?
   - White/Caucasian
   - South Asian (e.g. East Indian, Pakistani, Sri Lankan)
   - East Asian (e.g., China, Japan, Korea)
   - Middle Eastern (e.g., Egypt, Iran, Lebanon)
   - Latin American
   - Aboriginal (First Nations, Métis, or Inuit)
   - Black/African/Caribbean

B. Drinking Habits

1. What kind of water does your child usually drink at home?
   - Directly from the Tap
   - Barreled Water (e.g., Culligan)
   - Bottled Water
   - Filtered Water (e.g., Brita, Fridge filter)

2. Does your child use a refillable water bottle? ☐ ☐
   a. If yes, how often does your child use your refillable water bottle for drinking water?
      - Never ☐ Rarely ☐ Sometimes ☐ Usually ☐ Always ☐

3. Do you and your family use refillable water bottles? ☐ ☐

4. Does your child use a refillable water bottle at school? ☐ ☐

5. What does your child usually drink when you are playing sports or being physically active?
   - Juice
   - Water
   - Energy Drinks (e.g., Red Bull)
   - Sports Drinks (e.g., Gatorade Powerade)
   - Other (Please specify): ________________________
C. The Types of Food Your Child Eats & Drinks

1. In a typical day, about how many servings of fruit does your child eat?

Example – 1 serving is equal to:
- A piece of fresh fruit, like an apple
- A small bowl of fruit salad

   O None   O 1   O 2   O 3   O 4 or more

2. In a typical day, about how many servings of vegetables does your child eat?

Example – 1 serving is equal to:
- A carrot or other fresh vegetable (Do not count French fries, potato chips)
- A small bowl of green salad
- A small bowl of fresh or cooked vegetables

   O None   O 1   O 2   O 3   O 4 or more

3. Over the past week, how many times per day did your child drink:

<table>
<thead>
<tr>
<th>Number of Times per Day</th>
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<th>1</th>
<th>2</th>
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<tr>
<td>Water</td>
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<td>100% Fruit Juice</td>
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<td>White milk</td>
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<td>Chocolate milk</td>
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<tr>
<td>Regular pop with sugar</td>
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<td>Diet or sugar free pop</td>
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<td>Energy drinks</td>
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<td>Coffee</td>
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</tbody>
</table>
4. Over the past week, how many times per week did your child eat:

<table>
<thead>
<tr>
<th>Number of Times Per Week</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6 or more</th>
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<tbody>
<tr>
<td>Peanut Butter</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
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<td>Unsweetened breakfast cereal (like Cheerios, Rice Krispies)</td>
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<td>O</td>
<td>O</td>
<td>O</td>
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<td>O</td>
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<tr>
<td>Sweetened breakfast cereal (like Froot Loops, Frosted Flakes)</td>
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<td>O</td>
<td>O</td>
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<td>Cake, pie, or doughnuts</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
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<td>O</td>
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<tr>
<td>Potato chips</td>
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<td>O</td>
<td>O</td>
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<tr>
<td>Chocolate bar</td>
<td>O</td>
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<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>Pizza</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>French Fries</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
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<td>O</td>
</tr>
<tr>
<td>Hot Dog</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>Ice Cream</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>Candy</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
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<td>O</td>
</tr>
<tr>
<td>Granola Bar</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>Cookies</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
</tbody>
</table>

D. Eating & Drinking during the School Day

1. What is your child allowed to bring to school as a beverage (check all that apply)?
   - O Water
   - O 100% Fruit Juice
   - O Fruit-Flavoured drinks
   - O Milk
   - O Pop
2. Do you take part in your school's milk program?
   - Yes
   - No
   - My school does not have a milk program

3. Is your child allowed to leave the school grounds at lunch time?

4. During a normal school week, how many days per week does your child go home to eat lunch?
   - 1
   - 2
   - 3
   - 4
   - 5

5. During a normal school week, how many days per week does your child typically bring a lunch from home?
   - 1
   - 2
   - 3
   - 4
   - 5

6. During a normal school week, how many days per week does your child get lunch off school grounds at a store or restaurant?
   - 1
   - 2
   - 3
   - 4
   - 5

You're finished. Thank you for all your help!
Please return to your child’s school in the provided envelope.
Curriculum Vitae

Name:           Bridget Irwin

Post-secondary Education and Degrees:

The University of Toronto
Toronto, Ontario, Canada
2012-2016 B.A. (Honours) Health Studies and Human Geography

The University of Western Ontario
London, Ontario, Canada
2016-2018 M.Sc. Epidemiology and Biostatistics

Honours and Awards:

Canadian Institute of Health Research (CIHR) Canada Graduate Scholarship
2017

Related Work Experience:

Research Associate
Human Environments Analysis Laboratory
The University of Western Ontario
September 2016 - September 2018

Research Associate
Global Health Policy Laboratory
Wilfrid Laurier University
September 2018 - Present

Conference Presentations:

Oral Presentation
Irwin, B., Speechley, M., Wilk, P., Clark, A., & Gilliland, J.
*Promoting Healthy Beverage Consumption Habits in Children: Results of the Healthy Kids Community Challenge ‘Water Does Wonders’ Interventions in London, Ontario.*
London Health Research Day
London Convention Centre, London, ON, May 10 2018

Oral Presentation
Irwin, B., Speechley, M., Wilk, P., Clark, A., & Gilliland, J.
*Promoting Healthy Beverage Consumption Habits in Children: Results of the Healthy Kids Community Challenge ‘Water Does Wonders’ Interventions in London, Ontario.*
Pediatric Research Day
Victoria Hospital, London, ON, May 23 2018

Poster Presentation
Irwin, B., Speechley, M., Wilk, P., Clark, A., & Gilliland, J.
Canadian Public Health Association Conference
Fairmount Queen Elizabeth, Montreal, QC, May 30 2018

Oral Presentation
Irwin, B., Speechley, M., Wilk, P., Clark, A., & Gilliland, J.
Canadian Society of Epidemiology and Biostatistics Conference
Lakehead University, Thunder Bay, ON, June 16 2018