# BEVERAGE INTAKE BY CANADIAN CHILDREN AND ITS RELATIONSHIP TO OVERWEIGHT AND OBESITY

A Thesis Submitted to the College of

Graduate Studies and Research

in Partial Fulfillment of the Requirements

for the Degree Masters of Science

in the College of Pharmacy and Nutrition

Division of Nutrition and Dietetics

University of Saskatchewan

Saskatoon

By

Adrienne Dawn Danyliw

## PERMISSION TO USE MASTERS THESIS

In presenting this thesis in partial fulfillment of the requirements for a masters degree from the University of Saskatchewan, I agree that the Libraries of this University may make it freely available for inspection. I further agree that permission for copying of this thesis in any manner, whole or in part, for scholarly purposes may be granted by the professors who supervised my thesis work:

Dr. Susan J. Whiting, Ph.D.
Dr. Hassanali Vatanparast, M.D. Ph.D.
College of Pharmacy and Nutrition

In their absence, permission may be granted by the Dean of the College of Pharmacy and Nutrition. It is understood that any copying or publication or use of this thesis or parts thereof for financial gain shall not be allowed without my written permission. It is also understood that due recognition shall be given to me and the University of Saskatchewan in any scholarly use which may be made of any material in my thesis.
Request for permission to copy or to make other use of material in this thesis in whole or part should be addressed to:

Dean of the College of Pharmacy and Nutrition
University of Saskatchewan
110 Science Place
Saskatoon, Saskatchewan S7N 5C9

# ABSTRACT

Intake of sweetened beverages in North America has risen in past decades. Concurrently, the prevalence of overweight and obesity among children has increased. To our knowledge, there has been no examination of the relationship between children's beverage intake and body mass index (BMI) with nationally representative Canadian data. The objective of this study was to examine the relationship between beverage patterns and BMI in Canadian children. Data from the Canadian Community Health Survey 2.2 (2004) included: dietary information, collected via 24-hour recall, and demographics, socio-economic status, physical activity, and food security, collected by interview, and measured anthropometrics.

In this study, subjects aged 2 to 18 years (n=10,038) were included if they had complete anthropometric, dietary and socio-demographic information. The following groups were created: 2 to 5 years (both sexes), 6 to 11 years female, 6 to 11 years male, 12 to 18 years female, 12 to 18 years male. Beverage data categorized and grouped into four categories: sugar-sweetened, nutrient-based, alcoholic, and non-caloric. Descriptive analysis was completed for intake of beverages, energy, vitamin C, and calcium. Cluster analysis identified beverage patterns by age-sex groups and allowed comparisons across clusters. Multinomial logistic regression analysis was completed. Results were weighted and bootstrapped to obtain population-level estimates and account for the complex survey design.

Children who drank mostly sweetened beverages consumed 16-18% of total daily energy from such drinks. Across age groups, older boys and girls drank more sweetened beverages than preceding groups ($p<0.05$). In cluster analyses, five beverage clusters emerged for children 2 to 5 years, six clusters for 6 to 11 years, and four clusters for 12 to 18 years. No significant relationship emerged between beverage pattern and BMI among children 2 to 5 years, girls 6 to 11 years, or youth 12 to 18 years (both sexes). Boys 6 to 11 years whose beverage pattern was characterized by 'soft drink' intake (553 g ± 29) had increased odds of overweight/obesity (OR 2.28, 95% C.I. 1.25-4.15) compared to a 'moderate' beverage pattern. Data for boys aged 6 to 11 years suggest that sweetened beverages may be associated with overweight and obesity.

# ACKNOWLEDGEMENTS

I would like to express sincere gratitude to my co-supervisors, Drs Susan Whiting and Hassan Vatanparast. Your immense knowledge, patience, and enthusiasm made my experience in research a wonderful journey.

Thank you to my committee members Dr Carol Henry and Dr Angela Bowen. Your time, thoughtfulness and suggestions have improved my work and expanded my knowledge and skills in research. Thank you also to my external examiner for your time and experience.

I have been very fortunate over the past two years to have received financial support from the Canadian Institutes of Health Research, the College of Pharmacy and Nutrition, the College of Graduate Studies and Research, the Hope Hunt Scholarship, the Canadian Nutrition Society, and the Canadian Home Economics Foundation.

This experience as a graduate student has been made extra-special by my fellow graduate students in Pharmacy and Nutrition, and in Community Health and Epidemiology, and the School of Public Health, your support, understanding, and tutoring has helped me in so many ways. I would especially thank Nooshin Nikpartow for her expert guidance and partnership on all parts of this project. To the staff at the SKY-Research Data Centre, I am extremely grateful for your friendly smiles and encouraging words.

Finally, I would like to thank my family and especially to Jeff, for his endless patience, understanding and support while I completed my degree.

# TABLE OF CONTENTS

# LIST OF TABLES

# LIST OF FIGURES

# LIST OF ABBREVIATIONS

| | |
|---|---|
| AI | Adequate Intake |
| AMPM | Automated Multiple Pass Method |
| BIA | Bioelectrical Impedance Analysis |
| BMI | Body Mass Index |
| BNS | Bureau of Nutritional Science |
| CCC | Cubic Clustering Criterion |
| CCHS | Canadian Community Health Survey |
| CDC | Centre for Disease Control and Prevention |
| CI | Confidence Interval |
| CNF | Canadian Nutrient File |
| CSFII | Continuing Survey of Food Intake of Individuals |
| DXA | Dual X-ray Absorptiometry |
| DRI | Dietary Reference Intakes |
| ECOG | European Childhood Obesity Group |
| EER | Estimated Energy Requirement |
| FDC | Food Descriptions (file name) |
| FDCD_DEN | Food Description Code, with Descriptions in English |
| FDCD_FGE | Food Description Code, with Food Group in English |
| FFQ | Food Frequency Questionnaire |
| FID | Food and Ingredient Details (file name) |
| FIDD_CDE | Food and Ingredient Details, Code |
| FRL | Food at the Recipe Level (file name) |
| GI | Glycemic Index |
| HFCS | High Fructose Corn Syrup |
| HFSSM | Household Food Security Survey Model |
| HS | General Health (file name) |
| IOTF | International Obesity Task Force |
| Kcal | Kilocalorie(s) |
| MF | Milk Fat |
| NHANES | National Health and Nutrition Examination Survey |
| NSS | Nutrition Survey System |
| OR | Odds Ratio |
| PAI | Physical Activity Index |
| PAM | Partitioning Around Medoids |
| PFS | Pseudo-F- Statistic |
| PI | Ponderal Index |
| R24 | Twenty-four Hour Recall (file name) |
| RDA | Recommended Dietary Allowance |
| REE | Resting Energy Expenditure |
| SIDE | Software for Intake Distribution Estimation |
| SEM | Standard Error of the Mean |
| US | United States |
| USDA | United States Department of Agriculture |
| WC | Waist Circumference |

| | |
|---|---|
| WHO | World Health Organization |
| WIC | Women Infants and Children |

# 1. INTRODUCTION

## *1.1 Rationale*

Examining food and beverage intake at a population level is necessary to identify nutrition problems and potential avenues for intervention, especially as nutrition related chronic diseases such as obesity become more prevalent (Gibson, 2005). Beverages, in particular, are a growing area of research as they relate to the development of overweight and obesity in children. Beverages are an important component of children's overall diet. Fruit drink, carbonated beverages, milk, and apple juice were among the top five foods consumed by preschoolers (Skinner et al., 1999). Among children 19-24 months, beverages contributed approximately one third of the daily intake of energy, calcium, vitamins A, C and D, protein and zinc (Skinner, Ziegler, & Ponza, 2004). Beverages also contribute energy: approximately 17.5% of energy intake by 6 to 11 year old American children in 1999-2002 was from beverages (Storey, Forshee, & Anderson, 2006). Dietary habits, including beverage consumption, are developed in young childhood and may be carried into adolescence and adulthood (Lanigan, Turnbull, & Singhal, 2007). In addition, beverage intake can be a predictor of overall diet quality. National data from the US indicated that milk and juice consumption were positively associated with overall nutrient intakes while sweetened beverage consumption was negatively associated with nutrient intakes (Ballew, Kuester, & Gillespie, 2000).

Despite the importance of beverages in children's diets, until recently, there has been little national-level Canadian data on beverage consumption. The Canadian Community Health Survey (CCHS) 2.2, conducted in 2004, provided data on children's beverage consumption by age and sex groups (Garriguet, 2008a). It is unclear how Canadians' beverage intake patterns have changed over time. There is no national-level Canadian data on beverage consumption trends, rather, there is only food disappearance data (Statistics Canada, 2009), which cannot reveal demographic patterns of consumption. By focusing research on young children, and comparing the results to older children, the opportunity to examine trend-like data is available.

Although there are no Canadian data on trends, information from the United States (US) National Health and Nutrition Examination Survey (NHANES) has indicated a rise in children's sweetened beverage consumption over time (Nielsen & Popkin, 2004). Some authors argue that this rise in sweetened beverage intake has contributed to overweight or obesity among young children (Barnard, 2010; Dubois, Farmer, Girard, & Peterson, 2007; Faith, Dennison, Edmunds, & Stratton, 2006; Kral et al., 2008; LaRowe, Moeller, & Adams, 2007; Linardakis, Sarri, Pateraki, Sbokos, & Kafatos, 2008; Nelson, Carpenter, & Chiasson, 2006; Welsh et al., 2005). However, others have not found a relationship between sweetened beverage consumption and weight gain or other measures of overweight or obesity among young children (Newby et al., 2004; O'Connor, Yang, & Nicklas, 2006). The potential mechanisms for the relationship between sweetened beverage intake and weight gain have not been elucidated, but may be related to poor satiety from beverages leading to excess energy intake (DiMeglio & Mattes, 2000; Harrington, 2008; Mattes, 2006; Raben, Vasilaras, Moller, & Astrup, 2002).

Despite a lack of data on beverage consumption trends in Canada, the prevalence of overweight and obesity in 2004 was 21% for preschoolers and has doubled among Canadian children 6 to 11 and 12 to 17 years over the past 30 years (Shields, 2006). Children who are overweight or obese often remain overweight or obese as adults (Dietz, 2004; Freedman et al., 2005; Guo, Wu, Chumlea, & Roche, 2002). The presence of overweight and obesity increase the risk of chronic diseases, including heart disease, diabetes (Freedman, Khan, Dietz, Srinivasan, & Berenson, 2001; Goran, Ball, & Cruz, 2003; Raghuveer, 2010). In addition, emotional and social challenges have been associated with obesity among children (Friedlander, Larkin, Rosen, Palermo, & Redline, 2003; Strauss & Pollack, 2003; Tsiros et al., 2009). Some researchers have highlighted the importance of identifying risk factors for, and preventing obesity among children as young as infants and preschoolers (Lanigan, Barber, & Singhal, 2010; Reinehr, Kleber, Lass, & Toschke, 2010; Trapp, Ryan, Ariza, Garcia, & Binns, 2009). The prevalence of obesity in the US has been forecasted to further increase, especially among children 6-9 years old (Basu, 2009), thus there is urgency to better understand and act on the many factors contributing to this epidemic.

*1.2 Hypothesis*

Children, whose beverage consumption is predominately from sweetened beverages, would have a higher body mass index-for-age than those children who do not exhibit this pattern of sweetened beverage consumption.

*1.3 Objectives*

To examine the relationship between beverage intake patterns and body mass index in Canadian children 2 to 5 years old as compared to older children (6 to 11 year olds and 12 to 18 year olds). Specifically, the research objectives are:

1. To describe beverage consumption patterns, socio-demographics, and selected nutrient intake of Canadian children by age and sex
2. To cluster data on children into non-overlapping beverage groups
3. To compare prevalence of overweight and obesity, energy, calcium and vitamin C intake, household income, caregivers' education, ethnicity, and household food security of preschool children in various beverage clusters
4. To determine whether there is an effect of beverage intake pattern on body mass index-for-age and the risk of overweight and obesity

*1.4 Significance*

To our knowledge, this is the first research study to use cluster analysis to examine the relationship between beverage intake and overweight and obesity among Canadian children at a national level. The present study uses cluster analysis to determine predominant patterns of beverage consumption among children. This allows for testing of the hypothesis that children who drink predominantly sweetened beverages will have a higher body mass index (BMI) for-age and higher odds of overweight and obesity compared to children who have a moderate beverage consumption pattern. Using data from CCHS 2.2 allows for controlling of a variety of potential confounders such as energy intake and physical activity. Additionally, CCHS 2.2 data allows for estimates at the population level, and therefore, the ability to generalize the results to the Canadian population.

This research will inform health professionals and researchers about the role of beverages as it relates to Canadian children's weight while adjusting for other factors known to play a role in obesity. It also provides Canadian beverage data that will be comparable to data from the US and elsewhere. It adds to the dietary patterning literature with a focus on beverages, where the literature to date has generally focused on total diet patterns. Finally, it provides the opportunity to inform nutrition policies at daycares, schools and elsewhere.

### *1.5 Summary*

Sweetened beverage intake among children is rising around the world. This increase in sweetened beverages may be contributing to the rise in overweight and obesity among children. To date there is no national-level data exploring the relationship between sweetened beverage intake and overweight and obesity in Canadian children. The present study examines the beverage intake of Canadian children, categorizes children into groups based on their beverage intake and tests the association between beverage intake and overweight and obesity while adjusting for a variety of potential confounders.

# 2. LITERATURE REVIEW

### *2.1 Beverages*

#### *2.1.1 Definition of Beverages*

Beverages are defined as "all fluids consumed by humans, including water" (Popkin et al., 2006). Often, fluids consumed as a meal, such as soup and liquid meal replacements are excluded from the definition of beverages (Popkin et al., 2006). Throughout human history, water and breastmilk were the only two beverages consumed for over 100,000 years (Wolf, Bray, & Popkin, 2008). It is estimated that animal milk may have been consumed circa 9,000 BC, followed by wine, beer, and juice around 8,000 BC, and an increase in the variety of beverages produced and consumed began in 12$^{th}$ century AD with brandy, coffee, tea, lemonade and liquor becoming more common (Wolf et al., 2008). Citrus juices gained recognition when they were found to prevent scurvy (Wolf et al., 2008). Soft drinks became common in the mid-to-late 1800's and Coca-cola™ appeared on the market in 1886 in the United States (Wolf et al. 2008).

Beverages provide a variety of nutrients including carbohydrate, vitamin C, calcium, folate, magnesium and many others. Current research often groups sweet beverages together, but the specific beverages included in that category differ across studies. Some researchers include juice in the sweetened beverage group (Linardakis et al., 2008), while others separate citrus juice from non-citrus juice (Forshee & Storey, 2003), and others include flavoured milks (Jansen, Mackenbach, Joosten-van Zwanenburg, & Brug, 2010), and still others differentiate between soft drinks (e.g. fruit drinks) and sodas (e.g. colas) (Malik, Schulze, & Hu, 2006).

Despite these differences, beverages can be categorized based on their nutrient and energy content. Four categories of beverages emerge: 1) sugar sweetened- low nutrient 2) nutrient based beverages 3) alcoholic beverages, and 4) beverages that provide no additional energy or nutrients. Each of these categories contain different types of beverages. For example, sugar-sweetened beverages contain fruit drinks, soft drinks and sweetened coffees and teas. Nutrient-based beverages contain milk, and fruit juice. Alcoholic beverages include wine, beer, and spirits. Those beverages with no additional energy include water and artificially sweetened drinks.

#### *2.1.1.1 Sweetened Beverages*

Sweetened beverages contain caloric sweeteners, water, and flavourings. Sweetened beverages can include fruit drinks, lemonade, iced tea, carbonated non-diet beverages, sports drinks, energy drinks, slushies and more. In North America, high-fructose corn syrup is a common sweetener in beverages, while sucrose is more common in Europe (Malik et al., 2006; Treidlinger & Dedhar, 2009). Although sweetened beverages provide energy from sucrose, glucose, fructose, or a combination thereof, they are not nutrient dense (Popkin et al., 2006). Over time however, sweetened beverages have contributed to an increase in consumption of added sugar (Popkin & Nielsen, 2003).

Fruit drinks are beverages that "contain less than 100 percent juice, and often have other ingredients added such as water, flavours and sugars, including sucrose, fructose and glucose" (American Beverage Association, 2009). Some fruit drinks have added nutrients such as vitamin C (Popkin, 2006). In Canada, fruit drinks are labeled "beverage", "punch", or "cocktail" and are distinct from 100% juice (Canadian Food Inspection Agency, 2003). Examples of fruit drinks include *Sunny Delight*™, Hawaiian punches, and lemonades.

Caloric sodas include any carbonated or non-carbonated sweetened beverage that may include flavourings (Popkin et al., 2006). Examples of soda include cola-type carbonated beverages, lemon-lime flavoured carbonated beverages, and sports drinks that do not contain any fruit juice. As cited in (Treidlinger & Dedhar, 2009), the Beverage Marketing Corporation found that carbonated beverages were "the largest beverage category both in volume and per capita consumption" from 2004 to 2006 in Canada. According to Statistics Canada and after adjusting for losses, Canadians consumed over 70 liters of soft drinks per person per year, an equivalent of 205 mL per person per day (Statistics Canada, 2009).

Coffee and tea, common beverages consumed by Canadians (Garriguet, 2008b) are naturally unsweetened and when consumed as such are considered to be low-calorie. Individuals, however, often add sugar or other sweeteners such as honey to their tea or coffee. Pre-sweetened and flavoured teas are also available on the market. These pre-sweetened beverages, whether hot or cold, do not provide significant nutrients other than calories and therefore are included in the sweetened beverage, low-nutrient category.

#### *2.1.1.2 Nutrient Based Beverages*

Nutrient based beverages include all types of milk and 100% fruit juice. These types of beverages provide nutrients beyond energy, such as calcium and vitamin C. Milk, according to CCHS 2.2, includes all milk, regardless of fat content (Garriguet, 2008a; Garriguet, 2008b). The category also includes cow's and goat's milk. Beverages made with milk are included in this category, such as hot chocolate or café latte made with milk. Condensed milk and milk added to cereals are not included in the definition of milk as a beverage (Garriguet, 2008a). Milk is an important source of many nutrients, including calcium, vitamin D (when fortified), potassium, magnesium, riboflavin, vitamin B6, vitamin B12, zinc, and vitamin A (Ilich & Kerstetter, 2000; Weaver, 2010). It also provides protein, carbohydrate, and varying amounts of fat depending on the type of milk consumed. Milk has been defined as a nutrient dense beverage (Rampersaud, Bailey, & Kauwell, 2003), indicating its beneficial nutrient to energy ratio and has also been associated with reduced risk of low bone mass, metabolic syndrome, stroke, and some types of cancer (Weaver, 2010).

Juice has been defined as "the liquid obtained from or present in fruit or vegetables" (Soanes & Stevenson, 2005). Juice in Canada is labeled "100% juice" and can only contain juice from a fruit or vegetable, and have similar nutritional properties of the original product (Canadian Food Inspection Agency, 2003). Juice contains less fibre than whole fruit or vegetables. However, juice contains more nutrients than fruit drinks that are essentially sugar, water and flavouring. Juice from different fruit or vegetables have different nutrient profiles, including carbohydrate and caloric content (Rampersaud, 2007). Juice consumption has also been positively associated with vitamin C intake among children 2 to 17 years (Ballew et al., 2000).

*2.1.1.3 Alcoholic Beverages*

A standard alcoholic drink is 341 mL beer (12 oz), 142 mL wine (5 oz), or 42 mL spirits (1.5 oz) (Centre for Addiction and Mental Health, 2008). Alcoholic beverages provide energy in the form of ethanol (7 kcal/g) and, for beer and wine, small amounts of protein and carbohydrates (Health Canada, 2008b). Minimal amounts of vitamins and minerals are present in beer, wine, and spirits (Health Canada, 2008b). Moderate alcohol consumption among adults has been associated with reduced all-cause mortality, and wine may offer some protection against heart disease (Ferreira & Willoughby, 2008; Guerrero, Garcia-Parrilla, Puertas, & Cantos-Villar, 2009). However, alcohol is the most commonly consumed drug in the world, and its abuse is associated with high risk of morbidity and mortality (Ferreira & Willoughby, 2008). The Centre for Addiction and Mental Health has produced low-risk drinking guidelines stating that individuals should consume no more than two drinks per day, women should consume no more than nine drinks per week, and men should consume no more than 14 drinks per week (Centre for Addiction and Mental Health, 2008). Among other restrictions, these guidelines only apply to those over the legal drinking age (Centre for Addiction and Mental Health, 2008), and people under the legal drinking age should not consume alcohol.

*2.1.1.4 Non-caloric Beverages*

Water, artificially sweetened drinks, and plain coffee and tea are beverages that offer no or few calories (Health Canada, 2008b). Generally, these beverages do not offer any nutrients, unless fortified. Water can be obtained from municipal or well sources, or purchased in bottles. Bottled water in Canada can be purchased in many forms. “Spring water” is water from an underground source that is safe for consumption from the point of origin, “mineral water” is similar to spring water, but has a higher content of dissolved mineral salts (Health Canada, 2009). Distilled or de-mineralized bottled water have specific requirements that allow them to carry those labels. Some bottled water can be from municipal sources, and may have undergone further treatment to remove chlorine or other compounds (Health Canada, 2009). Carbonation and ozone may also be added to bottled water (Health Canada, 2009), but these do not alter the nutrient or caloric content.

Artificial sweeteners approved to use in foods and beverages in Canada include aspartame, acesulfame-potassium and sucralose (Health Canada, 2010). Artificial sweeteners common in beverages can be 200-600 times as sweet as sucrose (American Dietetic Association, 2004), therefore only small quantities are added to match the sweetness of caloric beverages. These sweeteners are regulated in Canada under the Food and Drugs Act and Regulations (Health Canada, 2010). Acceptable daily intake levels are set and are based on body weight; aspartame, for example, has an acceptable daily intake of 40 mg/kg (Health Canada, 2005). One can (355 mL) of diet cola has 185 mg of aspartame (Health Canada, 2008a). The American Dietetic Association's most recent position statement on nutritive and non-nutritive sweeteners stated that "…consumers can safely enjoy a range of nutritive and nonnutritive sweeteners when consumed in a diet that is guided by current federal nutrition recommendations…" (American Dietetic Association, 2004, pg 255). However, some research has shown that consumption of artificial sweeteners may contribute to weight gain in rats (Swithers, Baker, & Davidson, 2009) possibly due to the disruption of hormonal and neuro-behavioural pathways when there is dissociation between sweet tastes and caloric content (Ludwig, 2009). More research is needed in this area.

Wolf and colleagues in a short history on beverages stated that coffee consumption likely began in the 14$^{th}$ or 15$^{th}$ century in Yemen (2008). Modern coffee can be consumed in many ways, from boiled to brewed to espresso. When consumed plain, coffee contains few or no calories (Health Canada, 2008a). Similarly, tea consumption has a long and varied history (Wolf et al., 2008). Tea leaves steeped in water provide few or no calories (Health Canada, 2008a). Therefore, plain tea and coffee are considered non-caloric beverages.

### *2.1.2 Beverage Consumption Among Children*

For the purpose of this study, childhood is defined as 2-18 year olds and includes preschool children, school-aged children and adolescents. Statistics Canada has published cross-sectional descriptive information on beverage consumption patterns of Canadians from 2004 (Garriguet, 2008a; Garriguet, 2008b). Young Canadian children consumed approximately one liter of beverages per day (Garriguet, 2008a). Amounts (in grams) of selected beverages consumed by Canadian children are presented in Figure 2.1 (Garriguet, 2008a). Overall, juice intake exceeded that of sweetened beverages (fruit drinks plus soft drinks) in children 1-3 years, but the reverse was true for children 4 years old and up. Milk intake was highest among 1-3 year olds, and soft drink consumption increased among ascending age categories (Figure 2.1).

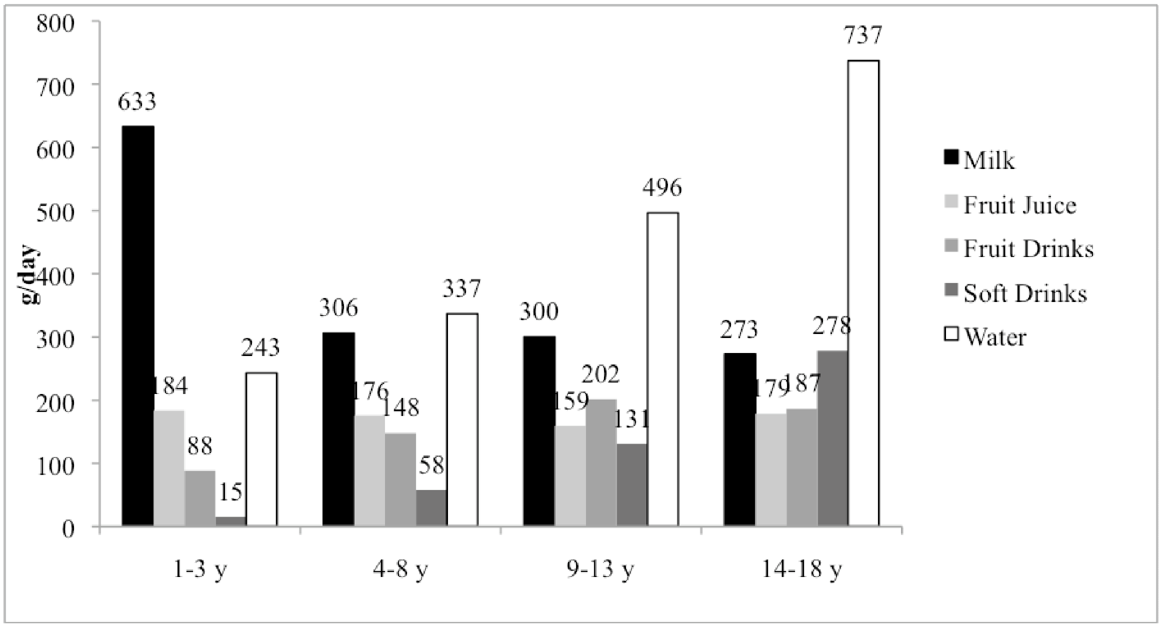



Figure 2.1: Average daily consumption of selected beverages by Canadian children by age group in 2004. Adapted from Garriguet, 2008a.

In a nationally representative sample of American children aged 2 to 5 years in 1999-2002, O'Connor et al. found a mean total beverage consumption of 754 g (95% CI: 721-787 g), excluding water (O'Connor et al., 2006). Most children consumed milk on the day of survey, and nearly 50% of children consumed either juice or fruit drink (Table 2.1) (O'Connor et al., 2006). Children drank mostly milk, while sweetened beverages exceeded their intake of fruit juice (Table 2.1). Estimated water consumption by American children 2-3 years old in 1994-96/1998 was 437 mL/day, and for children 3-6 years old was 514 mL/day (Kahn & Stralka, 2009).

Table 2.1: Mean consumption of beverages and percentage of children 2 to 5 years who consumed specified beverage*

| Beverage | Mean (95% CI) | % consumers |
|---|---|---|
| **Milk** | 345 g (309 -381) | 82.6% |
| **Fruit Juice** | 131 g (113 – 150) | 47.9% |
| **Fruit drinks** | 139 g (118 - 161) | 44.2% |
| **Soda** | 91 g (78 - 104) | 39.2% |

*National Health and Nutrition Examination Survey 1999-2002. Adapted from O'Connor et al., 2006.

*2.1.2.1 Beverage Consumption Trends Among Children*

Currently in Canada, we rely on food disappearance data as a proxy to estimate trends in beverage consumption. The CCHS 2.2 (2004) is the most recent national nutrition survey in Canada since provincial nutrition surveys in the 1970's. Food and beverage disappearance statistics are available for Canada from 1981 onwards and provide data that estimate beverage consumption (Statistics Canada, 2009). After adjusting for losses, beverage trends since 1981 indicate a general rise in soft drink and tea availability, a decrease in milk, and relatively stable values for coffee and juices (Figure 2.2) (Statistics Canada, 2009). Some suggest that there has been a fall in milk and a rise in soft drink consumption in Canada (Vatanparast & Whiting, 2007). Using food disappearance data, milk consumption decreased approximately 18% while soft drink intake increased 84% between 1975 and 2005 in Canada (Vatanparast & Whiting, 2007). The availability of beverages, even after adjusting for losses, is not necessarily equal to consumption.

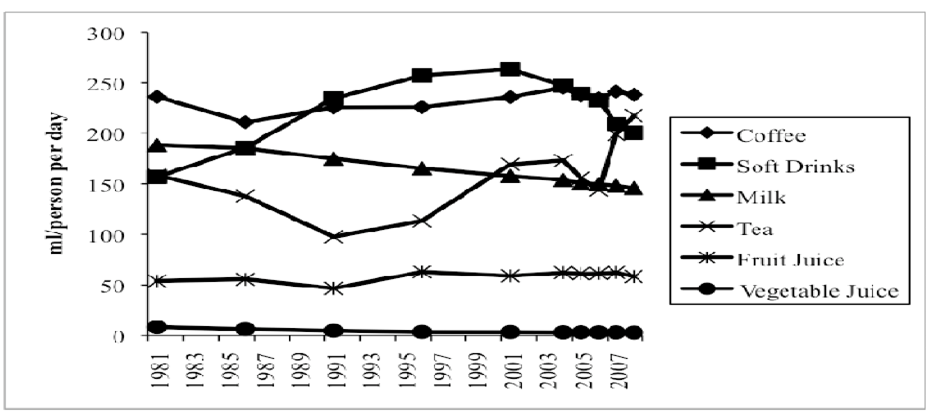



Figure 2.2: Availability of selected beverages in Canada from 1981 to 2008, adjusted for losses (Statistics Canada, 2009).[1]

[1] Figure 2.2 was created using data from http://www.statcan.gc.ca/pub/21-020-x/21-020-x2008001-eng.htm

National-level historic data on beverage consumption in the US are available. These trends indicate a rise in children's sweetened beverage consumption accompanied by a fall in milk consumption (Forshee, Anderson, & Storey, 2006; Nielsen & Popkin, 2004; Popkin, 2010; Wilkinson Enns, Mickle, & Goldman, 2002; Yen & Lin, 2002). A study comparing soft drink intakes of 6-17 year old children from 1977-1978 to 1994-1998 found an increase in the prevalence of soft drink intake as well as an increase in the volume of soft drinks consumed (French, Lin, & Guthrie, 2003). Per capita caloric intake of beverages was compared from 1977 through to 2006, and researchers found that the intake of soda and fruit drinks increased from 87 kcal/person to 154 kcal/person, juice increased from 33 kcal/person to 54 kcal/person, while high fat milk decreased yet low fat milk intake increased (Popkin, 2010).

Research using the US National Family Opinion Research/Beverage Unit's Share of Intake Panel during 1987-88, 1992-93, and 1997-98 found that children 1-5 years decreased consumption of soft drinks while milk intake remained stable (Park, Meier, Bianchi, & Song, 2002). Despite this, most reports show an increase in sweetened beverage and soft drink intake over time and a decrease in milk intake for all children (Nielsen & Popkin, 2004; Yen & Lin, 2002). A recent report specified trends in preschool-aged children's beverage intake (Wang, Bleich, & Gortmaker, 2008) using NHANES data from 1988-1994 and 1999-2004 and showed that per capita juice consumption had increased from 55 kcal/day to 69 kcal/day, and that sugar sweetened beverages increased 107 kcal/day to 124 kcal/day (Wang et al., 2008). Although the caloric intake increase is relatively small, increases in total calories without a subsequent increase in energy expenditure may lead to excess weight gain over time (Duffey & Popkin, 2006; Rajeshwari, Yang, Nicklas, & Berenson, 2005).

#### *2.1.2.2 Beverage Consumption Recommendations for Children*

Information on food and beverage intake becomes relevant when compared to recommendations. Canada's Food Guide recommends two servings (500 mL) of fluid milk per day for children two to eight years old (Health Canada, 2007a). American recommendations are similar to those in Canada: *My Pyramid* for preschoolers recommends two cups of low fat milk per day (skim or 1% milk fat) (United States Department of Agriculture, 2009).

There is no requirement set for 100% juice, as whole fruit is encouraged (Health Canada, 2007a). However, due to concerns regarding excess juice consumption, paediatric organizations have recommended limiting juice intake to 4-6 oz (112 to 168 mL) per day for young children (Canadian Paediatric Society, 2006; Committee on Nutrition, 2001). These organizations have highlighted the nutritional differences between fruit juice and fruit drinks, indicating that fruit drinks are not a substitute for 100% juice.

Sweetened beverages, including fruit drinks, soft drinks and sweetened coffee and teas do not have specific recommendations or limitations. However, Health Canada advises Canadians to "limit your intake of soft drinks, sports drinks, energy drinks, fruit drinks, punches, sweetened hot and cold beverages and alcohol. These beverages can be high in calories and low in nutrients" (Health Canada, 2007a). Canada's Food Guide recommends water to drink, which is especially important for children and older adults as their sense of thirst may be compromised while their needs are high (Health Canada, 2007a).

The Beverage Guidance Panel (Popkin et al., 2006) provided recommendations for Americans based on the risks and benefits of various beverages. The recommendations are arranged in six levels based on caloric and nutrient value, where those at the highest level (sweetened beverages with no nutrients) should be limited 0 to 8 fl oz per day (0 – 224 mL), followed by caloric beverages with some nutrients (0-8 oz, or 0-224 mL), non-calorically sweetened beverages (0-32 oz, or 0-896 mL), low-fat milk (0-16 oz, or 0-448 mL), unsweetened beverages e.g. tea or coffee (0-40 oz, or 0-1.12 L) and finally water (20-50 oz, or 560-1400 mL) (Popkin et al., 2006).

### *2.2 Overweight and Obesity Among Children*

The rise in prevalence of overweight and obesity in children is of concern around the world (James, 2008), and some have predicted it to further increase (Basu, 2009). Children who are overweight or obese during childhood often remain overweight or obese as adults, and may be at higher risk for chronic diseases such as type 2 diabetes and cardiovascular disease (Malik et al., 2006; Raghuveer, 2010).

Measurement of overweight and obesity in children occurs in many forms. Body-mass index, BMI-for-age percentiles, and BMI-for-age-z-scores are calculated using a child's height and weight (BMI=kg/$m^2$). In the case of percentiles and z-scores, age and sex are considered. BMI-for-age is plotted on a sex-specific chart where the y-axis is BMI and the x-axis is age and the resulting data points fall along a growth curve that is measured in centiles. The curve shows a decrease in BMI between the ages of 4 and 6, followed by a gradual rise in BMI throughout childhood (Dietitians of Canada & Canadian Paediatric Society, 2010). These measurements are not direct measures of adiposity, rather they provide a proxy measure of fatness. BMI and BMI-for-age have been assessed using a variety of tools including growth reference charts such as the Centre for Disease Control and Prevention growth charts (Kuczmarski et al., 2000) and BMI- cut points as defined by the International Obesity Task Force criteria (Cole, Bellizzi, Flegal, & Dietz, 2000). More direct measures of adiposity include waist circumference, skinfold thickness, bio-impedance analysis, and dual x-ray absorptiometry (DXA) (Hubert, Guinhouya, Allard, & Durocher, 2009).

Obesity in childhood is complex and multi-factorial, and as such, is still not well-understood. Non-modifiable factors such as parental weight, family history, sex and ethnicity have been associated with childhood overweight and obesity (Lytle, 2009; Olstad & McCargar, 2009). Socio-economic factors such as household income, education, and food security have also been associated with child weight (Murasko, 2009; Taveras, Gillman, Kleinman, Rich-Edwards, & Rifas-Shiman, 2010). In addition, physical and sedentary activity levels during childhood are also important in energy balance (Fulton et al., 2009; Ramic et al., 2009).

### *2.2.1 Preschool-aged Children*

Young children are developing food and beverage habits that may last a lifetime. Many of these habits are formed in the preschool years and are continued to older childhood. Here, we focus on the preschool stage, and compare it to older children. The term ‘infants’ refers to children under 1 year of age, and ‘toddler’ refers to those children 12 to 24 months (Fox, Pac, Devaney, & Jankowski, 2004). Preschool aged children are between 2 and 5 years old. School aged children are generally 6 to 11 years, and may also include adolescents (12 to 18 years). Each of these periods of development is associated with unique milestones that normal healthy children are able to achieve. Some argue that early life – intrauterine, infancy and preschool – are critical time periods for the prevention of obesity (Olstad & McCargar, 2009).

Compared to infants and toddlers, the rate of physical growth in preschool-aged children is slower (Kuczmarski et al., 2000). This slowed growth is reflected in the recommended growth monitoring schedules. The Canadian Paediatric Society and Dietitians of Canada recommend growth monitoring seven times before the age of 24 months, but only twice between 2 and 6 years (Dietitians of Canada, Canadian Paediatric Society, College of Family Physicians of Canada, & Community Health Nurses Association of Canada, 2004). Despite a slower pace in physical growth, preschoolers show rapid progress in the development of gross and fine motor, social, language, and cognitive skills. Eating is a social skill that is developed in the preschool years. A child who is two years old will copy parent's behaviour (Canadian Paediatric Society, 1996), including mealtime behaviour, and caregivers' reactions to foods. Preschoolers value and thrive on daily routines (Canadian Paediatric Society, 1996), which include regular meals and snacks. They are also gaining a sense of increased independence and increased defiant behaviour (Canadian Paediatric Society, 1996), which can make feeding preschoolers a trying experience for parents and caregivers. Patterns of eating that are established in childhood are often carried into adulthood (Lanigan et al., 2007), therefore formation of healthy food and beverage consumption patterns in the preschool years is important for future health.

### *2.2.2 School-aged Children and Adolescents*

Preschool children grow into school aged children and adolescents, yet they retain some of their food and beverage habits along the way. School aged children and adolescents demonstrate different developmental, growth and dietary behaviour compared to younger children (Esposito, Fisher, Mennella, Hoelscher, & Huang, 2009). Peer influences become more important as parental influences decrease (Esposito et al., 2009). A review on the environmental influences on dietary behaviour summarized factors that differ across the lifespan (Larson & Story, 2009). For school aged children, social and peer networks, as well as the school environment and restaurant and fast-food establishments played a role in food and beverage choices (Larson & Story, 2009). Other influences such as television, music and other electronics also play a role in food and beverage choices (Peneau et al., 2009). School aged children have a slower rate of growth, until puberty when growth rate increases (Kuczmarski et al., 2000). Nakano et al. (2010) suggested a critical window of increased risk for overweight and obesity for school aged children in Japan that differed for boys (7-11 years), and for girls (9-11 years). In Canada, the prevalence of obesity among school-aged children has doubled over the past three decades from approximately 13% to 26% among children 6 to 11 years old and 14% to 29% among 12 to 17 year olds (Shields, 2006) (Table 2.2).

Table 2.2 Percentage of overweight and obesity among Canadian children in 2004 by age group, (adapted from Sheilds, 2006)

| | 2-5 years | 6-11 years | 12-17 years |
|---|---|---|---|
| **Overweight (%)** | 15 | 18 | 20 |
| **Obese (%)** | 6 | 8 | 9 |

*2.2.3 Measurement of Overweight and Obesity in Children*

Data on the prevalence of overweight and obesity depend on accurate measurements and the tool on which growth is measured. Measures of overweight and obesity such as waist circumference, bio-impedance analysis, DXA and skinfold thickness are commonly used in research to determine adiposity and can be more sensitive than BMI (Hubert et al., 2009), yet in large studies these methods can be expensive, time-consuming and impractical. Indirect measures of adiposity, such as BMI, are used in large surveys such as CCHS 2.2 (Health Canada, 2006). Measured height and weight are preferable to self-reported or parental-reported height and weights (Himes, 2009). In children, there are challenges in accurately measuring height and weight, and thus calculating BMI and BMI-for-age. Child-error such as fidgeting and hydration, calibration of equipment, as well as intra- and inter-observer variability are potential sources of measurement errors (Himes, 2009). In CCHS 2.2 trained interviewers measured height and weight of children (Health Canada, 2006) and these were used to determine BMI.

As BMI and BMI-for-age are proxy measures of adiposity, research has been conducted on the validity of these measures. Freedman and Sherry (2009) authored a review of the validation studies and stated that among children who have BMI-for-age > $95^{th}$ percentile, BMI is a fairly good estimate of adiposity with 70-80% sensitivity and 95% specificity. Children who have a BMI-for-age between $85\text{-}94^{th}$ percentile "are more likely to have adverse levels of multiple risk factors and to become obese adults; their risks however are lower than those of obese children" (Freedman & Sherry, 2009). Similar results were found by Flegal and colleagues (2010) who used DXA to assess the accuracy of BMI-for-age in predicting adiposity. In children

8-19 years old who participated in NHANES 1999-2004, those who had a high BMI-for-age (≥95$^{th}$ percentile), were more likely to have high adiposity as determined by DXA (Flegal et al., 2010). Children who had a BMI-for-age < 85$^{th}$ percentile were less likely to have high adiposity (Flegal et al., 2010).

*2.2.3.1 Growth References and Standards*

Overweight and obesity can be assessed using BMI in a variety of methods such as growth charts (e.g. CDC or WHO growth charts) or cut-points (e.g. Cole criteria). Each of these carries its own statistical errors that are inherent in the development of the tool (Himes, 2009). In addition, the growth charts on which measurements are plotted were designed for different purposes such as identification of health risk of populations (e.g. Cole criteria) or characterizing healthy growth patterns (e.g. WHO growth charts), or a combination of clinical use and population study (e.g. CDC).

The growth reference charts commonly used in current public health practice in Canada are from the Centres for Disease Control and Prevention in the United States, published in 2000 (Kuczmarski et al., 2000; Dietitians of Canada et al., 2004). These growth charts were developed using five national surveys between 1963 and 1994, plus supplementary data on infants that was not available from the national surveys (Kuczmarski et al., 2002). Body mass index-for-age growth reference charts from the CDC have been developed for children two to 20 years of age and have been recommended for use in Canada (Dietitians of Canada et al., 2004). These charts provide a visual method of monitoring individual children's growth, and are commonly used in population studies (Kuczmarski et al., 2002). The BMI-for-age charts are distinct for boys and girls, but both follow a similar pattern that begin with a rise in BMI after birth followed by a decrease in BMI until approximately age 6 (Kuczmarski et al., 2002). This drop in BMI is termed the adiposity rebound. Some research shows that an early adiposity rebound increases risk of the development of overweight and obesity later in childhood (Williams & Goulding, 2009).

Upon release of the CDC growth charts in 2000, definitions on assessment of children's growth were provided based on percentiles: those children who had BMI-for-age between the 85$^{th}$ and 95$^{th}$ percentile were "at risk of overweight", and those who were ≥ 95$^{th}$ percentile were “overweight” (Dietitians of Canada et al., 2004). In 2004, Canadian health agencies released recommendations on how to use the CDC growth charts, including BMI-for-age growth reference charts. The Canadian recommendations stated that the term “overweight” was to be used for children who had a BMI-for-age between $85^{th}$ and $95^{th}$ percentiles and “obese” for children who had a BMI $\geq 95^{th}$ percentile (Dietitians of Canada et al., 2004). The CDC growth charts are well suited to correctly identifying children with excess adiposity when BMI-for-age is $\geq 95^{th}$ percentile, and less so when BMI-for-age is $<95^{th}$ percentile (Dietitians of Canada et al., 2004; Freedman et al., 2009). The Canadian recommendations also highlighted that BMI-for-age growth charts by CDC were appropriate for use for children suspected of overweight and obesity, but for children $< 5^{th}$ percentile who may be at risk for underweight or stunting should be assessed using other tools such as weight-for-stature growth charts (Dietitians of Canada, 2004).

The CDC growth reference charts were based on measurements of American children and are reflective of the growth pattern of children in that country, whether or not recommended feeding practices were followed. Growth standards, as opposed to growth references, are designed to describe the growth patterns of children of mothers who follow recommended practices such as exclusive breastfeeding until 6 months and not smoking (de Onis, Garza, Onyango, & Borghi, 2007). These growth standards therefore, describe how children *should* grow (de Onis et al., 2007).

International growth standards have been released from the World Health Organization (WHO Multicentre Growth Reference Study Group, 2006). Their use in Canada was under consideration (Canadian Paediatric Society, 2009) until recent guidelines were released on their use in Canada (Dietitians of Canada, Canadian Paediatric Society, The College of Family Physicians of Canada, Community Health Nurses Association of Canada, 2010). These standards were developed using data from children from multiple countries who were fed according to recommendations; children were prospectively followed and measured frequently (WHO Multicentre Growth Reference Study Group, 2006). The World Health Organization Child Growth Standards are for children from birth to age five, and the Growth Reference 2007 are for children from 5-19 years. These growth standards include recommendations on cut-offs for over nutrition that differ from the CDC cut-offs (Dietitians of Canada, Canadian Paediatric Society, The College of Family Physicians of Canada, Community Health Nurses Association of

Canada, 2010). The suggested cut-offs for the WHO growth charts are presented in Table 2.3. The Canadian recommendations on use of the WHO growth charts were not available until early 2010 (Dietitians of Canada, Canadian Paediatric Society, The College of Family Physicians of Canada, Community Health Nurses Association of Canada, 2010).

In comparing the CDC charts to the WHO charts, more children will be identified as overweight and obese with the WHO standards, although most differences will occur among children 24 months or less (Dietitians of Canada, Canadian Paediatric Society, The College of Family Physicians of Canada, Community Health Nurses Association of Canada, 2010). Some authors have questioned the WHO cut-offs for overweight and obesity as the growth standards are intentionally describing a healthy population, thus establishing risk-based cut offs from this group is counter-intuitive (Himes, 2009).

Table 2.3 Recommended cut-offs for screening for over nutrition by the World Health Organization*

| **Parameter** | **Age 2 to 5 years (Growth Standards)** | **Age 5 to 19 years (WHO Reference 2007)** |
|---|---|---|
| Risk for overweight | >85$^{th}$ percentile | Not applicable |
| Overweight | > 97$^{th}$ percentile | > 85$^{th}$ percentile |
| Obese | > 99.9$^{th}$ percentile | > 97$^{th}$ percentile |
| Severe Obesity | Not applicable | > 99.9$^{th}$ percentile |

* adapted from Dietitians of Canada, Canadian Paediatric Society, The College of Family Physicians of Canada, Community Health Nurses Association of Canada, 2010

The International Obesity Task Force (IOTF) criteria are BMI cut-points for overweight and obesity that have been extrapolated for children from adult definitions of overweight (BMI >25 kg/m$^2$), and obesity (BMI >30 kg/m$^2$) (Cole et al., 2000). The IOTF criteria area also know as the "Cole criteria". The adult cut-points for overweight and obesity are defined based on health risk.  These criteria were developed to create a standard definition of overweight and obesity for children that could be used to compare research worldwide (Cole, 2000). The centile curves for children 2 to 18 years were developed using data from an ethnically diverse population including that from Brazil, Great Britain, Hong Kong, the Netherlands, Singapore, and the United States (Cole, 2000). The IOTF criteria are recommended for population use rather than for evaluation of individual children's growth (Himes, 2009). Compared to the CDC growth charts (2000), IOTF cut offs for overweight and obesity correspond to 82-84$^{th}$ and 96-97$^{th}$ percentiles on the CDC charts (Himes, 2009). Al-Raees et al. compared the IOTF and WHO criteria among a population of Baharanian preschool children, and found that the WHO criteria estimates of overweight and obesity was two times higher than when the IOTF criteria were used (Al-Raees, Al-Amer, Musaiger, & D'Souza, 2009), a similar result to when WHO criteria are compared to CDC criteria (Dietitians of Canada, Canadian Paediatric Society, The College of Family Physicians of Canada, Community Health Nurses Association of Canada, 2010).

### *2.3 Beverages and Overweight and Obesity Among Children*

#### *2.3.1 Potential Mechanisms*

No clear mechanism has been determined for sweetened beverages causing excess weight gain. However, many have been proposed, including the lack of satiety provided by sweetened beverages leading to a positive energy balance, the adiposity-promoting effect of high fructose corn syrup (HFCS) and that sweetened beverages often replace milk which may play a role in weight control (Bachman, Baranowski, & Nicklas, 2006; Malik et al., 2006).

Researchers have found that beverages provide less satiety and there is no equivalent decrease in consumption of calories from solid food when beverages are consumed (DiMeglio & Mattes, 2000; Harrington, 2008; Mattes, 2006; Raben et al., 2002). In a classic study, a cross-over design was used to assess the difference on energy compensation between a liquid form of carbohydrates versus a solid form (jelly beans) (DiMeglio & Mattes, 2000). Authors found that liquid carbohydrate, such as sweetened beverages, do not provide satiety or compensation of energy intake over time (DiMeglio & Mattes, 2000). Experimental studies in adults have shown that energy-containing beverages did not provide satiety (St-Onge et al., 2004) and increase total energy intake, indicating no compensatory effect (Hartline-Grafton, Rose, Johnson, Rice, & Webber, 2009; Van Wymelbeke, Beridot-Therond, de La Gueronniere, & Fantino, 2004). In an intervention study on adolescents, Ebbeling and colleagues found that subjects who were overweight and changed their sweetened beverage intake to a non-caloric beverage lost the most weight compared to those who were not in the upper tertile of BMI (Ebbeling et al., 2006). It is less clear how beverage intake affects young children's appetite and caloric intake.

Birch and colleagues studied preschoolers' intake of food following consumption of various beverages to determine the extent children showed caloric compensation (Birch, McPhee, & Sullivan, 1989). Beverages included those sweetened with sucrose, low-glucose maltodextrin, and non-caloric beverages with aspartame, as well as a control of water (Birch et al., 1989). Authors found that young children do exhibit some caloric compensation, with sweetened beverages as opposed to adults (Birch et al., 1989). Researchers also noted that beverages sweetened with aspartame suppressed intake of food, and they suggest that it is due to post-ingestion cues of sweetness (Birch et al., 1989).

These findings are opposite to that of Wilson and colleagues who looked at the compensatory effects of milk and chocolate milk at a lunch meal and found no decrease in food intake at lunch time (Wilson, 2000), nor at an afternoon snack, despite consumption of higher calorie chocolate milk at lunch time (Wilson, 1999). Similar results were found by Buyken, who found no relationship between glycemic index (GI), BMI, and increased fatness in a longitudinal study of 2-7 year olds in Germany (Buyken et al., 2008). They proposed that toddlers eat frequently and the postprandial effects of high GI foods are not seen because preschoolers eat a snack or meal before effects of hunger are apparent (Buyken et al., 2008). It is important to note that GI, on a population level, is not only related to carbohydrate foods such as sweetened beverages, but to mixtures of foods (Schulz et al., 2005). Overall, young children may have imprecise energy regulation (Birch & Fisher, 1997; Mrdjenovic & Levitsky, 2005), and obese children may be less able to regulate energy intake (Alvina & Araya, 2004), be less responsive to internal satiety cues, and more responsive to environmental cues (Carnell & Wardle, 2009).

Some have noted that the rise in obesity has paralleled the rise in use of high-fructose corn syrup and suggested that it may play a role in this increase (Bray, 2008; Bray, 2010). High fructose corn syrup (HFCS) is a sweetener that includes fructose and glucose (Bray, Nielsen, & Popkin, 2004). HFCS-55 (55% fructose) is 1.28 times a sweet as sucrose and is commonly used in sweetened beverages (Bray et al., 2004). Fructose is absorbed differently than sucrose and does not stimulate insulin secretion or leptin production- both of which are appetite supressors (Bray et al., 2004; Elliott, Keim, Stern, Teff, & Havel, 2002; Teff et al., 2004). Studies on mice have shown an increase in weight with HFCS consumption (Jurgens et al., 2005), and studies on adults have shown a decrease in insulin response and leptin secretion, but an increase in ghrelin levels, which authors state may contribute to weight gain (Teff et al., 2004) and changes in lipid profiles (Havel, 2005; Stanhope & Havel, 2008). It is not clear how HFCS affects young children's endocrine system.

In a commentary by White (2008) it was argued that there is no significant metabolic difference between HFCS and other sweeteners such as sugar and honey. They argue that the rise in HFCS has been accompanied by a decrease in sucrose, therefore has not contributed to an increase in the total amount of sweeteners available (White, 2008). White (2008) also states that studies examining the relationship between HFCS and obesity have used inappropriate models such as very high fructose concentrations, pure fructose, or animal models that do not reflect current human consumption patterns. However, it must be noted that this author has relationships with the food and beverage industry, including corn refiners (White, 2008). Papers that have been supported by industry rarely conclude that sweetened beverages (or HFCS) are associated with an increase health risk (Lesser, Ebbeling, Goozner, Wypij, & Ludwig, 2007). Some of the authors who have received support from beverage industry include Forshee, Nicklas, and Skinner, among others. Despite this debate, more research is needed to understand the impact of fructose-sweetened beverages on weight gain in humans (Brown, Dulloo, & Montani, 2008; Elliott et al., 2002; Havel, 2005; Stanhope et al., 2009).

It may also be that sweetened beverages replace milk intake among children, which may play a role in weight control (Bachman et al., 2006; Malik et al., 2006). Some authors have found that milk consumption among children (mean age 7.5 years) was inversely associated with age and sex adjusted BMI z-scores (Barba, Troiano, Russo, Venezia, & Siani, 2005). Others have looked at 9-10 year olds and compared their resting energy expenditure (REE) in a cross over design with either milk or fruit beverage (St-Onge, Claps, Heshka, Heymsfield, & Kosteli, 2007). Authors found that REE increased with milk supplementation over that of fruit drink supplementation (St-Onge et al., 2007). They conclude that milk has a preferential effect on metabolic energy expenditure (St-Onge et al., 2007). In a study on adults, St-Onge and colleagues found that a mixed nutrient beverage (Boost ™) increased the thermic effect of food and increased satiety ratings, relative to a sugar-only beverage, showing a potential mechanism for weight gain in adults who drink sweetened beverages (St-Onge et al., 2004). It is unclear if this relationship would be seen in young children.

*2.3.2 Potential Confounders*

The etiology of obesity in childhood is complex. Socio-demographic factors, such as sex, ethnicity, household income, household education, and household food security status have been associated with obesity in children. In addition, sedentary and physical activity behaviours have been related to the development of obesity in children. Each of these factors will be briefly reviewed here.

In a longitudinal study on children's nutrient intake and weight, Skinner et al. found that girls were more likely to have higher percent body fat than boys (Skinner, Bounds, Carruth, & Ziegler, 2003). This study was among white children 2 months until 8 years, and mostly from middle- to upper socio-economic status (Skinner et al., 2003). However, CCHS 2.2 data showed no sex difference in the prevalence of obesity among 2 to 5 year olds or 6 to 11 year olds (Shields, 2006). Girls 12 to 17 years old had a significantly lower prevalence of overweight and obesity (combined) than boys of the same age (Table 2.2) (Shields, 2006).

Taveras et al. (2010) examined ethnic differences in early life focusing on known risk factors for obesity. This study was based in the US, and used three major ethnic groups: White, Black, and Hispanic. They found that Black and Hispanic children were more likely to have a higher intake of sugar sweetened beverages compared to White children (OR 4.11 Black, 2.48 Hispanic) and these ethnic groups had higher prevalence of BMI-for-age >95$^{th}$ percentile among children 3 years old (Taveras et al., 2010). Among Canadian children 2-17 years, those of Southeast/East Asian descent had lower prevalence of overweight and obesity (combined) compared to White children, however there was uncertainty in this estimate (Shields, 2006). Canadian Aboriginal off-reserve children had a higher prevalence of overweight and obesity (combined) compared to White children (Shields, 2006). Despite oversampling of Aboriginal Canadians in CCHS 2.2, some authors state that indigenous populations included in national surveys is inadequate (Ruben, 2009). Data on the prevalence of overweight and obesity among on-reserve Aboriginal children is often limited to specific communities and thus not representative of Canada (Willows, 2005).

Socio-economic factors have also been associated with childhood overweight and obesity. Murasko et al., using NHANES 1999-2006 data, found an inverse relationship between family socio-economic status and prevalence of childhood overweight and obesity among 2-19 year olds, where those with higher income (adjusted for inflation) had lower risk of overweight and obesity (Murasko, 2009). Similar results were found where high parental income and education was associated with lower body weight among young children (Bhargava, Jolliffe, & Howard, 2008). Some have found that the prevalence of overweight and obesity is increasing at a faster rate among US children living in low-socio-economic households compared to the total population (Singh, Siahpush, & Kogan, 2010). Among children in Canada, those who lived in households with income that was considered low-middle, middle, or upper-middle had a higher prevalence of overweight and obesity (combined) compared to children in high income households (Shields, 2006). In addition, Canadian children living in households where the highest level of education was less than secondary school graduation had higher prevalence of overweight and obesity compared to those children living in higher education households (Shields, 2006).

Food security "exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life" (Agriculture and Agri-Food Canada, 1998). Food insecurity is the absence of food security. In Canada, 13% of households with children less than 6 years old experience food insecurity, and 15% of households with three or more children experience food insecurity (Health Canada, 2007b). Food insecurity often occurs when food is difficult to access during times of limited finances but does not necessarily mean that people are hungry, rather they may compromise their food choices and thus nutrient adequacy (Kirkpatrick & Tarasuk, 2007). However, caregivers who experience food insecurity often protect their children from food insecurity by sacrificing their own dietary intake (McIntyre et al., 2003). Despite this, food insecurity has been associated with overweight among children, especially girls 2 to 5 years of age (Metallinos-Katsaras, Sherry, & Kallio, 2009). Others have found no relationship between overweight and food insecurity among children (Bhargava et al., 2008; Gundersen, Lohman, Garasky, Stewart, & Eisenmann, 2008), and adolescents (Lohman, Stewart, Gundersen, Garasky, & Eisenmann, 2009).

Physical and sedentary activity levels are important considerations when examining the overweight and obesity among children. Skinner et al. (2003) completed a longitudinal study on children 2 months until 8 years old, and found that sedentary activity was positively related to percent body fat. National level data from the US between 1999-2006 have shown that sedentary activities such as television viewing or computer use were more common among overweight or obese youth (Fulton et al., 2009). Similarly, among Canadian children 6 to 11 years, those who spend more than two hours per day at a computer or watching television have a higher prevalence of overweight and obesity compared to children who have less than or equal to one hour of screen time (Shields, 2006). Among adolescents 12-17 years, those who spent more than 20 hours per week in front of a screen (television or computer) had a higher prevalence of overweight and obesity compared to those who had less than 10 hours per week of screen time (Shields, 2006). The prevalence of overweight and obesity among 6 to 11 year olds was not significantly different between children who had different levels of physical activity (Shields, 2006).

### *2.3.3 Previous Research*

There has been a growing amount of research on the relationship between beverage intake and children's weight and adiposity. None, however, used national-level Canadian data. Table 2.4 presents a summary of studies on preschool aged children, beginning with cross-sectional studies, followed by longitudinal studies. Table 2.5 presents information on school-aged children, and includes experimental studies. A number of meta-analyses on the subject have also been completed, and are summarized in Table 2.6. Despite the large amount of literature on the subject, there is little consensus. This may be due to the inconsistencies in the methodologies such as different ways of measuring intake of sweetened beverages (e.g. as servings, as cups, as cans or bottles, as grams or milliliters), the different beverages included as "sweetened beverages", and the different methods of assessing intake (e.g. questionnaires to parents, validated FFQ, 24-hour recalls, 3-day food records, or weighed food records).

Table 2.4: Studies on beverages and overweight and obesity among preschool-aged children

| Reference (n in study) | Population | Year(s) data collected | Anthropometrics | Dietary assessment | Beverage categories | Outcome measurement | Key Findings |
|---|---|---|---|---|---|---|---|
| **Cross sectional studies** | | | | | | | |
| Dennison, 1997 (n= 225) | Convenience sample, New York mostly white, low-mid income, both sexes, 2-5y | 1992/ 93 | Ht & wt measured | 7 d diet records | 100% juice, milk, soda pop, other sweetened drinks | Height – for-age; PI, BMI (Ham) | 100% juice associated with short statue and obesity |
| Dennison, 1999 (n= 163) | Convenience sample, New York, mostly white, low-mid income, both sexes 2-5y | 1992/ 93 | Ht & wt measured | 14 d diet records | 100% juice | BMI, PI | Apple & grape juice inversely associated with ht; apple juice associated with BMI and PI [a] |
| O'Connor, 2006 (n= 1160) | NHANES, both sexes, 2-5y | 1999-2002 | Ht & wt measured | 24-hr recall | 100% juice, fruit drinks, milk, sweetened soft drink, diet drinks | BMI %tiles (CDC); wt | No association between beverage intake and wt or BMI [ab] |
| Nelson, 2006 (n= 526) | WIC, New York City, mostly Hispanic & Black, both sexes, 2-4y | 2003 | Ht & wt measured | Parent report | Plain milk, flavoured milk, non-juice fruit drinks, fruit juice, water, soda, sweetened iced tea | BMI %tiles (CDC) | Consuming >1 non-juice fruit drink/ d was associated with increased risk of overweight [b] |
| LaRowe, 2007 (n=541) | NHANES, both sexes 2-5y | 2001/ 02 | Ht & wt measured | 24-hr recall | Fruit juice, high-fat milk, reduced-fat milk, soda, diet soda, sweetened beverages, coffee & tea, water | BMI %tiles (CDC) | No difference in BMI across beverage patterns [b] |
| Linardakis, 2008 (n= 856) | Crete, Greece, both sexes, 4-7y | 2004/ 05 | Ht, wt, WC measured | 3-d wei-ghed records | Sugar added beverages: soft drinks, fruit juices with added sugar | BMI (IOTF), WC | High consumers had higher BMI levels, higher risk of obesity [a] |
| Nicklas, 2008 (n= 3618) | NHANES, both sexes, 2-11y | 1999-2002 | Ht & wt measured | 24-hr recall | 100% juice | %tiles for BMI ; WC, skinfold (CDC) | No association between juice intake and overweight [a]* |
| **Longitudinal** | | | | | | | |
| Alexy, 1999 | Germany; | 1990- | Measure | 3-d | 100% juice, fruit | BMI % | BMI not correlated with juice intake |

| Reference (n in study) | Population | Year(s) data collected | Anthropometrics | Dietary assessment | Beverage categories | Outcome measurement | Key Findings |
|---|---|---|---|---|---|---|---|
| (n= 205) | DONALD study, both sexes, 3-5y | 1997 | d height & weight yearly | weighed food records yearly | drinks, sweetened beverages (soda & colas), milk, water | tiles (ECOG) | |
| Skinner, 1999 (n= 105) | White, mid-upper SES, both sexes, 2mo-36 mo | 1994-1995 | Ht & wt measured | 1-24 hr recall, 2 d food records | Milk, juice, soda pop, other drinks (eg: lemonade) | BMI %tiles (Ham); PI | No relationship between juice and height, BMI or PI * |
| Skinner, 2001 (n= 72) | White children in Southern US city, both sexes, 2-6y | 1992-1999 | Ht & wt measured at 72 mo | 24-hr recalls, 2 records | 100% juice, milk, carbonated beverages, other drinks (e.g. lemonade) | BMI %tiles, PI, wt | Longitudinal juice intake not related to ht, wt or BMI. Negative association with PI * |
| Newby, 2004 (n= 1345) | WIC North Dakota, both sexes, 2-5 y | 1995-1998 | Ht & wt measured, data collected over mean of 8.4 mo | FFQ | 100% fruit juice, fruit drink, soda, diet soda, milk | Wt change, BMI change, BMI %tiles (CDC) | No association between any beverage intake and wt change or BMI change [a] |
| Welsh 2005 (n= 10904) | WIC Missouri, both sexes, 2-3y | 1999-2001 | Ht & wt from chart | FFQ, parent report | Sweet drink: juice, fruit drink, soda | BMI %tiles (CDC) | Positive association for overweight/ at risk for overweight at baseline and who consumed 1-3 sweet drinks/d [a] |
| Faith, 2006 (n=2801) | WIC in New York, both sexes, 1-4y | 1999/ 2000 - 2002 | Ht & wt measured every 6 mo, from chart | Caregiver completed questionnaire | 100% juice (not clear if juice and drink were distinguished) | BMI z-score slope (CDC) | Among children who were ≥85$^{th}$% for BMI, increased juice intake was associated with excess adiposity gain |
| Dubois, 2007 (n=1499) | Quebec, Canada, both sexes, 4-5y | 1998-2002 | Ht & wt measured at 2.5, 3.5, 4.5 y | 24-hr recall, FFQ | Sugar sweetened beverages: regular carbonated drinks, fruit flavoured drinks | BMI %tile (CDC) | Regular SSB consumption between meals from 2.5-4.5y doubled the odds of being overweight at 4.5 y (OR 2.1-2.4), moreso in low-income families (OR 2.7-3.4) [ab] |
| Kral, 2008 (n=49) | Children were labeled High or Low risk based on mothers' pre- | | Ht, wt, WC measured yearly | Yearly 3-d weighed food | Milk, fruit juice, fruit drinks, soda, diet soda, & combinations thereof | BMI z-score, WC | No association with BMI, but WC increased in both groups with soda consumption [a] |

| Reference (n in study) | Population | Year(s) data collected | Anthropometrics | Dietary assessment | Beverage categories | Outcome measurement | Key Findings |
|---|---|---|---|---|---|---|---|
| | pregnancy BMI | | | diaries | | | |
| Nissinen, 2009 (n=2139) | Cardiovascular Risk in Young Finns Study, both sexes, 3-18y (b) | 1980, 2001 | Ht & wt measured | Self-administered questionnaire (b) and end | Sugar-sweetened soft drinks | BMI (IOTF) | An increase in soft drink intake from childhood to adulthood was associated with increased BMI and odds of overweight among women, but not men [b] |

*: received beverage industry funding
a: adjusted for energy intake
b: adjusted for physical activity
(b): baseline
BIA: Bioelectrical Impedance Analysis
CDC: Centre for Disease Control and Prevention cutpoints: 85$^{th}$ – 95$^{th}$ percentile for BMI = at-risk-for overweight; 95$^{th}$ percentile = overweight
CSFII: Continuing Survey of Food Intakes of Individuals
DXA: Dual X-ray Absorptiometry
ECOG: European Childhood Obesity Group cutpoints: >90$^{th}$ percentile BMI = obese
FFQ: Food Frequency Questionnaire
Ham: Hammer cutpoints: >75$^{th}$ percentile= overweight; ≥90$^{th}$ percentile = obese
IOTF: International Obesity Task Force
NHANES: National Health and Nutrition Examination Survey
PI: Ponderal index =wt (kg)/ht (m)$^3$
WC: Waist Circumference
WIC: Women Infants and Children

Table 2.5: Studies on beverages and overweight and obesity among school- aged children

| Reference (n in study) | Population | Year data collected | Anthropo metrics | Dietary assessment | Beverage categories | Outcome measurement | Key Findings |
|---|---|---|---|---|---|---|---|
| **Cross sectional studies** | | | | | | | |
| Ramic, 2009 (n= 530) | Bosnia-Herzegovina, both sexes, 7-14y | | Ht & wt measured | Question naire | Not stated | BMI %tiles | No relationship between carbonated beverage consumption and BMI |
| Jansen, 2010 (n=1095) | Dutch, both sexes, 9-12 y | 2006 | Ht & wt measured | Question naire | lemonade, soft drinks, fruit juice (except orange and grapefruit drinks), sports drinks, chocolate milk and yougurt drinks | BMI (IOTF) | No association between sweetened drink intake and overweight |
| Gibson, 2007 (n=1294) | UK National Dietary and Nutritional Survey of Young People, both sexes, 7-18y | 1997 | Ht & wt measured | 7-d weighed recall | Caloric soft drinks | BMI, BMI z-score (IOTF) | High consumers (>396kJ/d) were at highest risk of overweight, although the relationship was non-linear * |
| LaRowe, 2007 (n=793) | NHANES, both sexes, 6-11y | 2001/ 02 | Ht & wt measured | 24-hr recall | Fruit juice, high-fat milk, reduced-fat milk, soda, diet soda, sweetened beverages, coffee & tea, water | BMI %tiles (CDC) | BMI was higher in water, sweetened drinks and soda patterns [b] |
| Gillis, 2003 (n=181) | Obese & non-obese Caucasian Canadians, both sexes, 4-16y | 2001 | Ht & wt measured; BIA | 24-hr recall, modified FFQ | Regular soda pop, sugar sweetened drinks | NHANES definition of obesity | Obese boys consumed more sugar sweetened drinks than girls. Positive association between sugar sweetened drinks and body fat. |
| Nicklas, 2003 (n= 1562) | Bogalusa heart study; African American and Euro-American, both sexes, 10y | 1973-1994^ | Ht & wt measured | 24-hr recall | Sweetened beverages included soft drinks, fruit drinks, sweetened coffee & teas | BMI (CDC) | Intake of sweetened beverages was associated with increased risk of overweight among European Americans [a] |
| Rodriguez-Artalejo, 2003 (n=1112) | Spain, both sexes, 6-7y | 1998-9 | Ht & wt measured | FFQ by caregiver | Sweetened soft drinks | BMI | Sweetened soft drinks associated with higher energy intake but not BMI [a] |

| **Reference (n in study)** | **Population** | **Year data collected** | **Anthropo metrics** | **Dietary assessment** | **Beverage categories** | **Outcome measurement** | **Key Findings** |
|---|---|---|---|---|---|---|---|
| Forshee, 2003 (n= 3311) | CSFII, both sexes, 6-19y | 1994-6&98 | "described elsewhere" | "described elsewhere" | Milk, fruit drinks/ades, carbonated soft drinks, citrus juice, non-citrus juice | BMI | BMI was not related to beverage consumption in boys; in girls BMI was negatively related to milk and positively related to diet drink consumption * |
| Giammattei, 2003 (n=385) | Schools in Santa Barbara county, both sexes, 11-14y | 2000-2001 | Ht & wt measured | 18 item questionnaire | Soft drinks | BMI %tiles, z-scores (CDC) | ≥ 3 soft drinks/day associated with higher BMI z-score |
| Forshee, 2004 (n=2216) | NHANES, both sexes, 12-16y | 1988-1994 | Ht & wt measured | 24-hr recall, FFQ | Regular carbonated soft drinks, fruit drinks/ades, diet soft drinks | BMI | No relationship between BMI and soft drinks or fruit drinks; diet drinks were associated with BMI for females * [ab] |
| Novotny, 2004 (n=323) | Oahu, Hawaii, girls, 9-14y | 2000-2001 | Ht, wt, iliac skinfold thickness measured | 3-d diet record | Soda | Weight, body fat | Weight was positively associated with soda intake [ab] |
| Andersen, 2005 (n= 1489) | Norway, both sexes, 9, 13y | 1993 & 2000 | Self-reported ht & wt | Pre-coded food diary | Sweets included sweetened beverages | BMI %tile (IOTF) | No association between sweetened soft drinks and overweight [ab] |
| Barba, 2005 (n=884) | Italy, both sexes, 7.5y | 2000-2002 | Ht & wt measured | FFQ by caregiver | Milk | BMI z-score (IOTF) | Milk consumption was inversely associated with BMI z-scores [b] |
| Sanigorski, 2007 (n=1944) | Australia, both sexes, 4-12y | N/A | Ht & wt measured | interview parents on children's usual intake | Soft drinks, fruit juice/drink, cordials (energy containing mineral water, sports drinks) | BMI (IOTF) | Children who had >2 fruit drinks or ≥3 soft drinks on the previous day were more likely to be overweight/obese |
| Denova-Gutierrez, 2008 (n=1055) | Mexico, Health Workers Cohort Study, both sexes, 10-19y | 2004-2006 | Ht & wt measured, DXA | FFQ | Colas, flavoured sodas, flavoured water with sugar, diet cola | BMI, body composition, WC, body fat | High consumers of sweetened beverages were more likely to have higher BMI and body fat. Increased consumption of sweetened beverages as associated with increased odds of obesity and excess body fat |

| Reference (n in study) | Population | Year data collected | Anthropo metrics | Dietary assessment | Beverage categories | Outcome measurement | Key Findings |
|---|---|---|---|---|---|---|---|
| **Longitudinal Studies** | | | | | | | |
| Tam, 2006 (n=268) | Australian, both sexes, 7.7y at (b) | 1996/ 97 to 2001/ 02 | Ht & wt measured | 3 d food record | Soft drinks, fruit juice/drinks, milk | BMI (IOTF) | Intake of soft drinks were associated with weight gain after 5y |
| Johnson, 2007 (n=1230) | Avon Longitudinal Study of Parents and Children UK, both sexes, aged 5,7,9y | 1997-2001 | Ht & wt measured, DXA | 3 d food records | Sugar sweetened beverages, milk, fruit juice, low energy drinks, water | Fat mass | No association between sweetened beverage intake and fatness at age 9 |
| Mrdjenovic, 2003 (n=21) | Children participating in Cornell Summer Day Camp, both sexes, 6-13y | 1997 | Ht & wt measured | Weighed food records | Milk, fruit juice, sweetened drinks (fruit drinks, powdered drinks, soda, <100% juice) | BMI | High consumers of sweetened beverages experienced weight gain compared to lower consumers. |
| Ludwig, 2001 (n=548) | Planet Health; Boston US, ethnically diverse, both sexes, 11.7y at baseline | 1995-1997 | Ht, wt, triceps skinfold thickness measured | Youth-FFQ | Soda, sweetened fruit drink, unsweetened iced tea, diet soda, fruit juice | BMI | Each additional SSB serving BMI increased by 0.24; OR 1.6 (1.14-2.24) fully adjusted model change in consumption and incidence of obesity (classified as non-obese at baseline) [ab] |
| Phillips, 2004 (n=196) | Non-obese pre-menarchal girls; Massachusetts Institute of Technology Growth and Development Study, 8-12y | 1990-1993; followed until 4y post menarche | Ht, wt, BIA measured | FFQ yearly | Sugar sweetened soda included as an energy dense snack food | BMI z-score (CDC), % BF | Soda positively related to BMI z-score but not %BF *[ab] |
| Berkey, 2004 (n=12,192) | GUTS, both sexes, 9-14y | 1996 (b), 97, 98 | Ht & wt self-reported | Annual FFQ | Sugar added beverages (soda, sweetened iced tea, fruit drinks), fruit juice, milk | Change in BMI | SSB was associated with increased BMI in boys; children who increased intake by 2 servings gained weight the following year; when E added to the model, results were NS [ab] |
| Blum, 2005 (n=164) | Convenience sample, 94% | 1992-1996 | Ht & wt measured | 24 hr recall | Milk, juice, diet soda, sugar sweetened | BMI z-score | Diet soda was associated with increased BMI z-score at 2 yrs [a] |

| Reference (n in study) | Population | Year data collected | Anthropo metrics | Dietary assessment | Beverage categories | Outcome measurement | Key Findings |
|---|---|---|---|---|---|---|---|
| | white, both sexes, grades 3-6 | | | | | | |
| **Experimental studies** | | | | | | | |
| James, 2004 (n=644) | Primary schools in England, both sexes, 7-11y | 2001-2002 | Ht, wt, WC measured | 3 d self-reported diaries; at (b) & end | Carbonated drinks, diet carbonated drinks, carbonated drinks with caffeine, water | BMI %tile & z-scores (1990 British growth ref) | Carbonated beverage consumption decreased in intervention group, increased in control; %age of overweight increased in control group and decreased in intervention groups |
| Ebbeling, 2006 (n=103) | Both sexes, 13-18y, followed for 25 weeks | 2003-2004 | Ht & wt measured | 24-hr diet and physical activity recalls | Soft drinks, fruit drinks | Sex, age, group x baseline BMI | Consumption decreased in intervention group but not in control group; net difference in change in BMI was not significant; those who had higher BMI at baseline decreased BMI in intervention group, more than controls * |
| Sichieri, 2008 (n=1140) | Brazil, both sexes, 9-12y | 2005 | Ht & wt measured | 24 hr recall at (b) and end | Sugar sweetened carbonated beverages, other sugar-sweetened beverages, milk juice, powdered flavoured beverages | Change in BMI (IOTF) | Carbonated drinks consumption decreased but BMI did not; girls who were overweight at baseline showed BMI reduction compared to controls |

^ seven cross-sectional studies combined
*: received beverage industry funding
a: adjusted for energy intake
b: adjusted for physical activity
(b): baseline
BIA: Bioelectrical Impedance Analysis
CDC: Centre for Disease Control and Prevention cutpoints: 85$^{th}$ – 95$^{th}$ percentile for BMI = at-risk-for overweight; 95$^{th}$ percentile = overweight
CSFII: Continuing Survey of Food Intakes of Individuals
DXA: Dual X-ray Absorptiometry
FFQ: Food Frequency Questionnaire
IOTF: International Obesity Task Force
NHANES: National Health and Nutrition Examination Survey
WC: Waist Circumference
WIC: Women Infants and Children

Table 2.6: Meta-analyses on beverage intake and overweight and obesity

| Author, year | Inclusion/exclusion criteria | Studies reviewed (type, #) | Results/Conclusion |
|---|---|---|---|
| Summerbell, 2009 | Varied based on beverage type | Only cohort studies examined. 1 on water, 7 on milk, 3 non-carbonated sugary drinks, 2 on carbonated beverages, 6 on juice | No association with weight gain and obesity for any beverage type, yet results are mixed |
| Malik 2006; | Searched publications from 1966- 2005 for sugar sweetened beverages and the risk of weight gain in adults and children; cohort must be ≥6 mo | 30 total: 15 (13) cross-sectional, 10 (5) cohort, 5 (2) experimental; the # of studies on children is in ( ) | Concluded that there may be a relationship between SSB and weight; studies included both adults and children; advised to reduce intake of SSB and replace with water, milk or small amounts of 100% juice |
| Vartanian, 2007 | Meta-analysis; soft drink consumption and nutrition and health outcomes; keywords: soft drink, soda, sweetened beverage. Outcomes included energy intake, body weight, milk intake, calcium intake, nutrition, health. Included both adults & children | 88 studies; large variability in study designs | Soft drink intake is associated with increased energy intake and body weight; also negative association with milk, calcium and other nutrients; recommend a reduction in soft drink consumption |
| Forshee 2008 | searched for RCTs and longitudinal studies of SSB and weight/ BMI among children and adolescents between 1966 and 2006; excluded ecological and cross-sectional studies; also reviewed unpublished databases | 12 that met criteria, but used 8 in longitudinal meta-analysis, 2 in RCT meta-analysis individually analyzed the other 2 studies | Longitudinal studies showed varied results; RCT's showed a positive non-significant weak association; two independent studies not included in meta-analysis showed significant results with a small magnitude; concludes that reducing SSB's would be beneficial nutritionally, but likely not have a large effect on wt * |
| O'Neil, 2008 | Assess relationship between 100% juice consumption and weight in children and adolescents. | 9 cross-sectional, 12 longitudinal | 3 cross-sectional studies reported positive association (6 did not), but were small, convenience samples; 3 longitudinal studies showed positive association (9 did not) |
| Harrington, 2008 | Online search between 2000-2006, keywords: "adolescents and obesity" "interventions" "sugar-sweetened beverages" and "glycemic index"; reviewed only intervention studies | 9 studies identified as single intervention manipulation in relation to glycemic index or SSB; 2 randomized, concluded a positive relationship, 5 observation or secondary analysis concluded positive analysis | Additional research needed; recommended limiting SSB consumption, especially in schools |
| Olsen 2009 | Keywords: "soft drinks obesity children", sugar sweetened beverages obesity children", "soft drinks weight change", "sugar sweetened | 14 prospective studies, 5 experimental studies | 8 of the prospective studies and 3 experimental studies found a positive relationship between sweetened beverage intake and weight measures. Concluded that sweetened |

| Author, year | Inclusion/exclusion criteria | Studies reviewed (type, #) | Results/Conclusion |
|---|---|---|---|
| | beverages weight change”, “dietary intake beverages obesity risk”. Included those with soft drinks or sweetened beverages as exposure and any weight related changes as outcome; excluded those that combined other calorically sweetened foods or had exposures not related to weight; excluded cross-sectional studies | | beverage intake is a determinant of obesity. |

* industry funded

Some of the studies presented in Table 2.4 have found a relationship between sweetened beverage intake and weight or BMI in preschoolers. LaRowe and colleagues examined national US data on beverage intake of preschool and school-aged children using cluster analysis (LaRowe et al., 2007). A sweetened-beverage cluster did not emerge for young children, only for those 6 to 11 years old (LaRowe et al., 2007). This could be due to the small sample size (n=541 preschool children) and the relatively small volume of sweetened beverage consumed by this age group compared to other beverages such as milk, juice and water. O'Connor used NHANES 1999-2002 data to examine the relationship between beverage intake among preschoolers and weight and did not find a relationship (O'Connor et al., 2006).

Among families with low income in the US, children had an increased odds of overweight if the child was drinking more than one non-juice fruit drink per day (OR1.57, 95%CI 1.03-2.40) (Nelson et al., 2006). Welsh looked at preschoolers enrolled in the Women Infants and Children program (WIC), which is a program for low income families, and found a positive relationship between sweet drinks and weight. Researchers included juice along with other sweetened beverages in this study (Welsh et al., 2005).

In Canada, a longitudinal study on children in Quebec 2.5 to 4.5 years old found that those who regularly drank sweetened beverages between meals were more likely to be overweight than those children who did not regularly consume sweetened beverages between meals (adjusted OR 2.36, 95% CI 1.10-5.05) (O'Mara, 2008). Data from this longitudinal study also showed that children who consumed sweetened beverages at least four to six times per week (regular consumers) and had insufficient income were more likely to be overweight at 4.5 years than regular consumers who had sufficient income (Dubois et al., 2007).

Malik and colleagues (2006) completed a systematic review on sweetened beverage intake and children's weight and suggested that there may be a positive association. These authors also reanalyzed a meta-analysis by Forshee and colleagues (2008) examining beverage intake and weight. Malik used different statistics and found a positive association between sweetened beverage intake and weight (Malik, Willett, Hu, 2008). The original meta-analysis by Forshee et al. (2008) included studies on children between 2 and 19 years old, but only had included one study on 2 to 5 year old children, making it impossible to determine the effect on preschoolers alone.

Children's weight status may affect consumption of sweetened beverage, and subsequent weight gain, demonstrating a differential effect of sweetened beverage on weight for some children. Obese children 4 to 16 years old drank more sweetened beverages than non-obese children (Gillis & Bar-Or, 2003). Kral et al. (2008) found that children 3 to 5 years old who were born at a higher risk of obesity, based on maternal pre-pregnancy BMI, had an increased intake of sweetened beverages compared to children whose mothers had a normal pre-pregnancy BMI. In this same study, children who drank increasing amounts of soda over time had an increased waist circumference at 5 to 6 years of age (Kral et al., 2008).

Other researchers have not found an association between sweetened beverage intake in preschoolers and weight. O'Connor and colleagues used NHANES 1999-2002 data and looked specifically at preschool children 2 to 5 years and did not find a relationship between sweetened beverage intake and weight (O'Connor et al., 2006). Children in this study drank nearly 5 oz (140 mL) of fruit drink and 3 oz (84 mL) of soft drinks per day. Authors found that increased beverage intake increased energy intake, but there was no relationship to BMI. They suggest that studying preschoolers through their adiposity rebound may provide additional information that is not available in cross-sectional data (O'Connor et al., 2006).

A longitudinal study on low-income preschoolers in North Dakota found no association between any beverage intake and weight or BMI; however, methodological challenges and lack of controlling for parental obesity, physical activity and screen time were limitations of the study (Newby et al., 2004). A longitudinal study on slightly older children (5-7 years) in Britain did not find an association between sweetened beverages and fatness (Johnson, Mander, Jones, Emmett, & Jebb, 2007). These authors suggest that the sweetened beverage intake was not high enough in this population to determine an effect (Johnson et al., 2007). A meta-analysis on children of all ages (2-19 years) found that sweetened beverage intake was not associated with increased BMI (Forshee et al., 2008). However, this study was re-analyzed by others who concluded a positive relationship (Malik et al., 2008).

Comparison of studies on weight or obesity is difficult as there may be potential misclassification on reporting beverage intakes, especially in overweight participants who may underreport sweetened beverage consumption (Bes-Rastrollo & Martinez-Gonzalez, 2008). Also, studies have used different methods and criteria for defining children as overweight or obese, making it difficult to compare them appropriately (Ogden, 2004). Many studies did not control for confounding variables that impact children's weight such as physical activity, inactivity, total diet, or socio-economic factors such as household income or caregivers' education.

*2.4 Dietary Assessment Methods*

An estimate of usual dietary intake is necessary to assess the relationship between diet and disease or diet and health. An individual's food and beverage intake on a given day can be significantly different from another day (within-person variability) and different from another individual (between-person variability) (Health Canada, 2006). For this reason, estimates of usual intake are necessary and can be obtained using tools such as food frequency questionnaires (FFQ), or statistical adjustment of two 24-hour recalls (Health Canada, 2006).

*2.4.1 Twenty-four Hour Recall*

The 24-hour recall is a dietary assessment method in which all foods and beverages consumed within the previous 24 hours are recorded. At a population level, the 24-hour recall has a low burden for both interviewee and interviewer, is open-ended and cost effective (Biro, Hulshof, Ovesen, Amorim Cruz, & EFCOSUM Group, 2002). The 24-hour recall can be an appropriate tool to measure the intake of groups of people (Basch et al., 1990; Biro et al., 2002; Johnson, Driscoll, & Goran, 1996; Montgomery et al., 2005; Persson & Carlgren, 1984; Reilly, Montgomery, Jackson, MacRitchie, & Armstrong, 2001). However, a single 24- hour recall is not an accurate measure of individual dietary intake (Montgomery et al., 2005; Persson & Carlgren, 1984; Reilly et al., 2001). The automated multiple pass method (AMPM) for the 24-hour recall is the method of dietary assessment used in the CCHS 2.2 (Health Canada, 2006). Validation studies have shown that the AMPM accurately predicts energy and nutrient intake for groups (Blanton et al., 2006), especially among normal weight subjects (Moshfegh et al., 2008). The AMPM is a specific process with five steps designed to optimize reporting of foods and beverages consumed (Health Canada, 2006). The AMPM used in CCHS 2.2 was adapted from that of the United States Department of Agriculture, and included modifications such as for the Canadian food supply and translating the tool into French (Health Canada, 2006).

Twenty-four hour recalls are often used to assess children's dietary intake. Children who are less than seven years old do not have the cognitive skills to accurately report their own food intake (Livingstone & Robson, 2000; Livingstone, Robson, & Wallace, 2004): therefore, parents or other caregivers must provide this information. For children under 6 years old who participated in CCHS 2.2, a parent or guardian was interviewed to obtain dietary information (Health Canada, 2006).

Generally, parents or caregivers of young children report their children's intake moderately well (Basch et al., 1990), however there are a number of situations with increased potential for error. Parental recall improves in a home environment, with 96% of parents accurately reporting children's intakes at home (Klesges, Klesges, Brown, & Frank, 1987). Mothers who stayed at home were more able to report their child's intake compared to mothers who were not at home (Baranowski, Sprague, Baranowski, & Harrison, 1991). Parents may over-report food intake for children under 2 years (Devaney, Ziegler, Pac, Karwe, & Barr, 2004; Fisher et al., 2008), while accuracy increases for preschool-aged children (Baranowski et al., 1991; Basch et al., 1990; Johnson et al., 1996; Klesges et al., 1987).

Common sources of variability in dietary recalls are errors in estimating portion sizes and omission of foods eaten (Rumpler et al., 2008). Variability in reporting dietary intake among children less than seven years may be because various caregivers provide food for children (parents, childcare workers, grandparents etc.), but only one person reports the child's intake on the interview day. Errors in portion size estimation also influence the accuracy of caregiver's reporting (Basch et al., 1990; Livingstone & Robson, 2000; Livingstone et al., 2004; Montgomery et al., 2005; Reilly et al., 2001).

After the age of seven, children's cognitive ability to recall, process, and explain dietary intake improves rapidly (Livingstone et al., 2004). A 24-hour recall that is conducted jointly with the child aged 7-11 years and a parent or caregiver has been identified as valid at a group level as children provide important details about food consumed (Lytle et al., 1993; Sobo, Rock, Neuhouser, Maciel, & Neumark-Sztainer, 2000). In CCHS 2.2, children 6 to 11 years participated jointly with a caregiver in the 24-hour recall (Health Canada, 2006).

Children over the age of 12 years independently reported their food and beverage intake for CCHS 2.2 using the AMPM 24-hour recall (Health Canada, 2006). As children are able to provide their own account of food and beverage intake, they simultaneously enter adolescence, which can be a time where factors such as body image, time constraints and desire for social approval influence the accuracy of reporting (Livingstone et al., 2004). Bandini et al. (1990)

found a tendency for youth to underreport energy intake, and this was higher among adolescents who were obese. Despite the cognitive ability for older children to report their food and beverage intake over the previous 24 hours, the accuracy of the dietary assessment may be compromised.

It appears that despite these limitations, the 24- hour recall is an appropriate tool to assess food and beverage intake by groups of children. It needs to be recognized that parents' report of infants and toddlers' food intake may be less accurate than for preschooler-aged children's intake. Improved accuracy of intake is achieved when the older child and the parent/caregiver participate together in the dietary recall. The accuracy of adolescents' self-reported intake is reduced and may underestimate actual intake.

### *2.4.2 Other Methods*

Other methods of estimating usual food and beverage consumption of populations include food disappearance data and food frequency questionnaires. Food disappearance data, also called food balance sheets, provide "a comprehensive picture of the pattern of a country's food supply during a specified reference period" (Food and Agriculture Organization of the United Nations, 2010). The tool uses data on food supply, including production and importation, as well as data on food usage after adjusting for losses by export, food for livestock, and seed to estimate consumption (Food and Agriculture Organization of the United Nations, 2010). Statistics Canada reports information on food disappearance data for beverages, and this provides some historical information on estimated beverage consumption (Statistics Canada, 2009). Food disappearance data is often reported as per-capita consumption using national population statistics (Gibson, 2005). The main limitation to food disappearance data is the potential for error in each data collection step, including assessment of food supply, usage, and population estimates (Food and Agriculture Organization of the United Nations, 2010; Gibson, 2005). Disappearance data is, at best, an estimate of a population's food and beverage consumption and does not provide information on consumption by specific population subgroups, such as children (Food and Agriculture Organization of the United Nations, 2010). As described above, food disappearance data is used in Canada to estimate trends of beverage consumption.

Food frequency questionnaires can be used to assess usual dietary intake (Block et al., 1986). In general, a FFQ contains a list of foods with options for respondents to choose how frequently the items are consumed (Gibson, 2005). The tool can be completed relatively quickly with low respondent burden, and data entry is rapid due to closed-ended answers. Food frequency questionnaires can be used to obtain information on specific foods or beverages or can provide an estimate of total food intake and dietary diversity. To obtain estimates of energy intake, the FFQ must allow for respondents to include information on portion sizes consumed (Gibson, 2005). Despite their ease of use, the validity of FFQ depends on many factors including the specific questions used, the length of the tool, the population under study, and perceived (un)desirability of the food or beverage in question (Cade, Thompson, Burley, & Warm, 2002; Molag et al., 2007; Moore, Tapper, Moore, & Murphy, 2008).

For children under 9-12 years, a parent or caregiver generally provides information on a FFQ because completion of the tool requires a high degree of cognitive skills (Livingstone & Robson, 2000; Livingstone et al., 2004). Relative validity has been shown for parents' or caregivers' report of their preschool-aged child's intake (Huybrechts, De Backer, De Bacquer, Maes, & De Henauw, 2009). A FFQ developed to assess beverage intake by children under 5 years old has been shown to be relatively valid (Marshall, Eichenberger Gilmore, Broffitt, Levy, & Stumbo, 2003). Additionally, FFQs focusing on beverage intake by adolescents have been shown to be reasonably reproducible over time (Rockett, Wolf, & Colditz, 1995) and show fair validity (Nelson & Lytle, 2009). Selected questions about food, but not beverage, intake were posed in CCHS 2.2 (Health Canada, 2006).

### *2.5 Statistical Methods*

#### *2.5.1 Cluster analysis*

Cluster analysis is a method used in dietary patterning. It is a data-driven method and is often compared to factor analysis and principal components analysis (Moeller et al., 2007; Slattery, 2010). Each of these methods attempts to describe patterns within the data, which can be then described or used to test hypotheses. Cluster analysis groups individuals into non-overlapping groups based on their dietary intake, and produces results that can be "meaningful, interpretable, associated with health outcomes, and show some reproducibility across populations" (Moeller et al., 2007). Many studies have used cluster analysis to examine diet-disease relationships (Kant, 2004; Kant, 2010), but to our knowledge, only one US study focused on beverage patterns (LaRowe et al., 2007).

Three methods of cluster analysis are presented by Newby and Tucker (2004): K-means, Wards, and partitioning around medoids (PAM). K-means and Wards methods are the most common (Moeller et al., 2007). K-means method of cluster analysis is iterative, non-hierarchical, and requires researchers to pre-specify the number of clusters (Moeller et al., 2007; Newby & Tucker, 2004). The K-means method is designed to maximize the distance between clusters whereas Ward's method aims to maximize variance between clusters. The K-means method uses the mean values of the input variable and is sensitive to outliers (Kant, 2004; Newby & Tucker, 2004). Data-driven methods of dietary patterning require decisions by researchers at multiple stages. Newby et al. (2004), described four stages where subjectivity is present: 1) in choosing the primary data structure (e.g. how to group beverage data together), 2) in determining the format of the input variables (e.g. g or calories per unit of beverages) and whether data should be adjusted or transformed, 3) in determining how many patterns are obtained, reported or analyzed, and 4) naming of the resulting patterns. Similar steps have been described by others (Kant, 2004; Moeller et al., 2007; Slattery, 2010). It is recommended to clearly document the decisions made throughout cluster analysis to increase interpretability and reproducibility (Moeller et al., 2007). As with other methods of dietary patterning, cluster analysis is reliant on the type and quality of the dietary data (e.g. FFQ or 24-hour recall) (Slattery, 2010).

### *2.5.2 Statistical Modeling*

Pearson chi-square ($\chi^2$) test is commonly used to test for differences in categorical variables across a number of groups, such as sex across beverage clusters. Analysis of variance (ANOVA) is used to test differences in continuous variables across groups, however, the requirement by Statistics Canada to weight and bootstrap data did not allow for ANOVA in STATA. Therefore, an alternate method such as examining the overlap of the 95% weighted confidence intervals can be used. Linear and logistic regression methods are used to describe the direction and strength of the relationship between several variables. Linear regression assesses the impact of a continuous dependent variable (e.g. BMI-for-age percentiles) while logistic regression examines the impact of a categorical variable (e.g. normal weight versus overweight/obese). Regression techniques allow for assessment of the impact of a variety of factors on the outcome.

# 3. METHODOLOGY

The present study was conducted using data from CCHS 2.2 and occurred in four major stages. The first stage was data processing and cleaning. In this stage, identification and coding of beverage data and variables of interest was completed. This was followed by clustering data on children by beverage intake in order to determine beverage patterns. Once final clusters were determined, it was possible to test for differences across clusters using statistical techniques including regression analyses. Finally the results are interpreted considering the limitations of CCHS 2.2 data and results from other studies.

### *3.1 Canadian Community Health Survey 2.2*

The Canadian Community Health Survey (CCHS) Cycle 2.2 data were used to explore the relationship between children's beverage intake and body mass index. This survey is a nationally representative cross sectional survey of Canadians that focused on food and nutrient intake in 2004 (Health Canada, 2006). The CCHS 2.2, as the first comprehensive national nutrition survey after more than three decades, had a final sample size of 35,107 individuals who provided information on their demographics, socioeconomic status, and nutrition and health status (Health Canada, 2006).

CCHS 2.2 data has two main components: dietary recall information and general health information. The dietary recall information is in a file labeled R24 and the general health information is in a file labeled HS. Dietary recall information from all subjects was obtained using a 24-hour food recall. Thirty percent of subjects completed a second 24-hour recall in order to obtain usual estimates of intake (Health Canada, 2006). Usual intakes are calculated using specific software (Software for Intake Distribution Estimation), and are necessary to determine prevalence of inadequacy for certain nutrients (Health Canada, 2006). In the current analysis, only one day of intake was used because the calculated mean does not change if using one or two days of intake, only the distribution changes (Health Canada, 2006). Children 12 years and up provided their own dietary recall data, children between 6 and 11 years provided dietary information along with their parent or caregiver. Children under 6 years had a parent or caregiver report their food intake.

The dietary recall component is subdivided into two files: Food and Ingredient Details (FID) and Food Recipe Level (FRL). These files are structured similarly and include sample identification numbers. The FID file contains nutrient information on foods and ingredients, while the FRL file contains nutrient information for recipes of foods. Descriptive information on foods is in a separate file labeled FDC (Food Description). The FDC file does not contain identification numbers, but does contain food groupings and codes that correspond to those from the Nutrition Survey System (NSS) which was built using the Canadian Nutrient File (CNF) at the Bureau of Nutritional Sciences (BNS) (Health Canada, 2006). The CNF is continually updated and contains nutrient values largely based on information from the United States Department of Agriculture Nutrient Database for Standard Reference but with Canadian regulations, fortification values, and unique Canadian foods (Health Canada, 2006). The FDC file contains information from CNF 2005, which includes information on 5370 food items found in Canadian food market. The data files of CCHS 2.2, excluding supplement intake data files and accessory files (e.g. bootstrap weight files, FDC etc.), are depicted in Figure 3.1.

The second component of CCHS 2.2, general health information, includes data on measured heights and weights, household food security, household education, income and socio-demographic characteristics among other factors. All of these files were used to assess the relationship between beverage intake and children's body mass index.

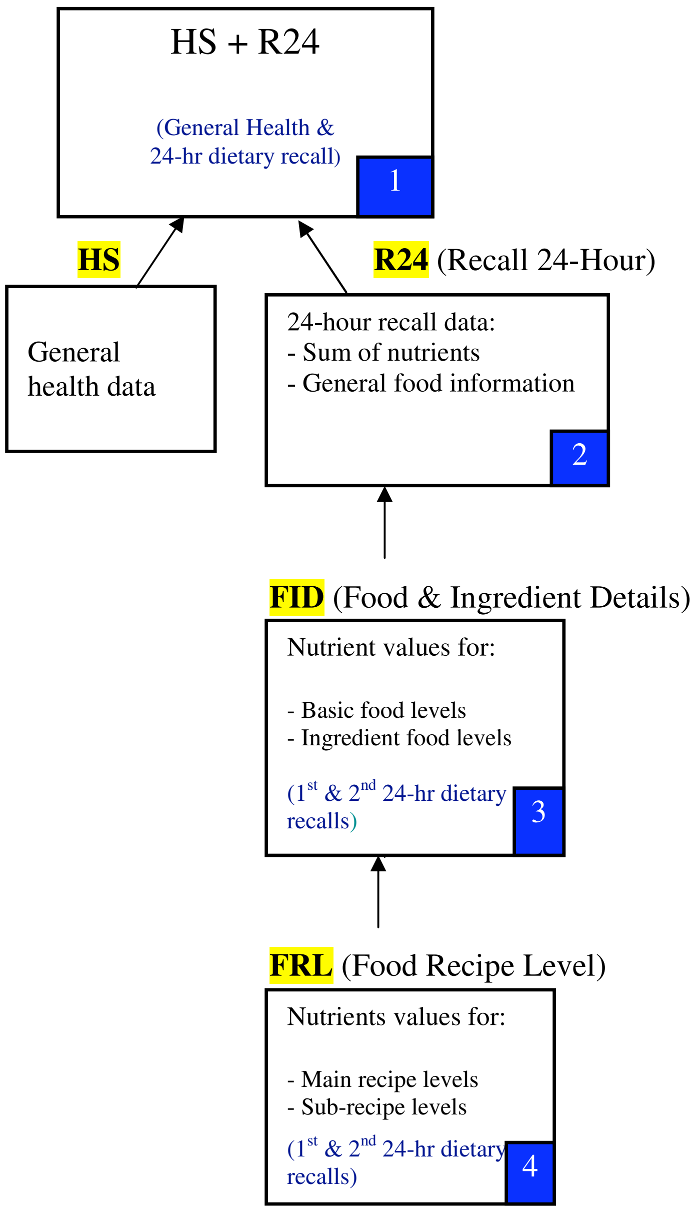



Figure 3.1: Canadian Community Health Survey 2.2 data files.

### *3.1.1 Statistical Analyses and Interpretation*

Data analysis was conducted in four stages: 1) processing, cleaning and descriptive analysis; 2) determining pattern of beverage intake; 3) advanced statistical modeling; and 4) interpretation.

#### *3.1.1.1 Data Processing, Cleaning and Descriptive Analysis of Beverages*

This stage comprised the necessary steps for data processing, cleaning, creating new variables, aggregating beverage and nutrient data. It also included aggregating demographic, anthropometric, and socioeconomic data from different files. This stage included creating the final data set for the next stages. This stage also included defining inclusion and exclusion criteria.

Processing of beverage data occurred in five steps. The first step was identifying beverages. The second step was to categorize beverages into groups that were appropriate to the research questions. Thirdly, appropriate codes were assigned to beverages in the FID and FRL files. The fourth step involved merging multiple beverage intakes by individuals to create total beverage intake by category within individuals. For example if subject #1 drank milk three times and fruit juice once, these separate entries would be merged to create a variable indicating a total volume of milk consumed and a total volume of juice consumed. Finally as step 5, the newly created beverage variables were merged with the HS file, where other information exist, including socio-economic status, demographics and nutrient intake data from the first 24-hour recall such as the total energy (kcal), calcium (mg), and vitamin C (mg).

Beverages were identified and isolated from the FDC file (Appendix A, Flow Chart 1). This was completed using three variables within the FDC file: FIDD_CDE, which contained unique food codes corresponding to the codes in the NSS; FDCD_DEN, which was the name (in English) of the food according to CNF; and FDCD_FGE, which was the food group description (in English) from the BNS. Of note, French versions of the files and variables exist. Table 3.1 provides an example of the data contained within the variables of interest.

Table 3.1: Example of data within food description file

| **FIDD_CDE** | **FDCD_DEN** | **FDCD_FGE** |
|---|---|---|
| 113 | Milk, fluid, whole, pasteurized, homogenized, 3.3% fat content | Milk, whole |

Items confirmed as beverages were separated and transferred to an Excel file. Examples of items not identified as beverages include undiluted evaporated milk, condensed milk, undiluted frozen juice or drink concentrate, drink powders or crystals, instant coffee powder. If these items were consumed in a diluted form, they were included as beverages. Fluids used in recipes (e.g., milk in a cake recipe), milk added to cereal, coffee or tea were not included as beverages. Infant formulas were not included in beverage categories, as they are not routinely recommended for consumption beyond 12 months of age (Canadian Paediatric Society, Dietitians of Canada and Health Canada, 2005).

Following identification of beverages, the FDCD_DEN and FDCD_FGE variables were used to classify beverages. The information provided by these variables allowed for classification of beverages based on their energy and nutrient content. Information in the FIDD_CDE variable was used to search the CNF for some beverages to assist with appropriate classification. Based on energy and nutrient content, beverages in the 17 categories were aggregated in 4 groups: sugar sweetened-low nutrient beverages, nutrient-based beverages, alcoholic beverages, and beverages with no additional energy (Table 3.2). Alcoholic beverage intake of children was not analyzed, as it was assumed to be zero or negligible.

Table 3.2: Beverage groups identified for Canadian Community Health Survey 2.2

| **Beverage Category** | **Types of beverages in category** |
|---|---|
| *I-Sugar-sweetened low nutrient* | |
| 1- Fruit Drinks | Fruit drink containing <100% fruit juice from concentrate, fruit flavoured beverages, lemonade, fortified or not |
| 2- Regular soft drinks | Carbonated beverages, colas, clear sodas, fruit-flavoured sodas (e.g. lemon-lime, orange etc), non-alcoholic beer |
| 3- Teas, sweetened | Iced tea, spiced, instant |
| 4- Coffee, sweetened | Instant, brewed, flavoured (e.g. cappuccino, mocha, but with whitener not milk) |
| *II- Nutrient-based Beverages* | |
| 5- Plain milk | Skim, 1%, 2% and whole milk (includes those with added milk solids, diluted evaporated milk, with extra calcium) |
| 6- Milk-based beverages; high-fat (>2%MF) | Milk shakes, iced cappuccino, eggnog, whole chocolate milk, hot chocolate with whole milk, (all) malted milks- unless specified with low fat milk, coffee substitute mixed with whole milk, milk-based smoothie, latte, café au lait |

| | |
|---|---|
| 7- Milk based beverages: low fat (≤2%) | Skim milk latte, low fat chocolate milk (or where MF was not specified), mixed milk beverages where low-fat milk was specified e.g. eggnog mix, instant breakfast |
| 8- Other types of Milk | Soy based beverages, goats milk, rice beverage, whey beverages, buttermilk, sheep milk, protein shakes |
| 9- Vegetable juice | 100% vegetable juices (carrot, tomato) |
| 10- Fruit juice | 100% fruit juices, sweetened fruit juice |
| *III- Alcoholic beverages* | |
| 11- Beer | All types of beer |
| 12- Wine | All types of wine |
| 13- Other alcoholic beverages | Cocktails, spirits, liqueurs, coolers |
| *IV- No additional Energy/Caloric Beverages* | |
| 14- Water | Tap and bottled water, club soda, Perrier type |
| 15- Diet drinks | Colas and non-colas with sugar-substitute (aspartame), fruit drinks with aspartame or sucralose, “low-calorie”, non-alcoholic wine |
| 16- Tea | No added sugar/cream; brewed, instant, herbal |
| 17- Coffee | No added sugar/cream; brewed, instant, caffeinated, decaffeinated, chicory |

All of the beverages identified were assigned a code (1 through 17) according to the 17 beverage categories created (Appendix A, Flow Chart 2). A beverage category variable was created using SAS (version 9.2). The beverage variable categorized over 400 unique beverage codes (FIDD_CDE) into the 17 specified beverage categories. The new beverage category variable was exported to the FID and FRL files. These files contain dietary information from the initial 24-hour recall and the second 24-hour recall, which was completed with 30% of the initial sample to determine usual intake. Only the information from the initial 24-hour recall was used, as the calculated mean does not vary between one day of intake and calculated usual intake (Health Canada, 2006). After removing data from the second recall, the FID and FRL files were merged to create one file containing all of the beverage data using SAS. Data were evaluated after merging the two files to avoid repetition (Appendix A, Flow Chart 3).

The structure of the FID and FRL files is such that for each individual surveyed, multiple rows of dietary information exist which represent multiple food items that individual consumed in 24 hour prior to the interview. That is, if an individual consumed 15 foods or beverages during the period in question, 15 lines of information (rows of a spreadsheet) would be present for that subject. The format of the FID and FRL files were converted so that each individual only had one line of data, essentially summing the volume of beverages consumed. This was done using the SORT command in SAS. At this stage, subjects were identified and removed if any dietary information was missing (n=82). The resulting file was saved and labelled as a beverage file. The beverage file was then merged with the HS file according to individual identification numbers (Appendix A, Flow Chart 3). These steps created a file that contained demographic, anthropometric, socioeconomic variables as well as beverage intake information for the over 35,000 subjects in CCHS 2.2.

*3.1.1.1.1 Demographic, Anthropometric and Socioeconomic Variables*

This section describes processing, cleaning, creating new variables and aggregating data for age/sex groups, height and weight data, calculation of BMI-for-age percentiles, and creation of categorical variables for household education, income, ethnicity and household food security status. The exclusion criteria, numbers of subjects in each category, and variables of interest are summarized in Figure 3.2 and Figure 3.3, and the steps are illustrated in Appendix A, Flow Chart 4.

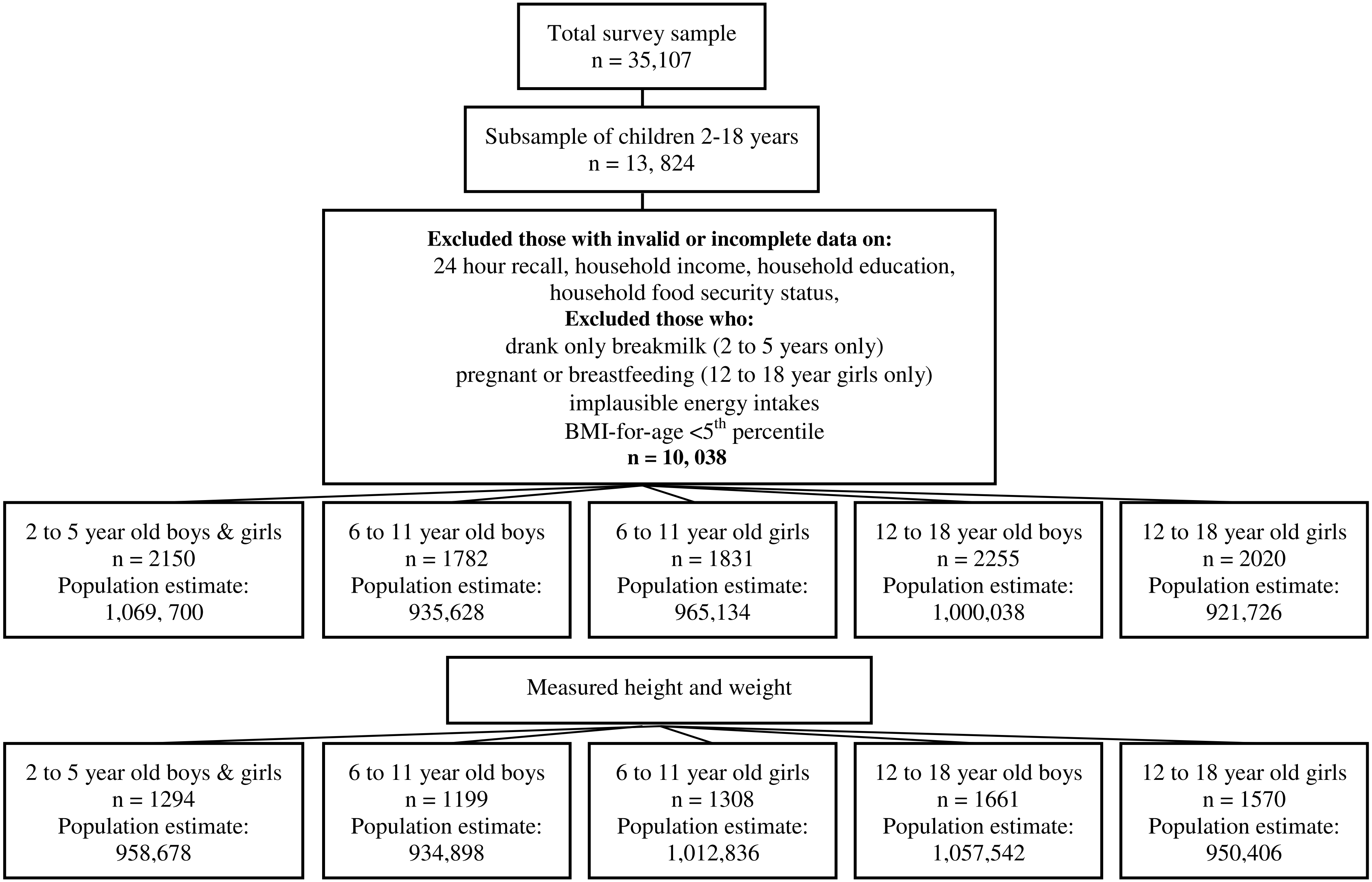



Figure 3.2: Summary of exclusion criteria, number of subjects in age-sex

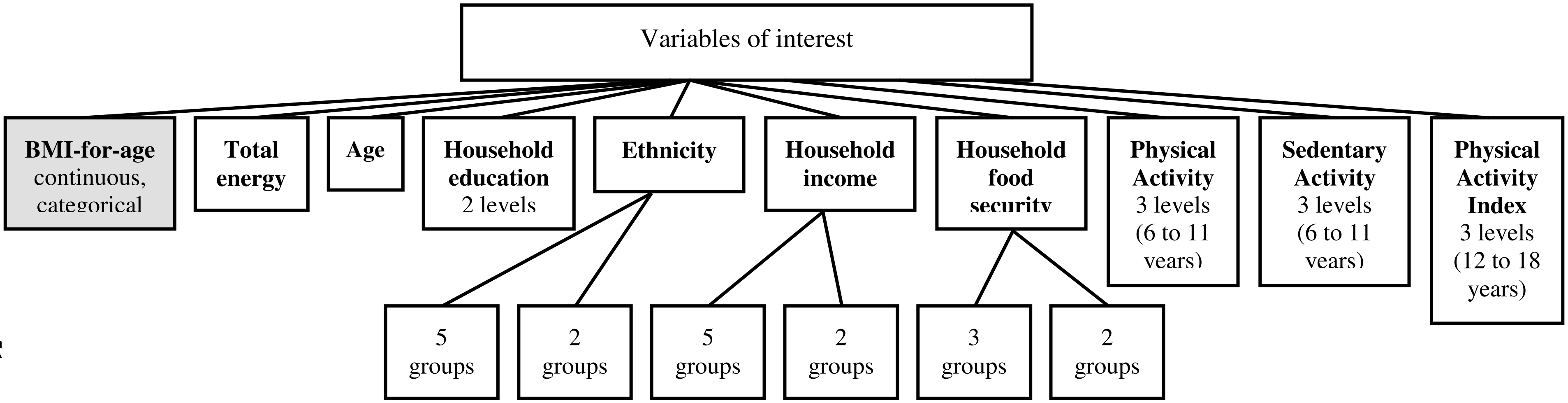



Figure 3.3: Summary of variables of interest

Subjects were categorized into age and sex groups (2 to 5 years, 6 to 11 years, 12 to 18 years, for boys and girls), by using the variable "age in months" and "sex" in the HS file to create six unique groups (Table 3.3) (Appendix A, Flow Chart 5).

Table 3.3: Group codes for age and sex

| Group | Age in months | Sex |
|---|---|---|
| 1 | 24-71 | M |
| 2 | 24-71 | F |
| 3 | 72-143 | M |
| 4 | 72-143 | F |
| 5 | 144-227 | M |
| 6 | 144-227 | F |

The CCHS 2.2 subjects had self-reported heights and weights. In a subsample of participants, height and weight were measured. Of children who were measured, a standing height was taken. To be able to generalize data on measured height and weight to general population, specific weighting values ("h5_bw" weights) were provided by Statistics Canada (Statistics Canada, 2009a). These weighting variables only allowed inclusion of individuals who had *measured* height and weight, and provided appropriate population estimates. Thus, any calculations that included height and weight (e.g. BMI) only included subjects who had *measured* height and weight. All calculations for beverage intakes and socio-demographics included subjects who had measured or self-reported heights and weights using "master" weighting variables.

Height and weight variables were used to create a variable for BMI-for-age percentiles. The BMI-for-age percentiles were created using a SAS program offered by Centres for Disease Control and Prevention which is designed to generate a dataset that contains indices of the anthropometric status of children from birth to 20 years of aged based on the 2000 CDC growth charts. The program was used to create variables for BMI-for age percentiles and z-scores, stature-for-age percentiles and z-scores, and weight-for-age percentiles and z-scores (Centers for Disease Control and Prevention, 2009).

BMI-for-age percentile variable was used to group subjects into weight categories using criteria from the CDC to create BMI-for-age categories: normal BMI-for-age $5^{th}$ to $84.99^{th}$ percentile, overweight as BMI $85^{th}$ to $94.99^{th}$ percentile, and obese as $\geq 95^{th}$ percentile. Underweight was defined as sex-specific BMI-for-age $<5^{th}$ percentile (Appendix A, Flow Chart

6). The same cut points were endorsed by the Canadian Paediatric Society, Dietitians of Canada, the College of Family Physicians of Canada, and the Community Health Nurses Association of Canada in 2004 (Dietitians of Canada, Canadian Paediatric Society, College of Family Physicians of Canada, & Community Health Nurses Association of Canada, 2004). Experts in the US defined BMI-for-age between the 85-95$^{th}$ percentiles as "at risk for overweight" and Canadian experts name the category "overweight". US experts defined BMI-for-age ≥ 95$^{th}$ percentile as "overweight", whereas Canadians use the term "obese" to describe the same category (Dietitians of Canada, Canadian Paediatric Society, College of Family Physicians of Canada, & Community Health Nurses Association of Canada, 2004). Here, the Canadian terminology is used.

Data from the HS file on household education, household income, ethnicity, and household food security were used. In CCHS 2.2, household education was defined as the highest level of education attained by any member of the household. Initially, four categories of household education were used: less than secondary school graduation, secondary school graduation, some post secondary education, and post secondary graduation. Less than five subjects in any breakdown was considered to be too small (small cell size) and therefore household education was collapsed into two categories: secondary school graduation or less, and at least some post secondary school education.

Household income was recorded as total household income before taxes. Income levels were defined based on income information in combination with the number of people living in the household. Table 3.4 provides details of five categories of income levels. However, due to small cell sizes, these were collapsed into two: low and high household income adequacy. The lowest and low-income categories were combined to create a low income category, and the middle, upper, and highest income categories were combined to create a high income category.

Table 3.4: Household income levels as defined by total income and number of people residing in the home, 5 categories

| **Income adequacy level** | | | | | |
|---|---|---|---|---|---|
| | **"Low Income"** | | **"High Income"** | | |
| Number of people in household | Lowest Income | Low Income | Middle Income | Upper- Income | Highest Income |
| 1-2 | <$10,000 | $10,000 -$15,000 | $15,000- $29,999 | $30,000- $59,999 | ≥ $60,000 |
| 3-4 | <$10,000 | $10, 000- $20,000 | $20,000- $39,999 | $40,000- $79,999 | ≥ $80,000 |
| 5+ | <$15, 000 | $15,000-$30,000 | $30,000- $59,999 | $60,000- $79,999 | ≥ $80,000 |

In the CCHS 2.2 interview, ethnicity or racial background was self-identified and included 13 options for respondents to select, including "other" (Table 3.5). Initially these ethnicity groups were collapsed into five categories: 1) White 2) Black 3) Southeast/East Asian 4) Aboriginal 5) Other, as in Shields (2006). The White, Black and Aboriginal ethnicity categories remained the same, while the Southeast/East Asian category included Southeast Asian, Korean, Filipino, Japanese, and Chinese. The Other category included South Asian, Arab, West Asian, Latin American, Multiple and Other. In later analysis, there were small cell sizes in some age-sex categories. Therefore, in order to be consistent, ethnicity was ultimately collapsed into two categories: White and Non-white.

Table 3.5: Original and collapsed ethnicity categories

| **CCHS Ethnicity categories** | **Initial Collapsed Ethnicity Categories** | **Final Collapsed Ethnicity Categories** |
|---|---|---|
| White | White | White |
| Black | Black | Non-white |
| Southeast Asian | Southeast/East Asian | |
| Korean | | |
| Filipino | | |
| Japanese | | |
| Chinese | | |
| Aboriginal | Aboriginal | |
| South Asian | Other | |
| Arab | | |
| West Asian | | |
| Latin American | | |
| Multiple | | |
| Other | | |

CCHS: Canadian Community Health Survey

Household food security information was available in CCHS 2.2 and collected using the Household Food Security Survey Model (HFSSM). This is an 18 item questionnaire that "focuses on self-reports of uncertain, insufficient or inadequate food access, availability and utilization due to limited financial resources, and the compromised eating patterns and food consumption that may result" (Health Canada, 2007b). The tool measured food security for adults and children in the household, and based on the responses given, Statistics Canada created a derived variable assigning the household to particular level of food security: food secure, food insecure moderate (without hunger), and food insecure severe (with hunger). It is important to note that Health Canada in its report on food security uses different labels for these categories as they more accurately match the intent of the measure: food secure, food insecure (moderate), and food secure (severe) (Health Canada, 2007b). The three categories of food security were used in further analysis. In some cases due to small cell sizes, we collapsed food security into two categories: food secure and food insecure by merging moderate and severe food insecurity.

Data on physical activity were available for children 6 to 11 years as the number of hours per week that they were physically active during leisure time. Physical activity for children was defined as "activity that increased their heart rate and makes them feel out of breath some of the time or warmer than usual" (Health Canada, 2006). These data were graphed to determine the most appropriate way of grouping the data. For each sex, it was determined that physical activity level was to be divided into thirds, where the lowest activity level was considered low, followed by medium and high activity levels.

The Physical Activity Index (PAI) was calculated for all respondents over 12 years, and is defined as the "average daily energy an individual would expend on leisure time physical activity" (Health Canada, 2006). It is based on respondents' recall of activities over the past three months, including frequency and duration of each activity (Health Canada, 2006). Three categories for PAI were established within the CCHS 2.2 data: *inactive* was <1.5 kcal/kg/day, *moderately active* was 1.5-<3 kcal/kg/day, and *active* was ≥ 3 kcal/kg/day (Health Canada, 2006). These categories were used in analysis for boys and girls 12 to 18 years.

Levels of sedentary activity were also collected in this survey. For children 6 to 11 years, sedentary activity was "the number of hours per day that they watched television or videos or played video games or spent on a computer" (Health Canada, 2006). For children 12 to 17 years, sedentary activity was defined as "the amount of leisure time they spent on a computer, playing video games, watching television and reading" (Health Canada, 2006). No sedentary activity data was available for 18 year olds. For both age groups, the data was graphed to determine the most appropriate way of grouping the data. It was determined that sedentary activity level was to be divided into thirds, where the lowest sedentary activity level was considered low, followed by medium and high sedentary activity levels. The same cut-points were applied to both boys and girls within each age group.

*3.1.1.1.2 Inclusion Criteria*

Children 2 to 18 years old with valid 24-hour recall data, complete data for household income, household education, household food security, and ethnicity were included. The number of participants pre- and post- application of the exclusion criteria are provided in Table 3.6.

Table 3.6: Subject numbers (n) pre- and post- exclusion criteria, by age-sex groups

| | **Pre-exclusion n** | **Post- exclusion n** |
|---|---|---|
| **2 to 5 years, boys** | 1466 | 1101 |
| **2 to 5 years, girls** | 1352 | 1049 |
| **6 to 11 years, boys** | 2240 | 1782 |
| **6 to 11 years, girls** | 2191 | 1831 |
| **12 to 18 years, boys** | 3334 | 2255 |
| **12 to 18 years, girls** | 3241 | 2020 |
| **TOTAL** | **13,824** | **10,038** |

Children were excluded if BMI-for-age was less than the $5^{th}$ percentile, as was done in the study by LaRowe and colleagues (2007). Children who received only breast milk were further excluded; a criterion only applicable to children in the age range 2 to 5 years old. Few children over two years old consumed infant formula; therefore it was not included in the beverage categories. Girls who were pregnant or breastfeeding were excluded, which only occurred in the 12 to 18 year age group. Finally, children with implausible energy intakes were not included.

Implausible energy reporters were determined as follows. For children 2 to 5 years, implausible intakes were those either less than 800 kcal or greater than 2,700 kcal per day. Energy intakes less than 900 kcal or greater than 3,500 kcal for children 6 to 11 years old were considered implausible. These exclusion criteria were the same as those defined by LaRowe et al. (2007). For children 12 to 18 years, implausible energy intakes were considered to be less than 1200 calories or more than 4900 calories. Implausible energy intakes for 12 to 18 year olds were determined by calculating minimum and maximum estimated energy requirements (EER), subtracting 10% from the minimum, and adding 10% to the maximum and rounding up or down to the nearest 100 calories. Adding or subtracting 10% was chosen because this was a similar amount used by LaRowe et al. (2007) (i.e., maximum implausible intake set by LaRowe et al. was approximately 10% above the maximum EER). All values used for energy exclusion criteria are those that were beyond the estimated energy requirements (EER) as calculated using the dietary reference intakes (Table 3.7).

Table 3.7: Calculated minimum and maximum estimated energy requirements for 2 to 5, 6 to 11, and 12 to 18 year olds as per dietary reference intakes

| | Minimum EER | Maximum EER |
|---|---|---|
| 2-5 years | **808.7 kcal** (24 mo, 3rd percentile for height & weight) | **1921.8 kcal** (71.5 mo, 97th percentile for height & weight) |
| 6-11 years | **1121.9 kcal** (Female, 72 mo, 3rd percentile for height & weight, sedentary) | **3228.0 kcal** (Male, 143.5 mo, 97th percentile for height & weight, very active) |
| 12-18 years | **1337.5 kcal** (Female, 144 mo, 3rd % percentile for height & weight, sedentary) | **4414.4 kcal** (Male, 227.5 mo, 97th percentile for height & weight, very active) |

*3.1.1.2 Determining Pattern of Beverage Intakes*

At this stage the children were classified into distinct groups based on the dominant pattern of beverage intakes from the groups presented in Table 3.2. Following similar procedure as LaRowe at al. 2007, cluster analysis (FASTCLUS procedure in SAS) was used to determine the pattern of beverage intakes. The FASTCLUS procedure categorizes participants into non-overlapping groups in an iterative process by comparing Euclidean distances using the “K-means method” (SAS Institute Inc., 2009). This method is a recent approach used to identify patterns of food and beverage intake (Moeller et al., 2007). As the procedure is sensitive to outliers, subjects were removed if the intake of beverage group was ≥ 5 standard deviations from the mean. These subjects were returned to the dataset once the optimal number of clusters was determined. With the K-means method, it was necessary to predefine the number of clusters. The procedure was started with 40 clusters and clusters with less than or equal to 5 members were temporarily removed.

Optimal number of clusters was determined using cubic clustering criterion (CCC), pseudo-F statistic (PFS), and interpretability. The values of CCC and PFS for each cluster set (3 through 20 cluster sets) were recorded and then assessed using a line graph to identify ‘peaks’ in the values (Appendix A, Flow Chart 7). The cluster set(s) at which CCC and PFS both peaked were explored for interpretability. Interpretability was assessed using mean intake of each beverage category within each individual cluster. For example, where mean milk intake among individuals in Cluster 1 was much higher than among any other clusters, this was identified as a unique cluster. For interpretability to be achieved, a clear and unique pattern of intake for each cluster was necessary (Appendix A, Flow Chart 8).

Once the optimal number of clusters for each age-sex group was identified, the mean intake in grams was calculated for each beverage group, as well as for the total beverage consumption and mean percentage of total energy from beverages for each cluster. Percent energy from sugar sweetened beverages and nutrient-based beverages were also calculated for each beverage cluster. The means and frequencies for sample characteristics (e.g., household education, food security, ethnicity, income) were determined, as well as mean calcium and vitamin C intake for each cluster (Appendix A, Flow Chart 9).

*3.1.1.3 Advanced Statistical Modeling*

To test differences in categorical variables of interest across beverage patterns, $\chi^2$ tests were used. These included sex (for 2 to 5 year olds only), ethnicity, household income adequacy, household food security status, household education, and BMI-for-age classification. For continuous variables, 95% confidence intervals were examined and where no overlap existed, the results were considered to be statistically significant (Health Canada 2006). The continuous variables included beverage groups, total beverage intake, percent energy from beverages, percent energy from sweetened beverages, percent energy from nutrient-based beverages, calcium and vitamin C intake. Analysis of variance was attempted, however the required weighting variable and bootstrapping command were not compatible with this method of analysis in STATA.

Bivariate linear regression was used to test the association between independent variables and BMI-for-age in its continuous form. Variables that were significant at $p<0.20$ were included in the model or if they were considered biologically important (Pahwa, 2008). Results from bivariate linear regression analysis were only used to inform us regarding potential associations between variables and BMI-for-age. BMI-for-age was then categorized into groups based on recommended cut-points endorsed by the Centres for Disease Control and Prevention and Dietitians of Canada. Due to small cell sizes, the overweight and obese BMI-for-age categories were collapsed into one category of overweight/obese.

Bivariate logistic regression was used to evaluate the association between the outcome variable overweight/obesity (categorical variable: normal, overweight/obese based on BMI-for-age) with each of the following independent variables beverage pattern, energy intake, age, sex (for 2 to 5 year only), household income, ethnicity, household food security, and household education. For 6 to 11 year olds, physical and sedentary activity variables were also included. For 12 to 18 year olds, physical activity index was included in the bivariate analysis. Variables with results from bivariate analysis with $p < 0.20$ and biological justification for association with overweight/obesity were included in the final model (Pahwa, 2008). For variables with high collinearity (e.g. household food security and household income), the variable that had a stronger relationship to overweight/obese was included in the model. All regression analyses were weighted and bootstrapped using measured height-weight weighting variables to obtain estimates at population level. Alpha was set at the level of 0.05 unless otherwise it has been mentioned. A variety of statistical packages were used in various stages of analyses, including SAS version 9.2, STATA version 10 and 11, SPSS version 16, and Excel 2007.

# 4. RESULTS

Results are presented according to the stages of analysis. First, descriptive information on the socio-demographic characteristics of each age-sex group is presented. This is followed by descriptive information on beverage intake of each age-sex group. Nutrient intake and BMI-for-age by age-sex group are then presented. At this stage, cluster analysis was completed, thus results by cluster-group are presented for each age-group beginning with socio-demographic information. This is followed by information on beverage intake by cluster for each age group. Nutrient intake and BMI-for-age by cluster-group follows. Finally, results from linear and logistic regression analysis are shown.

*4.1 Descriptive Results*

Data on number of participants, age, ethnicity, and household characteristics are presented here. A total of 10,038 children were included in this analysis. The numbers of participants, weighted and un-weighted, are presented by age group and sex in Table 4.1. Specific weighting variables were developed by Statistics Canada to account for the fewer subjects who had measured heights and weights, therefore the population represented is similar to the original weighted value. All results were weighted and bootstrapped.

Table 4.1: Weighted and un-weighted number of participants by age and sex group and for all subjects and those who had measured height and weight

| | **2-5 years** | **6-11 years** | | **12-18 years** | |
|---|---|---|---|---|---|
| **All subjects** | **Both sexes** | **Male** | **Female** | **Male** | **Female** |
| Un-weighted | 2150 | 1782 | 1831 | 2255 | 2020 |
| Weighted | 1,069,700 | 935,628 | 965,134 | 1,000,038 | 921,726 |
| **Measured Height & Weight** | | | | | |
| Un-weighted | 1294 | 1199 | 1308 | 1661 | 1570 |
| Weighted | 958,678 | 934,898 | 1,012,836 | 1,057,542 | 921,725 |

Boys and girls in each age group had similar mean ages. Boys and girls 2 to 5 years old had mean ages of 3.5 ± 0.05 y and 3.5 ± 0.06 y, respectively. Among those children 6 to 11 years, boys and girls had a mean age of 8.5 ± 0.07 years and 8.6 ± 0.06 years, respectively. Among those children 12 to 18 years, boys were, on average 14.7 ± 0.07 years old and girls were 14.8 ± 0.08 years old. Distribution of ethnicity was the same among all age groups, with most identifying as White, followed by Other, Southeast/East Asian, Black, and Aboriginal (Table 4.2).

Table 4.2: Distribution of ethnicity across age and sex groups

| | **2-5 years** | | **6-11 years** | | **12-18 years** | |
|---|---|---|---|---|---|---|
| **Ethnicity** | **Male** | **Female** | **Male** | **Female** | **Male** | **Female** |
| White (%) | 79 | 77 | 75 | 80 | 83 | 85 |
| Black (%) | 3 | 3 | 5 | 4 | 2 | 2 |
| Southeast/ East Asian (%) | 5 | 6 | 6 | 4 | 5 | 5 |
| Aboriginal (%) | 1 | 1 | 2 | 2 | 1 | 2 |
| Other (%) | 10 | 14 | 12 | 11 | 9 | 6 |

Approximately 90% of children in all age-sex groups were from households with middle-income or higher (Table 4.3). Most children were from food secure households, and of those children who were in food insecure households, most experienced moderate food insecurity (Table 4.3). Approximately 80-85% of children lived in households where at least one member of the household had at least some post-secondary education. Across all age-sex groups, 15-20% of children lived in households with high-school education or less (Table 4.3).

Table 4.3: Household characteristics of boys and girls by age and sex

| | **2-5 years** | | **6-11 years** | | **12-18 years** | |
|---|---|---|---|---|---|---|
| | **Male** | **Female** | **Male** | **Female** | **Male** | **Female** |
| **Household income level (%)** | | | | | | |
| Lowest | 2.5 | 1.5 | 2.6 | 1.7 | 3.0 | 2.4 |
| Low-middle | 6.8 | 8.5 | 9.7 | 9.9 | 6.9 | 7.3 |
| Middle | 21.9 | 23.2 | 24.3 | 24.2 | 22.1 | 23.2 |
| Upper-middle | 36.1 | 35.6 | 30.6 | 32.0 | 31.7 | 32.0 |
| Highest | 32.8 | 31.2 | 32.8 | 32.3 | 36.3 | 35.1 |
| **Household food security status (%)** | | | | | | |
| Food insecure - severe | 2.0 | 2.2 | 3.8 | 1.7 | 2.0 | 1.3 |
| Food insecure - moderate | 7.5 | 8.1 | 6.1 | 6.0 | 5.4 | 5.1 |
| Food secure | 90.5 | 89.7 | 90.2 | 92.3 | 92.6 | 93.6 |
| **Highest household education level (%)** | | | | | | |
| Less than secondary school graduation | 4.9 | 4.7 | 5.2 | 6.8 | 6.8 | 4.9 |
| Secondary school graduation | 10.5 | 10.9 | 12.4 | 13.2 | 10.8 | 10.5 |
| Some post-secondary | 5.4 | 6.4 | 7.4 | 8.3 | 8.4 | 8.2 |
| Post-secondary graduation | 79.2 | 77.9 | 75.0 | 71.7 | 74.0 | 76.4 |

*4.1.1 Descriptive Beverage Intake*

Mean beverage intake for each of the 14 categories for each age-sex group is presented. Summary intakes of three main beverage categories including sugar sweetened beverages, nutrient based beverages and non-caloric beverages are also presented. Alcoholic beverage intake was not assessed.

The intake of beverages by boys 2 to 5 years old is presented in Table 4.4. Girls' beverage intake is presented in Table 4.5. By examining the overlap of the 95% confidence interval, boys drank significantly more nutrient-based beverages, and total beverages than girls ($p<0.05$). The top three beverages consumed by both boys and girls were water (314 ±15 g, 320 ± 17 g, respectively), milk (310 ± 16 g, 287 ± 12 g, respectively), and fruit juice (228 ± 18 g, 168 ± 12 g, respectively). Over half of total beverage intake was from nutrient based beverages for both boys and girls (58% and 56% respectively). Sixteen percent of boys' and 14% of girls' beverage intake was from sugar-sweetened low-nutrient beverages. Water was the main non-caloric beverage consumed for both boys and girls.

Table 4.4: Mean intake, standard error (SEM) and 95% confidence interval of beverages (g) by boys 2 to 5 years

| | Mean | SEM | 95% Confidence Interval | |
|---|---|---|---|---|
| **Sugar Sweetened Beverages (g)** | **200** | **12** | **176** | **224** |
| Fruit Drink | 166 | 11 | 145 | 188 |
| Soft Drink | 28 | 5 | 18 | 37 |
| Sweetened Tea | 5 | 2 | 2 | 8 |
| Sweetened Coffee | 1 | 1 | 0 | 2 |
| **Nutrient Based Beverages (g)** | **725** | **24** | **677** | **773** |
| Milk (plain) | 310 | 16 | 279 | 340 |
| High fat flavoured milk | 143 | 12 | 119 | 168 |
| Low fat flavoured milk | 29 | 5 | 20 | 38 |
| Other milks | 13 | 4 | 6 | 20 |
| Vegetable Juice | 2 | 1 | 0 | 4 |
| Fruit Juice | 228 | 18 | 192 | 264 |
| **No Additional Energy Beverages (g)** | **325** | **15** | **295** | **354** |
| Water | 314 | 15 | 285 | 343 |
| Diet Drinks | 2 | 1 | 1 | 3 |
| Tea (plain) | 9 | 2 | 4 | 14 |
| Coffee (plain) | 0 | 0 | 0 | 0 |
| ***Total Beverage Intake (g)*** | ***1253*** | ***30*** | ***1195*** | ***1311*** |

Table 4.5: Mean intake, standard error (SEM) and 95% confidence interval of beverages (g) by girls 2 to 5 years

| | Mean | SEM | 95% Confidence Interval | |
|---|---|---|---|---|
| **Sugar Sweetened Beverages (g)** | **158** | **10** | **138** | **177** |
| Fruit Drink | 133 | 9 | 114 | 151 |
| Soft Drink | 20 | 3 | 14 | 25 |
| Sweetened Tea | 5 | 2 | 1 | 10 |
| Sweetened Coffee | 0 | 0 | . | . |
| **Nutrient Based Beverages (g)** | **624** | **25** | **575** | **673** |
| Milk (plain) | 287 | 12 | 263 | 311 |
| High fat flavoured milk | 137 | 22 | 93 | 180 |
| Low fat flavoured milk | 22 | 5 | 13 | 31 |
| Other milks | 8 | 2 | 4 | 12 |
| Vegetable Juice | 3 | 1 | 1 | 5 |
| Fruit Juice | 168 | 12 | 145 | 190 |
| **No Additional Energy Beverages (g)** | **332** | **18** | **297** | **367** |
| Water | 320 | 17 | 287 | 354 |
| Diet Drinks | 3 | 1 | 1 | 5 |
| Tea (plain) | 7 | 2 | 3 | 12 |
| Coffee (plain) | 1 | 1 | . | 4 |
| ***Total Beverage Intake (g)*** | ***1114*** | ***30*** | ***1055*** | ***1173*** |

Beverage intakes of boys and girls 6 to 11 years are presented in Table 4.6 and Table 4.7 respectively. Overall, boys drank significantly more total beverages than girls ($p<0.05$). Boys also drank more milk and more nutrient-based beverages than girls ($p<0.05$). The top three beverages consumed by both boys and girls were water (442 ±19 g, 408 ±16 g respectively), milk (321 ± 11 g, 271 ± 10 g respectively), and fruit drink (202 ±9 g, 196 ±10 g respectively). This was followed by fruit juice for both boys and girls (153 ±10 g, 131± 9 g respectively). By weight, approximately one fifth of total beverage intake by boys and girls 6 to 11 years was from sugar sweetened beverages (22% and 23% respectively). Water was the main non-caloric beverage consumed for both boys and girls.

Table 4.6: Mean intake, standard error (SEM) and 95% confidence interval of beverages (g) by boys 6 to 11 years

| | **Mean** | **SEM** | **95% Confidence Interval** | |
|---|---|---|---|---|
| **Sugar Sweetened Beverages (g)** | **312** | **13** | **287** | **337** |
| Fruit Drink | 202 | 9 | 184 | 219 |
| Soft Drink | 97 | 8 | 81 | 113 |
| Sweetened Tea | 13 | 3 | 8 | 18 |
| Sweetened Coffee | 0 | 0 | 0 | 0 |
| **Nutrient Based Beverages (g)** | **603** | **15** | **574** | **631** |
| Milk (plain) | 321 | 11 | 299 | 344 |
| High fat flavoured milk | 86 | 10 | 67 | 106 |
| Low fat flavoured milk | 33 | 4 | 24 | 41 |
| Other milks | 5 | 2 | 2 | 9 |
| Vegetable Juice | 5 | 1 | 2 | 7 |
| Fruit Juice | 153 | 10 | 134 | 172 |
| **No Additional Energy Beverages (g)** | **481** | **19** | **444** | **518** |
| Water | 442 | 19 | 405 | 480 |
| Diet Drinks | 13 | 3 | 7 | 19 |
| Tea (plain) | 25 | 4 | 17 | 33 |
| Coffee (plain) | 1 | 0 | 0 | 1 |
| ***Total Beverage Intake (g)*** | ***1396*** | ***27*** | ***1344*** | ***1448*** |

Table 4.7: Mean intake, standard error (SEM) and 95% confidence interval of beverages (g) by girls 6 to 11 years

| | **Mean** | **SEM** | **95% Confidence Interval** | |
|---|---|---|---|---|
| **Sugar Sweetened Beverages (g)** | **286** | **11** | **264** | **308** |
| Fruit Drink | 196 | 10 | 176 | 215 |
| Soft Drink | 81 | 6 | 70 | 93 |
| Sweetened Tea | 9 | 2 | 5 | 12 |
| Sweetened Coffee | 1 | 1 | . | 2 |
| **Nutrient Based Beverages (g)** | **505** | **16** | **473** | **536** |
| Milk (plain) | 271 | 10 | 250 | 291 |
| High fat flavoured milk | 63 | 6 | 51 | 74 |
| Low fat flavoured milk | 29 | 4 | 21 | 37 |
| Other milks | 4 | 2 | 1 | 7 |
| Vegetable Juice | 7 | 3 | 0 | 13 |
| Fruit Juice | 131 | 9 | 113 | 150 |
| **No Additional Energy Beverages (g)** | **432** | **16** | **400** | **464** |
| Water | 408 | 16 | 376 | 440 |
| Diet Drinks | 5 | 1 | 3 | 7 |
| Tea (plain) | 18 | 2 | 14 | 23 |
| Coffee (plain) | 1 | 0 | 0 | 1 |
| ***Total Beverage Intake (g)*** | ***1224*** | ***22*** | ***1180*** | ***1267*** |

For children 12 to18 years, boys' and girls' intake of beverages are presented in Tables 4.8 and 4.9 respectively. Boys drank significantly more total beverages than girls ($p<0.05$). Boys drink more soft drinks and milk than girls ($p<0.05$). Overall, boys drank more sugar sweetened beverages and nutrient based beverages than girls ($p<0.05$). Both boys and girls consumed mostly water: 739 ± 28 g and 672 ± 26 g, respectively. The second most consumed beverage group for both boys and girls was milk: 375 ± 14 g for boys, and 281 ± 14 g for girls. Following water and milk, the third most consumed beverage among boys was soft drink (300 ± 14 g), and for girls was fruit drink (224 ±13 g). For boys, 28% of beverage intake was from sugar-sweetened beverages and one third from nutrient-based beverages (32%), with the remaining volume of beverages from non-caloric beverages (39%), mostly water. For girls, 23% of beverages by weight were from sugar sweetened beverages, 31% were from nutrient-based beverages, and the remainder from non-caloric beverages, mostly water (44%).

Table 4.8: Mean intake, standard error (SEM) and 95% confidence interval of beverages (g) by boys 12 to 18 years

| | **Mean** | **SEM** | **95% Confidence Interval** | |
|---|---|---|---|---|
| **Sugar Sweetened Beverages (g)** | **582** | **20** | **542** | **622** |
| Fruit Drink | 248 | 13 | 222 | 273 |
| Soft Drink | 300 | 14 | 273 | 327 |
| Sweetened Tea | 34 | 6 | 21 | 46 |
| Sweetened Coffee | 0 | 0 | 0 | 1 |
| **Nutrient Based Beverages (g)** | **661** | **19** | **624** | **698** |
| Milk (plain) | 375 | 14 | 347 | 403 |
| High fat flavoured milk | 66 | 7 | 53 | 79 |
| Low fat flavoured milk | 40 | 6 | 27 | 53 |
| Other milks | 6 | 2 | 2 | 11 |
| Vegetable Juice | 7 | 3 | 2 | 12 |
| Fruit Juice | 167 | 11 | 146 | 188 |
| **No Additional Energy Beverages (g)** | **817** | **29** | **760** | **873** |
| Water | 739 | 28 | 685 | 794 |
| Diet Drinks | 18 | 3 | 11 | 24 |
| Tea (plain) | 38 | 4 | 29 | 47 |
| Coffee (plain) | 22 | 3 | 16 | 28 |
| ***Total Beverage Intake (g)*** | ***2083*** | ***37*** | ***2010*** | ***2155*** |

Table 4.9: Mean intake, standard error (SEM) and 95% confidence interval of beverages (g) by girls 12 to 18 years

| | Mean | SEM | 95% Confidence Interval | |
|---|---|---|---|---|
| **Sugar Sweetened Beverages (g)** | **416** | **17** | **384** | **449** |
| Fruit Drink | 224 | 13 | 199 | 249 |
| Soft Drink | 172 | 10 | 152 | 192 |
| Sweetened Tea | 18 | 3 | 12 | 25 |
| Sweetened Coffee | 2 | 1 | 0 | 4 |
| **Nutrient Based Beverages (g)** | **550** | **17** | **516** | **583** |
| Milk (plain) | 281 | 14 | 254 | 309 |
| High fat flavoured milk | 62 | 6 | 49 | 74 |
| Low fat flavoured milk | 31 | 5 | 22 | 40 |
| Other milks | 3 | 1 | 1 | 5 |
| Vegetable Juice | 9 | 3 | 4 | 15 |
| Fruit Juice | 163 | 10 | 144 | 182 |
| **No Additional Energy Beverages (g)** | **789** | **28** | **733** | **845** |
| Water | 672 | 26 | 620 | 724 |
| Diet Drinks | 31 | 5 | 21 | 40 |
| Tea (plain) | 54 | 7 | 41 | 67 |
| Coffee (plain) | 33 | 4 | 24 | 41 |
| ***Total Beverage Intake (g)*** | ***1776*** | ***34*** | ***1709*** | ***1843*** |

*4.1.2 Descriptive Nutrient Intake*

Mean energy, calcium, and vitamin C intake were calculated for boys and girls among each age group and is presented in Table 4.10. Boys' intake of each of the nutrients is higher than girls of the same age. Energy intake increased across increasing age groups for both boys and girls. Calcium intake among girls 6 to 11 years was lower than among girls 2 to 5 years and 12 to 18 years. Vitamin C intake among boys 6 to 11 years was lower compared to boys in other age groups. Girls' intake of Vitamin C increased across age groups (Table 4.10).

Table 4.10: Mean and standard error (SEM) of intake of selected nutrients by age-sex group

| | 2-5 years | | 6-11 years | | 12-18 years | |
|---|---|---|---|---|---|---|
| | **Male** | **Female** | **Male** | **Female** | **Male** | **Female** |
| **Energy (kcal)** | 1687 ± 23 | 1598 ± 24 | 2064 ±23 | 1934 ±21 | 2681 ± 28 | 2225 ± 25 |
| **Calcium (mg)** | 1044 ± 21 | 991 ± 27 | 1085 ±19 | 950 ±18 | 1267 ± 24 | 1021 ± 25 |
| **Vitamin C (mg)** | 160 ± 5 | 131 ± 4 | 144 ±5 | 142 ±5 | 164 ± 5 | 159 ± 4 |

*4.1.3 Descriptive BMI-for-age*

Approximately two-thirds of children 2 to 5 years old had a BMI-for-age considered ‘normal’: 61% and 65%, for boys and girls respectively. Seventeen percent (17%) of boys and girls were considered ‘overweight’, and 21% of boys were ‘obese’ while 17% of girls were ‘obese’.

Two-thirds (66%) of boys 6 to 11 years had a BMI-for-age considered ‘normal’, while 73% of girls of the same age had a BMI-for-age considered ‘normal’. Nineteen percent (19%) of boys were considered ‘overweight’, while 15% of girls were considered ‘overweight’. More boys than girls were considered ‘obese’: 16% and 13%, respectively.

Most boys and girls 12 to 18 years were considered normal weight, 69% and 79%, respectively. A higher proportion of boys were considered overweight than girls: 17% and 14% respectively. Similarly, a higher percentage of boys were considered obese compared to girls, 14% for boys and 7% for girls.

*4.2 Results by Cluster*

Cluster analysis was completed separately for 2 to 5 year olds, 6 to 11 year olds, and 12 to 18 year olds. This procedure was used to sort children into non-overlapping groups according to their dominant pattern of beverage intake. Separate clustering solutions were obtained for each age group, and thus the results presented are arranged by increasing age. For each age group, data by cluster is presented on sociodemographics, beverage intake, nutrient intake and BMI-for-age.

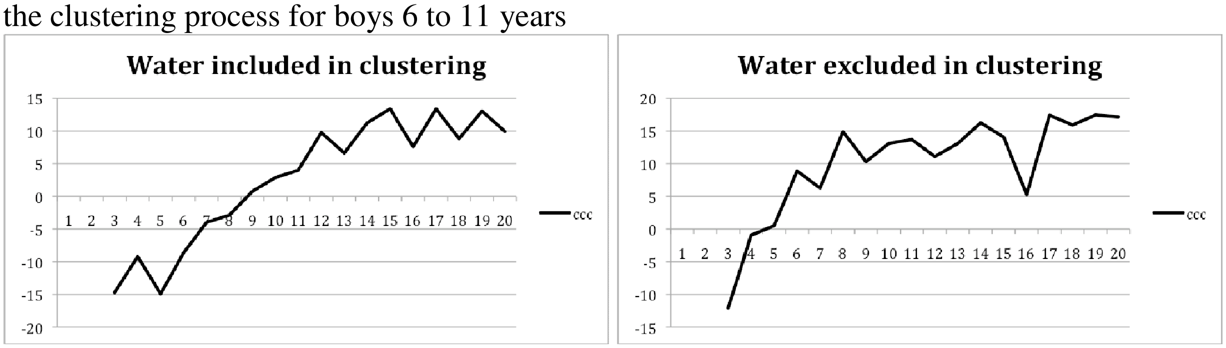
The optimal clustering solution for each age group was determined based on the cubic clustering criterion, pseudo-F-statistic and interpretability. For children 2 to 5 years old, data on boys and girls were combined for cluster analysis and a five cluster solution was most appropriate. For all older age groups, boys and girls were analyzed separately. The most appropriate clustering pattern for older children were as follows: a six cluster solution for both boys and girls 6 to 11 years old and a four-cluster solution for boys and girls 12 to 18 years old. The beverage clusters were named using the predominant beverage in each. The names and the number of subjects in each clustering solution are presented in Table 4.11. The ‘moderate’ cluster was named as such because children in this group drank smaller amounts of a variety of beverages.

Table 4.11 Numbers of boys and girls in each cluster

| | 2-5 years | 6-11 years | | 12-18 years | |
|---|---|---|---|---|---|
| **Cluster** | **Both sexes** | **Male** | **Female** | **Male** | **Female** |
| ***Soft Drink Cluster*** | - | 219 | 193 | 393 | 255 |
| ***Fruit Drink Cluster*** | 315 | 275 | 326 | 351 | 350 |
| ***Fruit Juice Cluster*** | 320 | 192 | 206 | - | - |
| ***Milk Cluster*** | 422 | 322 | 348 | 378 | 405 |
| ***High-Fat Milk Cluster*** | 268 | 144 | 139 | - | - |
| ***Moderate Cluster*** | 825 | 630 | 619 | 1133 | 1010 |

Prior to finalizing the clusters for each category, an exploratory analysis was completed examining the impact of water on the clustering process. When water was included in the cluster analysis as a separate beverage (note, it is always included as a beverage in the data), the cubic clustering criterion (CCC) did not produce early and positive peaks, as necessary for interpretation. Figure 4.1 provides an example of the CCC values produced with data on boys 6 to 11 years when water was included and when water was excluded from the clustering process. The graph on the left has a positive peak at 12 clusters, which is poorly interpretable. The graph on the right shows an early positive peak at 6 clusters, which better allows for interpretation of the clusters. Similar exploratory analysis was performed for the other age-sex groups, and repeatedly, late and multiple peaks for CCC occurred when water was included (data not shown). The decision was made to exclude water from the clustering process, and to describe the intake of water within the clusters that emerged.

Figure 4.1: Cubic clustering criterion graphs produced when water was included and excluded in the clustering process for boys 6 to 11 years



*4.2.1 Children 2 to 5 Years Old*

Across the five clusters for 2 to 5 year olds, children in the ‘high-fat flavoured milk’ cluster were significantly younger (3.2 years ± 0.1) than children in the ‘fruit juice’ cluster (3.6 years ± 0.1, $p<0.05$). There was a significant difference in sex and ethnicity across clusters (Table 4.12). It appeared that there were proportionally more boys in the ‘fruit juice’ cluster and proportionally more girls in the ‘moderate’ cluster, compared to other clusters. A lower percentage of non-white children were in the ‘fruit juice’ cluster while a higher percentage of non-white children were in the ‘high-fat milk’ cluster, when compared to other clusters. No difference was observed across clusters using the chi-square test for household income level, food security, and household education (Table 4.12).

Table 4.12: Socio-demographic characteristics of each beverage pattern among children aged 2 to 5 years

| | ***Fruit Drink*** | ***Fruit Juice*** | ***Milk*** | ***High Fat Milk*** | ***Moderate*** | **p- value** |
|---|---|---|---|---|---|---|
| **Sex (%)*** | | | | | | **0.0318** |
| Male | 49.1% | 61.1% | 53.7% | 51.0% | 44.6% | |
| Female | 51.0% | 38.9% | 46.3% | 49.0% | 55.4% | |
| **Ethnicity (%)*** | | | | | | **0.0056** |
| White | 79.6% | 85.5% | 80.2% | 65.7% | 78.2% | |
| Non-white | 20.4% | 14.5% | 19.8% | 34.3% | 21.8% | |
| **Household income level (%)** | | | | | | 0.09 |
| High | 85.7% | 93.6% | 92.4% | 89.0% | 90.4% | |
| Low | 14.3% | 6.4% | 7.6% | 11.1% | 9.6% | |
| **Food security (%)** | | | | | | 0.46 |
| Food secure | 86.7% | 90.2% | 88.2% | 92.1% | 91.6% | |
| Food insecure | 13.3% | 9.9% | 11.8% | 7.9% | 8.4% | |
| **Household education (%)** | | | | | | 0.64 |
| At least some post secondary | 81.4% | 83.9% | 87.2% | 86.6% | 83.7% | |
| Secondary or less | 18.6% | 16.1% | 12.9% | 13.5% | 16.4% | |

* statistically significant across beverage patterns using Pearson chi-square test

Among 2 to 5 year olds, within each beverage cluster the defining beverage intake was the highest intake ($p<0.05$) (Table 4.13). Children 2 to 5 years in the 'moderate' cluster had the lowest total beverage intake and lowest percent energy from beverages compared to all other clusters ($p<0.05$). Children 2 to 5 years old in the 'milk' cluster and 'high fat milk' cluster had higher calcium intake compared to all other clusters, although the intake between the two milk clusters was not significantly different from each other (Table 4.14). The 'fruit juice' and 'fruit drink' clusters had the highest intakes of vitamin C compared to all other clusters ($p<0.05$). Children in the 'fruit juice' cluster had significantly more vitamin C intake compared to those in the 'fruit drink' cluster ($p<0.05$). Using $\chi^2$ test across beverage clusters, there was no significant difference for BMI classifications for 2 to 5 year olds (Table 4.15).

Table 4.13: Mean intake of beverage groups across beverage patterns in children aged 2 to 5 years

| **Beverage Group** | ***Fruit Drink*** | ***Fruit Juice*** | ***Milk*** | ***High Fat Milk*** | ***Moderate*** |
|---|---|---|---|---|---|
| | | | **Mean ± SEM** | | |
| **Fruit Drink (g)** | **556* ± 19** | 68 ± 11 | 94 ± 11 | 96 ± 19 | 73 ± 5 |
| **Soft Drink (g)** | 21 ± 5 | 23 ± 6 | 11 ± 3 | 15 ± 4 | **35[a] ± 6** |
| **Milk (g)** | 222 ± 16 | 222 ± 18 | **787* ± 24** | **46* ± 14** | 206 ± 8 |
| **High Fat Milk (g)** | 52 ± 10 | **65[b] ± 12** | 48 ± 12 | **688* ± 47** | 32 ± 4 |
| **Fruit Juice (g)** | **56* ± 13** | **719* ± 43** | 138 ± 12 | 135 ± 17 | 109 ± 6 |
| **Water (g)** | 316 ± 30 | 274 ± 28 | 352 ± 28 | 276 ± 27 | 332 ± 18 |
| **Total beverage intake (g)** | **1275[a] ± 48** | 1426 ± 62 | 1461 ± 44 | 1304 ± 71 | **865* ± 23** |

* significantly different from other clusters $p<0.05$
a: significantly different from *Milk* cluster
b: significantly different from *Moderate* cluster

Table 4.14: Mean intake of selected nutrients across beverage patterns in children aged 2 to 5 years

| **Beverage Group** | ***Fruit Drink*** | ***Fruit Juice*** | ***Milk*** | ***High Fat Milk*** | ***Moderate*** |
|---|---|---|---|---|---|
| | | | **Mean ± SEM** | | |
| **% energy from beverages** | **28[ab] ± 1** | 33 ± 1 | 32 ± 1 | 34 ± 1 | **18* ± 0** |
| **% energy from SSB** | **16* ± 1** | 2 ± 0 | 3 ± 0 | 3 ± 1 | 3 ± 0 |
| **% energy from NBB** | **12* ± 1** | 31 ± 1 | 30 ± 1 | 31 ± 1 | **14* ± 1** |
| **Calcium (mg)** | **863[ab] ± 27** | **897[ab] ± 28** | 1418 ± 35 | 1271 ± 62 | **816[ab] ± 21** |
| **Vitamin C (mg)** | **165* ± 11** | **267* ± 12** | 121 ± 5 | 125 ± 6 | 112 ± 4 |

* significantly different from other clusters $p<0.05$
a: significantly different from *Milk* cluster
b: significantly different from *High Fat Milk* cluster
SSB: sugar sweetened beverages
NBB: nutrient based beverages

Table 4.15: Proportion of children 2 to 5 years in three BMI classifications by beverage cluster

| **BMI classification (%)** | ***Fruit Drink*** | ***Fruit Juice*** | ***Milk*** | ***High Fat Milk*** | ***Moderate*** | **p-value** |
|---|---|---|---|---|---|---|
| Normal | 62.2% | 64.4% | 62.6% | 70.7% | 67.6% | 0.84 |
| Overweight | 17.7% | 22.6% | 20.0% | 14.4% | 18.3% | |
| Obese | 20.1% | 13.0% | 17.5% | 15.0% | 14.1% | |

*4.2.2 Children 6 to 11 Years Old*

For both boys and girls 6 to 11 years, a six cluster solution was most appropriate. Among boys 6 to 11 years, those in the 'high fat milk' cluster (7.6 ± 0.2 y) were significantly younger than boys in the other clusters, except those in the 'fruit juice' cluster (8.4 ± 0.2 y) ($p<0.05$). Boys in the 'soft drink' cluster (8.9 ± 0.2 y) were significantly older than children in the 'moderate' cluster (8.4 ±0.1 y). Boys in the 'fruit drink' cluster were 8.9 ± 0.2 years, and those in the 'milk' cluster were 8.4 ±0.2 years. Across clusters, there was a significant difference for ethnicity ($p<0.001$), possibly due to the high proportion of non-white children in the 'high-fat milk' cluster (Table 4.16), however this was not determined as post-hoc tests were not able to be completed. Similarly, there was a significant difference among household income for boys 6 to 11 years across clusters ($p<0.05$), where a relatively high proportion of children in the 'high-fat milk' cluster lived in lower income households. There was no significant difference across clusters for food security status, household education, physical activity, or sedentary activity (Table 4.16).

Among girls 6 to 11 years, those who drank mostly soft drinks were significantly older (9.2 ± 0.1 y) than children in all other clusters ($p<0.05$). Girls in the 'fruit drink' cluster had an average age of 8.6 ± 0.1 y. Girls in the 'fruit juice' cluster were 8.5 ± 0.2 years, those in the 'milk' cluster were 8.6 ± 0.1 years, those in the 'high-fat milk' cluster were 8.2 ± 0.2 years, and those in the 'moderate' cluster were 8.5 ± 0.1 years. There were no significant differences across clusters for ethnicity, household income, food security, household education, physical activity or sedentary activity (Table 4.17). Of note, although not statistically significant, a higher proportion of children had a 'non-white' ethnicity among the 'high fat milk' cluster, similar to boys 6 to 11 years. More children in the 'soft drink' cluster lived in households with low household income compared to children in other clusters, although this was not significant.

Table 4.16: Socio-demographic characteristics of each beverage pattern among boys 6 to 11 years

| | ***Soft Drink*** | ***Fruit Drink*** | ***Fruit Juice*** | ***Milk*** | ***High Fat Milk*** | ***Moderate*** | **p-value** |
|---|---|---|---|---|---|---|---|
| **Ethnicity (%) *** | | | | | | | **0.0003** |
| White | 77.7% | 81.9% | 84.5% | 83.1% | 53.8% | 71.3% | |
| Non-white | 22.3% | 18.1% | 15.5% | 16.9% | 46.2% | 28.7% | |
| **Household income (%)*** | | | | | | | **0.0374** |
| High | 85.1% | 90.4% | 92.7% | 92.9% | 78.0% | 86.2% | |
| Low | 14.9% | 9.6% | 7.3% | 7.1% | 22.0% | 13.8% | |
| **Food security (%)** | | | | | | | 0.19 |
| Food secure | 91.6% | 86.8% | 91.0% | 95.4% | 91.5% | 88.0% | |
| Food insecure | 8.4% | 13.2% | 9.0% | 4.6% | 8.5% | 12.0% | |
| **Household education (%)** | | | | | | | 0.78 |
| At least some post secondary | 81.0% | 84.9% | 80.1% | 86.3% | 79.2% | 81.7% | |
| Secondary or less | 19.0% | 15.1% | 19.9% | 13.7% | 20.8% | 18.3% | |
| **Physical activity (%)** | | | | | | | 0.55 |
| High | 27.3% | 30.2% | 25.7% | 23.0% | 28.9% | 23.1% | |
| Moderate | 36.1% | 37.8% | 38.6% | 44.0% | 25.7% | 36.3% | |
| Low | 36.7% | 32.1% | 35.8% | 33.1% | 45.4% | 40.6% | |
| **Sedentary activity (%)** | | | | | | | 0.98 |
| Low | 20.5% | 17.6% | 24.0% | 19.7% | 16.8% | 20.5% | |
| Moderate | 44.0% | 41.1% | 45.1% | 44.1% | 47.2% | 44.3% | |
| High | 35.5% | 41.3% | 30.9% | 36.2% | 35.9% | 35.2% | |

* significantly different across clusters p<0.05 using Pearson chi-square test

Table 4.17: Socio-demographic characteristics of each beverage pattern among girls 6 to 11 years

| | ***Soft Drink*** | ***Fruit Drink*** | ***Fruit Juice*** | ***Milk*** | ***High Fat Milk*** | ***Moderate*** | **p-value** |
|---|---|---|---|---|---|---|---|
| **Ethnicity (%)** | | | | | | | 0.32 |
| White | 75.9% | 85.9% | 78.4% | 82.2% | 71.9% | 80.6% | |
| Non-white | 24.1% | 14.1% | 21.6% | 17.8% | 28.1% | 19.4% | |
| **Household income (%)** | | | | | | | 0.21 |
| High | 80.8% | 88.5% | 85.6% | 91.2% | 85.6% | 90.9% | |
| Low | 19.2% | 11.5% | 14.4% | 8.8% | 14.4% | 9.1% | |
| **Food security (%)** | | | | | | | 0.24 |
| Food secure | 89.7% | 91.0% | 90.5% | 96.9% | 93.5% | 91.8% | |
| Food insecure | 10.4% | 9.0% | 9.5% | 3.1% | 6.5% | 8.3% | |
| **Household education (%)** | | | | | | | 0.18 |
| At least some post secondary | 82.0% | 78.0% | 81.0% | 86.0% | 70.0% | 79.0% | |
| Secondary or less | 18.0% | 22.0% | 19.0% | 14.0% | 30.0% | 21.0% | |
| **Physical activity (%)** | | | | | | | 0.79 |
| High | 23.2% | 22.7% | 20.5% | 19.8% | 19.5% | 18.9% | |
| Moderate | 39.9% | 38.9% | 28.8% | 37.5% | 32.3% | 37.6% | |
| Low | 36.9% | 38.5% | 50.8% | 42.7% | 48.2% | 43.5% | |
| **Sedentary activity (%)** | | | | | | | 0.38 |
| Low | 15.6% | 26.0% | 23.4% | 15.9% | 23.0% | 22.5% | |
| Moderate | 41.1% | 44.8% | 44.3% | 55.4% | 45.9% | 46.5% | |
| High | 43.3% | 29.2% | 32.3% | 28.8% | 31.1% | 31.1% | |

Among boys 6 to 11 years who drank mostly ‘fruit drinks’ (mean 708 ± 19 g), they drank a relatively small amount of ‘fruit juice’ (58 ± 13 g) (Table 4.18). The opposite was true for boys who drank mostly ‘fruit juice’ (653 ± 29 g), as they drank less fruit drink (64g ± 13 g). Boys in the ‘milk’ cluster drank an average of 859 ± 18 g of milk, while boys in other clusters drank less than 250g or one cup of milk. There was no significant difference of water intake across clusters ($p>0.05$).

Girls 6 to 11 years old who drank mostly fruit drinks (mean intake 622 ± 21 g) drank less fruit juice (56 ± 9 g). Similar to boys, girls who drank mostly fruit juice (572 ±36 g) drank relatively less fruit drink (121 ± 26 g). Girls who were in the ‘soft drink’ cluster drank, on average, 467 ± 23 g of soft drink on the previous day. The girls in the ‘milk’ cluster drank 722 ± 17 g of milk, while consumption of milk among other clusters was less than 200 g. Those who were in the moderate cluster had the lowest total beverage intake (898 ± 31 g) compared to all other clusters ($p<0.05$). There was no significant difference across clusters for water intake, which ranged from 326 ± 47 g to 497 ± 62 g (Table 4.19).

Table 4.18: Mean intake of beverage groups across beverage patterns in boys aged 6 to 11 years

| **Beverage group** | ***Soft Drink*** | ***Fruit Drink*** | ***Fruit Juice*** | ***Milk*** | ***High Fat Milk*** | ***Moderate*** |
|---|---|---|---|---|---|---|
| **Fruit Drink (g)** | 151 ± 17 | **708* ± 19** | **64* ± 13** | 141 ± 17 | 143 ± 18 | 111 ± 8 |
| **Soft Drink (g)** | **553* ± 29** | **72[a] ± 14** | 54 ± 14 | 32 ± 8 | **64[a] ± 15** | 23 ± 4 |
| **Milk (g)** | 210 ± 17 | 220 ± 18 | 214 ± 26 | **859* ± 18** | **70* ± 17** | 248 ± 10 |
| **High fat milk (g)** | 34 ± 8 | 32 ± 7 | 32 ± 10 | 38 ± 9 | **609* ± 59** | 23 ± 5 |
| **Fruit Juice (g)** | 109 ± 29 | 58 ± 13 | **653* ± 29** | **112[ab] ± 13** | **140[ab] ± 24** | 71 ± 7 |
| **Water (g)** | 531 ± 56 | 385 ± 36 | 383 ± 62 | 366 ± 36 | 601 ± 95 | 448 ± 31 |
| **Total beverage intake (g)** | 1681 ± 81 | 1542 ± 55 | 1459 ± 79 | 1644 ± 53 | 1693 ± 140 | **1048* ± 31** |

* significantly different than all clusters
a: significantly different from *Moderate* cluster
b: significantly different from *Fruit Drink* cluster

Table 4.19: Mean intake of beverage groups across beverage patterns in girls aged 6 to 11 years

| **Beverage group** | ***Soft Drink*** | ***Fruit Drink*** | ***Fruit Juice*** | ***Milk*** | ***High Fat Milk*** | ***Moderate*** |
|---|---|---|---|---|---|---|
| **Fruit Drink (g)** | 111 ± 15 | **622* ± 21** | 121 ± 26 | 76 ± 10 | 142 ± 31 | 97 ± 8 |
| **Soft Drink (g)** | **467* ± 23** | 42 ± 9 | 52 ± 14 | 38 ± 7 | **57[a] ± 14** | 22 ± 4 |
| **Milk (g)** | 142 ± 16 | 189 ± 12 | 181 ± 19 | **722* ± 17** | 172 ± 34 | 170 ± 10 |
| **High Fat Milk (g)** | 25 ± 9 | 30 ± 7 | 28 ± 9 | **50[a] ± 10** | **472* ± 30** | 16 ± 4 |
| **Fruit Juice (g)** | 70 ± 13 | 56 ± 9 | **572* ± 36** | 87 ± 10 | 106 ± 19 | 65 ± 6 |
| **Water (g)** | 326 ± 47 | 417 ± 38 | 375 ± 47 | 403 ± 33 | 497 ± 62 | 422 ± 28 |
| **Total beverage intake (g)** | 1195 ± 67 | 1409 ± 47 | 1383 ± 54 | 1445 ± 43 | 1497 ± 100 | **898* ± 31** |

* significantly different from other clusters $p<0.05$
a: significantly different from *Moderate* cluster

Boys 6 to 11 years who drank ‘fruit drinks’ and ‘soft drinks’ had a higher proportion of calories coming from sugar-sweetened beverages, 16% and 14%, respectively. Boys in the ‘milk’, ‘high fat milk’ and ‘fruit juice’ clusters had 4%, 4% and 2% respectively, of energy coming from sugar sweetened beverages, yet had 24%, 24% and 22% of energy coming from nutrient-based beverages respectively (Table 4.20). Boys in the ‘moderate’ cluster had significantly less energy coming from beverages (15%) compared to all other clusters ($p<0.05$). The total calcium intake was highest among boys in the ‘milk’ and ‘high-fat milk’ clusters: 1668 ± 41 mg, and 1231 ± 80 mg respectively. The total intake of vitamin C was highest among boys in the ‘fruit juice’ cluster (255 ± 15 mg) and ‘fruit drink’ cluster (207 ± 12 mg) (Table 4.20)

Those girls 6 to 11 years who were in the moderate cluster had the lowest percent energy from beverages (13%) compared to all other clusters (Table 4.21). Girls in the ‘fruit drink’ and ‘soft drink’ clusters had 15% and 14%, respectively, of their total energy intake from sugar sweetened beverages. Children in the ‘milk’, ‘high fat milk’ and ‘fruit juice’ clusters had 23%, 23%, and 20% of their total energy intake from nutrient based beverages. Girls in the ‘milk’ cluster had the highest total calcium intake compared to all other clusters at 1462 ± 31 mg ($p<0.05$), while girls in the ‘soft drink’ cluster has the lowest total calcium intake overall (661 ± 36 mg). The girls in the ‘fruit drink’ and ‘fruit juice’ clusters had the highest intakes of total vitamin C compared to other clusters at 191 ± 10 mg and 259 ± 11 mg, respectively (Table 4.21).

Table 4.20: Mean intake (± SEM) of selected nutrients across beverage patterns in boys aged 6 to 11 years

| Beverage group | *Soft Drink* | *Fruit Drink* | *Fruit Juice* | *Milk* | *High Fat Milk* | *Moderate* |
|---|---|---|---|---|---|---|
| **% energy from beverages** | 23 ± 1 | 24 ± 1 | 24 ± 1 | 27 ± 1 | **28[a] ± 2** | **15* ± 1** |
| **% energy from SSB** | 14 ± 1 | **16[b] ± 1** | 2 ± 0 | 4 ± 0 | 4 ± 0 | 3 ± 0 |
| **% energy from NBB** | 9 ± 1 | **8[b] ± 1** | 22 ± 1 | 24 ± 1 | 24 ± 2 | **12* ± 1** |
| **Calcium (mg)** | 900 ± 46 | 937 ± 39 | 933 ± 50 | **1668* ± 41** | **1231* ± 80** | 940 ± 25 |
| **Vitamin C (mg)** | 124 ± 15 | **207[c] ± 12** | **255[d] ± 15** | 133 ± 7 | 125 ± 16 | **102[e] ± 5** |

* significantly different than all clusters
a: significantly different from *Soft Drink* cluster
b: significantly different from all other clusters, except *Soft Drink* cluster
c: significantly different from all except *Fruit Juice* cluster
d: significantly different from all except *Fruit Drink* cluster
e: significantly different from *Fruit Drink, Fruit Juice*, and *Milk* clusters



Table 4.21: Mean intake (±SEM) of selected nutrients across beverage patterns in girls aged 6 to 11 years

| Beverage group | *Soft Drink* | *Fruit Drink* | *Fruit Juice* | *Milk* | *High Fat Milk* | *Moderate* |
|---|---|---|---|---|---|---|
| **% energy from beverages** | 21 ± 1 | 23 ± 1 | 24 ± 1 | 25 ± 1 | **28[a] ± 2** | **13* ± 1** |
| **% energy from SSB** | **14[b] ± 1** | **15[b] ± 1** | 4 ± 1 | 3 ± 0 | 4 ± 1 | 4 ± 0 |
| **% energy from NBB** | 7 ± 1 | 8 ± 0 | **20[a] ± 1** | **23[c] ± 1** | **23[c] ± 2** | 9 ± 1 |
| **Calcium (mg)** | **661* ± 36** | 839 ± 28 | 960 ± 556 | **1462* ± 31** | **1073[d] ±57** | 795 ± 23 |
| **Vitamin C (mg)** | 97 ± 8 | **191* ± 10** | **259* ± 11** | 108 ± 7 | 138 ± 17 | 107 ± 7 |

* significantly different from other clusters p<0.05
a: significantly different from *Soft Drink* cluster
b: significantly different from *High Fat Milk, Milk, Moderate*, and *Fruit Juice* clusters
c: significantly different from *Fruit Drink* and *Soft Drink* clusters
d: significantly different from all clusters, except *Fruit Juice* cluster

Among boys 6 to 11 years, a chi-square test for BMI-classification across beverage clusters was not significant (p=0.37). However, the proportion of boys who were considered overweight and obese was higher among the 'soft drink' cluster (Table 4.22). To examine this further the overweight and obese categories were combined and a chi-square test was repeated, but was not significant (p=0.15). Using chi-square test across clusters, there was no significant difference for BMI-classification categories among girls 6 to 11 years (p=0.7) (Table 4.23).

Table 4.22: Proportion of boys 6 to 11 years in three BMI-classifications by beverage cluster

| | ***Soft Drink*** | ***Fruit Drink*** | ***Fruit Juice*** | ***Milk*** | ***High Fat Milk*** | ***Moderate*** |
|---|---|---|---|---|---|---|
| **Normal** | 52.5% | 72.2% | 70.6% | 65.6% | 69.7% | 74.7% |
| **Overweight** | 28.9% | 11.9% | 16.1% | 19.0% | 19.4% | 14.8% |
| **Obese** | 18.6% | 15.9% | 13.4% | 15.4% | 10.8% | 10.5% |

Table 4.23: Proportion of girls 6 to 11 years in three BMI-classifications by beverage cluster

| | ***Soft Drink*** | ***Fruit Drink*** | ***Fruit Juice*** | ***Milk*** | ***High Fat Milk*** | ***Moderate*** |
|---|---|---|---|---|---|---|
| **Normal** | 71.6% | 76.4% | 75.9% | 71.0% | 76.5% | 70.2% |
| **Overweight** | 20.6% | 15.0% | 11.7% | 20.2% | 13.5% | 15.0% |
| **Obese** | 7.8% | 8.6% | 12.4% | 8.8% | 9.9% | 14.9% |

### *4.2.3 Children 12 to 18 Years Old*

For boys and girls 12 to 18 years, a four cluster solution was most appropriate. Across clusters, boys aged 12 to 18 years in the 'soft drink' cluster (15.2 ± 0.1 years) were significantly older than all other clusters (p<0.05). Boys in the 'fruit drink', 'milk', and 'moderate' clusters were 14.4 ± 0.1 years, 14.5 ± 0.1 years, 14.6 ± 0.1 years, respectively. There was a significant difference across clusters for ethnicity where a larger proportion of children were White in the soft drink group, compared to other clusters (Table 4.24). Chi-square test also showed a significant difference in food security status across clusters, while household income level across clusters was nearly significant (Table 4.24). There was no significant difference across clusters for household education or physical activity status.

Table 4.24: Socio-demographic characteristics of each beverage pattern among boys aged 12 to 18 years

| | *Soft drink* | *Fruit drink* | *Milk* | *Moderate* | p- value |
|---|---|---|---|---|---|
| **Ethnicity (%)*** | | | | | **0.0036** |
| White | 90.3% | 86.7% | 87.2% | 79.3% | |
| Non-white | 9.7% | 13.3% | 12.8% | 20.7% | |
| **Household income (%)** | | | | | 0.05 |
| High | 86.3% | 87.6% | 96.6% | 90.2% | |
| Low | 13.7% | 12.4% | 3.4% | 9.8% | |
| **Food security (%)*** | | | | | **0.0379** |
| Food secure | 95.4% | 90.7% | 97.3% | 91.0% | |
| Food insecure | 4.6% | 9.3% | 2.7% | 9.1% | |
| **Household education (%)** | | | | | 0.21 |
| At least some post secondary | 77.2% | 80.8% | 86.4% | 83.3% | |
| Secondary or less | 22.9% | 19.2% | 13.6% | 16.7% | |
| **Physical activity index (%)** | | | | | 0.78 |
| Active | 50.6% | 53.5% | 54.2% | 49.2% | |
| Moderate | 21.0% | 23.9% | 23.8% | 23.6% | |
| Inactive | 28.4% | 22.6% | 22.0% | 27.2% | |

* significantly different across clusters p<0.05 using Pearson chi-square test

Among girls 12 to 18 years, there was no significant difference in age across cluster groups. Girls in the ‘soft drink’, ‘fruit drink’, ‘milk’, and ‘moderate’ clusters were 15.2 ± 0.2 years, 14.6 ± 0.2 years, 14.7 ± 0.2 years, and 14.9 ± 0.1 years, respectively. Nor was there a difference across clusters for household income level, household education, or physical activity status (Table 4.25). There was, however, a significant difference across clusters for food security status, where the girls in the soft drink category had a higher prevalence of household food insecurity in comparison to other clusters. Ethnicity was also significantly different across clusters with a larger proportion of girls who were Non-White in the ‘soft drink’ and ‘moderate’ clusters compared to those in the ‘fruit drink’ and ‘milk’ clusters (Table 4.25).

Table 4.25: Socio-demographic characteristics of each beverage pattern among girls aged 12 to 18 years

| | *Soft Drink* | *Fruit Drink* | *Milk* | *Moderate* | **p-value** |
|---|---|---|---|---|---|
| **Ethnicity (%)*** | | | | | **0.0224** |
| White | 83.1% | 90.0% | 90.9% | 81.8% | |
| Non-white | 16.9% | 10.0% | 9.1% | 18.2% | |
| **Household income (%)** | | | | | 0.29 |
| High | 84.6% | 91.7% | 92.1% | 90.6% | |
| Low | 15.4% | 8.3% | 7.9% | 9.5% | |
| **Food security (%)*** | | | | | **0.0053** |
| Food secure | 86.3% | 93.4% | 97.7% | 93.9% | |
| Food insecure | 13.7% | 6.6% | 2.3% | 6.1% | |
| **Household education (%)** | | | | | 0.23 |
| At least some post secondary | 78.4% | 84.5% | 87.1% | 85.3% | |
| Secondary or less | 21.6% | 15.6% | 12.9% | 14.7% | |
| **Physical activity index (%)** | | | | | 0.75 |
| Active | 28.4% | 31.5% | 35.3% | 27.4% | |
| Moderate | 30.9% | 28.3% | 27.9% | 29.7% | |
| Inactive | 40.7% | 40.2% | 36.8% | 42.9% | |

* significantly different across clusters $p<0.05$ using Pearson chi-square test

Data for boys' beverage intake by cluster is presented in Table 4.26. Boys in the 'milk' cluster drank, on average, 1116 ± 37 g of milk on the day of the recall, which was nearly half of their total beverage intake. Children in the 'soft drink' cluster drank 1059 ± 29 g of soft drinks, and they drank significantly less fruit juice and water compared to boys in the 'moderate' cluster ($p<0.05$). Boys in the 'fruit drink' cluster drank 994 ± 35 g of fruit drinks and drank a similar amount of fruit juice as boys in the 'milk' cluster (Table 4.26).

Table 4.26: Mean intake (± SEM) of beverage groups across beverage patterns in boys aged 12 to 18 years

| **Beverage group** | *Soft Drink* | *Fruit Drink* | *Milk* | *Moderate* |
|---|---|---|---|---|
| **Fruit Drink (g)** | 151 ± 25 | **994* ± 35** | 143 ± 20 | 103 ± 7 |
| **Soft drink (g)** | **1059* ± 29** | 131 ± 19 | 174 ± 17 | 146 ± 10 |
| **Milk (g)** | 233 ± 23 | 277 ± 21 | **1116* ± 37** | 233 ± 10 |
| **High Fat Milk (g)** | 51 ± 13 | 52 ± 11 | 63 ± 18 | 75 ± 10 |
| **Fruit Juice (g)** | **89[a] ± 17** | 143 ± 33 | 146 ± 20 | 204 ± 16 |
| **Water (g)** | **563[a] ± 48** | 726 ± 61 | 703 ± 69 | 808 ± 43 |
| **Total beverage intake (g)** | 2339 ± 69 | 2489 ± 93 | 2460 ± 84 | **1782* ± 50** |

* significantly different from all other clusters ($p<0.05$)
a: significantly different from *Moderate* cluster

Girls 12 to 18 years old who were in the 'fruit drink' cluster drank significantly less milk than girls in the 'moderate' and 'milk' clusters, but not less than those in the 'soft drink' cluster ($p<0.05$). Girls in the 'moderate' cluster had the highest intake of fruit juice compared to all other clusters ($p<0.05$) (Table 4.27).

Table 4.27: Mean intake (± SEM) of beverage groups across beverage patterns in girls aged 12 to 18 years

| **Beverage group** | ***Soft Drink*** | ***Fruit Drink*** | ***Milk*** | ***Moderate*** |
|---|---|---|---|---|
| **Fruit Drink (g)** | 87 ± 13 | **829* ± 37** | 127 ± 16 | 91 ± 7 |
| **Soft Drink (g)** | **786* ± 39** | 103 ± 17 | 63 ± 11 | 86 ± 8 |
| **Milk (g)** | 144 ± 15 | **$184^{a}$ ± 17** | **836* ± 35** | 133 ± 8 |
| **Fruit Juice (g)** | 98 ± 19 | 77 ± 15 | 130 ± 17 | **221* ± 15** |
| **Water (g)** | **$459^{a}$ ± 57** | 627 ± 51 | **$582^{a}$ ± 47** | 775 ± 43 |
| **Total beverage intake (g)** | 1804 ± 85 | 2056 ± 81 | 1928 ± 65 | **$1615^{bc}$ ± 50** |

* significantly different from all clusters
a: significantly different from *Moderate* cluster
b: significantly different from *Milk* cluster
c: significantly different from *Fruit Drink* cluster

Boys 12 to 18 years old who were in the 'moderate' cluster had the lowest percent energy intake from beverages compared to all other clusters ($p<0.05$). All clusters showed a mean calcium intake from food of over 1000 mg/day, although the boys in the 'milk' cluster had significantly higher intake of calcium compared to all other clusters ($p<0.05$). Boys in the 'fruit drink' cluster had significantly higher vitamin C intake compared to boys in other clusters ($p<0.05$) (Table 4.28).

Table 4.28: Mean intake (± SEM) of selected nutrients across beverage patterns in boys aged 12 to 18 years

| **Beverage group** | ***Soft Drink*** | ***Fruit Drink*** | ***Milk*** | ***Moderate*** |
|---|---|---|---|---|
| **% energy from beverages** | 27 ± 1 | 27 ± 1 | 29 ± 1 | **17* ± 1** |
| **% energy from SSB** | **$18^{ab}$ ± 1** | **$17^{ab}$ ± 1** | 5 ± 0 | 5 ± 0 |
| **% energy from NBB** | 8 ± 1 | 9 ± 1 | **24* ± 1** | 12 ± 0 |
| **Calcium (mg)** | 1,095 ± 43 | 1,203 ± 39 | **2,103* ± 53** | 1,099 ± 30 |
| **Vitamin C (mg)** | 114 ± 8 | **286* ± 19** | 148 ± 11 | 150 ± 7 |

* significantly different from all other clusters ($p<0.05$)
a: significantly different from *Moderate* cluster
b: significantly different from *Milk* cluster

Girls 12 to 18 years old who were in the 'fruit drink' cluster had 18.2% of total energy from sugar-sweetened beverages, and had significantly more vitamin C intake compared to all other clusters (Table 4.29). The group of children in the 'moderate' cluster had the lowest percentage of energy intake from all beverages (16.9%). Children in the 'milk' cluster drank, on average, 836 ± 35 g of milk and had the highest intake of calcium compared to all other clusters (p<0.05).

Table 4.29: Mean intake (± SEM) of selected nutrients across beverage patterns in girls aged 12 to 18 years

| **Beverage group** | ***Soft Drink*** | ***Fruit Drink*** | ***Milk*** | ***Moderate*** |
|---|---|---|---|---|
| **% energy from beverages** | 24 ± 1 | 27 ± 1 | 26 ± 1 | **17* ± 1** |
| **% energy from SSB** | **16[ab] ± 1** | **18[ab] ± 1** | 4 ± 0 | 4 ± 0 |
| **% energy from NBB** | 7 ± 1 | 8 ± 1 | **22* ± 1** | **12* ± 1** |
| **Calcium (mg)** | 808 ± 46 | 904 ± 35 | **1705* ± 74** | 848 ± 23 |
| **Vitamin C (mg)** | **115[a] ± 12** | **223* ± 12** | 138 ± 8 | 156 ± 6 |

* significantly different from all clusters
a: significantly different from *Moderate* cluster
b: significantly different from *Milk* cluster

Among boys 12 to 18 years using chi square test across beverage clusters, there was no significant difference for BMI classifications, p=0.0704 (Table 4.30). However, when the categories of "overweight" and "obese" were combined, there was a significant difference across clusters (p=0.0377) in a way that the proportion of overweight and obesity was higher among those in the 'moderate' cluster compared to other clusters.  There was no significant difference for girls 12 to 18 years across clusters for BMI-for-age classifications p= 0.5455 (Table 4.31).

Table 4.30: Proportion of boys 12 to 18 years in three BMI classifications by beverage cluster

| | ***Soft Drink*** | ***Fruit Drink*** | ***Milk*** | ***Moderate*** |
|---|---|---|---|---|
| **Normal** | 75.6% | 74.0% | 74.1% | 64.3% |
| **Overweight** | 12.7% | 11.8% | 11.6% | 20.5% |
| **Obese** | 11.7% | 14.2% | 14.4% | 15.2% |

Not significant using Pearson chi-square test (p > 0.05)

Table 4.31: Proportion of girls 12 to 18 years in three BMI classifications by beverage cluster

| | ***Soft Drink*** | ***Fruit Drink*** | ***Milk*** | ***Moderate*** |
|---|---|---|---|---|
| **Normal** | 77.0% | 75.6% | 81.1% | 75.9% |
| **Overweight** | 11.9% | 14.2% | 14.6% | 15.7% |
| **Obese** | 11.2% | 10.2% | 4.3% | 8.3% |

Not significant using Pearson chi-square test (p > 0.05)

*4.3 Advanced Statistical Modeling*

In order to determine whether beverage intake patterns predict BMI-for-age and the risk of overweight and obesity, linear and logistic regression models were used. Results are presented by age group beginning with linear regression, followed by results from logistic regression analysis.

*4.3.1 Linear Regression*

For all age groups, bivariate analysis was completed for linear regression with data from children 2 to 5 years old. Variables that were significant at p<0.20 were included in the full model or if they were considered to be biologically important.

In the final linear model for children 2 to 5 years old, a significant positive relationship between 'milk' cluster and BMI-for-age was found. A negative relationship between non-white ethnicity and BMI-for-age was found. These associations were found after adjusting for energy intake, age, and sex ($R^2$ = 0.0323, p<0.05) (Table 4.32).

Table 4.32: Final model, linear regression, 2 to 5 year olds

| Regression Coefficient ± SEM | | | | | | |
|---|---|---|---|---|---|---|
| Outcome variable | Ethnicity (non-white) | *Milk* cluster | *Fruit Juice* cluster | *High Fat Milk* cluster | *Fruit Drink* cluster | $R^2$ |
| **BMI-for-age** | -6.68 ± 3.37 | 7.73 ± 3.28 | 4.72 ± 3.53 | -4.00 ± 4.38 | 5.17 ± 3.38 | 0.0323 |
| **p-value** | 0.048 | 0.019 | NS | NS | NS | |

Adjusted for energy, age, sex
NS: not significant

In the final model for boys 6 to 11 years old, a significant positive association between BMI-for-age in its continuous form and the 'soft drink' cluster were found (Table 4.33). A high level of sedentary activity was positively related to BMI-for-age ($R^2$ = 0.0864, p<0.0001).

Table 4.33: Final model, linear regression, boys 6 to 11 years old

| **Regression Coefficient** ± SEM | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Outcome variable** | Sedentary activity (high) | *Fruit drink* cluster | *High fat milk* cluster | *Soft drink* cluster | *Milk* cluster | *Fruit juice* cluster | $R^2$ |
| **BMI-for-age** | 14.13 ± 3.76 | 2.42 ± 3.61 | 3.48 ± 4.94 | 9.46 ± 3.64 | 7.1 ± 3.77 | 0.28 ± 3.99 | 0.0864 |
| **p-value** | <0.001 | NS | NS | 0.010 | NS | NS | |

Adjusted for energy, age, ethnicity
NS: not significant

Among girls 6 to 11 years, no beverage clusters were significantly related to BMI-for-age in its continuous form after adjusting for energy intake, age, ethnicity, sedentary activity and household education (Table 4.34). The main predictors of increasing BMI-for age were Black ethnicity, sedentary activity (positively related), and education level (negatively related) ($R^2$ = 0.0510, p<0.005).

Table 4.34: Final model, linear regression, girls 6 to 11 years old

| | Regression Coefficient ± SEM | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Outcome variable** | Ethnicity (Black) | Education (< high school) | Sedentary activity (high) | *Fruit drink* cluster | *High fat milk* cluster | *Soft drink* cluster | *Milk* cluster | *Fruit juice* cluster | $R^2$ |
| **BMI-for-age** | 16.70 ± 6.39 | -6.53 ± 3.26 | 12.81 ± 3.56 | -4.81 ± 3.42 | -2.39 ± 5.50 | -0.24 ± 3.91 | -2.56 ± 3.68 | -2.12 ± 4.18 | 0.05 |
| **p-value** | 0.009 | 0.046 | <0.001 | NS | NS | NS | NS | NS | |

Adjusted for energy and age
NS: not significant

Analysis for boys 12 to 18 years showed a significant negative relationship between BMI-for-age and physical activity level, where those who were most active were less likely to have high-BMI-for age (p<0.05) (Table 4.35). No beverage clusters were significant in the final model ($R^2$ = 0.0338, p<0.05).

Table 4.35: Final model, linear regression, boys 12 to 18 years old

| | Regression Coefficients (± SEM) | | | | |
|---|---|---|---|---|---|
| **Outcome variable** | Physical activity index (active) | *Milk* cluster | *Soft drink* cluster | *Fruit drink* cluster | $R^2$ |
| **BMI-for-age** | -7.80 ± 3.00 | -1.20 ± 3.45 | -3.40 ± 3.51 | -0.18 ± 3.18 | 0.0338 |
| **p-value** | 0.010 | NS | NS | NS | |

Adjusted for energy, age, ethnicity, food insecurity
NS: not significant

For girls, 12 to 18 years, linear regression showed that energy intake was negatively related to BMI-for-age ($R^2$ = 0.082, p<0.0001) (Table 4.36). Black ethnicity, and household food insecurity were positively associated with BMI-for-age.

Table 4.36: Final model, linear regression, girls 12 to 18 years old

| | Regression Coefficients (± SEM) | | | | | | |
|---|---|---|---|---|---|---|---|
| **Outcome variable** | Energy | Ethnicity (Black) | Food insecurity (no hunger) | *Fruit drink* cluster | *Milk* cluster | *Soft drink* cluster | $R^2$ |
| **BMI-for-age** | -0.01 ± 0.00 | 18.25 ± 5.67 | 8.50 ± 3.39 | 2.33 ± 2.66 | -4.92 ± 2.73 | 1.92 ± 3.14 | 0.082 |
| **p-value** | <0.001 | 0.001 | 0.013 | NS | NS | NS | |

Adjusted for age, education, physical activity
NS: not significant

*4.3.2 Logistic Regression*

Logistic regression was used to compare children with normal BMI-for-age to those with BMI-for-age considered overweight or obese. In a similar fashion to linear regression, bivariate analysis was completed for logistic regression. Variables that were significant at p <0.20 were included in the model or if they were considered to be biologically important (Pahwa, 2008). The same variables considered for inclusion in linear regression, were considered for logistic regression. The reference categories remained the same for logistic regression.

The bivariate analysis for 2 to 5 year olds showed that household income, ethnicity and household food security were significant predictors of overweight/obesity. Food security, which was more strongly related to the outcome, rather than household income, was used in the final model due to the collinearity of these two variables. Compared to White children, Non-white children had lower odds of overweight/obesity (OR 0.57, 95% CI 0.34-0.95) (Table 4.37). No beverage clusters were significant in the final model after adjusting for energy, age, sex, ethnicity, and household food security.

Table 4.37: Final model, logistic regression (normal vs. overweight/obese), 2 to 5 year olds

| | **Odds Ratio** | **95% Confidence Interval** | **p-value** |
|---|---|---|---|
| Energy (kcal) | 0.99 | 0.99-1.00 | 0.993 |
| Age | 0.96 | 0.80-1.16 | 0.660 |
| Sex (female) | 0.90 | 0.62-1.32 | 0.604 |
| **Ethnicity (non-white)** | **0.57** | **0.34-0.95** | **0.031** |
| Food security (no hunger) | 1.79 | 0.88-3.67 | 0.111 |
| Food security (hunger) | 0.32 | 0.07-1.43 | 0.135 |
| *Milk* cluster | 1.23 | 0.72-2.12 | 0.449 |
| *Fruit juice* cluster | 1.13 | 0.63-2.05 | 0.677 |
| *High fat milk* cluster | 0.92 | 0.49-1.73 | 0.792 |
| *Fruit drink* cluster | 1.21 | 0.72-2.03 | 0.472 |

Reference groups: sex (male), food security (food secure), cluster (moderate)

For boys 6 to 11 years, bivariate analysis showed that energy intake, high sedentary activity and soft drink beverage cluster were significantly related to overweight and obesity. Age, food security, and ethnicity were included in the model. Boys 6 to 11 years, who were in the 'soft drink' cluster had a higher odds of overweight and obesity compared to boys in the 'moderate' beverage cluster (OR 2.28 95% CI: 1.25-4.15) (Table 4.38).

Table 4.38: Final model, logistic regression (normal vs overweight/obese), boys 6 to 11 years old

| | Odds Ratio | 95% Confidence Interval | p-value |
|---|---|---|---|
| **Energy (kcal)** | **1.00** | **1.00-1.00** | **0.047** |
| Age | 1.03 | 0.89-1.19 | 0.696 |
| Ethnicity (non-white) | 1.62 | 0.93-2.82 | 0.090 |
| Food insecurity | 1.37 | 0.65-2.85 | 0.406 |
| Sedentary activity (moderate) | 1.23 | 0.63-2.39 | 0.542 |
| **Sedentary activity (high)** | **2.33** | **1.20-4.56** | **0.013** |
| *Fruit juice* cluster | 1.15 | 0.57-2.31 | 0.705 |
| ***Soft drink* cluster** | **2.28** | **1.25-4.15** | **0.007** |
| *Fruit drink* cluster | 0.98 | 0.54-1.76 | 0.944 |
| *Milk* cluster | 1.42 | 0.70-2.91 | 0.333 |
| *High fat milk* cluster | 1.06 | 0.40-2.80 | 0.913 |

Reference groups: ethnicity (white), food security (food secure), sedentary activity (low), cluster (moderate)

For girls 6 to 11 years, logistic regression showed that beverage cluster was not a significant predictor for overweight and obesity. High sedentary activity was positively related to overweight and obesity (Table 4.39).

Table 4.39: Final model, logistic regression (normal vs overweight/obese), girls 6 to 11 years old

| | Odds Ratio | 95% Confidence Interval | p-value |
|---|---|---|---|
| Energy | 1.00 | 1.00-1.00 | 0.380 |
| Age | 0.96 | 0.88-1.11 | 0.806 |
| Food insecurity (no hunger) | 0.93 | 0.49-1.78 | 0.826 |
| Food insecurity (with hunger) | 0.28 | 0.07-1.08 | 0.065 |
| Sedentary activity (moderate) | 1.76 | 0.93-3.34 | 0.082 |
| **Sedentary activity (high)** | **3.16** | **1.58-6.34** | **0.001** |
| *Fruit drink* cluster | 0.77 | 0.42-1.40 | 0.387 |
| *High fat milk* cluster | 0.77 | 0.29-2.10 | 0.616 |
| *Soft drink* cluster | 0.86 | 0.41-1.80 | 0.694 |
| *Milk* cluster | 0.98 | 0.53-1.80 | 0.943 |
| *Fruit juice* cluster | 0.77 | 0.36-1.65 | 0.494 |

Reference groups: Food insecurity (food secure), sedentary activity (low), cluster (moderate)

For boys 12 to 18 years, no beverage cluster appeared in the final model. For girls 12 to 18 years, logistic regression only showed energy intake as a significant predictor for overweight and obesity (Table 4.41). No beverage clusters were considered significantly related to overweight/obesity among girls 12 to 18 years old.

Table 4.40: Final model, logistic regression (normal vs. overweight/obese), boys 12 to 18 years old

| | **Odds Ratio** | **95% Confidence Interval** | **p-value** |
|---|---|---|---|
| Energy | 1.00 | 1.00-1.00 | 0.107 |
| Age | 0.93 | 0.85-1.02 | 0.133 |
| Physical activity index (moderately active) | 0.64 | 0.40-1.03 | 0.064 |
| Physical activity index (active) | 0.65 | 0.41-1.03 | 0.067 |
| *Milk* cluster | 0.66 | 0.38-1.15 | 0.145 |
| *Soft drink* cluster | 0.68 | 0.40-1.16 | 0.159 |
| *Fruit drink* cluster | 0.68 | 0.40-1.16 | 0.158 |

Reference groups: physical activity index (inactive), cluster (moderate)

Table 4.41: Final model, logistic regression (normal vs. overweight/obese), girls 12 to 18 years old

| | **Odds Ratio** | **95% Confidence Interval** | **p-value** |
|---|---|---|---|
| **Energy** | **1.00** | **1.00-1.00** | **0.027** |
| Age | 0.98 | 0.86-1.10 | 0.681 |
| Income (lowest) | 0.54 | 0.15-1.94 | 0.341 |
| Income (low-mid) | 1.63 | 0.76-3.53 | 0.210 |
| Income (mid) | 1.20 | 0.69-2.11 | 0.518 |
| Income (mid-high) | 1.57 | 0.97-2.56 | 0.069 |
| Education (less than secondary) | 1.34 | 0.82-2.18 | 0.247 |
| Physical activity index (moderately active) | 0.89 | 0.55-1.44 | 0.640 |
| Physical activity index (active) | 1.09 | 0.69-1.74 | 0.704 |
| *Fruit drink* cluster | 1.09 | 0.62-1.91 | 0.771 |
| *Milk* cluster | 0.86 | 0.48-1.54 | 0.611 |
| *Soft drink* cluster | 1.09 | 0.60-1.97 | 0.772 |

Reference groups: income (highest), education (at least secondary), physical activity index (inactive), cluster (moderate)

# 5. DISCUSSION

This study produced both descriptive and hypothesis-tested results for children in three age groups: preschool-aged (2 to 5 years), school-aged (6 to 11 years), and adolescents (12 to 18 years). The descriptive results are described and contextualized first with a focus on beverage and nutrient intakes. The prevalence of overweight and obesity is presented for all age groups. This is followed by results from cluster analysis, and a discussion on the relationships between beverages and overweight and obesity. Finally limitations of the present study and recommendations for the future are presented.

## *5.1 Descriptive Data*

### *5.1.1 Children 2 to 5 Years Old*

For young Canadian children 2 to 5 years old, the top three beverages consumed were water, milk and fruit juice. Garriguet (2008a), who also used CCHS 2.2 data, found similar results for related age groups (1 to 3 and 4 to 8 years). The results presented here expand on those presented by Garriguet (2004), who presented data on beverages in five categories. The current analysis includes 14 sub categories of beverages that are grouped broadly into three groups: sugar sweetened beverages, nutrient-based beverages, and beverages with no additional energy. Garriguet found that boys and girls 1 to 3 years, respectively, consumed 28 and 27% of their energy from beverages (2008a). Boys and girls 4 to 8 years consumed 21% and 18% energy from beverages, which was significantly less than younger children (1 to 3 years) ($p<0.05$) (Garriguet, 2008a). The analysis by Garriguet also described the percentage of consumers of selected beverages (2008a). At least 70% of children 1 to 8 years consumed water, 80-88% consumed milk, 49-62% consumed juice, and 28-45% consumed fruit drinks (Garriguet, 2008a). A small proportion of children 1 to 3 years consumed soft drinks (8% and 6% for boys and girls, respectively), however this rose significantly among boys and girls 4 to 8 years (19% and 17%, respectively) (Garriguet, 2008a). Compared to children in the US (NHANES 1999-2002), our data show that Canadian children drank more milk, fruit drinks and fruit juice, but less water and soft drinks. Canadian 2 to 5 years old drank more total milk (all types of milk and flavoured milks) than children in the US; approximately 100 g and 137 g more for girls and boys, respectively (O'Connor, Yang, & Nicklas, 2006).

Canadian boys (228 g/d) and girls (168 g/d) 2 to 5 years old drank more fruit juice than US children (132 g/d for both boys and girls) (O'Connor et al., 2006). Data from NHANES (1988-2004) showed that energy intake from fruit juice and sugar sweetened beverages among preschoolers increased over time (Wang, Bleich, & Gortmaker, 2008). Canadian boys drank more fruit drink (166 g/d) than US children (both sexes, 139 g/d), while Canadian girls drank a similar amount of fruit drink (133 g/d) (O'Connor et al., 2006).

American children 2 to 6 years old drank an average of 325 mL of water per day, according data from NHANES 2005/2006 (Popkin, 2010). The same data showed children 7 to 12 years drank 509 mL/day, and children 13 to 17 years drank 773 mL/day (Popkin, 2010). CSFII 1994-96/1998 reported that children 2 to less than 3 years consumed an average of 185 mL of water as a beverage (Kahn & Stralka, 2009). These authors found that most water consumed by children was in the form of reconstituted juices or drinks or in foods and not as a plain beverage (Kahn & Stralka, 2009).

The current study showed that Canadian preschool boys and girls drank 28 g/d (95% confidence interval [CI] 18-27 g/d) and 20 g/d (95% CI 14-25 g/d) of soft drinks, respectively. There was no significant sex difference for soft drink consumption in this age group ($p>0.05$). The mean intakes of soft drink by Canadian boys and girls were lower than the amount of soft drinks consumed by US children (91 g, 95% CI 78-103 g), both sexes combined (O'Connor et al., 2006).

Nutrient intake data can be compared to the Dietary Reference Intakes (DRI), which are joint Canadian and American recommendations nutrients including calcium and vitamin C. Data on mean calcium intake for 2 to 5 year old boys (1044 mg/d) and girls (991 mg/d) was above

DRI Adequate Intake (AI) of 500 mg (1 to 3 years) and 800 mg (4 to 8 years) (Institute of Medicine, 1997; Institute of Medicine, 2000b). The limitation of the AI is that it was set with caution due to insufficient evidence, and thus “only limited inferences can be made about the adequacy of groups” (Health Canada, 2006a).

Overall, Canadian children 1 to 8 years had median calcium intakes that are above the AI (Health Canada & Statistics Canada, 2008), indicating that the prevalence of inadequacy was likely low for that age group. Considering one cup (250 mL) of milk has approximately 300 mg of calcium (Health Canada, 2008b) then the current sample showed boys' intake of calcium from milk would be approximately 578 mg (55% of total intake) and girls' intake of calcium from milk would be approximately 535 mg (54% of total intake).

Mean vitamin C intake for boys (160 mg/d) and girls (131 mg/d) was well above the estimated average requirements (EAR) of 13 mg for children 1-3 years, and 22 mg for 4 to 8 year olds (Institute of Medicine, 2000a). The EAR is a value set with more evidence and confidence than the AI. The amount of vitamin C varies in to the type of fruit juice. For example, one cup (250 mL) of orange juice provides 98 mg vitamin C, 250 mL apple juice with added vitamin C provides 83 mg vitamin C, and one cup of grape juice with added vitamin C provides 23 mg (Health Canada, 2008a). Some, but not all, fruit drinks often have vitamin C added. For example, 250 mL of fruit punch with vitamin C has 100 mg vitamin C, 250 mL of lemonade has 101 mg; however, citrus punch that does not have added vitamin C has 38 mg, and fruit punch (no added vitamin C) has only 3 mg (Health Canada, 2008a). If it is assumed that 250 mL of fruit juice or fruit drink contains approximately 90 mg of vitamin C, then boys 2 to 5 years received 89% of vitamin C from beverages, and girls received 82% of total vitamin C intake from beverages.

### *5.1.2 Children 6 to 11 Years Old and 12 to 18 Years Old*

Results on beverage intake for school aged children (6 to 11 years) and adolescents (12 to 18 years) showed an increasing consumption of sweetened beverages across the age groups, a pattern which continued from preschool-aged children. This relationship remained after accounting for energy intake. Although data from CCHS 2.2 were cross sectional, the beverage pattern of children 6 to 11 years old may have been influenced by their intake as younger children. Similarly, the children 12 to 18 years old may have been influenced by their previous pattern of intake. As such, it is important to pay attention to the beverage patterns of young children and gather data of their beverage intake over time. Data from the US indicate that consumption of sweetened beverages has been on the rise among children (Popkin, 2010; Wang, Ludwig, Sonneville, & Gortmaker, 2009). It is possible that a similar pattern has occurred among Canadian children (Vatanparast & Whiting, 2007), although longitudinal data are not available.

For nutrient-based beverages, there was no significant difference in intake across the age groups, after adjusting for energy intake. Trends on milk intake among American children indicate a decline in milk consumption (Popkin, 2010), while 100% juice consumption appears to be on the rise (Popkin, 2010; Wang et al., 2008). Some have suggested that children may be replacing milk with sweetened beverage intakes (Keller, Kirzner, Pietrobelli, St-Onge, & Faith, 2009; Whiting et al., 2001). In the present study, sweetened beverage intake increased across age groups while there was no increase in nutrient-based beverage intake despite an overall rise in energy intake with age, suggesting possible replacement of nutrient based beverages with sweetened beverages. It is important to note that CCHS 2.2 was cross-sectional, and actual trends in intake over time are not possible to assess.

Mean vitamin C intake across all age groups was above the requirement (EAR) for all age-sex groups (Institute of Medicine, 2000a). The mean calcium intake for boys and girls 6 to 11 years (1085 mg/d, 950 mg/d respectively) were lower than the AI for children 9 to 13 years (1300 mg), although higher for children 4 to 8 years (800 mg) (Institute of Medicine, 1997). Among children 12 to 18 years, the mean intake of calcium for both boys and girls (1267 mg/d and 1021 mg/d, respectively) was below the AI for children 14 to 18 years (1300 mg) (Institute of Medicine, 1997). It is not possible to determine the prevalence of inadequacy for calcium among these children due to the tentative value of the AI (Health Canada, 2006).

### *5.1.3 Overweight and Obesity*

BMI-for-age percentiles on the CDC growth charts (2000) and the criteria for overweight ($85^{th}$ - $95^{th}$ percentile), and obesity ($\geq 95^{th}$ percentile) were used as was recommended at the time of analysis (Dietitians of Canada, Canadian Paediatric Society, College of Family Physicians of Canada, & Community Health Nurses Association of Canada, 2004). In this analysis, over one third of boys and girls 2 to 5 years old were considered overweight or obese. According to the growth reference charts, we would expect approximately 10% of children to fall in the overweight category (85th-95th percentile) and 5% to fall in the obese category (95-100th percentile). It is important to note that the percentages for the current sample have already excluded those children who are underweight (approximately 4% of total sample size), therefore overestimate the proportion of children considered overweight and obese.

Over the past 30 years, the prevalence of overweight and obesity among children 6 to 11 years and 12 to 17 years in Canada has doubled (Shields, 2006). Similar patterns of increasing rates of overweight and obesity have been seen in the US (Basu, 2009) and around the world (James, 2008). In the current study, the proportion of children overweight and obese decreased across increasing age groups (boys: 38% (2 to 5 years), 35% (6 to 11 years), 31% (12 to 18 years), girls: 34%, 28%, 21% respectively). These figures are different from previously reported data on CCHS 2.2 (Shields, 2006) and may be due to the exclusion of underweight children in this analysis which decreases the total population, this increasing the proportion of children considered overweight or obese. In addition, the variation may be due to the different tools used to assess the prevalence of overweight and obesity as the current analysis used CDC growth charts, while Sheilds (2006) had used the IOTF criteria. Generally, the CDC give higher estimates of overweight and obesity for younger children and lower estimates for older children (Flegal, 2001).

## *5.2 Cluster Analysis and Regression Analyses*

### *5.2.1 Children 2 to 5 Years Old*

Data on boys and girls were combined for cluster analysis for 2 to 5 year olds in order to compare our results with that from LaRowe et al. (2007), who presented beverage intake by cluster among children 2 to 5 and 6 to 11 years. The focus of the current study was on 2 to 5 year olds, so similar inclusion criteria to that of LaRowe et al. (2007) were used to facilitate comparison.

A five beverage-cluster solution was determined to be the most appropriate for CCHS 2.2 data. Most children were in the ‘moderate’ beverage cluster, with 825 subjects (38% of 2 to 5 year olds in the sample) were categorized in this pattern. In descending order, this was followed by the 'milk' cluster (20%), the 'fruit drink' and 'fruit juice' clusters (15% each), and the 'high fat (flavoured) milk' cluster (12%). LaRowe and colleagues found a four-cluster solution to be the most appropriate with the following clusters: mix/light, high fat milk, water and fruit juice clusters (LaRowe, Moeller, & Adams, 2007). In that study, most children also were classified in the mix/light category (46% of preschool-aged children). However, that study had included water in the clustering process, therefore the second largest cluster was the 'water' cluster (24%), followed by the 'high fat milk' cluster (17%), and the 'fruit juice' cluster (13%) (LaRowe et al., 2007). Water was not a cluster in the current analysis, as the exploratory analysis suggested it was most appropriate to exclude water from the clustering process, yet describe the intake across clusters. Table 5.1 shows a comparison of clusters between the current study and that by LaRowe et al. (2007).

Table 5.1 Beverage cluster solutions for Canadian (current study) and American children 2 to 5 years old (LaRowe et al., 2007).

| **Beverage Cluster Names** | |
|---|---|
| **Current Study** | **LaRowe et al. (2007)** |
| *Moderate* | *Mix/light* |
| *Milk* | *Water* |
| *Fruit drink* | *High fat milk* |
| *Fruit juice* | *Fruit juice* |
| *High fat milk* | - |

Canadian children in the 'fruit juice' cluster drank more fruit juice than US children in the parallel cluster (719 g, 585 g, respectively). Compared to the results found by LaRowe and colleagues (2007), Canadian preschoolers in a 'high fat milk' group drank less high fat milk than US children in the 'high fat milk' cluster (688 g vs. 786 g, respectively). However, the specific beverages included in each category were slightly different, for example the US study included 2% plain milk in the high fat milk category (LaRowe et al., 2007), whereas we included 2% milk in the plain milk category.

Both US and Canadian preschoolers who were in the moderate/ mix/light group had similar total beverage intakes, 853 g and 865 g respectively. This may be an indication that the clustering processes were similar, and may provide evidence for the reliability of the method. Additionally, the percentage of energy from beverages were similar for similar clusters in both studies: 35% (US) and 34% (Canada) energy from beverages for those in the 'high fat milk' cluster; 29% (US) and 28% (Canada) energy from beverages for those in the ‘fruit juice’ cluster; 19% (US) and 18% (Canada) energy from beverages for those in the ‘mix/light’ and ‘moderate’ clusters (LaRowe et al., 2007).

Our research and that of LaRowe and colleagues (2007) compared various socio-demographic characteristics across beverage clusters. Both studies found significant differences across clusters for age, sex, and ethnicity. The children in the ‘high fat milk’ clusters appeared to be younger than other clusters, while US children in the ‘fruit juice’ cluster appeared to be older than Canadian children in the similar cluster. This latter finding may be due to the higher, and possibly more widespread intake of juice among Canadian children. Analysis on US NHANES 1999-2002 data showed that 55% of children 2 to 3 years consumed 100% juice (Nicklas, O'Neil, & Kleinman, 2008), which is similar to 58% of Canadian girls and 62% of Canadian boys 1 to 3 years who consumed juice (Garriguet, 2008a). However, a higher proportion of boys and girls 4 to 8 years drank juice in Canada (54% and 49% respectively) compared to US children 4 to 8 years (41%) (Garriguet, 2008a; Nicklas et al., 2008). Approximately 10% more school aged children (9 to 18 years) in Canada drank 100% juice than US children (Garriguet, 2008a; Nicklas et al., 2008; O'Neil, Nicklas, & Kleinman, 2010).

Sex differences across clusters in Canadian children appeared to be mostly among those in the ‘fruit juice’ category, while in the US study, it was mostly among those in the ‘water’ category. It is unknown whether including water in the clustering process would results in a sex difference in a ‘water’ cluster. Canadian and US ethnic patterns are different, and both showed a significant difference across clusters. In Canadian children, a higher proportion of children in the ‘fruit juice’ cluster were White (85.5%) compared to those in the similar cluster in the US (67.1%) (LaRowe et al., 2007). A similar pattern was seen across comparable clusters between the two studies. In the US, more non-white children were in the ‘mix/light’ cluster compared to all other clusters, while in Canada, those in the ‘high fat milk’ cluster were more likely to be non-white.

When comparing results on overweight and obesity across clusters and between the current study and that by LaRowe and colleagues (2007), it appeared that more Canadian children were classified as overweight or obese (range across clusters: 29.3% to 37.7%) compared to US children (range across clusters: 15.0% to 26.9%). In the study by LaRowe and colleagues (2007), the highest proportion of children who had a BMI-for-age greater than the $85^{th}$ percentile were in the ‘high fat milk’ category (26.9%), while in our data, the ‘high fat milk’ cluster had the lowest proportion of children who were considered overweight or obese. This may be due to the difference in beverages included in the ‘high fat milk’ cluster in our study compared to that by LaRowe et al. (2007). It may also be due to differences in the characteristics of the two ‘high fat milk’ clusters such as age, ethnicity, or physical activity which impact overweight and obesity. In the study by LaRowe et al. (2007), the lowest proportion of children considered overweight or obese was in that of the ‘mix/light’ cluster (15.0%), while in our results, we found the lowest proportion of overweight and obese children in the ‘high fat milk’ cluster.

In linear regression, the current data showed those children of non-white ethnicity were less likely to have a higher BMI-for-age compared to those who were White. Those children who drank mostly milk were more likely to have a higher BMI-for-age compared to those in the ‘moderate’ cluster, after adjusting for energy, age, and sex ($p<0.05$). The relationship between BMI and the milk cluster disappeared when BMI-for-age was collapsed into risk-based categories (normal, overweight, and obese), therefore milk consumption may lead to an increased BMI-for-age percentile, but not necessarily an increased risk for overweight and obesity as defined by BMI-for-age cutpoints of $85^{th}$-$94^{th}$ and $\geq 95^{th}$ percentiles. A US study using NHANES data found that children’s milk intake (2 to 18 years), either flavoured or plain milk, was not associated with increased BMI compared to non-milk drinkers (Murphy, Douglass, Johnson, & Spence, 2008). Similarly, other studies have shown that milk intake was not associated with overweight and obesity or adiposity among children (Fiorito, Marini, Francis, Smiciklas-Wright, & Birch, 2009; Huh, Rifas-Shiman, Rich-Edwards, Taveras, & Gillman, 2010).

Although earlier studies suggested a possible relationship between juice intake and weight gain (Dennison & Rockwell, 1997; Dennison, Rockwell, Nichols, & Jenkins, 1999), most studies on juice intake among young children and its relationship to obesity or adiposity have not found significant associations (Alexy, Sichert-Hellert, Kersting, Manz, & Schoch, 1999; Johnson, Mander, Jones, Emmett, & Jebb, 2007; Newby et al., 2004; Nicklas et al., 2008; Skinner & Carruth, 2001; Tam et al., 2006).

Results from the present study showed that there were no significantly higher or lower odds of overweight and obesity across clusters for children 2 to 5 years old, after adjusting for energy, age, sex, food security, and ethnicity. Similarly, after adjusting for age, sex, ethnicity, household income, Healthy Eating Index, physical activity, and birth weight, LaRowe et al. (2007) found no significant difference across clusters for 2 to 5 year olds. Both studies used the CDC 2000 growth reference charts and the same definition for overweight and obesity. The lack of difference across clusters may be because preschoolers are better able to compensate for extra calories from beverages compared to older children and adults (Birch, McPhee, & Sullivan, 1989). The lack of difference may also be due to the relatively low mean intake of sweetened beverages among all 2 to 5 year olds (158 g/d).

Other studies on preschoolers' sweetened beverage intake show no relationship to overweight and obesity (Johnson et al., 2007; Newby et al., 2004). Newby and colleagues studied American preschoolers' beverage intake and found that fruit drink intake was not associated with increased risk of overweight or obesity (Newby et al., 2004). Similar results found by a British study, where there was no association between sweetened beverages at 5 and 7 years and fatness at 9 years (Johnson et al., 2007). However, Fiorito and colleagues (2009) found that sweetened beverage, but not milk or juice, intake among girls at 5 years of age, predicted adiposity at 5, 6, 9, 11, 13, and 15 years of age, after adjusting for energy intake. Overall sweetened beverage intake remained stable over time (Fiorito et al., 2009). This means that our study, which showed that sweetened beverage intake increases with increasing age may put additional risk for older children. Additionally, some research shows that, among girls, sweetened beverage intake (soda) at a young age predicts higher soda intake later in childhood (Fiorito, Marini, Mitchell, Smiciklas-Wright, & Birch, 2010).

### *5.2.2 Children 6 to 11 Years Old*

For both boys and girls 6 to 11 years olds, a six-cluster solution was found to be most appropriate with both sexes having the following clusters: 'soft drink', 'fruit drink', 'milk', 'high fat milk', 'fruit juice' and 'moderate'. LaRowe et al. (2007) found that a five cluster solution was most appropriate for 6 to 11 year olds (boys and girls combined) with the following cluster names: 'mix/light', 'high fat milk', 'water', 'sweetened drinks', and 'soda'. Similar to younger children, most 6 to 11 year olds were 'moderate' beverage drinkers (35% boys, and 34% girls), and this was consistent with the study that had 34% of the sample in the 'mix/light' cluster (LaRowe et al., 2007).

Table 5.2 Beverage cluster solutions for Canadian (current study) and American children 6 to 11 years old (LaRowe et al., 2007).

| **Beverage Cluster Names** | | |
|---|---|---|
| **Current Study** | | **LaRowe et al. (2007)** |
| **Boys** | **Girls** | **Both sexes** |
| *Moderate* | *Moderate* | *Mix/light* |
| *Soft drink* | *Soft drink* | *Soda* |
| *Fruit drink* | *Fruit drink* | *Sweetened drinks* |
| *Milk* | *Milk* | *Water* |
| *High fat milk* | *High fat milk* | *High fat milk* |
| *Fruit juice* | *Fruit juice* | - |

In examining the relationship between sweetened beverages and overweight and obesity among 6 to 11 year olds, boys in the 'soft drink' cluster had a higher odds of overweight and obesity compared to boys in the 'moderate' beverage pattern after adjusting for energy, age, ethnicity, household food security and sedentary activity (OR 2.28, 95% CI: 1.25-4.15). In the study by LaRowe and colleagues (2007), the prevalence of overweight and obesity was compared across clusters, and the 'sweetened drinks' and 'soda' clusters had higher proportion of children >85$^{th}$ percentile than children in the 'mix/light cluster' and the 'high fat milk' cluster. However, the 'water' cluster had the highest proportion of children >85$^{th}$ percentile compared to all other clusters and this relationship remained when adjusted for a variety of potential confounders (LaRowe et al., 2007). Water provides no calories, so this result may be an indication of other factors in the diet, the cross- sectional nature of the data, or it may be due to the statistical challenge of creating appropriate clusters when water is included during the clustering process, as determined during the exploratory analysis.

Several studies have also shown a positive relationship between sweetened beverage intake and overweight and obesity among school-aged children (Gibson & Neate, 2007; Gillis & Bar-Or, 2003; Ludwig, Peterson, & Gortmaker, 2001; Mrdjenovic & Levitsky, 2003; Nicklas, Yang, Baranowski, Zakeri, & Berenson, 2003; Novotny, Daida, Acharya, Grove, & Vogt, 2004; Phillips et al., 2004; Sanigorski, Bell, & Swinburn, 2007; Tam et al., 2006). However, other studies have not found such a relationship (Andersen et al., 2005; Berkey, Rockett, Field, Gillman, & Colditz, 2004; Forshee, Anderson, & Storey, 2004; Jansen, Mackenbach, Joosten-van Zwanenburg, & Brug, 2010; Johnson et al., 2007; Ramic et al., 2009; Rodriguez-Artalejo et al., 2003). The inconsistencies of the results may be due to inconsistencies in methodologies, including measuring beverage intake (FFQ, 24 hour recall or other), measuring overweight and obesity (BMI-for-age percentiles, percent body fat or other), and statistical adjustment (or not) for potential confounders including birth weight, socio-demographics, energy intake or physical activity. In addition, some of the studies that found negative results were funded by soft drink industries (Forshee & Storey, 2003; Forshee et al., 2004); therefore, the results should be interpreted with caution.

Despite the contradictions in the literature, our results show that boys 6 to 11 years old who drank mostly soft drinks, had a higher odds of overweight and obesity compared to children who had a more moderate beverage pattern. This may be due to sweetened beverages replacing milk consumption (Barba, Troiano, Russo, Venezia, & Siani, 2005; St-Onge, Claps, Heshka, Heymsfield, & Kosteli, 2007). Because we controlled for energy intake, the relationship is likely not due to lack of satiety from beverages increasing total energy intake. Although HFCS may be contributing to the increased risk of overweight and obesity, the caloric sweetener is also used in fruit drinks, with which we did not find any relationships with risk of overweight and obesity among any age-sex group.

*5.2.3 Patterns Across Age Groups*

Across age groups, children in sweetened beverage clusters have increased intake of the defining beverage (i.e. soft drinks or fruit drinks). All age groups had a 'fruit drink' and 'milk' cluster thus allowing comparisons across age groups. Intake of fruit drinks increased across age groups: children 2 to 5 years old who were in the 'fruit drink' cluster consumed an average of 556 ± 19 g of fruit drinks, 6 to 11 year olds consumed 708 ± 19 g, and 622 ± 21 g (boys and girls respectively), and 12 to 18 year olds consumed 994 ± 35 g, and 829 ± 37 g (boys and girls respectively). The volume of fruit drinks consumed by older children is high, 3.5 to 4 times more than the recommendation by the Beverage Guidance Panel (Popkin et al., 2006). It is unknown what the beverage pattern of these children was prior to data collection in 2004. However, the rapid rise of intake across age groups is of concern because individuals may be drinking fruit drink rather than more nutritious beverages such as milk.

Milk clusters were also present in all age groups. Among those in the milk clusters, younger children (2 to 5 years) drank more milk than girls 6 to 11 years (787 ± 24 g, 472 ± 30 g, respectively), this is a pattern consistent with data that shows a decreasing volume of milk consumption by girls over time as well as fewer consumers (Fiorito et al., 2010). Within the milk cluster, boys' intake of milk increased across the age groups, to over 1 litre among those 12 to 18 years old. Girls 12 to 18 years old, who were in the 'milk' cluster, drank 836 ± 35 g or approximately 3.3 cups of milk. Canada's Food Guide recommends girls 14 to 18 years to consume 3 to 4 servings of Milk and Alternatives per day; one cup of milk is equivalent to one serving (Health Canada, 2007a), thus girls in the milk cluster met the recommendations.

Overall, children drank mostly water, milk, and fruit juice. However, sweetened beverage intake rose across the age groups. Cluster analysis showed that some school-aged children and adolescents drank large amounts of sweetened beverages including fruit drinks and soft drinks. Boys 6 to 11 years old who drank mostly soft drinks ('soft drink' cluster) had a over two times higher odds of overweight and obesity compared to boys who drank a moderate beverage pattern ($p<0.05$). No other beverage clusters were associated with increased risk of overweight and obesity. Nutrient-based beverage intake, such as from fruit juice and milk, contributed to nutrient intake of vitamin C and calcium and to meeting recommendations, especially among children who drank higher amounts of these beverages.

### *5.3 Limitations*

This study has limitations in the data and the approach. First the data source, Canadian Community Health Survey 2.2 is a cross sectional survey, therefore we are unable to determine temporality of the results. CCHS 2.2 data does exclude some Canadians, including those who live in the three territories, people living on-reserve or in some remote locations, in institutions, and full-time members of the Canadian Forces (Health Canada, 2006). The survey does, however, have a high response rate (76.5%) and represents approximately 98% of the population in the ten provinces, including proportional representation from urban and rural populations (Health Canada, 2006).

In CCHS 2.2, only one 24-hour recall was used, which may result in misclassifying children due to day-to-day variation in beverage intake. However, the mean value from one day of intake is similar to that of the adjusted two-day intake; only the variation is reduced when two-days of intake are used and adjusted using SIDE (Health Canada, 2006). Data for children 2 to 6 years was provided by parents or caregivers (Health Canada, 2006); therefore, errors in reporting of foods and beverages consumed and their quantity may be introduced at this stage. Errors in providing beverage data may also occur for children 6 to 11 years (intake was reported in combination with parent/caregiver) and 12 to 18 years (independently reported intake).

In the approach to this study, BMI-for-age as per the CDC growth reference charts (2000) were used, which were current at the time of analysis. Since then, the WHO has released growth standards, which may be more appropriate to assess children's growth as they are based on ideal growth patterns (Dietitians of Canada, Canadian Paediatric Society, The College of Family Physicians of Canada, Community Health Nurses Association of Canada, 2010).

Finally, cluster analysis is a data-driven method that requires decisions and interpretations by the researcher. We have documented how each of the decisions were made, and made efforts to offer the most logical interpretations of the data. Despite its limitations, cluster analysis provides interpretable and realistic groups of children based on their beverage intake, which goes beyond the traditional analysis of examining the mean intake. Identifying clusters allows children with common beverage intake patterns to be grouped together, thus allowing for exploration of other features that may be common to that group of children. Cluster analysis allowed us to classify children into sufficiently large groups to be able to assess group-level beverage intakes with measures of overweight and obesity.

### *5.4 Recommendations for Future Research*

National-level longitudinal studies on Canadians are needed to determine the role of beverages on the development or prevention of overweight and obesity in children in this country. Additional research is needed to elucidate the mechanisms of whether, and how, (sweetened) beverages contribute to energy imbalance and weight gain in children. The recently released WHO growth standards need to be compared to the existing tools that measure overweight and obesity in children. Continued research on the myriad of factors related to the development of overweight and obesity in children should continue in order to develop effective strategies to reduce the burden of this disease. However, the search for additional knowledge on overweight and obesity among children should not take precedence over timely action to prevent the rising tide of overweight and obesity.

Population-level action on overweight and obesity, such as policy, is warranted based on the potential for increased risk of overweight and obesity, as well as the low-nutrient, high-energy density of sweetened beverages. Policies such as taxes on sweetened beverages have been investigated (Brownell et al., 2009) and some argue that government inaction on obesity-related strategies is negatively impacting population health (Brownell, 2010). Local policy action at the school-level has also been shown to effective (Jones, Gonzalez, & Frongillo, 2010). However, critical appraisal of research and perspectives is needed, as the topic of beverage intake and health has become polarized (Mattes, 2010). Overall, limiting sweetened beverage intake for children will not cause harm, and may support healthy body weights and consequently prevent the potential risks for obesity related diseases later in life.

# REFERENCES


Agriculture and Agri-Food Canada. (1998). *Canada's action plan for food security: A response to the world food summit*. Ottawa: Government of Canada.

Al-Raees, G. Y., Al-Amer, M. A., Musaiger, A. O., & D'Souza, R. (2009). Prevalence of overweight and obesity among children aged 2-5 years in Bahrain: A comparison between two reference standards. *International Journal of Pediatric Obesity, 4*(4), 414-416.

Alexy, U., Sichert-Hellert, W., Kersting, M., Manz, F., & Schoch, G. (1999). Fruit juice consumption and the prevalence of obesity and short stature in German preschool children: Results of the DONALD study. Dortmund nutritional and anthropometrical longitudinally designed. *Journal of Pediatric Gastroenterology and Nutrition, 29*(3), 343-349.

Alvina, M., & Araya, H. (2004). Rapid carbohydrate digestion rate produced lesser short-term satiety in obese preschool children. *European Journal of Clinical Nutrition, 58*(4), 637-642.

American Beverage Association. (2009). *American Beverage Association.* Retrieved January/23, 2009, from http://www.ameribev.org/

American Dietetic Association. (2004). Position of the American dietetic association: Use of nutritive and nonnutritive sweeteners*. Journal of the American Dietetic Association, 10*4(2), 255-275.

Andersen, L. F., Lillegaard, I. T., Overby, N., Lytle, L., Klepp, K. I., & Johansson, L. (2005). Overweight and obesity among Norwegian schoolchildren: Changes from 1993 to 2000. *Scandinavian Journal of Public Health, 3*3(2), 99-106.

Bachman, C. M., Baranowski, T., & Nicklas, T. A. (2006). Is there an association between sweetened beverages and adiposity*? Nutrition Reviews, 6*4(4), 153-174.

Ballew, C., Kuester, S., & Gillespie, C. (2000). Beverage choices affect adequacy of children's nutrient intakes*. Archives of Pediatrics & Adolescent Medicine, 15*4(11), 1148-1152.

Bandini, L. G., Schoeller, D. A., Cyr, H. N., & Dietz, W. H. (1990). Validity of reported energy intake in obese and nonobese adolescents. *The American Journal of Clinical Nutrition, 52*(3), 421-425.

Baranowski, T., Sprague, D., Baranowski, J. H., & Harrison, J. A. (1991). Accuracy of maternal dietary recall for preschool children. *Journal of the American Dietetic Association, 91*(6), 669-674.

Barba, G., Troiano, E., Russo, P., Venezia, A., & Siani, A. (2005). Inverse association between body mass and frequency of milk consumption in children. *The British Journal of Nutrition, 93*(1), 15-19.

Barnard, N. D. (2010). Trends in food availability, 1909-2007. *The American Journal of Clinical Nutrition, 91*(5), 1530S-1536S.

Basch, C. E., Shea, S., Arliss, R., Contento, I. R., Rips, J., Gutin, B., et al. (1990). Validation of mothers' reports of dietary intake by four to seven year-old children. *American Journal of Public Health, 80*(11), 1314-1317.

Basu, A. (2009). Forecasting distribution of body mass index in the United States: Is there more room for growth? *Medical Decision Making : An International Journal of the Society for Medical Decision Making*. Published online November 25, 2009 doi: 10.1177/0272989X09351749

Berkey, C. S., Rockett, H. R., Field, A. E., Gillman, M. W., & Colditz, G. A. (2004). Sugar-added beverages and adolescent weight change. *Obesity Research, 12*(5), 778-788.

Bes-Rastrollo, M., & Martinez-Gonzalez, M. A. (2008). Differential underreporting and other caveats about sugar-sweetened beverages and weight gain. *The American Journal of Clinical Nutrition, 88*(5), 1450-1; author reply 1451-2.

Bhargava, A., Jolliffe, D., & Howard, L. L. (2008). Socio-economic, behavioural and environmental factors predicted body weights and household food insecurity scores in the early childhood longitudinal study-kindergarten. *The British Journal of Nutrition, 100*(2), 438-444.

Birch, L. L., & Fisher, J. O. (1997). Food intake regulation in children. fat and sugar substitutes and intake. *Annals of the New York Academy of Sciences, 819*, 194-220.

Birch, L. L., McPhee, L., & Sullivan, S. (1989). Children's food intake following drinks sweetened with sucrose or aspartame: Time course effects. *Physiology & Behavior, 45*(2), 387-395.

Biro, G., Hulshof, K. F., Ovesen, L., Amorim Cruz, J. A., & EFCOSUM Group. (2002). Selection of methodology to assess food intake. *European Journal of Clinical Nutrition, 56 Suppl* 2, S25-32.

Blanton C.A., Moshfegh A.J., Baer D.J., Kretsh M. J. (2006). The USDA Automated Multiple-Pass Method Accurately Estimates Group Total Energy and Nutrient Intake. *Journal of Nutrition, 136*, 2594-2599.

Block, G., Hartman, A. M., Dresser, C. M., Carroll, M. D., Gannon, J., & Gardner, L. (1986). A data-based approach to diet questionnaire design and testing. *American Journal of Epidemiology, 12*4(3), 453-469.

Blum, J. W., Jacobsen, D. J., & Donnelly, J. E. (2005). Beverage consumption patterns in elementary school aged children across a two-year period. *Journal of the American College of Nutrition, 2*4(2), 93-98.

Bray, G. A. (2008). Fructose: Should we worry*? International Journal of Obesity, 3*2(Suppl 7), S127-31.

Bray, G. A. (2010). Soft drink consumption and obesity: It is all about fructose. *Current Opinion in Lipidology, 2*1(1), 51-57.

Bray, G. A., Nielsen, S. J., & Popkin, B. M. (2004). Consumption of high-fructose corn syrup in beverages may play a role in the epidemic of obesity. *The American Journal of Clinical Nutrition, 7*9(4), 537-543.

Brown, C. M., Dulloo, A. G., & Montani, J. P. (2008). Sugary drinks in the pathogenesis of obesity and cardiovascular diseases. *International Journal of Obesity (2005), 32 Suppl* 6, S28-34.

Brownell, K. D. (2010). Government intervention and the nation's diet: The slippery slope of inaction. *American Journal of Bioethics, 10*(3), 1-2.

Brownell, K. D., Farley, T., Willett, W. C., Popkin, B. M., Chaloupka, F. J., Thompson, J. W., et al. (2009). The public health and economic benefits of taxing sugar-sweetened beverages. *The New England Journal of Medicine, 361*(16), 1599-1605.

Buyken, A. E., Cheng, G., Gunther, A. L., Liese, A. D., Remer, T., & Karaolis-Danckert, N. (2008). Relation of dietary glycemic index, glycemic load, added sugar intake, or fiber intake to the development of body composition between ages 2 and 7 y. *The American*

*Journal of Clinical Nutrition, 88*(3), 755-762.

Cade, J., Thompson, R., Burley, V., & Warm, D. (2002). Development, validation and utilisation of food-frequency questionnaires - a review. *Public Health Nutrition,* 5(4), 567-587.

Canadian Food Inspection Agency. (2003). *Guide to food labelling and advertising*. Retrieved January/15, 2009, from http://www.inspection.gc.ca/english/fssa/labeti/guide/ch2e.shtml#a2_2

Canadian Paediatric Society, Dietitians of Canada and Health Canada. (2005). *Nutrition for healthy term infants*. Retrieved January/14, 2009, from http://www.hc-sc.gc.ca/fn-an/pubs/infant-nourrisson/nut_infant_nourrisson_term-eng.php

Canadian Paediatric Society. (1996). In Canadian Paediatric Society. (Ed.), *Well beings: A guide to promote the physical health, safety and emotional well-being of children in child care centres and family day care homes*. (2nd ed. ed.). Ottawa: Canadian Paediatric Society.

Canadian Paediatric Society. (2006). *Feeding your baby in the first year*. Retrieved January/14, 2009, from http://www.caringforkids.cps.ca/pregnancy&babies/Feeding.htm

Canadian Paediatric Society. (2009). *The use of growth charts for assessing and monitoring growth in Canadian infants and children*. Retrieved July/22, 2009, from http://www.cps.ca/english/statements/N/cps04-01.htm

Carnell, S., & Wardle, J. (2009). Appetitive traits in children. New evidence for associations with weight and a common, obesity-associated genetic variant. *Appetite, 5*3(2), 260-263.

Centers for Disease Control and Prevention. (2009). *A SAS program for the CDC growth charts*. Retrieved September/1, 2009, from http://www.cdc.gov/nccdphp/dnpao/growthcharts/resources/sas.htm

Centre for Addiction and Mental Health. (2008). *Low-risk drinking guidelines*. Retrieved July/7, 2009, from http://www.camh.net/About_Addiction_Mental_Health/Drug_and_Addiction_Information/low_risk_drinking_guidelines.html

Cole, T. J., Bellizzi, M. C., Flegal, K. M., & Dietz, W. H. (2000). Establishing a standard definition for child overweight and obesity worldwide: International survey. *BMJ (Clinical Research Ed.), 320*(7244), 1240-1243.

Committee on Nutrition. (2001). American academy of pediatrics: The use and misuse of fruit juice in pediatrics. *Pediatrics, 107*(5), 1210-1213.

de Onis, M., Garza, C., Onyango, A. W., & Borghi, E. (2007). Comparison of the WHO child growth standards and the CDC 2000 growth charts. *The Journal of Nutrition, 137*(1), 144-148.

Dennison, B. A., & Rockwell, H. L. (1997). Excess fruit juice consumption by preschool-aged children is associated with short stature and obesity. *Pediatrics, 99*(1; 1), 15.

Dennison, B. A., Rockwell, H. L., Nichols, M. J., & Jenkins, P. (1999). Children's growth parameters vary by type of fruit juice consumed. *Journal of the American College of Nutrition, 18*(4), 346-352.

Denova-Gutierrez, E., Jimenez-Aguilar, A., Halley-Castillo, E., Huitron-Bravo, G., Talavera, J. O., Pineda-Perez, D., et al. (2008). Association between sweetened beverage consumption and body mass index, proportion of body fat and body fat distribution in Mexican adolescents. *Annals of Nutrition & Metabolism, 53*(3-4), 245-251.

Devaney, B., Ziegler, P., Pac, S., Karwe, V., & Barr, S. I. (2004). Nutrient intakes of infants and toddlers. *Journal of the American Dietetic Association, 104*(1 Suppl 1), s14-21.

Dietitians of Canada & Canadian Paediatric Society. (2010). A health professional's guide for using the new WHO growth charts. Retrieved Aug/10, 2010, from http://www.cps.ca/english/statements/N/DC_HealthProGrowthGuide_BW.pdf.

Dietitians of Canada, Canadian Paediatric Society, College of Family Physicians of Canada, & Community Health Nurses Association of Canada. (2004). The use of growth charts for assessing and monitoring growth in Canadian infants and children. *Canadian Journal of Dietetic Practice and Research, 65*(1), 22-32.

Dietitians of Canada, Canadian Paediatric Society, The College of Family Physicians of Canada, Community Health Nurses Association of Canada. (2010). *Promoting optimal monitoring of child growth in Canada: Using the new WHO growth charts*. Retrieved July/12, 2010, from http://www.dietitians.ca/pdf/Growth_Charts_DC_full_report_Mar12.pdf

Dietz, W. H. (2004). Overweight in childhood and adolescence. *The New England Journal of Medicine, 350*(9), 855-857.

DiMeglio, D. P., & Mattes, R. D. (2000). Liquid versus solid carbohydrate: Effects on food intake and body weight. *International Journal of Obesity and Related Metabolic Disorders: Journal of the International Association for the Study of Obesity, 24*(6), 794-800.

Dubois, L., Farmer, A., Girard, M., & Peterson, K. (2007). Regular sugar-sweetened beverage consumption between meals increases risk of overweight among preschool-aged children. *Journal of the American Dietetic Association, 107*(6), 924-34; discussion 934-5.

Duffey, K. J., & Popkin, B. M. (2006). Adults with healthier dietary patterns have healthier beverage patterns. *The Journal of Nutrition, 136*(11), 2901-2907.

Ebbeling, C. B., Feldman, H. A., Osganian, S. K., Chomitz, V. R., Ellenbogen, S. J., & Ludwig, D. S. (2006). Effects of decreasing sugar-sweetened beverage consumption on body weight in adolescents: A randomized, controlled pilot study. *Pediatrics, 117*(3), 673-680.

Elliott, S. S., Keim, N. L., Stern, J. S., Teff, K., & Havel, P. J. (2002). Fructose, weight gain, and the insulin resistance syndrome. *The American Journal of Clinical Nutrition, 76*(5), 911-922.

Esposito, L., Fisher, J. O., Mennella, J. A., Hoelscher, D. M., & Huang, T. T. (2009). Developmental perspectives on nutrition and obesity from gestation to adolescence. *Preventing Chronic Disease, 6*(3), A94.

Faith, M. S., Dennison, B. A., Edmunds, L. S., & Stratton, H. H. (2006). Fruit juice intake predicts increased adiposity gain in children from low-income families: Weight status-by-environment interaction. *Pediatrics, 118*(5), 2066-2075.

Ferreira, M. P., & Willoughby, D. (2008). Alcohol consumption: The good, the bad, and the indifferent. *Applied Physiology, Nutrition, and Metabolism, 33*(1), 12-20.

Fiorito, L. M., Marini, M., Francis, L. A., Smiciklas-Wright, H., & Birch, L. L. (2009). Beverage intake of girls at age 5 y predicts adiposity and weight status in childhood and adolescence. *The American Journal of Clinical Nutrition, 90*(4), 935-942.

Fiorito, L. M., Marini, M., Mitchell, D. C., Smiciklas-Wright, H., & Birch, L. L. (2010). Girls' early sweetened carbonated beverage intake predicts different patterns of beverage and nutrient intake across childhood and adolescence. *Journal of the American Dietetic Association, 110*(4), 543-550.

Fisher, J. O., Butte, N. F., Mendoza, P. M., Wilson, T. A., Hodges, E. A., Reidy, K. C., et al. (2008). Overestimation of infant and toddler energy intake by 24-h recall compared with weighed food records. *The American Journal of Clinical Nutrition, 88*(2), 407-415.

Flegal, K.M., Ogden, C.L., Wei R. et al. (2001). Prevalence of overweight in US children: a comparison of US growth charts from the Centres for Disease Control and Prevention with other reference values for body mass index. *American Journal of Clinical Nutrition,* *73*(6):1086-93.

Flegal, K. M., Ogden, C. L., Yanovski, J. A., Freedman, D. S., Shepherd, J. A., Graubard, B. I., et al. (2010). High adiposity and high body mass index-for-age in US children and adolescents overall and by race-ethnic group. *American Journal of Clinical Nutrition, 91*(4), 1020-1026.

Food and Agriculture Organization of the United Nations. *Standardized food balance sheet.* Retrieved July/22, 2010 http://www.fao.org/waicent/faostat/agricult/fbs-e.htm

Forshee, R. A., & Storey, M. L. (2003). Total beverage consumption and beverage choices among children and adolescents*. International Journal of Food Sciences and Nutrition, 54*(4), 297-307.

Forshee, R. A., Anderson, P. A., & Storey, M. L. (2004). The role of beverage consumption, physical activity, sedentary behavior, and demographics on body mass index of adolescents*. International Journal of Food Sciences & Nutrition, 55*(6), 463-478.

Forshee, R. A., Anderson, P. A., & Storey, M. L. (2006). Changes in calcium intake and association with beverage consumption and demographics: Comparing data from CSFII 1994-1996, 1998 and NHANES 1999-2002*. Journal of the American College of Nutrition, 25*(2), 108-116.

Forshee, R. A., Anderson, P. A., & Storey, M. L. (2008). Sugar-sweetened beverages and body mass index in children and adolescents: A meta-analysis*. The American Journal of Clinical Nutrition, 87*(6), 1662-1671.

Fox, M. K., Pac, S., Devaney, B., & Jankowski, L. (2004). Feeding infants and toddlers study: What foods are infants and toddlers eating?*. Journal of the American Dietetic Association, 104*(1 Suppl 1), s22-30.

Freedman, D. S., & Sherry, B. (2009). The validity of BMI as an indicator of body fatness and risk among children*. Pediatrics, 124 Suppl* 1, S23-34.

Freedman, D. S., Khan, L. K., Dietz, W. H., Srinivasan, S. R., & Berenson, G. S. (2001). Relationship of childhood obesity to coronary heart disease risk factors in adulthood: The Bogalusa heart study*. Pediatrics, 108*(3), 712-718.

Freedman, D. S., Khan, L. K., Serdula, M. K., Dietz, W. H., Srinivasan, S. R., & Berenson, G. S. (2005). The relation of childhood BMI to adult adiposity: The Bogalusa heart study. *Pediatrics, 115*(1), 22-27.

Freedman, D. S., Wang, J., Thornton, J. C., Mei, Z., Sopher, A. B., Pierson, R. N.,Jr, et al. (2009). Classification of body fatness by body mass index-for-age categories among children. *Archives of Pediatrics & Adolescent Medicine, 16*3(9), 805-811.

French, S. A., Lin, B. H., & Guthrie, J. F. (2003). National trends in soft drink consumption among children and adolescents age 6 to 17 years: Prevalence, amounts, and sources, 1977/1978 to 1994/1998. *Journal of the American Dietetic Association, 10*3(10), 1326-1331.

Friedlander, S. L., Larkin, E. K., Rosen, C. L., Palermo, T. M., & Redline, S. (2003). Decreased quality of life associated with obesity in school-aged children. *Archives of Pediatrics & Adolescent Medicine, 15*7(12), 1206-1211.

Fulton, J. E., Wang, X., Yore, M. M., Carlson, S. A., Galuska, D. A., & Caspersen, C. J. (2009). Television viewing, computer use, and BMI among U.S. children and adolescents. *Journal of Physical Activity & Health, 6 Suppl* 1, S28-35.

Garriguet, D. (2008a). Beverage consumption of children and teens. *Health Reports, 1*9(4), 1.

Garriguet, D. (2008b). Beverage consumption of Canadian adults. *Health Reports, 1*9(4), 23-29.

Giammattei, J., Blix, G., Marshak, H. H., Wollitzer, A. O., & Pettitt, D. J. (2003). Television watching and soft drink consumption: Associations with obesity in 11- to 13-year-old schoolchildren. *Archives of Pediatrics & Adolescent Medicine, 15*7(9), 882-886.

Gibson, R. (2005). *Principles of nutritional assessmen*t (2nd ed.). New York: Oxford University Press.

Gibson, S., & Neate, D. (2007). Sugar intake, soft drink consumption and body weight among British children: Further analysis of national diet and nutrition survey data with adjustment for under-reporting and physical activity. *International Journal of Food Sciences & Nutrition, 5*8(6), 445-460.

Gillis, L. J., & Bar-Or, O. (2003). Food away from home, sugar-sweetened drink consumption and juvenile obesity. *Journal of the American College of Nutrition, 2*2(6), 539-545.

Goran, M. I., Ball, G. D., & Cruz, M. L. (2003). Obesity and risk of type 2 diabetes and cardiovascular disease in children and adolescents. *The Journal of Clinical Endocrinology and Metabolism, 8*8(4), 1417-1427.

Guerrero, R. F., Garcia-Parrilla, M. C., Puertas, B., & Cantos-Villar, E. (2009). Wine, resveratrol and health: A review. *Natural Product Communications,* 4(5), 635-658.

Gundersen, C., Lohman, B. J., Garasky, S., Stewart, S., & Eisenmann, J. (2008). Food security, maternal stressors, and overweight among low-income US children: Results from the national health and nutrition examination survey (1999-2002). *Pediatrics, 122*(3), e529-540.

Guo, S. S., Wu, W., Chumlea, W. C., & Roche, A. F. (2002). Predicting overweight and obesity in adulthood from body mass index values in childhood and adolescence. *The American Journal of Clinical Nutrition, 76*(3), 653-658.

Harrington, S. (2008). The role of sugar-sweetened beverage consumption in adolescent obesity: A review of the literature. *Journal of School Nursing, 24*(1), 3-12.

Hartline-Grafton, H. L., Rose, D., Johnson, C. C., Rice, J. C., & Webber, L. S. (2009). Energy density of foods, but not beverages is positively associated with body mass index in adult women. *European Journal of Clinical Nutrition, 63*, 1411-1418.

Havel, P. J. (2005). Dietary fructose: Implications for dysregulation of energy homeostasis and lipid/carbohydrate metabolism. *Nutrition Reviews, 63*(5), 133-157.

Health Canada. (2005). *Aspartame*. Retrieved July/7, 2010, from http://www.hc-sc.gc.ca/fn-an/securit/addit/sweeten-edulcor/aspartame-eng.php

Health Canada. (2006). *Canadian Community Health Survey, cycle 2.2 nutrition (2004) - A guide to accessing and interpreting the data* No. H164-20/2006E. Ottawa: Minister of Health, Office of Nutrition Policy and Promotion, Health Products and Food Branch, Health Canada.

Health Canada. (2007a). *Eating well with Canada's food guide*. Retrieved January/14, 2009, from http://www.hc-sc.gc.ca/fn-an/food-guide-aliment/index-eng.php

Health Canada. (2007b). *Income-related household food security in Canada*. Retrieved Feb/27, 2009, from www.hc-sc.gc.ca/fn-an/surveill/nutrition/commun/index_e.html

Health Canada. (2008a). *Canadian nutrient file*. Retrieved January/15, 2009, from http://205.193.93.51/cnfonline/newSearch.do?applanguage=en_CA

Health Canada. (2008b). *Nutrient values of some common foods*. Retrieved January/15, 2009, from http://www.hc-sc.gc.ca/fn-an/alt_formats/hpfb-dgpsa/pdf/nutrition/nvscf-vnqau-eng.pdf

Health Canada. (2009). *Frequently asked questions about bottled water*. Retrieved July/7, 2010, from http://www.hc-sc.gc.ca/fn-an/securit/facts-faits/faqs_bottle_water-eau_embouteillee-eng.php

Health Canada. (2010). *Sugar substitutes*. Retrieved July/7, 2010, from http://www.hc-sc.gc.ca/fn-an/securit/addit/sweeten-edulcor/index-eng.php

Health Canada & Statistics Canada. (2008). *Canadian Community Health Survey, Cycle 2.2 (2004): Nutrient Intakes from Food Provincial, Regional and National Summary Data Tables. Volume 1*. H164-45/1-2008E-PDF. Ottawa: Minister of Health, Health Canada.

Himes, J. H. (2009). Challenges of accurately measuring and using BMI and other indicators of obesity in children. *Pediatrics, 124 Suppl* 1, S3-22.

Hubert, H., Guinhouya, C. B., Allard, L., & Durocher, A. (2009). Comparison of the diagnostic quality of body mass index, waist circumference and waist-to-height ratio in screening skinfold-determined obesity among children. *Journal of Science & Medicine in Sport, 1*2(4), 449-451.

Huh, S. Y., Rifas-Shiman, S. L., Rich-Edwards, J. W., Taveras, E. M., & Gillman, M. W. (2010). Prospective association between milk intake and adiposity in preschool-aged children. *Journal of the American Dietetic Association, 11*0(4), 563-570.

Huybrechts, I., De Backer, G., De Bacquer, D., Maes, L., & De Henauw, S. (2009). Relative validity and reproducibility of a food-frequency questionnaire for estimating food intakes among Flemish preschoolers. *International Journal of Environmental Research and Public Health,* 6(1), 382-399.

Ilich, J. Z., & Kerstetter, J. E. (2000). Nutrition in bone health revisited: A story beyond calcium. *Journal of the American College of Nutrition, 1*9(6), 715-737.

Institute of Medicine. (1997). *Dietary reference intakes for calcium, phosphorous, magnesium, vitamin D, and flouride*. Washington D.C.: National Academy Press.

Institute of Medicine. (2000a). *Dietary reference intakes for vitamin C, vitamin E, selenium, carotenoid*s. Washington: National Academy of Sciences. Retrieved from www.nap.edu

Institute of Medicine. (2000b). *Dietary reference intakes: Applications in dietary assessmen*t. Washington: National Academy of Sciences. Retrieved from http://www.nap.edu

James, J., Thomas, P., Cavan, D., & Kerr, D. (2004). Preventing childhood obesity by reducing consumption of carbonated drinks: Cluster randomised controlled trial. *BMJ, 32*8, 1237.

James, W. P. (2008). WHO recognition of the global obesity epidemic. *International Journal of Obesity (2005), 32 Suppl* 7, S120-6.

Jansen, W., Mackenbach, J. P., Joosten-van Zwanenburg, E., & Brug, J. (2010). Weight status, energy-balance behaviours and intentions in 9-12-year-old inner-city children. *Journal of*

*Human Nutrition and Dietetics : The Official Journal of the British Dietetic Association, 23*(1), 85-96.

Johnson, L., Mander, A. P., Jones, L. R., Emmett, P. M., & Jebb, S. A. (2007). Is sugar-sweetened beverage consumption associated with increased fatness in children*? Nutrition (Burbank, Los Angeles County, Calif.), 23*(7-8), 557-563.

Johnson, R. K., Driscoll, P., & Goran, M. I. (1996). Comparison of multiple-pass 24-hour recall estimates of energy intake with total energy expenditure determined by the doubly labeled water method in young children. *Journal of the American Dietetic Association, 96*(11), 1140-1144.

Jones, S. J., Gonzalez, W., & Frongillo, E. A. (2010). Policies that restrict sweetened beverage availability may reduce consumption in elementary-school children*. Public Health Nutrition, 13*(4), 589-595.

Jurgens, H., Haass, W., Castaneda, T. R., Schurmann, A., Koebnick, C., Dombrowski, F., et al. (2005). Consuming fructose-sweetened beverages increases body adiposity in mice. *Obesity Research, 13*(7), 1146-1156.

Kahn, H. D., & Stralka, K. (2009). Estimated daily average per capita water ingestion by child and adult age categories based on USDA's 1994-1996 and 1998 continuing survey of food intakes by individuals. *Journal of Exposure Science & Environmental Epidemiology, 19*(4), 396-404.

Kant, A. K. (2004). Dietary patterns and health outcomes. *Journal of the American Dietetic Association, 104*(4), 615-635.

Kant, A. K. (2010). Dietary patterns: Biomarkers and chronic disease risk. *Applied Physiology, Nutrition, and Metabolism, 35*(2), 199-206.

Keller, K. L., Kirzner, J., Pietrobelli, A., St-Onge, M. P., & Faith, M. S. (2009). Increased sweetened beverage intake is associated with reduced milk and calcium intake in 3- to 7-year-old children at multi-item laboratory lunches*. Journal of the American Dietetic Association, 109*(3), 497-501.

Kirkpatrick, S. I., & Tarasuk, V. (2007). Adequacy of food spending is related to housing expenditures among lower-income Canadian households. *Public Health Nutrition, 10*(12), 1464-1473.

Klesges, R. C., Klesges, L. M., Brown, G., & Frank, G. C. (1987). Validation of the 24-hour dietary recall in preschool children. *Journal of the American Dietetic Association, 87*(10), 1383-1385.

Kral, T. V., Stunkard, A. J., Berkowitz, R. I., Stallings, V. A., Moore, R. H., & Faith, M. S. (2008). Beverage consumption patterns of children born at different risk of obesity. *Obesity (Silver Spring, Md.), 16*(8), 1802-1808.

Kuczmarski, R. J., Ogden, C. L., Grummer-Strawn, L. M., Flegal, K. M., Guo, S. S., Wei, R., et al. (2000). CDC growth charts: United States. *Advance Data, (314)*(314), 1-27.

Kuczmarski, R. J., Ogden, C. L., Guo, S. S., Grummer-Strawn, L. M., Flegal, K. M., Mei, Z., et al. (2002). 2000 CDC growth charts for the United States: Methods and development. *Vital and Health Statistics. Series 11, Data from the National Health Survey, (246)*(246), 1-190.

Lanigan, J., Barber, S., & Singhal, A. (2010). Prevention of obesity in preschool children. *The Proceedings of the Nutrition Society, 69*(2), 204-210.

Lanigan, J., Turnbull, B., & Singhal, A. (2007). Toddler diets in the UK: Deficiencies and imbalances. 2. relationship of toddler diet to later health. *The Journal of Family Health Care, 17*(6), 197-200.

LaRowe, T. L., Moeller, S. M., & Adams, A. K. (2007). Beverage patterns, diet quality, and body mass index of US preschool and school-aged children. *Journal of the American Dietetic Association, 107*(7), 1124-1133.

Larson, N., & Story, M. (2009). A review of environmental influences on food choices. *Annals of Behavioral Medicine : A Publication of the Society of Behavioral Medicine, 38 Suppl 1*, S56-73.

Lesser, L. I., Ebbeling, C. B., Goozner, M., Wypij, D., & Ludwig, D. S. (2007). Relationship between funding source and conclusion among nutrition-related scientific articles. *PLoS Medicine, 4*(1), e5.

Linardakis, M., Sarri, K., Pateraki, M. S., Sbokos, M., & Kafatos, A. (2008). Sugar-added beverages consumption among kindergarten children of Crete: Effects on nutritional status and risk of obesity. *BMC Public Health, 8*, 279.

Livingstone, M. B., & Robson, P. J. (2000). Measurement of dietary intake in children. *The Proceedings of the Nutrition Society, 59*(2), 279-293.

Livingstone, M. B., Robson, P. J., & Wallace, J. M. (2004). Issues in dietary intake assessment of children and adolescents. *The British Journal of Nutrition, 92 Suppl 2*, S213-22.

Lohman, B. J., Stewart, S., Gundersen, C., Garasky, S., & Eisenmann, J. C. (2009). Adolescent overweight and obesity: Links to food insecurity and individual, maternal, and family stressors. *Journal of Adolescent Health, 45*(3), 230-237.

Ludwig, D. S. (2009). Artificially sweetened beverages: Cause for concern. *JAMA, 302*(22), 2477-2478.

Ludwig, D. S., Peterson, K. E., & Gortmaker, S. L. (2001). Relation between consumption of sugar-sweetened drinks and childhood obesity: A prospective, observational analysis. *Lancet, 357*(9255), 505-508.

Lytle, L. A. (2009). Examining the etiology of childhood obesity: The IDEA study. *American Journal of Community Psychology, 44*(3-4), 338-349.

Lytle, L. A., Nichaman, M. Z., Obarzanek, E., Glovsky, E., Montgomery, D., Nicklas, T., et al. (1993). Validation of 24-hour recalls assisted by food records in third-grade children. the CATCH collaborative group. *Journal of the American Dietetic Association, 93*(12), 1431-1436.

Malik, V. S., Schulze, M. B., & Hu, F. B. (2006). Intake of sugar-sweetened beverages and weight gain: A systematic review. *The American Journal of Clinical Nutrition, 84*(2), 274-288.

Malik, V. S., Willett, W. C., Hu, F. B. (2008). Sugar-sweetened beverages and BMI in children and adolescents: Reanalyses of a meta-analysis. *The American Journal of Clinical Nutrition,*

Marshall, T. A., Eichenberger Gilmore, J. M., Broffitt, B., Levy, S. M., & Stumbo, P. J. (2003). Relative validation of a beverage frequency questionnaire in children ages 6 months through 5 years using 3-day food and beverage diaries. *Journal of the American Dietetic Association, 103*(6), 714-20; discussion 720.

Mattes, R. (2006). Fluid calories and energy balance: The good, the bad, and the uncertain. *Physiology & Behavior, 89*(1), 66-70.

Mattes, R. (2010). Beverages and health. Proceedings of an international symposium. September 17-19, 2009. Indianapolis, Indiana, USA. *Physiology & Behavior, 10*0(1), 1-94.

McIntyre, L., Glanville, N. T., Raine, K. D., Dayle, J. B., Anderson, B., & Battaglia, N. (2003). Do low-income lone mothers compromise their nutrition to feed their children? *CMAJ: Canadian Medical Association Journal, 168*(6), 686-691.

Metallinos-Katsaras, E., Sherry, B., & Kallio, J. (2009). Food insecurity is associated with overweight in children younger than 5 years of age. *Journal of the American Dietetic Association, 109*(10), 1790-1794.

Moeller, S. M., Reedy, J., Millen, A. E., Dixon, L. B., Newby, P. K., Tucker, K. L., et al. (2007). Dietary patterns: Challenges and opportunities in dietary patterns research an experimental biology workshop, April 1, 2006. *Journal of the American Dietetic Association, 107*(7), 1233-1239.

Molag, M. L., de Vries, J. H., Ocke, M. C., Dagnelie, P. C., van den Brandt, P. A., Jansen, M. C., et al. (2007). Design characteristics of food frequency questionnaires in relation to their validity. *American Journal of Epidemiology, 166*(12), 1468-1478.

Montgomery, C., Reilly, J. J., Jackson, D. M., Kelly, L. A., Slater, C., Paton, J. Y., et al. (2005). Validation of energy intake by 24-hour multiple pass recall: Comparison with total energy expenditure in children aged 5-7 years. *The British Journal of Nutrition, 93*(5), 671-676.

Moore, G. F., Tapper, K., Moore, L., & Murphy, S. (2008). Cognitive, behavioral, and social factors are associated with bias in dietary questionnaire self-reports by schoolchildren aged 9 to 11 years. *Journal of the American Dietetic Association, 108*(11), 1865-1873.

Moshfegh A.J., Rhodes D.G., Baer D.J., Murayi T., Clemens J.C., Rumpler W.V., Paul D.R., Sebastian R.S., Kuczynski K.J., Ingwersen L.A., Staples R.C., Cleveland L.E. (2008). The US Department of Agriculture automated multiple-pass method reduces bias in the collection of energy intakes. *American Journal of Clinical Nutrition, 88*: 324-332.

Mrdjenovic, G., & Levitsky, D. A. (2003). Nutritional and energetic consequences of sweetened drink consumption in 6- to 13-year-old children. *The Journal of Pediatrics, 142*(6), 604-610.

Mrdjenovic, G., & Levitsky, D. A. (2005). Children eat what they are served: The imprecise regulation of energy intake. *Appetite, 44*(3), 273-282.

Murasko, J. E. (2009). Socioeconomic status, height, and obesity in children. *Economics and Human Biology, 7*(3), 376-386.

Murphy, M. M., Douglass, J. S., Johnson, R. K., & Spence, L. A. (2008). Drinking flavored or plain milk is positively associated with nutrient intake and is not associated with adverse effects on weight status in US children and adolescents. *Journal of the American Dietetic Association, 10*8(4), 631-639.

Nakano, T., Sei, M., Ewis, A. A., Munakata, H., Onishi, C., & Nakahori, Y. (2010). Weight and height growth velocities of Japanese boys and girls between age 7 and 14 years: A critical window for early adolescent overweight risk. *The Journal of Medical Investigation : JMI, 57*(1-2), 124-132.

Nelson, J. A., Carpenter, K., & Chiasson, M. A. (2006). Diet, activity, and overweight among preschool-age children enrolled in the special supplemental nutrition program for women, infants, and children (WIC). *Preventing Chronic Disease, 3*(2), A49.

Nelson, M. C., & Lytle, L. A. (2009). Development and evaluation of a brief screener to estimate fast-food and beverage consumption among adolescents. *Journal of the American Dietetic Association, 109*(4), 730-734.

Newby, P. K., & Tucker, K. L. (2004). Empirically derived eating patterns using factor or cluster analysis: A review. *Nutrition Reviews, 62*(5), 177-203.

Newby, P. K., Peterson, K. E., Berkey, C. S., Leppert, J., Willett, W. C., & Colditz, G. A. (2004). Beverage consumption is not associated with changes in weight and body mass index among low-income preschool children in North Dakota. *Journal of the American Dietetic Association, 104*(7), 1086-1094.

Nicklas, T. A., O'Neil, C. E., & Kleinman, R. (2008). Association between 100% juice consumption and nutrient intake and weight of children aged 2 to 11 years. *Archives of Pediatrics & Adolescent Medicine, 162*(6), 557-565.

Nicklas, T. A., Yang, S. J., Baranowski, T., Zakeri, I., & Berenson, G. (2003). Eating patterns and obesity in children. The Bogalusa heart study. *American Journal of Preventive Medicine, 25*(1), 9-16.

Nielsen, S. J., & Popkin, B. M. (2004). Changes in beverage intake between 1977 and 2001. *American Journal of Preventive Medicine, 27*(3), 205-210.

Nissinen, K., Mikkila, V., Mannisto, S., Lahti-Koski, M., Rasanen, L., Viikari, J., et al. (2009). Sweets and sugar-sweetened soft drink intake in childhood in relation to adult BMI and overweight. The cardiovascular risk in young Finns study. *Public Health Nutrition, 12*(11), 2018-2026.

Novotny, R., Daida, Y. G., Acharya, S., Grove, J. S., & Vogt, T. M. (2004). Dairy intake is associated with lower body fat and soda intake with greater weight in adolescent girls. *The Journal of Nutrition, 13*4(8), 1905-1909.

O'Connor, T. M., Yang, S., & Nicklas, T. A. (2006). Beverage intake among preschool children and its effect on weight status. *Pediatrics, 11*8(4), e1010-1018.

O'Mara, L. (2008). Children who consumed sugar-sweetened beverages between meals > or = 4 - 6 times/week at 2.5 - 4.5 years of age were more likely to be overweight at 4.5 years of age. *Evidence-Based Nursing, 11*(1), 24.

O'Neil, C. E., & Nicklas, T. A. (2008). A review of the relationship between 100% fruit juice consumption and weight in children and adolescents. *American Journal of Lifestyle Medicine, 2*(4), 315-354.

O'Neil, C. E., Nicklas, T. A., & Kleinman, R. (2010). Relationship between 100% juice consumption and nutrient intake and weight of adolescents. *American Journal of Health Promotion : AJHP, 2*4(4), 231-237.

Ogden, C. L. (2004). Defining overweight in children using growth charts. *Maryland Medicine : MM : A Publication of MEDCHI, the Maryland State Medical Society, 5*(3), 19-21.

Olsen, N. J., & Heitmann, B. L. (2009). Intake of calorically sweetened beverages and obesity. *Obesity Reviews: An Official Journal of the International Association for the Study of Obesity, 10*(1), 68-75.

Olstad, D. L., & McCargar, L. (2009). Prevention of overweight and obesity in children under the age of 6 years. *Applied Physiology, Nutrition, and Metabolism, 34*(4), 551-570.

Pahwa, P. (2008). Biostatistics I (805.3) [course materials]. University of Saskatchewan, Department of Community Health and Epidemiology.

Park, Y. K., Meier, E. R., Bianchi, P., & Song, W. O. (2002). Trends in children's consumption of beverages: 1987 to 1998. *Family Economics and Nutrition Review, 14*(2), 69.

Peneau, S., Mekhmoukh, A., Chapelot, D., Dalix, A. M., Airinei, G., Hercberg, S., et al. (2009). Influence of environmental factors on food intake and choice of beverage during meals in teenagers: A laboratory study. *British Journal of Nutrition, 102*(12), 1854-1859.

Persson, L. A., & Carlgren, G. (1984). Measuring children's diets: Evaluation of dietary assessment techniques in infancy and childhood. *International Journal of Epidemiology, 13*(4), 506-517.

Phillips, S. M., Bandini, L. G., Naumova, E. N., Cyr, H., Colclough, S., Dietz, W. H., et al. (2004). Energy-dense snack food intake in adolescence: Longitudinal relationship to weight and fatness. *Obesity Research, 12*(3), 461.

Phillips, S., Jacobs Starkey, L., & Gray-Donald, K. (2004). Food habits of Canadians: Food sources of nutrients for the adolescent sample. *Canadian Journal of Dietetic Practice and*

*Research : A Publication of Dietitians of Canada, 65*(2), 81-84.

Popkin, B. M. (2006). Global nutrition dynamics: The world is shifting rapidly toward a diet linked with noncommunicable diseases. *The American Journal of Clinical Nutrition, 84*(2), 289-298.

Popkin, B. M. (2010). Patterns of beverage use across the lifecycle. *Physiology & Behavior, 100*(1), 4-9.

Popkin, B. M., & Nielsen, S. J. (2003). The sweetening of the world's diet. *Obesity Research, 11*(11), 1325-1332.

Popkin, B. M., Armstrong, L. E., Bray, G. M., Caballero, B., Frei, B., & Willett, W. C. (2006). A new proposed guidance system for beverage consumption in the United States. *The American Journal of Clinical Nutrition, 83*(3), 529-542.

Raben, A., Vasilaras, T. H., Moller, A. C., & Astrup, A. (2002). Sucrose compared with artificial sweeteners: Different effects on ad libitum food intake and body weight after 10 wk of supplementation in overweight subjects. *The American Journal of Clinical Nutrition, 76*(4), 721-729.

Raghuveer, G. (2010). Lifetime cardiovascular risk of childhood obesity. *The American Journal of Clinical Nutrition, 91*(5), 1514S-1519S.

Rajeshwari, R., Yang, S., Nicklas, T. A., & Berenson, G. S. (2005). Secular trends in children's sweetened-beverage consumption (1973 to 1994): The Bogalusa heart study. *Journal of the American Dietetic Association, 105*(2), 208-214.

Ramic, E., Kapidzic-Durakovic, S., Karic, E., Batic-Mujanovic, O., Alibasic, E., & Zildzic, M. (2009). Influence of lifestyle on overweight and obesity in school-age children. *Medicinski Arhiv, 63*(5), 280-283.

Rampersaud, G. C. (2007). A comparison of nutrient density scores for 100% fruit juices. *Journal of Food Science, 72*(4), S261-6.

Rampersaud, G. C., Bailey, L. B., & Kauwell, G. P. (2003). National survey beverage consumption data for children and adolescents indicate the need to encourage a shift toward more nutritive beverages. *Journal of the American Dietetic Association, 103*(1), 97-100.

Reilly, J. J., Montgomery, C., Jackson, D., MacRitchie, J., & Armstrong, J. (2001). Energy intake by multiple pass 24 h recall and total energy expenditure: A comparison in a representative sample of 3-4-year-olds. *The British Journal of Nutrition, 86*(5), 601-605.

Reinehr, T., Kleber, M., Lass, N., & Toschke, A. M. (2010). Body mass index patterns over 5 y in obese children motivated to participate in a 1-y lifestyle intervention: Age as a predictor of long-term success. *The American Journal of Clinical Nutrition, 91*(5), 1165-1171.

Rockett, H. R., Wolf, A. M., & Colditz, G. A. (1995). Development and reproducibility of a food frequency questionnaire to assess diets of older children and adolescents. *Journal of the American Dietetic Association, 95*(3), 336-340.

Rodriguez-Artalejo, F., Garcia, E. L., Gorgojo, L., Garces, C., Royo, M. A., Martin Moreno, J. M., et al. (2003). Consumption of bakery products, sweetened soft drinks and yogurt among children aged 6-7 years: Association with nutrient intake and overall diet quality. *The British Journal of Nutrition, 89*(3), 419-429.

Ruben, A. R. (2009). Undernutrition and obesity in indigenous children: Epidemiology, prevention, and treatment. *Pediatric Clinics of North America, 56*(6), 1285-1302.

Rumpler W.V., Kramer M., Rhodes D.G., Moshfegh A.J., Paul D.R. (2008). Identifying sources of reporting error using measured food intake. *European Journal of Clinical Nutrition 62*:544-552.

Sanigorski, A. M., Bell, A. C., & Swinburn, B. A. (2007). Association of key foods and beverages with obesity in Australian schoolchildren. *Public Health Nutrition, 10*(2), 152-157.

Schulz, M., Liese, A. D., Mayer-Davis, E. J., D'Agostino, R. B.,Jr, Fang, F., Sparks, K. C., et al. (2005). Nutritional correlates of dietary glycaemic index: New aspects from a population perspective. *The British Journal of Nutrition, 94*(3), 397-406.

Shields, M. (2006). Overweight and obesity among children and youth. *Health Reports / Statistics Canada, Canadian Centre for Health Information, 17*(3), 27-42.

Sichieri, R., Paula Trotte, A., de Souza, R. A., & Veiga, G. V. (2008). School randomised trial on prevention of excessive weight gain by discouraging students from drinking sodas. *Public Health Nutrition,* , 1-6.

Singh, G. K., Siahpush, M., & Kogan, M. D. (2010). Rising social inequalities in US childhood obesity, 2003-2007. *Annals of Epidemiology, 20*(1), 40-52.

Skinner, J. D., & Carruth, B. R. (2001). A longitudinal study of children's juice intake and growth: The juice controversy revisited. *Journal of the American Dietetic Association, 101*(4), 432-437.

Skinner, J. D., Bounds, W., Carruth, B. R., & Ziegler, P. (2003). Longitudinal calcium intake is negatively related to children's body fat indexes. *Journal of the American Dietetic Association, 103*(12), 1626-1631.

Skinner, J. D., Carruth, B. R., Houck, K. S., Bounds, W., Morris, M., Cox, D. R., et al. (1999). Longitudinal study of nutrient and food intakes of white preschool children aged 24 to 60 months. *Journal of the American Dietetic Association, 99*(12), 1514-1521.

Skinner, J. D., Ziegler, P., & Ponza, M. (2004). Transitions in infants' and toddlers' beverage patterns. *Journal of the American Dietetic Association, 104*(1 Suppl 1), s45-50.

Slattery, M. L. (2010). Analysis of dietary patterns in epidemiological research. *Applied Physiology, Nutrition, and Metabolism, 35*(2), 207-210.

Soanes, C., & Stevenson, A. (2005). *The Oxford dictionary of English (revised edition) Oxford reference online*. Retrieved January/9, 2009, from http://www.oxfordreference.com/views/SEARCH_RESULTS.html?y=0&q=juice&x=0&ssid=862572736&scope=global&time=0.235943876297341

Sobo, E. J., Rock, C. L., Neuhouser, M. L., Maciel, T. L., & Neumark-Sztainer, D. (2000). Caretaker-child interaction during children's 24-hour dietary recalls: Who contributes what to the recall record*? Journal of the American Dietetic Association, 10*0(4), 428-433.

St-Onge, M. P., Claps, N., Heshka, S., Heymsfield, S. B., & Kosteli, A. (2007). Greater resting energy expenditure and lower respiratory quotient after 1 week of supplementation with milk relative to supplementation with a sugar-only beverage in children. *Metabolism: Clinical and Experimental, 5*6(12), 1699-1707.

St-Onge, M. P., Rubiano, F., DeNino, W. F., Jones, A.,Jr, Greenfield, D., Ferguson, P. W., et al. (2004). Added thermogenic and satiety effects of a mixed nutrient vs a sugar-only beverage. *International Journal of Obesity and Related Metabolic Disorders: Journal of the International Association for the Study of Obesity, 2*8(2), 248-253.

Stanhope, K. L., & Havel, P. J. (2008). Endocrine and metabolic effects of consuming beverages sweetened with fructose, glucose, sucrose, or high-fructose corn syrup. *The American Journal of Clinical Nutrition, 8*8(6), 1733S-1737S.

Stanhope, K. L., Schwarz, J. M., Keim, N. L., Griffen, S. C., Bremer, A. A., Graham, J. L., et al. (2009). Consuming fructose-sweetened, not glucose-sweetened, beverages increases visceral adiposity and lipids and decreases insulin sensitivity in overweight/obese humans. *The*

*Journal of Clinical Investigation, 119*(5), 1322-1334.

Statistics Canada. (2009). *Food statistics 2008* No. 21-020-X). Ottawa: Statistics Canada.

Statistics Canada. (2009a). *Canadian Community Health Survey - nutrition (CCHS): Detailed information for 2004 (cycle 2.2)*. Retrieved 06/03, 2010, from http://www.statcan.gc.ca/cgi-bin/imdb/p2SV.pl?Function=getSurvey&SDDS=5049&lang=en&db=imdb&adm=8&dis=2#2

Storey, M. L., Forshee, R. A., & Anderson, P. A. (2006). Beverage consumption in the US population. *Journal of the American Dietetic Association, 106*(12), 1992-2000.

Strauss, R. S., & Pollack, H. A. (2003). Social marginalization of overweight children. *Archives of Pediatrics & Adolescent Medicine, 157*(8), 746-752.

Summerbell, C. D., Douthwaite, W., Whittaker, V., Ells, L. J., Hillier, F., Smith, S., et al. (2009). The association between diet and physical activity and subsequent excess weight gain and obesity assessed at 5 years of age or older: A systematic review of the epidemiological evidence. *International Journal of Obesity, 33*(Suppl 3), S1-92.

Swithers, S. E., Baker, C. R., & Davidson, T. L. (2009). General and persistent effects of high-intensity sweeteners on body weight gain and caloric compensation in rats. *Behavioral Neuroscience, 123*(4), 772-780.

Tam, C. S., Garnett, S. P., Cowell, C. T., Campbell, K., Cabrera, G., & Baur, L. A. (2006). Soft drink consumption and excess weight gain in Australian school students: Results from the Nepean study. *International Journal of Obesity, 30*(7), 1091-1093.

Taveras, E. M., Gillman, M. W., Kleinman, K., Rich-Edwards, J. W., & Rifas-Shiman, S. L. (2010). Racial/ethnic differences in early-life risk factors for childhood obesity. *Pediatrics, 125*(4), 686-695.

Teff, K. L., Elliott, S. S., Tschop, M., Kieffer, T. J., Rader, D., Heiman, M., et al. (2004). Dietary fructose reduces circulating insulin and leptin, attenuates postprandial suppression of ghrelin, and increases triglycerides in women. *The Journal of Clinical Endocrinology and Metabolism, 89*(6), 2963-2972.

Trapp, L. W., Ryan, A. A., Ariza, A. J., Garcia, C. M., & Binns, H. J. (2009). Primary care identification of infants at high risk for overweight and obesity. *Clinical Pediatrics, 48*(3), 313-316.

Treidlinger, M., & Dedhar, G. (2009). *The Canadian soft drink industry.* Retrieved July/6, 2009, from http://www4.agr.gc.ca/AAFC-AAC/display-afficher.do?id=1172167862291&lang=eng

Tsiros, M. D., Olds, T., Buckley, J. D., Grimshaw, P., Brennan, L., Walkley, J., et al. (2009). Health-related quality of life in obese children and adolescents. *International Journal of Obesity, 33*(4), 387-400.

United States Department of Agriculture. (2009). *My pyramid for preschoolers*. Retrieved July/23, 2009, from http://www.mypyramid.gov/preschoolers/

Van Wymelbeke, V., Beridot-Therond, M. E., de La Gueronniere, V., & Fantino, M. (2004). Influence of repeated consumption of beverages containing sucrose or intense sweeteners on food intake. *European Journal of Clinical Nutrition, 58*(1), 154-161.

Vartanian, L. R., Schwartz, M. B., & Brownell, K. D. (2007). Effects of soft drink consumption on nutrition and health: A systematic review and meta-analysis. *American Journal of Public Health, 97*(4), 667-675.

Vatanparast, H., & Whiting, S. (2007). Trends in beverages intake of Canadians within last three decades; are they similar to the trend in the united states? [Abstract]. *Canadian Society of Nutritional Sciences Congress.*

Wang, Y. C., Bleich, S. N., & Gortmaker, S. L. (2008). Increasing caloric contribution from sugar-sweetened beverages and 100% fruit juices among US children and adolescents, 1988-2004. *Pediatrics, 121*(6), e1604-14.

Wang, Y. C., Ludwig, D. S., Sonneville, K., & Gortmaker, S. L. (2009). Impact of change in sweetened caloric beverage consumption on energy intake among children and adolescents. *Archives of Pediatrics & Adolescent Medicine, 163*(4), 336-343.

Weaver, C. M. (2010). Role of dairy beverages in the diet. *Physiology & Behavior, 100*(1), 63-66.

Welsh, J. A., Cogswell, M. E., Rogers, S., Rockett, H., Mei, Z., & Grummer-Strawn, L. M. (2005). Overweight among low-income preschool children associated with the consumption of sweet drinks: Missouri, 1999-2002. *Pediatrics, 115*(2), e223-9.

White, J. S. (2008). Straight talk about high-fructose corn syrup: What it is and what it ain't. *American Journal of Clinical Nutrition, 88*(6), 1716S-1721S.

Whiting, S. J., Healey, A., Psiuk, S., Mirwald, R., Kowalski, K., & Bailey, D. A. (2001). Relationship between carbonated and other low nutrient dense beverages and bone mineral content of adolescents. *Nutrition Research, 21*, 1107.

WHO Multicentre Growth Reference Study Group. (2006). Assessment of differences in linear growth among populations in the WHO multicentre growth reference study. *Acta Paediatrica (Oslo, Norway : 1992).Supplement, 45*0, 56-65.

Wilkinson Enns, C., Mickle, S. J., & Goldman, J. D. (2002). Trends in food and nutrient intakes by children in the United States. *Family Economics and Nutrition Review, 1*4(2), 56.

Williams, S. M., & Goulding, A. (2009). Patterns of growth associated with the timing of adiposity rebound. *Obesity (Silver Spring, Md.), 1*7(2), 335-341.

Willows, N. D. (2005). Determinants of healthy eating in aboriginal peoples in Canada: The current state of knowledge and research gaps. *Canadian Journal of Public Health, 96 Suppl* 3, S32-6, S36-41.

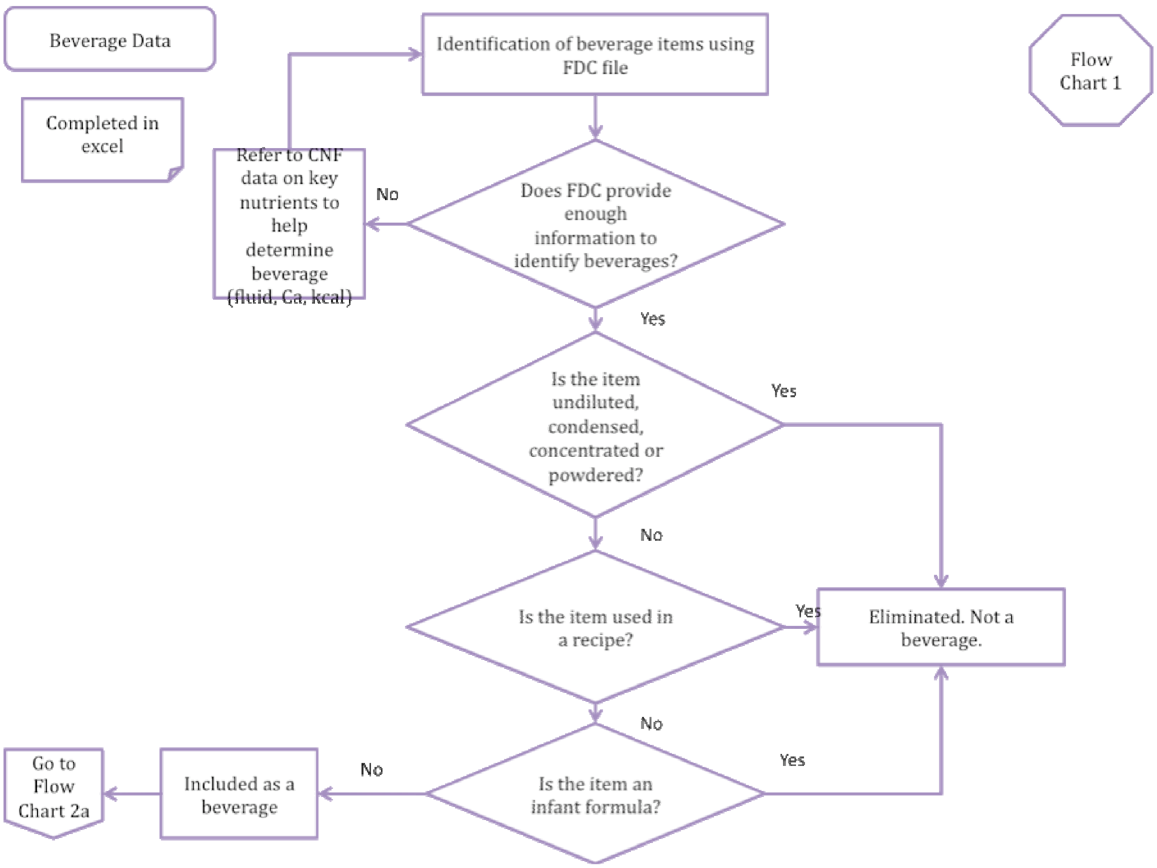
Wilson, J. F. (1999). Preschoolers' mid-afternoon snack intake is not affected by lunchtime food consumption. *Appetite, 3*3(3), 319-327.

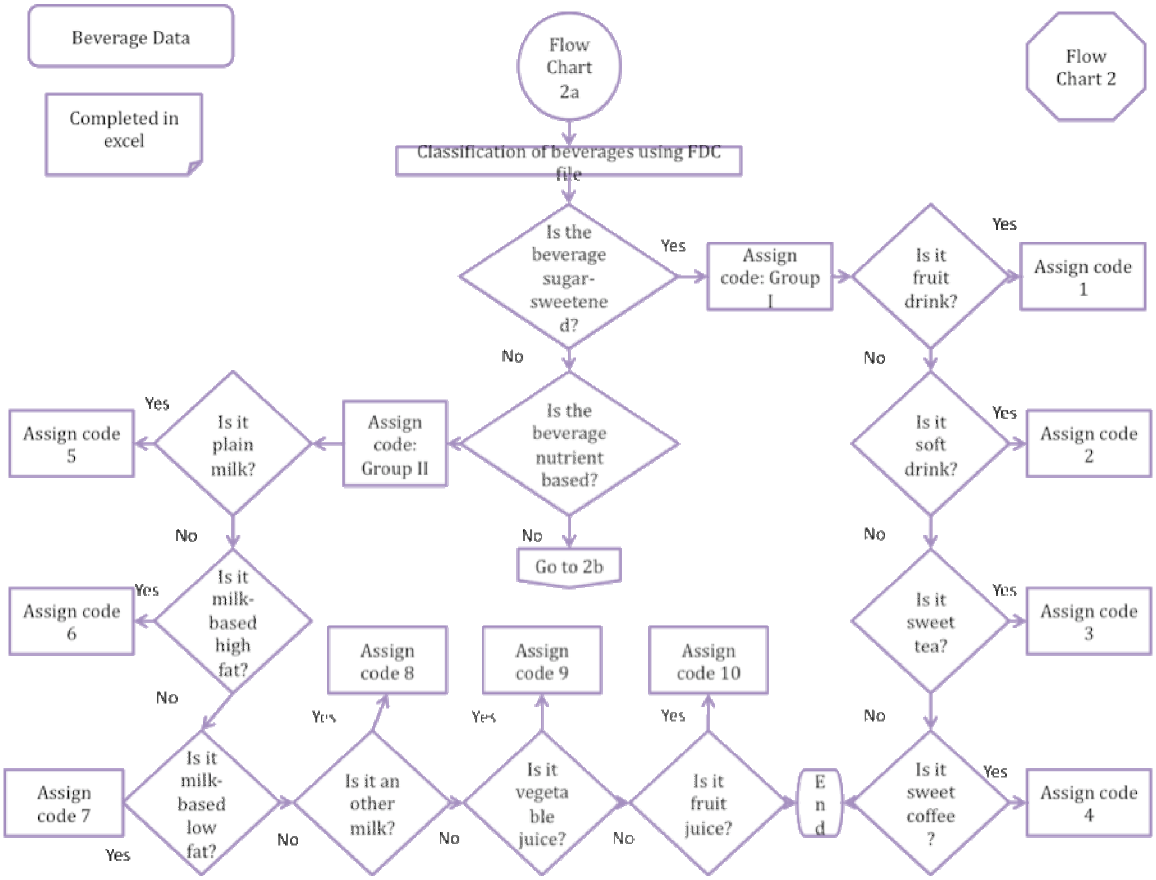
Wilson, J. F. (2000). Lunch eating behavior of preschool children. effects of age, gender, and type of beverage served. *Physiology & Behavior, 7*0(1-2), 27-33.

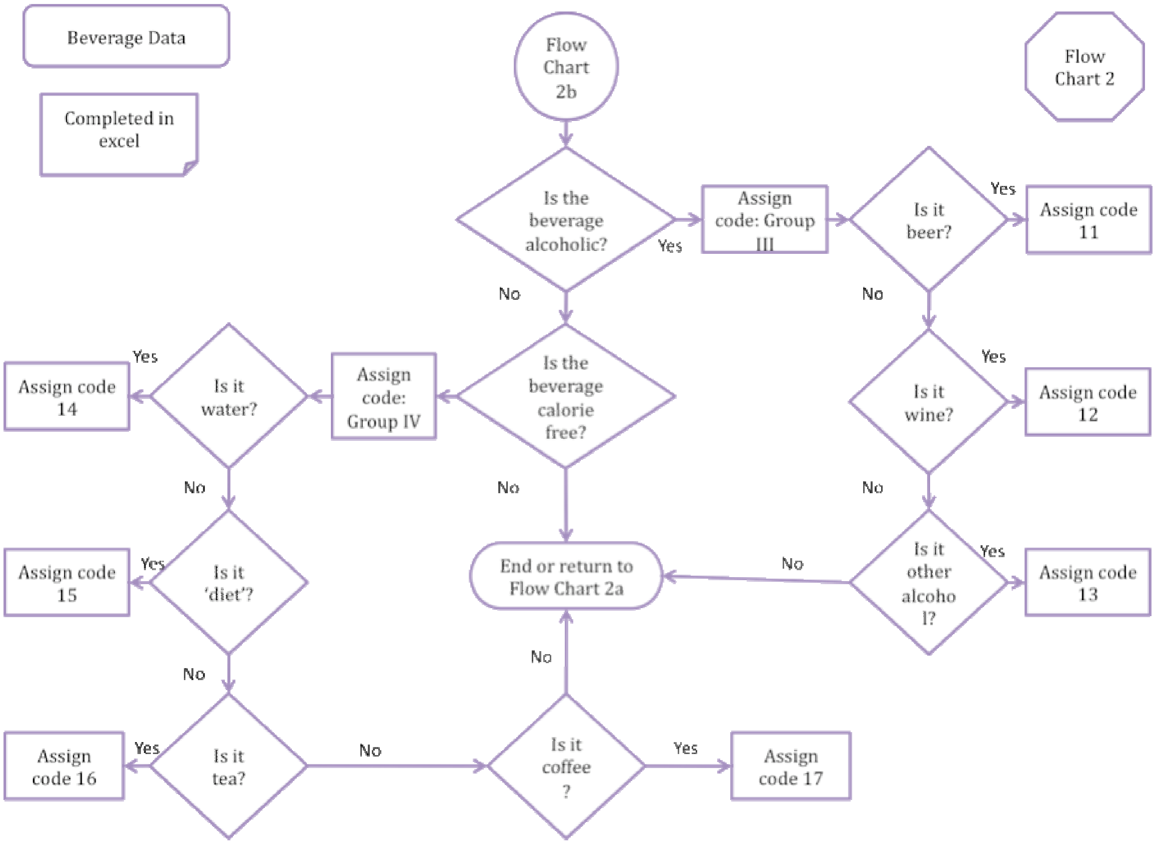
Wolf, A., Bray, G. A., & Popkin, B. M. (2008). A short history of beverages and how our body treats them. *Obesity Reviews : An Official Journal of the International Association for the Study of Obesity,* 9(2), 151-164.

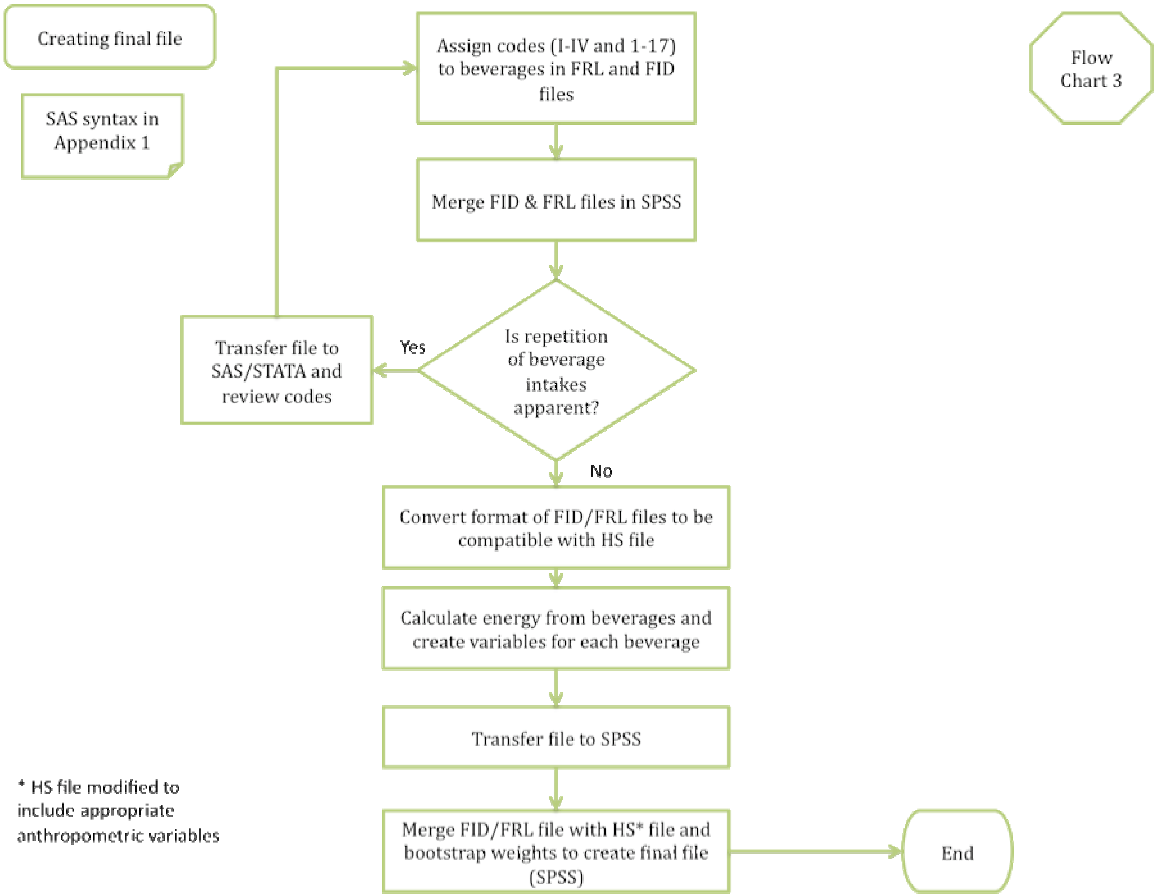
Yen, S. T., & Lin, B. (2002). Beverage consumption among US children and adolescents: Full-information and quasi maximum-likelihood estimation of a censored system. *European Review of Agricultural Economics, 2*9(1), 85-103.

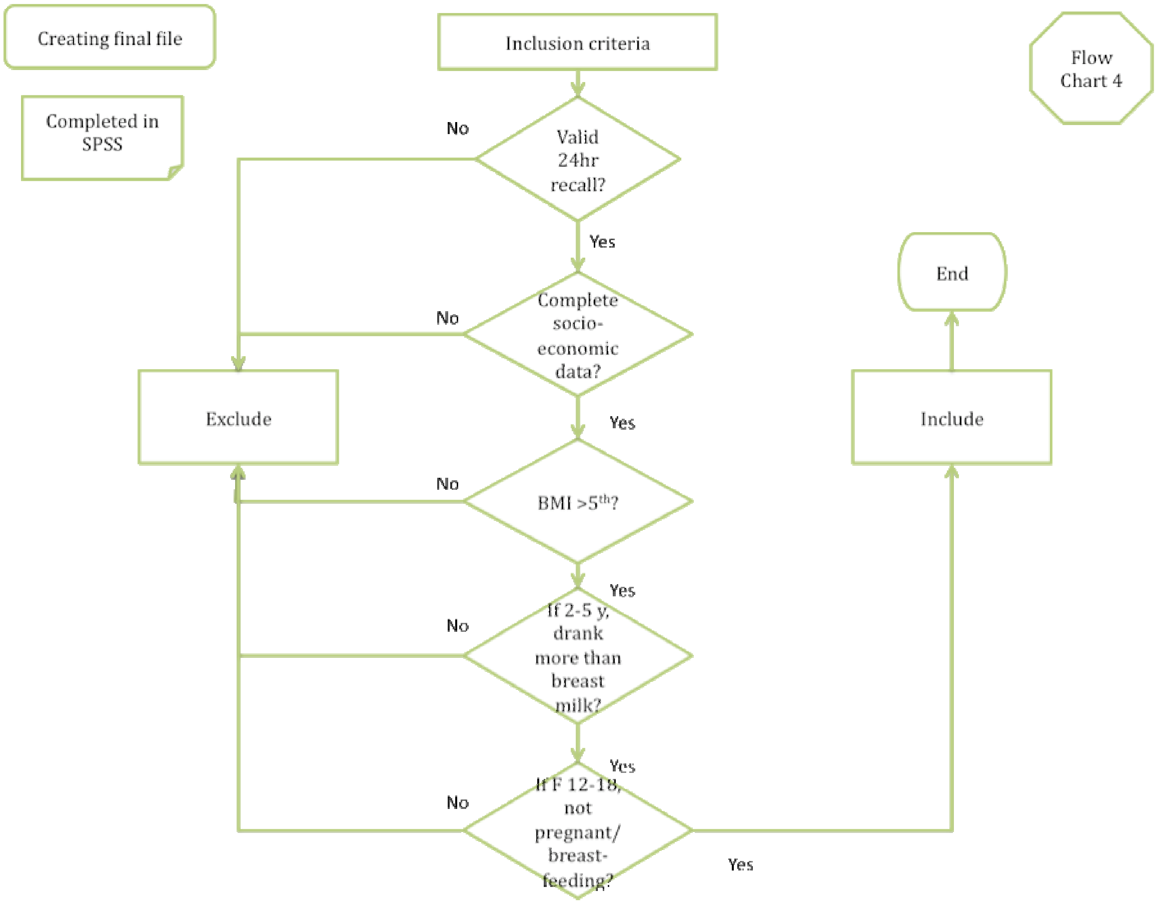
# APPENDIX A

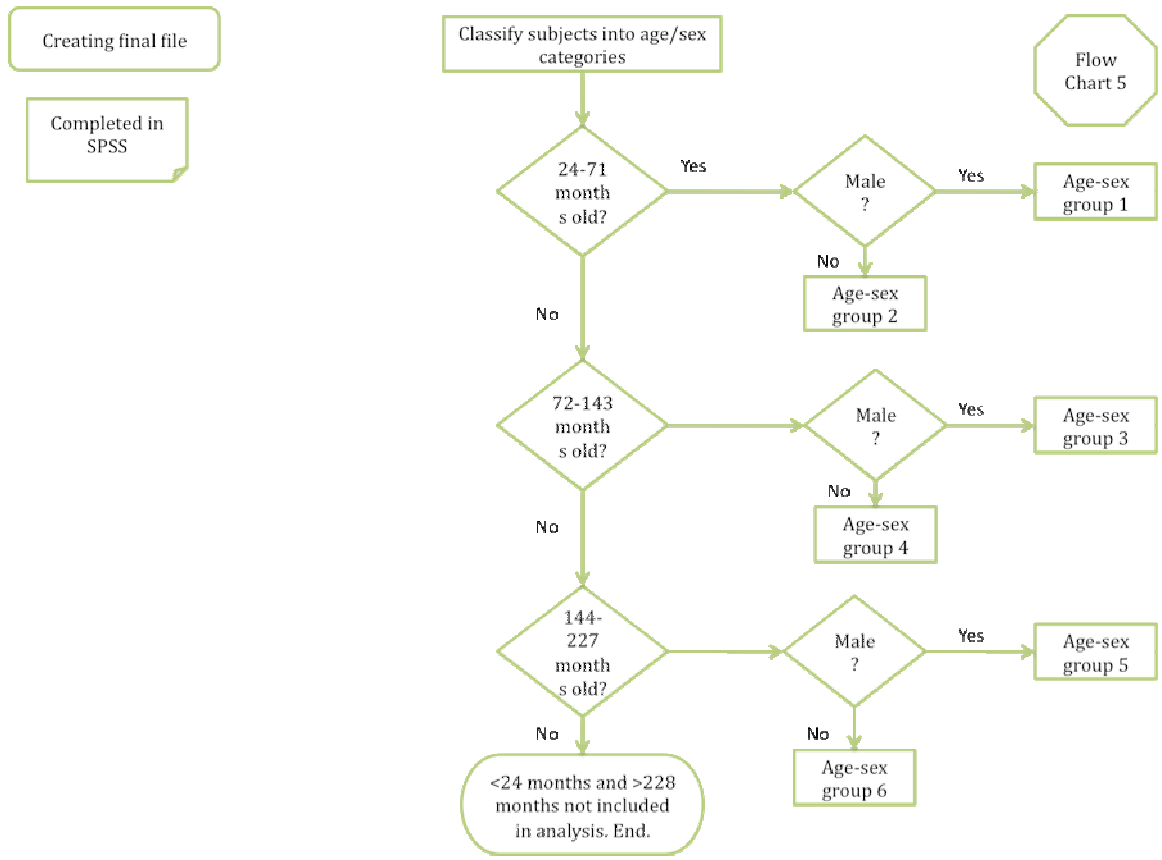

Beverage Data
Completed in excel
Identification of beverage items using FDC file
Flow Chart 1
Refer to CNF data on key nutrients to help determine beverage (fluid, Ca, kcal)
No
Does FDC provide enough information to identify beverages?
Yes
Is the item undiluted, condensed, concentrated or powdered?
Yes
No
Is the item used in a recipe?
Yes
Eliminated. Not a beverage.
No
Is the item an infant formula?
Yes
No
Included as a beverage
Go to Flow Chart 2a

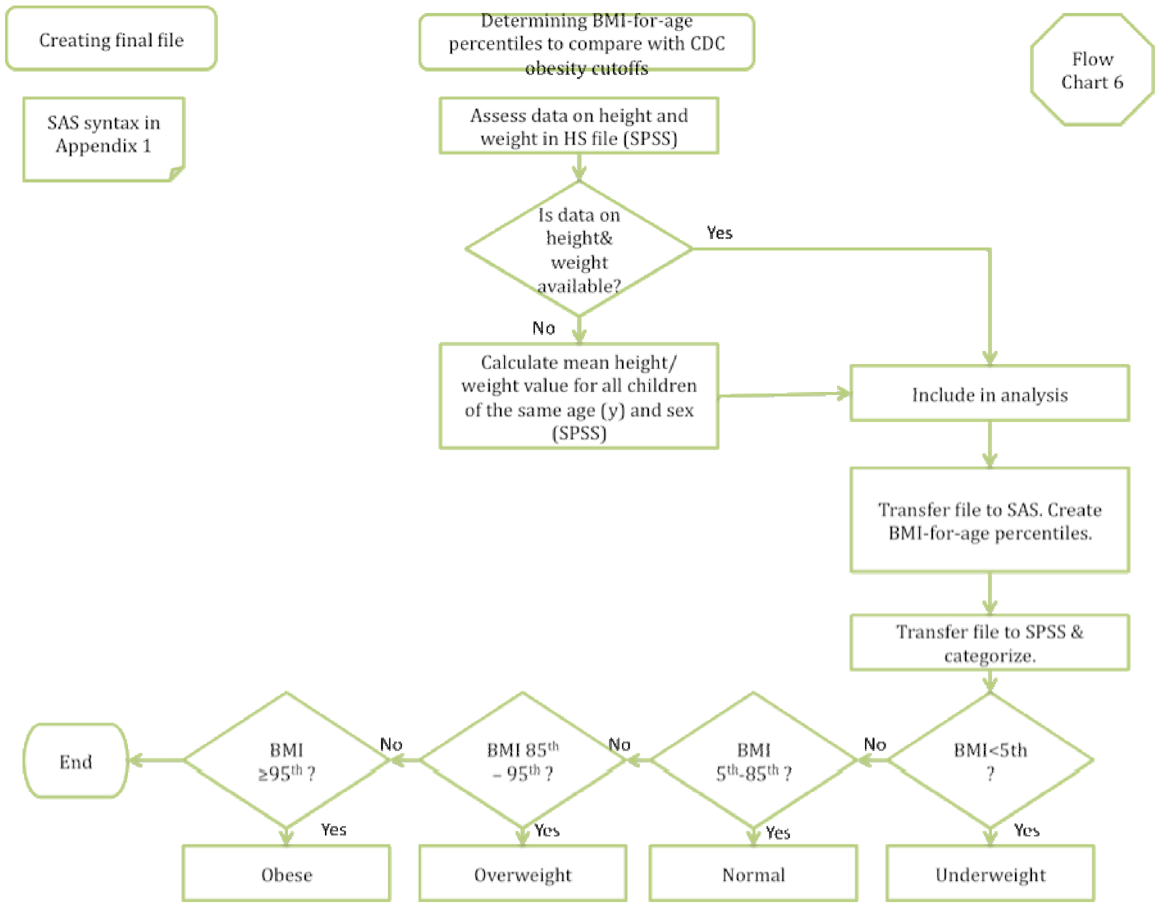

Beverage Data
Completed in excel
Flow Chart 2a
Flow Chart 2
Classification of beverages using FDC file
Is the beverage sugar-sweetened?
Yes
Assign code: Group I
Is it fruit drink?
Yes
Assign code 1
No
No
Is the beverage nutrient based?
Assign code: Group II
Is it plain milk?
Yes
Assign code 5
Is it soft drink?
Yes
Assign code 2
No
No
No
Go to 2b
Is it milk-based high fat?
Yes
Assign code 6
Is it sweet tea?
Yes
Assign code 3
Assign code 8
Assign code 9
Assign code 10
No
Yes
Yes
Yes
No
Assign code 7
Is it milk-based low fat?
Is it an other milk?
Is it vegetable juice?
Is it fruit juice?
End
Is it sweet coffee?
Yes
Assign code 4
Yes
No
No
No


Beverage Data
Completed in excel
Flow Chart 2b
Flow Chart 2
Is the beverage alcoholic?
Yes
No
Assign code: Group III
Is it beer?
Yes
Assign code 11
No
Is it wine?
Yes
Assign code 12
No
Is it other alcohol?
Yes
Assign code 13
No
Is the beverage calorie free?
No
End or return to Flow Chart 2a
Assign code: Group IV
Is it water?
Yes
Assign code 14
No
Is it 'diet'?
Yes
Assign code 15
No
Is it tea?
Yes
Assign code 16
No
Is it coffee?
Yes
Assign code 17
No

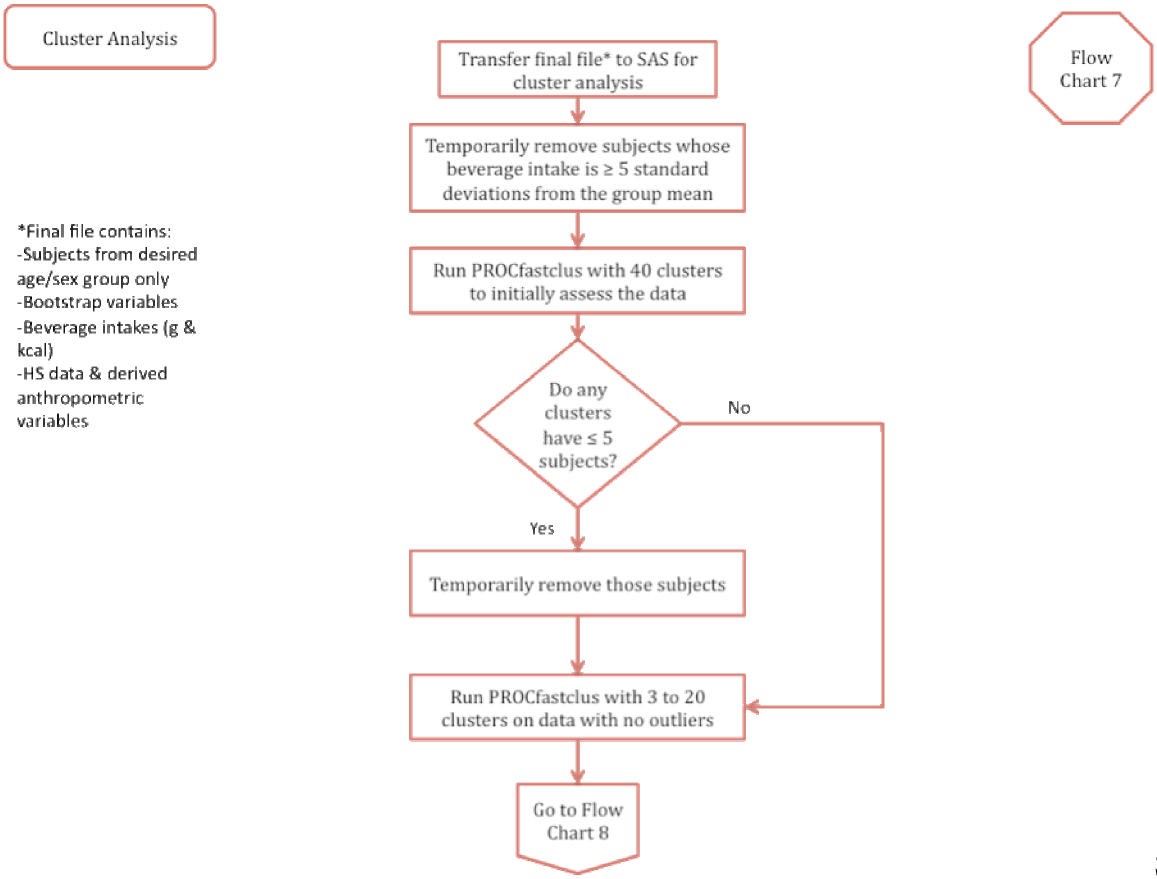

Creating final file
SAS syntax in Appendix 1
Assign codes (I-IV and 1-17) to beverages in FRL and FID files
Flow Chart 3
Merge FID & FRL files in SPSS
Transfer file to SAS/STATA and review codes
Yes
Is repetition of beverage intakes apparent?
No
Convert format of FID/FRL files to be compatible with HS file
Calculate energy from beverages and create variables for each beverage
Transfer file to SPSS
* HS file modified to include appropriate anthropometric variables
Merge FID/FRL file with HS* file and bootstrap weights to create final file (SPSS)
End


Creating final file
Completed in SPSS
Inclusion criteria
Flow Chart 4
Valid 24hr recall?
No
Yes
Complete socio-economic data?
No
Yes
End
Exclude
Include
BMI >5th?
No
Yes
If 2-5 y, drank more than breast milk?
No
Yes
If F 12-18, not pregnant/ breast-feeding?
No
Yes


Creating final file
Completed in SPSS
Classify subjects into age/sex categories
Flow Chart 5
24-71 month s old?
Yes
Male ?
Yes
Age-sex group 1
No
Age-sex group 2
No
72-143 month s old?
Male ?
Yes
Age-sex group 3
No
Age-sex group 4
No
144-227 month s old?
Male ?
Yes
Age-sex group 5
No
Age-sex group 6
No
<24 months and >228 months not included in analysis. End.



Creating final file
SAS syntax in Appendix 1
Determining BMI-for-age percentiles to compare with CDC obesity cutoffs
Flow Chart 6
Assess data on height and weight in HS file (SPSS)
Is data on height& weight available?
Yes
No
Calculate mean height/ weight value for all children of the same age (y) and sex (SPSS)
Include in analysis
Transfer file to SAS. Create BMI-for-age percentiles.
Transfer file to SPSS & categorize.
BMI<5th ?
BMI 5th-85th ?
BMI 85th – 95th ?
BMI ≥95th ?
No
No
No
Yes
Yes
Yes
Yes
End
Obese
Overweight
Normal
Underweight

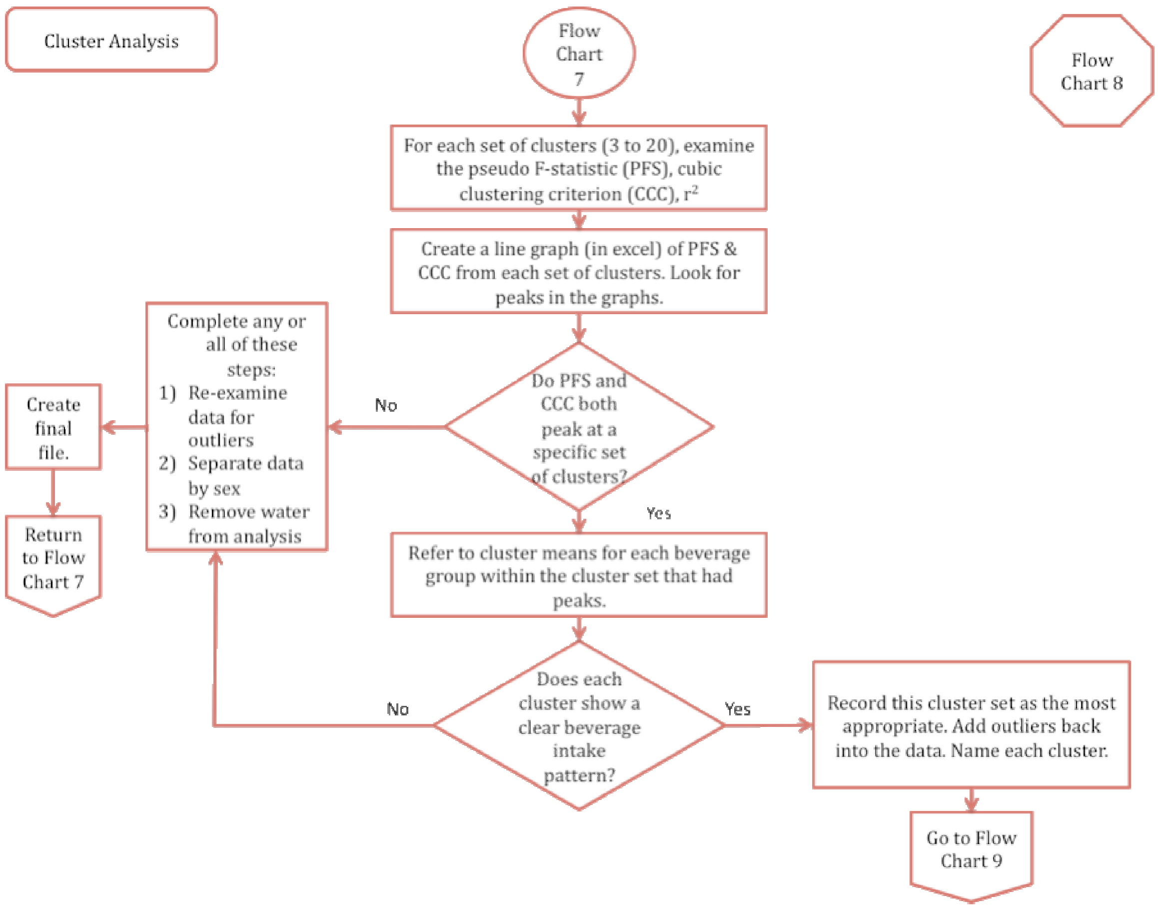



SAS

Syntax for Flow Chart 7:

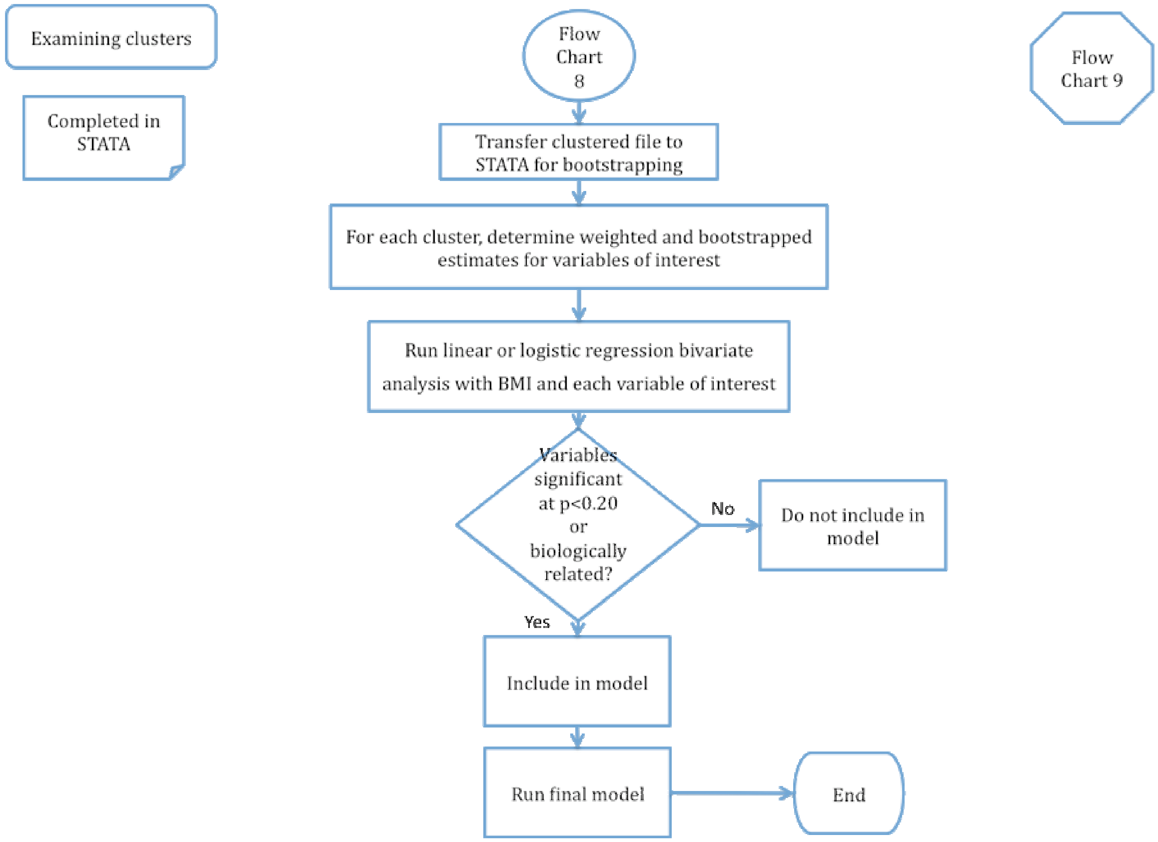
```
*********************************************************
Removing subjects whose intake is > 5 SD from mean
*********************************************************/
if frdn_wt > 1657 then flag_1=1;
if sfdn_wt > 1562 then flag_2=1;
if tswt_wt > 627 then flag_3=1;
if cfswt_wt > 98 then flag_4=1;
if milk_wt > 1796 then flag_5=1;
if mlkh_wt > 1061 then flag_6=1;
if mlkl_wt > 610 then flag_7=1;
if mlko_wt > 317 then flag_8=1;
if vegj_wt > 338 then flag_9=1;
if frj_wt > 1358 then flag_10=1;
if beer_wt > 657 then flag_11=1;
if wine_wt > 58 then flag_12=1;
if alcot_wt > 279 then flag_13=1;
if diet_wt > 556 then flag_15=1;
if tea_wt > 708 then flag_16=1;
if coffee_wt > 456 then flag_17=1;
flag_any=.;
if flag_1=1 or flag_2=1 or flag_3=1 or flag_4=1 or flag_5=1 or flag_6=1 or
flag_7=1 or flag_8=1 or flag_9=1 or flag_10=1 or flag_11=1 or flag_12=1 or
flag_13=1  or flag_15=1 or flag_16=1 or flag_17=1 then flag_any=1;
run;
```

```
************************************************************
initial clustering to identify clusters with < 5 subjects
************************************************************/
proc fastclus data=test maxclusters=40
maxiter=0 cluster=clus40 out=clust.prelim_40_up_nowater
outseed=clust.seed_k40_up_nowater drift;
where flag_any ne 1;
var frdn_wt sfdn_wt tswt_wt cfswt_wt milk_wt mlkh_wt mlkl_wt mlko_wt vegj_wt
frj_wt beer_wt
wine_wt alcot_wt diet_wt tea_wt coffee_wt;
run;
title "Prelim cluster children no water,exluding>=5SD";
data clusgen_nowater;
set clust.prelim_40_up_nowater;
***************************************************************
examined output to determine which clusters had < 5 subjects, then
temporarily deleted them in the following steps
***************************************************************/
if clus40=11 then delete;
if clus40=17 then delete;
if clus40=18 then delete;
if clus40=19 then delete;
if clus40=30 then delete;
if clus40=38 then delete;
run;
*****************************************************
Run fastclus on this data set with no outliers, running sets of 3-20 clusters
*****************************************************/
%macro nclus(n);
proc fastclus data=clusgen_nowater maxclusters=&n maxiter=50 cluster=clus_40
out=clust.noout_40_nowater_&n outseed=clust.seed_40up_nowater_&n drift;
var frdn_wt sfdn_wt tswt_wt cfswt_wt milk_wt mlkh_wt mlkl_wt mlko_wt vegj_wt
frj_wt beer_wt
wine_wt alcot_wt  diet_wt tea_wt coffee_wt;
title "No outliers using clusters maxclusters=&n, maxiter=50";
run;
%mend nclus;
%macro doclus (n1,n2);
%do i=&n1 %to &n2;
%nclus (&i);
%end;
%mend doclus;
%doclus (3,20);
run;
```




SAS Syntax for Flow Chart 8:

```
/*********************************************************
Determined a 5 cluster solution most appropriate, therefore, adding outliers
back into cluster set 5
*********************************************************/
proc fastclus data=clust.final_adults maxclusters=5 maxiter=0
cluster=clus_5 out=finclust.finalup_nowater_5
seed=finclust.seed_40up_nowater_5 replace=none;
var frdn_wt sfdn_wt tswt_wt cfswt_wt milk_wt mlkh_wt mlkl_wt mlko_wt vegj_wt
frj_wt beer_wt
wine_wt alcot_wt diet_wt tea_wt coffee_wt;
title "updated final adults 5 cluster set no water with replace=none";
run;
```




STATA Syntax for bootstrapping and regression analysis

**Commands needed to prepare for bootstrapping:**

```
svyset _n [pweight= wtsd_mhw], brrweight(bsw1-bsw500) vce(brr)
```

**Example of bi-variate linear regression syntax:**

```
svy: regress bmipct   cluster1 cluster2 cluster4 cluster5
```

**Example of linear regression model:**

```
svy: regress bmipct fsdddekc dhhd_age sex2 race2g2 cluster1 cluster2 cluster4
cluster5
```

**Example of bi-variate logistic regression syntax:**

```
svy: logistic  overweight2   cluster1 cluster2 cluster4 cluster5
```

**Example of logistic regression model:**

```
svy: logistic overweight2 fsdddekc dhhd_age sex2 race2g2 fs2 fs3 cluster1
cluster2 cluster4 cluster5
```