Beverage consumption in Auckland primary school children

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Abstract

Background: The New Zealand (NZ) Ministry of Health advises that plain water and plain low-fat milk should be consumed daily and that if children are to drink sugar-sweetened beverages (SSB) they should be limited. The latest comprehensive NZ beverage intake data in 8 to 12 year old children was published in 2008, however, fizzy drink intake data is updated annually. This means that NZ is lacking a full picture of children's beverage consumption. SSB intake has been associated with weight gain in some studies. However, most of these studies calculate adiposity using body mass index (BMI) and few measure body fat percentage (BF%). International and limited national evidence has identified home availability, parental encouragement, socioeconomic status, and knowledge in children as factors associated with SSB intake. Many NZ schools have become 'water-only' schools (WOS) to try to reduce SSB consumption.

Aim: To investigate beverage consumption in 8 to 12 year old Auckland primary school children.

Methods: This cross-sectional study evaluated beverage intake and associated factors using self-administered questionnaires. SSB consumption measurements consisted of 17 types of beverages, and different combinations of these. Body composition was measured using bioelectrical impedance analysis (BIA). Chi squared and Mann-Whitney tests were used to examine the associations between SSB consumption and the factors associated with it.

Results: Children (n=695, 9.9±0.7 years, 44.8% male) were recruited from 6 schools (4 WOS). Plain water and plain milk were consumed less than once per day by 11.6% and 54.7% of the children, respectively. Soft drink and fruit juice were consumed more than once per week by 30.6% and 39% of the children, respectively. SSBs (p<0.001), including fruit juice (p=0.021), had a positive relationship with BF% in girls. There was an increased likelihood of consuming beverages at least once per week if they were usually available at home. Receiving a lot of encouragement for healthy beverage intake from parents or school had an inverse relationship with SBB intake (p<0.001). Low socioeconomic status was inversely associated with SSB intake (p<0.001). WOS had a higher consumption of SSBs compared to non-WOS (p<0.001).

Conclusions: Too many children in this cohort were not meeting the NZ Ministry of Health recommendations for plain water and milk consumption. Thus, they may benefit

from increasing their intake, whilst decreasing their SSB intake. If parents limited SSB home availability and encouraged intake of healthy beverages it may contribute to a decrease in their children's SSB consumption. Our findings support a recommendation to include fruit juice in any public health actions to discourage SSB consumption. More research is needed to assess school water-only policies and their effect on SSB consumption.

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Firstly, thank you to my supervisors Dr Pamela von Hurst and Dr Cathryn Conlon for your invaluable support and guidance throughout this project. You gave this project wings. Also, thank you to all the participants for providing this project with wings to fly.

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Terminology

For the purpose of this thesis, the following terminology is used:

List of abbreviations

Abbreviation	Meaning
ADP	Air Displacement Plethysmography
BIA	Bioelectrical Impedance Analysis
BF%	Body Fat Percentage (%)
BMI	Body Mass Index
DXA	Dual-energy X-ray Absorptiometry
FFQ	Food Frequency Questionnaire
kg	Kilogram
m	Metre
Mdn	Median
n	Sample size
NZ	New Zealand
r	Effect size
SD	Standard Deviation
SSB	Sugar-Sweetened Beverage
U	Mann-Whitney U (Wilcoxon) statistic
WOS	Water-Only School
<	Less than
≤	Less than or equal to
>	More than
≥	More than or equal to

List of definitions

Definition	Meaning
Adolescents	Aged 13 to 19 years old
Community	Outside of the home and school environment
Soft drinks	Definition as per this study's food frequency questionnaire: standard soft drinks or other fizzy drinks e.g. Coke, Lemonade, Fanta, Mountain Dew
Sugar-sweetened beverages	Beverages which contain added sugar or other caloric sweeteners, including soft drinks, sports drinks, energy drinks, flavoured milks, flavoured water, and powdered or cordial fruit drinks. This excludes plain water, diet fizzy drinks, plain milk, 100% fruit and vegetable drinks, and alcoholic beverages (Riordan et al., 2017; Wetter & Hodge, 2016).
Water-only school	A school which only allows the sale of water and plain milk on school property (Ministry of Health, 2016c).

Poster presentation

Research from this project was presented at the Nutrition Society of New Zealand annual meeting, 28th to 30th November 2018. It was awarded the best poster prize.

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Conference abstract:

Sugar sweetened beverage consumption in Auckland primary school children

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Background: Sugar sweetened beverage (SSB) consumption has a positive relationship with unhealthy weight gain. Due to the high childhood obesity rates in New Zealand many schools have become 'water-only' schools (WOS) to try to decrease SSB consumption. However, the most recent comprehensive beverage consumption statistics were published 15 years ago in 2003. The aim of this study was to investigate beverage consumption in 8 to 12 year old Auckland primary school children.

Methods: This cross-sectional study evaluated beverage consumption using a self-administered questionnaire. Body composition was measured using bioelectrical impedance analysis (BIA).

Results: Children (n=695, 9.87±0.71 years, 44.8% male) were recruited from 6 schools (4 WOS). Plain water was consumed 5+ times per week by 93.1% of the children. Only 45.1% of the children consumed plain milk more than once per day and 16.4% consumed plain milk less than once per week. Flavoured milk was consumed by 6% of children 5+ times per week. Soft drink and juice were consumed more than once per week by 30.6% and 39%, respectively. Energy drinks and sports drinks were consumed never/less than once per week by 97.9% and 93.5%, respectively. Children from WOS consumed significantly more flavoured milk, flavoured powdered milk,

powdered fruit drink, fruit drink concentrate/cordial, soft drink, and tea than children from non-WOS. A positive relationship was found between consumption of all beverages and home availability, with an increased likelihood of consuming beverages 5+ times per week if they were usually available at home. Soft drink consumption had a significant positive relationship with body fat percentage.

Conclusions: Water consumption was adequate but an unfavourable percentage of children consumed milk never/less than once a week. Parents limiting SSB home availability may contribute to a decreased consumption in children. Limiting soft drink consumption may help children achieve a healthy body fat percentage. (Smirk, Conlon, Beck, Gammon, & von Hurst, 2018).

Chapter 1: Introduction

The high rates of international childhood obesity have plateaued in some settings, but are on the rise worldwide (World Health Organisation, 2016). In New Zealand (NZ) the high childhood obesity rates have been unchanged since 2011/2012 (Ministry of Health, 2017c). Thus, tackling the childhood obesity problem has been made a priority due to the physical and psychological co-morbidities associated with it (Daniels, 2009; Rankin et al., 2016). Sugar sweetened beverage (SSB) consumption has been proposed as a contributor to the childhood obesity problem due to the association between consumption and unhealthy child weight gain identified in many studies. However, there is a lack of high quality studies investigating this relationship, with two recent high quality meta-analyses identifying discrepant results in this relationship (Keller & Della Torre, 2015).

Understanding beverage consumption in children under 11 years old is important as longitudinal research has identified that persistent obesity is established before this age (Wardle, Brodersen, Cole, Jarvis, & Boniface, 2006). At the same body mass index (BMI), girls tend to have a higher body fat percentage (BF%) than boys (Staiano & Katzmarzyk, 2012). An association between BF% and SSB consumption in children of different genders has not been investigated in NZ. It would be beneficial to understand this association as SSB consumption has been proposed to be positively associated with BF%, and BMI does not measure BF% (Keller & Della Torre, 2015).

The most recent Children's National Nutrition Survey (n=3275) identified that sugar-sweetened beverages (SSB) were the primary contributor of sugar to children's diet, but this survey was published over 15 years ago (Ministry of Health, 2003). The latest NZ beverage survey (n=454) in the 8 to 12 year old age group identified that a variety of SSBs were consumed more than once per week by a large proportion of the children (National Research Bureau Ltd, 2008). More recent surveys have provided an update on soft drink consumption, but not the consumption of other beverages (Ministry of Health, 2017a). This leaves a knowledge gap for total beverage consumption data in the 8 to 12 year old age group.

There are several factors which influence SSB consumption including availability, particularly availability in the home environment. Home availability has been

associated with higher SSB consumption in international research on children of both a high and low socioeconomic status (Bere, Glomnes, Velde, & Klepp, 2008; Bogart et al., 2017; Ezendam, Evans, Stigler, Brug, & Oenema, 2010; Heredia, Ranjit, Warren, & Evans, 2016; Santiago-Torres, Adams, Carrel, LaRowe, & Schoeller, 2014; Zahid, Davey, & Reicks, 2017). This association has also been found in studies of NZ adolescents (Sundborn, Utter, Teevale, Metcalf, & Jackson, 2014; Utter et al., 2008). A NZ study in the 8 to 12 year old age group reported the frequency of beverage home availability, but it did not investigate the association between home availability and consumption (National Research Bureau Ltd, 2008).

Parental encouragement to consume healthy foods is associated with increased diet quality and positive dietary outcomes (Faught, Ploeg, Chu, Storey, & Veugelers, 2016; Van Lippevelde et al., 2013). Thus, parental encouragement to consume healthy beverages is a potential way in which parents have the potential to decrease their child's SSB consumption. Encouragement to consume healthy beverages may yield similar results, however to the best of our knowledge this has not been investigated in the wider evidence.

Schools have been recommended as a focal point for childhood obesity prevention initiatives by the American Institute of Medicine (Institute of Medicine, 2012). Approximately 10% of NZ schools have applied a water-only policy in an attempt to decrease SSB consumption and create a less obesogenic environment (Mansoor, Ali, & Richards, 2017; Ministry of Health, 2017b). A decrease in dental caries incidence has been observed in NZ children attending water-only schools (Thornley et al., 2017), but there is no research looking at the impact of this NZ policy on beverage consumption. Three overseas studies investigating the outcomes of similar policies found that water consumption increased, but they did not decrease SSB consumption (Laurence, Peterken, & Burns, 2007; Muckelbauer et al., 2009; Siega-Riz et al., 2011). It is unknown whether the NZ water-only school policy would show a similar effect on SSB consumption.

The NZ childhood obesity rates are disproportionately higher in Māori, Pacifica, and low socioeconomic children (Ministry of Health, 2017a, 2017c). In NZ the children living in the most deprived areas have the highest rates of obesity, and are exposed to a highly obesogenic environment (Mackay, Swinburn, Vandevijvere, & DSouza,

2018; Ministry of Health, 2017c). The most deprived areas have a higher density of fast food/takeaway and convenience outlets compared to the least deprived areas (Mackay et al., 2018). There is little evidence of child beverage consumption patterns in the NZ community.

Knowledge has the potential to influence children's beverage choices. Nutritional knowledge and SSB consumption have not been investigated in the 8 to 12 year old age group. However, research on eating behaviours, or beverage consumption in other age groups, indicate there may be a positive association. A relationship between nutritional knowledge and healthier eating behaviours has been identified in children aged 4 to 16 years old (Grosso et al., 2013). School education sessions for adolescents aged 12 to 14 years have shown to result in a lower SSB consumption (Singh, Paw, Brug, & van Mechelen, 2009).

1.1 Purpose of the study

A large proportion of NZ children are overweight and obese, which puts them at risk of physical and psychological co-morbidities (Daniels, 2009; Rankin et al., 2016). SSB consumption is proposed to have a positive relationship with childhood obesity (Keller & Della Torre, 2015), thus, it is imperative that SSB consumption and factors which may influence it in NZ are well understood to inform effective, evidence-based obesity prevention policies.

Information on SSB intake in NZ is outdated so there is a need for more information on all beverages. International research has identified a variety of factors which could influence child beverage consumption, such as home availability, parental encouragement, school policies, knowledge, and socioeconomic status (Bere et al., 2008; Bogart et al., 2017; Ezendam et al., 2010; Faught et al., 2016; Grosso et al., 2013; Heredia et al., 2016; Laurence et al., 2007; Mackay et al., 2018; Mazarello Paes et al., 2015; Ministry of Health, 2017c; Muckelbauer et al., 2009; Santiago-Torres et al., 2014; Siega-Riz et al., 2011; Singh et al., 2009; Sundborn et al., 2014; Utter et al., 2008; Van Lippevelde et al., 2013; Zahid et al., 2017). However, NZ is lacking recent research on these factors in the 8 to 12 year old age group. This research could provide a base of evidence to further investigate effective child obesity prevention policies, which could complement or build on NZ's childhood obesity plan.

1.2 Aims and objectives

Aim:

To investigate beverage consumption in 8 to 12 year old Auckland primary school children.

Objectives:

1. To determine the total beverage consumption and type of beverages consumed.
2. To determine whether there is a relationship between sugar-sweetened beverage consumption and body fat percentage.
3. To determine whether there are demographic differences in sugar-sweetened beverage consumption.
4. To determine whether there is a relationship between home availability of sugar-sweetened beverages and consumption of sugar-sweetened beverages.
5. To examine beverage consumption outside of the home and school environments.
6. To investigate differences in sugar-sweetened beverage consumption between water-only and non-water-only schools.
7. To determine whether there is a relationship between knowledge, attitudes, and consumption of sugar-sweetened beverages.

1.3 Structure of thesis

This thesis consists of four chapters, as well as a reference list and appendices. Chapter 1 provides justification for the research by introducing the study and outlining the aims and objectives. Chapter 2 is a review of the current literature on childhood obesity, beverage consumption, and a range of factors which could affect SSB consumption in children. Chapter 3 presents the research study as a manuscript intended for publication in the *Nutrients* journal (see appendix G for journal requirements). Chapter 4 concludes the thesis by presenting the main findings of the present study, strengths, limitations, and recommendations for further research. Chapter 4 is followed by the references, and appendices.

1.4 Contribution of researchers

This MSc project utilises data collected as part of the Children's Bone Study (which also validated the qualitative ultrasound and bioelectrical impedance analysis for measuring body composition and bone density, and investigated risk factors for type 2 diabetes, hypertension, and bone health), completed in Auckland, NZ. The candidate played a significant role in all aspects of data collection, data cleaning, and interpretation pertaining to the beverage consumption of children within the study. A detailed breakdown of all contributions by the candidate and other researchers is available below:

Researcher	**Contribution to research**
Emma Smirk (MSc Nutrition and Dietetics student)	Author of thesis, data collection, statistical analysis.
A/Prof Pamela von Hurst (Primary supervisor)	Primary investigator. Responsible for the study concept and design, development of questionnaires, SOP's, data collection, acquisition of funding, obtaining ethical approval, advised on statistical analysis, approval of final thesis.
Dr Cathryn Conlon (Co-supervisor)	Co-investigator, data collection, approval of final thesis.
Dr Kathryn Beck	Co-investigator, data collection
Dr Cheryl Gammon	Co-investigator, data collection
Owen Mugridge	Research manager, development of standard operating procedures, training of data collection team, study administration, data collection
Maya Carryer	Teaching consultant
David Alsford, Maya Carryer, Mia David, Maryam Delshad, Jasmine Foote, Dr Cheryl Gammon, Donna Lawgun, Tara Lemmon, Sanaz	Research assistants

Naghizadeh, Emma Ternouth, Alex Tava, PC Tong

Chapter 2: Literature review

2.1 Childhood obesity

Obesity is one of the most pressing and challenging problems negatively affecting the health of children worldwide (World Health Organisation, 2016). In New Zealand (NZ) 12% of children are obese, with a disproportionately high prevalence in Māori (18%), Pacifica (29%), and children living in the most deprived areas (Ministry of Health, 2017c). Childhood overweight and/or obesity is associated with negative health consequences such as type 2 diabetes, dyslipidaemia, sleep apnoea, and asthma (Daniels, 2009). It is also associated with psychological comorbidities such as low self-esteem, depression, and lower quality of life, which could be due to bullying and/or a negative stigma around obesity (Rankin et al., 2016).

Obese children are more likely to become obese adults, which in turn is associated with the development of several comorbidities such as cardiovascular disease, type 2 diabetes, and some cancers (Guh et al., 2009; Simmonds, Llewellyn, Owen, & Woolacott, 2016; Vucenik & Stains, 2012). Therefore, there is an increased risk of co-morbidities in children who become obese adults (Llewellyn, Simmonds, Owen, & Woolacott, 2016). Furthermore, obesity has a negative economic impact on the nation due to the increased health care and decreased productivity costs (Lal, Moodie, Ashton, Siahpush, & Swinburn, 2012).

Excessive body weight is the result of a combination of genetic and environmental factors (Silventoinen, Rokholm, Kaprio, & Sorensen, 2010). An obesogenic environment is described as an environment which consistently exposes children to situations or surroundings that may contribute to abnormal weight gain (Gauthier & Krajicek, 2013). NZ has an obesogenic environment due to the promotion of high-energy, nutrient poor food. The driving factor of this food is its taste, affordability and accessibility (Ministry of Health, 2012a).

A systematic review and meta-analysis identified that the majority of reviews on children and adolescents found a direct association between sugar-sweetened beverage (SSB) consumption and weight gain, overweight, or obesity, but there was discrepancy in the highest quality studies (Keller & Della Torre, 2015). The association

between SSB consumption and weight gain is partly due to the low satiety effects of SSBs which result in compensation at following meals (Malik, Schulze, & Hu, 2006), and/or the high glycaemic load of SSBs (Brand-Miller, Holt, Pawlak, & McMillan, 2002; Ludwig, 2000).

This literature review will explore childhood obesity, SSB consumption in NZ children, and interventions to decrease children's SSB consumption. It will begin by investigating the current childhood obesity and SSB consumption situation in NZ. This will be followed by evidence on factors which may influence childhood beverage consumption in a variety of environments. A comprehensive search strategy was undertaken using individual or a combination of key words which are relevant to this area of study, including: sugar sweetened, soft drink, fizzy drink, soda, energy drink, sports drink, carbonated, juice, primary school, child, school, obesity, overweight, body mass, BMI, fat, adiposity, weight, home, parent, role model, encourage, available, location, knowledge. These key words were searched in relevant article databases such as Web of Science, PubMed, and Google Scholar. Furthermore, articles were sourced from government websites, and reference lists of articles. Only full-text English journal articles which were published up to August 2018 were reviewed.

2.1.1 Measuring childhood obesity

Body mass index (BMI) is a commonly used indicator of overweight or obesity in adults and is calculated by dividing weight in kilograms (kgs) by height in squared metres (World Health Organisation, 2016). Obesity is the accumulation of excess body fat and is defined in adults (>18 years) as having a BMI greater than 30kg/m^2, or overweight if they have a BMI greater than 25kg/m^2 (Rolland-Cachera, 2011). When using BMI to define childhood obesity there are several different parameters or cut off points used by different organisations. The WHO (World Health Organisation) uses age-adjusted centiles to define overweight and obesity, and states that a child is obese if their BMI-for-age is two standard deviations greater than the median of the WHO growth reference, or overweight if they are one standard deviation greater (World Health Organisation, 2016). The International Obesity Task Force (IOTF) also categorises overweight and obesity in children, but uses different sex-specific cut off points to the adult cut off points (Cole & Lobstein, 2012).

BMI is often used in research as it is an inexpensive and easy way to study body mass (Stevens, McClain, & Truesdale, 2008; Stommel & Schoenborn, 2009). However, BMI calculates body mass rather than adiposity so it has been shown as a good measure in relatively fat children, but not in relatively thin children (Freedman & Sherry, 2009).

Differences in fat free mass are prominent in children of different ethnicities. When comparing European girls at the same BMI to South Asian and East Asian girls it was found that the South and East Asian girls had a higher body fat percentage (BF%), and the same was found for South Asian boys (Duncan, Duncan, & Schofield, 2009; Hudda et al., 2017). Indian children and adolescents have also shown to have a higher BF% at the same BMI compared to European children (Pandit, Chiplonkar, Khadilkar, Khadilkar, & Ekbote, 2009). The opposite was found for Pacifica and Māori girls who had a lower BF% at the same BMI compared to European girls (Duncan et al., 2009; Rush, Puniani, Valencia, Davies, & Plank, 2003). Yet the BMI of Pacifica children tends to be higher than the BMI of European children (Rush, Scragg, Schaaf, Juranovich, & Plank, 2009). There are also gender differences in BF%. At the same BMI girls tend to have a greater BF% than boys (Daniels, Khoury, & Morrison, 1997).

BF% is a more accurate measure of adiposity and provides an effective way to study ethnic differences. There are several methods to measure BF% such as dual-energy X-ray absorptiometry (DXA), bioelectrical impedance analysis (BIA), and air displacement plethysmography (ADP) (Zanini Rde, Santos, Chrestani, & Gigante, 2015). A DXA machine measures fat vs fat-free mass (Fields & Goran, 2000). However, due to the expensive initial purchasing costs of the DXA machine, it is not commonly owned (Fields & Goran, 2000). BF% measurements using BIA measurements are more common due to the ease of mobility and lower purchasing price of the machine (Zanini Rde et al., 2015).

BIA is a useful tool to measure adiposity in children as it is non-invasive. However, a recent systematic review has shown that BIA underestimated fat mass in both male and female children and adolescents, but had almost perfect reproducibility (Chula de Castro, Lima, & Silva, 2018). It is important that methods to measure BF% are validated in the population group of interest. DXA is often viewed as the ‘gold standard’ of body composition analysis and in a recent study (currently under review for publication) a strong correlation (r = 0.88, p = 0.001) between BF% on the BIA and

DXA was identified in 8 to 12 year old school children (n=127) in NZ (Delshad, Beck K.L., Conlon, Kruger, & von Hurst, 2018). Thus BIA may be a non-invasive, cost effective way of effectively measuring body composition in children.

2.1.2 Childhood obesity plan

Addressing obesity requires various interventions due to its multi-factorial nature (Gortmaker et al., 2011; Shackleton et al., 2016; Swinburn et al., 2011). NZ's Ministry of Health attempted a multi-factorial approach to tackle childhood obesity by introducing a 'childhood obesity plan' in October 2015. The plan consists of 22 initiatives and targets people under the age of 18 (Ministry of Health, 2017b). Several of this plan's initiatives include a 'health star rating' voluntary nutrition labelling system, new advertising codes on advertisements targeted towards children, partnering with the food industry to reformulate healthier products, and removal of SSBs from all NZ District Health Board hospitals and campus' (Advertising Standards Authority; Ministry of Health, 2017b, 2018).

One of the 'childhood obesity plan' initiatives involves encouraging schools to become 'health promoting schools'. This initiative was designed by the WHO and was adopted by NZ in 1991 (Ministry of Health, 2012b). It is a school-tailored intervention which aims to create an environment within the school that promotes healthy lifestyles (Langford et al., 2014). A common policy in 'health promoting schools' is to become a water-only school (refer to section 2.4.2.1 for more information) and a toolkit was developed to help facilitate the implementation of this (MidCentral District Health Board, 2016).

2.2 Nutritional intake in New Zealand children

2.2.1 Sources of food and beverage intake information in New Zealand

To inform evidence-based, effective public health policies that target the child obesity problem it is important to have a good understanding of NZ children's dietary intake. Some concerns in NZ children's diets, which have been identified in previous research, are a low intake of fruit and vegetables (section 2.2.2), and a high intake of high energy takeaways (section 2.2.3), sugar (section 2.2.4), and SSBs (section 2.3.2) (Ministry of Health, 2012a).

Several surveys completed on food and beverage consumption have collected information on NZ children's intake. The Children's National Nutrition Survey (2002) (n=3275, 5-14 years) was the last national nutrition survey to investigate the nutritional status of NZ children. Dietary data was collected through a 24 hour diet recall (Ministry of Health, 2003). More recently, in 2008/09, 'A National Survey of Children and Young People's Physical Activity and Dietary Behaviours in New Zealand' (n=2503, 5-24 years) was completed using a dietary habits questionnaire (Clinical Trials Research Unit, 2010). Several studies have looked at beverage consumption in NZ children, as summarised in table 2.1.

2.2.2 Fruit & vegetable intake

Fruit and vegetables are high in vitamins, minerals, and fibre, thus children are recommended to consume at least 3 servings of vegetables and 2 servings of fruit per day (Ministry of Health, 2012a). It was found in the NZ Health Survey 2016/2017 Annual Update that 44.6% of the 5 to 9 year old age group, and 51.3% of the 10 to 14 year old age group, met their fruit and vegetable guidelines or just vegetable guidelines (Ministry of Health, 2017a). The proportion of children meeting their fruit guidelines was higher at 74% for the 5 to 9 year old age group, and 66.1% for the 10 to 14 year old age group (Ministry of Health, 2017a).

2.2.3 High energy takeaways intake

Fast foods generally contain high concentrations of fat, sugar, and salt, which makes them energy dense and nutrient poor. High intake of these nutrients are associated with overweight and obesity as well as other health conditions (Ministry of Health, 2012a). Thus, it is recommended that children should not consume more than one fast food meal per week, and healthier fast food options should be selected whenever possible (Ministry of Health, 2016b). The NZ Health Survey 2016/2017 Annual Update identified that 75% of children aged 5 to 9 years old, and 73.3% of children aged 10 to 14 years old, had consumed takeaway food at least once in the past week (Ministry of Health, 2017a). The proportion of children who had consumed takeaways at least three times in the past week were between 8.4% and 8.5% for the 5 to 14 year old age group (Ministry of Health, 2017a).

Table 2.1. New Zealand studies/surveys on beverage consumption in children or adolescents

Study reference	Study Design	Results	Limitations	Strengths
NZ Health Survey Annual Update (Ministry of Health, 2017a)	n=4668 Aged: 0 to 14 years Data collection method: Face to face interview with parents/primary caregivers Dates data collected: July 2016 to June 2017	5 to 9 year old group consumed in past week ➢ 56.5% consumed fizzy drinks ≥ once ➢ 13.6% consumed fizzy drinks ≥ three times 10 to 14 year old group consumed in past week ➢ 66% consumed fizzy drinks ≥ once ➢ 22.5% consumed fizzy drinks ≥ three times	➢ Different SSBs were grouped together, thus consumption of one type of beverage is unknown. 'Fizzy drink' includes soda, diet, and energy drinks. ➢ Looked exclusively at these beverages	➢ Recent research ➢ Random sampling method
Youth'07 Survey (Sundborn et al., 2014)	n=8697 Aged: 13 to 17 years Data collection method: Self report questionnaire Dates data collected: 2007	➢ Intake of carbonated beverages was more than four times (29%), one to three times (45.4%), and no times (25.6%) per week ➢ Higher consumption was associated with being of a higher deprivation level, Pacifica ethnicity, and male ➢ A positive relationship was found between soft drink availability and consumption	➢ Exclusively looked at high school aged children ➢ Exclusively looked at soft drink consumption ➢ Did not differentiate between soft drinks and diet soft drinks	➢ Investigated the association between home availability and parental encouragement and soft drink consumption
NZ Children's Food and Drinks Survey	n=454 (aged 8-12) n=547 (aged 5-16, intake data) n=1133 (parents, home availability data) Aged: 5 to 16 years	8 to 12 year old age group: Consumed ≥once/week ➢ 35% sugar containing carbonated drinks ➢ 36% diet carbonated drinks ➢ 51% fruit juice ➢ 51% cordials / powdered fruit drinks	➢ The study did not investigate energy drink or sports drink consumption	➢ Investigated child consumption of a large range of beverages ➢ Reported beverage home availability

(National Research Bureau Ltd, 2008)	Data collection method: Food frequency questionnaire	➢ 21% flavoured water ➢ 25% flavoured milk Consumed > 5 days per week ➢ 5% sugar containing carbonated drinks ➢ 7% diet carbonated drinks ➢ 27% fruit juice ➢ 29% cordials / powdered fruit drinks ➢ 7% flavoured water ➢ 8% flavoured milk Consumed ≥ once/day ➢ 91% tap water ➢ 28% bottled water		➢ Investigated beverage consumption in the 8 to 12 year old age group
OPIC project (Utter et al., 2008)	n=17150 (25% NZ, 18% Australian, 42% Fijian, 15% Tongan children) Aged: 12 to 18 years Data collection method: Interview & questionnaires	NZ children who consumed beverage 4-5 days in past school week ➢ 30% consumed carbonated beverages ➢ 30 – 35% consumed fruit drinks	➢ Data was not exclusively collected from NZ, it was also collected from Australia, Fiji, and Tonga. ➢ High school aged children	➢ Large sample size
Children's National Nutrition Survey (Ministry of Health, 2003)	n=3275 Aged: 5 to 14 years Data collection method: 24 hour recall	➢ Beverages were the main source of sucrose consumption in children (26%) ➢ Beverages consisted of 11% of the total carbohydrates consumed	➢ Study is over 15 years old	➢ Investigated whole diet composition and nutritional status. ➢ Beverage consumption was investigated in the context of the whole diet

2.2.4 Sugar intake

The WHO guidelines advise that adults and children should limit their free sugar consumption to less than 10% of their total energy intake per day, with further benefits of a reduction to less than 5% of total energy (World Health Organisation, 2015). Aligning with this, it is recommended by the American Heart Association that children should not consume more than six teaspoons of sugar per day (Vos et al., 2017). The NZ Children's National Nutrition Survey (2002) found that children in NZ consume a median daily intake of 26 to 35 teaspoons per day, which is approximately four to six times more than the American Heart Association recommendation (Ministry of Health, 2003). This survey also identified that SSBs are the largest contributor to children's sugar intake, at 26% of total sugar intake (Ministry of Health, 2003).

2.3 Sugar-sweetened beverages

2.3.1 Health effects of sugar-sweetened beverage consumption

A range of SSB definitions are used in different studies (Riordan et al., 2017). However, for the purpose of this literature review SSBs will be defined as beverages which contained added sugar or other caloric sweeteners, including soft drinks, sports drinks, energy drinks, flavoured milks, flavoured water, fruit juice, and powdered or cordial fruit drinks. This excluded plain water, plain milk, diet fizzy drinks, 100% vegetable drinks, and alcoholic beverages (Riordan et al., 2017; Wetter & Hodge, 2016).

Plain water is the best beverage option for children (Clinical Trials Research Unit, 2010). It is preferred over SSBs as it does not contain energy or sugars that could lead to excessive energy consumption and dental issues (Clinical Trials Research Unit, 2010). Plain milk is also a good beverage option due to the protein, calcium, and riboflavin content (Clinical Trials Research Unit, 2010). It is recommended that children consume reduced or low-fat milk daily. This is because milk contains calcium which is important for developing healthy teeth and bones, and acquiring a high peak bone mass in children (Ministry of Health, 2012a). A child between the age 9 and 13 has a daily fluid requirement of 1.4L for females or 1.6L for males, and plain milk and plain water should make up the most of this volume (Ministry of Health, 2012a).

The NZ Ministry of Health recommends that if children consume carbonated drinks, fruit juice, cordials, and sports drinks that their intake is limited due to their high energy density, high sugar content, and poor nutrient content (Ministry of Health, 2012a). Diet/artificially sweetened drinks are also not recommended as their acidity could cause tooth erosion, as well as preserve a child's taste for sweetness (Ministry of Health, 2012a). The NZ Ministry of Health, and the American Academy of Pediatrics have recommended that children do not consume energy drinks due to their high caffeine content (Ministry of Health, 2012a). High caffeine consumption puts children at risk for negative physiological effects and potentially caffeine toxicity (Harris & Munsell, 2015). Due to the caffeine content of tea and coffee they are not recommended for children under the age of 13 (Ministry of Health, 2012a).

SSBs are also not recommended as a substantial amount of research has found an association between SSB consumption and weight gain, overweight, or obesity, although the highest quality articles showed discrepancy in this association (Keller & Della Torre, 2015; Ministry of Health, 2012a). Fruit juice is recommended to be limited as it is high in sugar, however, a meta-analysis showed that consumption was not associated with an increase in BMI z-score in 7 to 18 year old children (Auerbach et al., 2017; Ministry of Health, 2012a).

2.3.2 Intake of sugar-sweetened beverages in New Zealand

There are few studies which describe NZ children's SSB consumption. The details of these surveys are outlined in table 2.1. The last Children's National Nutrition Survey was published in 2003. Three beverage consumption surveys and annual fizzy drink consumption statistics have provided updated beverage consumption statistics (Ministry of Health, 2003, 2016a; National Research Bureau Ltd, 2008; Sundborn et al., 2014; Utter et al., 2008). However, these studies do not provide a comprehensive picture of beverage consumption in NZ primary school aged children as they either study adolescents, limited SSBs, or are outdated. Therefore, updated comprehensive beverage consumption data are required.

2.3.3 Children's ethnic background and sugar-sweetened beverage intake

The NZ Health Survey 2016/2017 Annual Update identified that Pacifica children between the ages of 2 and 14 years old had the highest consumption of fizzy drinks, with 70.9% consuming fizzy drinks at least once in the past week. This rate was

followed by Māori at 69.5%, Asian at 53.1%, and European/Other at 52% (Ministry of Health, 2017a). The proportion of children who consumed fizzy drinks at least three times in the past week was also high, with 26.7% of Pacifica, 23.9% of Māori, 14.1% of Asian, and 12.6% of European/Other consuming this (Ministry of Health, 2017a).

Ethnic differences in fruit juice consumption were also found in the NZ Children's Food and Drinks Survey. Fruit juice was reported to be consumed at least daily by 28% of Asian and European/other children. This was greater than Māori (13%) or Pacific (15%) children. Whereas, 36% of Asian, 31% of European/other, 32% of Māori, and 49% of Pacific consumed fruit juice at least once a week (National Research Bureau Ltd, 2008).

2.4 The role of environmental factors in beverage consumption

2.4.1 Home environment

The home food environment is very complex and there are many factors which could influence childhood SSB consumption (Rosenkranz & Dzewaltowski, 2008). Although children become more independent as they get older, the 10-12 age group has shown to still be influenced by their families (Verloigne, Van Lippevelde, Maes, Brug, & De Bourdeaudhuij, 2012). In particular, parents can play an important role in their children's food consumption behaviours (Faught et al., 2016; Sleddens, Gerards, Thijs, de Vries, & Kremers, 2011; Ventura & Birch, 2008; Verloigne et al., 2012).

There are multiple ways in which parents can support healthy eating behaviours in their children (Pyper, Harrington, & Manson, 2016). A framework was developed to categorise parental supportive behaviours to support physical activity, and this framework has since been adapted to other health promoting activities such as consumption of fruit and vegetables (Beets, Cardinal, & Alderman, 2010; Pyper et al., 2016). These parental supportive behaviour domains consist of 'conditional' which included parental role modelling, 'motivational' which included parental encouragement, and 'instrumental' which included home availability (Beets et al., 2010). Each of these domains will be investigated in this literature review to explore the influence of each domain on beverage consumption in the home environment.

Parent education sessions could be an effective way to decrease SSB consumption in primary school aged children and target all three support domains. In a study

(n=165, 5-9 years, 58% female) parents were educated on techniques to encourage healthy eating behaviours for their children such as portion size, label reading, and goal setting (Burrows, Warren, Baur, & Collins, 2008). This intervention significantly decreased child SSB consumption from 5% of total energy at baseline to 2.9% at 12 months post intervention. However, it is unknown if SSB consumption continued to decrease after the 12 month follow up measurement (Burrows et al., 2008).

2.4.1.1 Parental role modelling of beverage consumption

Parents can be a role model and influence their children's diet. Role modelling can be investigated by measuring parent's consumption of food or beverages (Yee, Lwin, & Ho, 2017). A 2017 systematic review and meta-analysis found a significant positive relationship between healthy food modelling behaviours and healthy food consumption in 28 of 31 studies on this relationship (Yee et al., 2017). This relationship was also found between unhealthy food modelling behaviours and unhealthy food consumption. Therefore, if parents have an unfavourable diet, this may negatively affect their children's diet (Yee et al., 2017). Due to this, the ability to effectively role model for children relies on parental knowledge for healthy food and beverages (Zahid et al., 2017).

A positive relationship has also been shown between dairy intake and parental dairy intake (role modelling) in several longitudinal and cross-sectional studies (Fisher, Mitchell, Smiciklas-Wright, Mannino, & Birch, 2004; Hanson, Neumark-Sztainer, Eisenberg, Story, & Wall, 2005; Zahid et al., 2017). One of these studies (n=194, 9-12 years) looked primarily at white, well-educated parents and showed that parental role modelling could play an important part in improving beverage choices in this population group (Zahid et al., 2017).

It is unknown whether parent's consumption of SSB influences their children's intake in NZ, but it is known that NZ adults consume SSBs and their consumption is often associated with unhealthy eating behaviours. SSB consumption was also associated with a decreased likelihood of consciously attempting to eat healthily (Robertson, Thyne, & Green, 2018).

2.4.1.2 Parental encouragement of healthy beverage consumption

Parental encouragement is verbal or non-verbal prompts by parents towards a child's behaviour, and affirmations of the behaviour (Beets et al., 2010). There is limited research on parental encouragement and the association with children's diet quality, with only two cross-sectional studies investigating this association. No studies investigated the relationship between parental encouragement and beverage consumption, although the association may be similar to parental encouragement and diet quality. A large cross-sectional study (n=8388, 10-11 years) identified that parental encouragement of healthy foods is associated with increased diet quality and decreased likelihood of being overweight in their children (Faught et al., 2016). Another cross-sectional study (n=6374, 10-12 years, 53.2% girls) identified the association between healthy foods and positive dietary outcomes, such as breakfast consumption (Van Lippevelde et al., 2013).

The latest parental encouragement dietary data in NZ was in the 2008 OPIC study (Utter et al., 2008). This study asked children how much support for healthy eating their parents provided. Two-thirds of the children said their mother showed a lot of support, and 50% said their fathers showed a lot of support (Utter et al., 2008).

2.4.1.3 Home availability of sugar-sweetened beverages

SSBs are unable to be consumed if they are not available to a child (Rosenkranz & Dzewaltowski, 2008). Therefore, it is important to limit SSB home availability and ensure that there are healthy beverages, such as plain water and plain milk, available at home. Several cross-sectional and cluster randomised trials have shown an association between home availability and SSB consumption (Bere et al., 2008; Bogart et al., 2017; Ezendam et al., 2010; Heredia et al., 2016). Two cross-sectional studies have identified this association in a range of population groups including a primarily white, well-educated population (n=194, 9-12 years), and minority groups (n=187, 10-14 years) (Santiago-Torres et al., 2014; Zahid et al., 2017).

Most of the evidence on home availability is observational, however, one randomised controlled trial (n=224, 15.2±0.7 years) on decreasing SSB home availability found a significant decrease in SSB consumption in overweight or obese adolescents compared to the control group (Ebbeling et al., 2012). The adolescents in the intervention group were delivered bottled water or diet drinks to their home every

fortnight for 1 year to displace all SSBs they were previously consuming. The parents also received monthly phone calls as motivation, reminders to continue with the intervention, and check in sessions with the children. The control group received no intervention. After this year SSB consumption had significantly decreased to almost zero, as well as a significant decrease in BMI, sugar intake, and energy intake. At the 2 year follow up, despite no active intervention, the experimental group consumed SSB less than the control group, but BMI was no longer significantly different between the two groups (Ebbeling et al., 2012). This is not a feasible public health intervention, but shows that home-based interventions with increased feasibility may be effective at reducing SSB consumption in children.

The only NZ research on the association between home availability and beverage consumption is in adolescents. Availability of SSBs in the home has been identified as a risk factor for higher SSB consumption by multiple studies involving NZ high school aged children (Sundborn et al., 2014; Utter et al., 2008). A cross-sectional NZ study (n=8697, 13-17 years) found that those who were in the high consumption of soft drink group were mostly those who said soft drinks were ‘usually’ available in the home (58%), compared to those who said they were ‘never’ available (15.1%) (Sundborn et al., 2014). It was proposed that if the home availability of soft drinks was reduced, alongside minimising availability at schools, then it could significantly decrease consumption. For this reason it was recommended that a high priority public health goal should be to have soft drinks removed from the home (Sundborn et al., 2014).

The association between SSB home availability and consumption has not been investigated in younger children in NZ. However, the NZ Children’s Food and Drinks Survey (2008) reported home availability statistics. Home availability at least 5 days per week was 8% for sugar-containing carbonated beverages, 6% diet carbonated beverages, 28% fruit juice, 24% cordials/powdered fruit drinks, 6% flavoured water, and 3% for flavoured milk in the 8 to 12 year old age group (National Research Bureau Ltd, 2008).

For parents to limit availability of SSBs they need to understand the negative impacts of SSB consumption on children, such as their association with obesity (Bogart et al., 2017). Involving or focussing the intervention on the parents is a good way to increase

intervention effectiveness (Bere et al., 2008; Mazarello Paes et al., 2015; van de Gaar, van Grieken, Jansen, & Raat, 2017).

2.4.2 School environment

Children consume approximately a third of their nutrient intake at school (Regan, Parnell, Gray, & Wilson, 2008), thus it has the potential to effectively influence children to consume healthy beverages. A systematic review and meta-analysis on childhood obesity prevention programmes identified that school based interventions, which aimed to improve diet, had a moderate strength of evidence to support their effectiveness (Wang et al., 2015). This systematic review supports the current recommendation by the American Institute of Medicine that schools should be a focal point for childhood obesity prevention initiatives (Institute of Medicine, 2012; Wang et al., 2015). A systematic review and meta-analysis on interventions to decrease SSB and/or increase water intake found that school interventions significantly decreased children's SSB consumption by a mean of 28mL/day^{-1} (Vargas-Garcia et al., 2017).

Nutrition education is a common intervention in obesity prevention and decreasing SSB consumption (Vargas-Garcia et al., 2017). The school curriculum has been shown to have sufficient evidence for creating behaviour change in school children, which can have a cost-effective impact on obesity (Dobbs et al., 2014). A systematic review found that interactive activities as part of the curriculum was an effective way to target SSB consumption (Tipton, 2016). These activities included case studies, creating goals, drawing, experiments, writing songs, quizzes, games, theatre sketches, puppet shows, and song competitions (Contento, Koch, Lee, Sauberli, & Calabrese-Barton, 2007; Cunha, de Souza, Pereira, & Sichieri, 2013; James, Thomas, Cavan, & Kerr, 2004; Sichieri, Trotte, de Souza, & Veiga, 2009).

School SSB based activities and education sessions have shown to decrease overweight, obesity, or BMI in multiple studies (James et al., 2004; Sichieri et al., 2009; Singh et al., 2009). One study (n=644, 7-11 years) encouraged children to adopt a healthy diet and replace SSB consumption with water in four hours of school sessions. After 12 months the intervention group had a 7.7% lower rate of overweight and obesity compared to the control group (James et al., 2004). A different study (n=1140, 9-12 years) encouraged students to replace SSB with water, which decreased soda consumption by 66mL in the intervention group compared to the control. There was

also a decrease of BMI in girls who were overweight at baseline (Sichieri et al., 2009). A third study (n=1108, 12-14 years) involved 11 education sessions on energy balance, including SSB consumption. These sessions resulted in significantly lower SSB consumption in the intervention group compared to the control immediately post intervention, at 8 months, and at 12 months after baseline measurements. However, after 20 months the significant difference in consumption had not been maintained (Singh et al., 2009; Veitch et al., 2011).

The school curriculum provides a convenient place for maintenance and follow up interventions. A systematic review identified that maintenance sessions are important for long-term decreases in SSB consumption (Avery, Bostock, & McCullough, 2015). Longer duration interventions, with multiple sessions, have been theorised to have greater effects on behaviour than shorter interventions. This is because the participants have an increased opportunity to learn and reflect on the desired behaviour (Stice, Shaw, & Marti, 2006).

2.4.2.1 Water-only schools

Complementing a school SSB education programme with environmental change can increase the effectiveness of the intervention (Avery et al., 2015). Restricting SSB consumption or changing access to SSBs in schools has been shown to significantly decrease SSB intake (Levy, Friend, & Wang, 2011; Tipton, 2016). The water-only school policy is encouraged by the NZ Ministry of Health as a way to create a healthy school environment where water and plain milk are the only beverages allowed to be sold at school (Ministry of Health, 2016c). This policy aligns with the American Institute of Medicine recommendation that all SSB should be banned from schools, with the exception of limited servings of 100% fruit juice (Institute of Medicine, 2007, 2012).

Ten percent of NZ schools are water-only, according to the Ministry of Education (2016) (Mansoor et al., 2017). Although this proportion may be higher in different regions of NZ. For example a survey done in the Wellington region found that 28% of primary schools had a water-only policy, with a further 15% not having a policy but described themselves as water-only (Mansoor et al., 2017). According to a NZ food environments assessment, 42% of NZ schools sell SSB, with most deprived schools selling less SSB (34%) than least deprived schools (44%) (Mackay et al., 2018).

Therefore, some schools in NZ may not be part of the water-only schools programme but have their own similar policy.

The impact of the NZ water-only school policy on SSB consumption has not been investigated, however, there is evidence of the dental benefits. A low socioeconomic NZ primary school implemented the water-only policy, as well as, encouraged and modelled healthy eating, and provided the children with free water bottles (Thornley et al., 2017). After implementation of the policy, the children in this school showed lower rates of dental caries and tooth extractions when compared to nine other low socioeconomic schools in the same area. The effects of this policy are not only beneficial for children's health but also for the economy as NZ spends an estimated $20 million on children's dental extractions annually (Thornley et al., 2017).

The limited international studies which have implemented policies similar to NZ's water-only schools policy identified that water consumption increased, but SSB consumption did not decrease (Laurence et al., 2007; Muckelbauer et al., 2009; Siega-Riz et al., 2011). A five semester American intervention study (n=3908, 10-14 years) removed all beverages, excluding water and low fat milk, from the school. The intervention also involved nutrition education during class and parental newsletters, cafeteria educational events, and taste testing new foods. The study did not show significant changes in SSB consumption, but the intervention group showed a 54mL increase in water consumption (Siega-Riz et al., 2011). In another study the school installed chilled water fountains, the children were encouraged to refill their free drink bottle, and had four sets of 45 minute educational lessons on the importance of water in the body (Muckelbauer et al., 2009). This intervention found that water consumption was 1.1 daily glasses of water greater in the intervention group compared to the control group (Muckelbauer et al., 2009). It was found that providing water bottles to the children was an incentive for the children to drink more water (Muckelbauer et al., 2009).

2.4.2.2 New Zealand school food programmes

In NZ there are several non-government school programmes which provide food and beverages to children in hundreds of schools, which are primarily low decile (Children's Commissioner, 2013). An example of this is the 'Fonterra milk for schools' programme which provides free refrigerators and daily milk to 70% of NZ primary schools

(Children's Commissioner, 2013; Fonterra, 2018). An evaluation of the 'Fonterra milk for schools' programme (n=511, 7-9 years) showed that the proportion of children meeting the NZ guidelines for milk and milk products significantly increased from prior to starting the programme (72%) to two years follow up (94%) (Marsh, Jiang, Carter, & Wall, 2018). Other programmes include 'KidsCan', 'KickStart', 'Garden to table', and 'Feed the need' which are run in NZ and provide children, particularly in low decile schools, with food for lunch (Children's Commissioner, 2013; Feed the Need, 2018).

2.4.3 Community environment

The type of foods featured in food outlets and advertising are two factors which could influence beverage choices. A cross-sectional study (n=483) has identified that fast food restaurant combination meals are a risk factor for higher SSB consumption and targeting these restaurants may help prevent childhood obesity (Cantor, Breck, & Elbel, 2016). A large proportion of NZ children are consuming takeaway food at least once a week (refer to section 2.2.3), however, it is unknown whether they consumed a SSB with that meal (Ministry of Health, 2017a).

A review of NZ food environments was completed on articles published from 2014 to 2017 (Mackay et al., 2018). It was found that a disproportionately obesogenic environment existed in the most deprived areas compared to the least deprived areas. In the most deprived areas there was increased fast food/takeaway accessibility per 10,000 people, with 13.7 places compared to the least deprived areas with 3.7 places. This disproportionate accessibility was also found with convenience stores. The most deprived schools had more of these outlets within 500m of the school than the least deprived schools (Mackay et al., 2018).

Advertisements for unhealthy foods were more prevalent outside schools in the most deprived areas (10 per km^2), compared to the least deprived areas (8.3 per km^2). These adverts were also found on TV, with an average of 8 adverts per hour for unhealthy foods played during children's peak viewing time (Mackay et al., 2018).

This research provides a good indication of risk factors for increased child SSB consumption in this environment. However, to the best of our knowledge there has been no NZ based research on beverage consumption in the community, when they are consumed, who they are consumed with, and the reason for selecting a beverage.

2.4.4 Children's level of deprivation

Children at the most socioeconomically deprived level had a higher consumption of fizzy drinks than those at the least socioeconomically deprived level, according to the NZ Health Survey 2016/2017 Annual Update (Ministry of Health, 2017a). At the most deprived level (quintile 5 of 5) 68.5% of the children had consumed fizzy drinks at least once in the past week, compared to 52.9% of children at the least deprived level (quintile 1) (Ministry of Health, 2017a). Whereas, 14% of children at the most deprived level consumed fizzy drinks at least three times in the past week, and compared to 26.1% at the least deprived level (Ministry of Health, 2017a).

2.5 Children's nutritional knowledge and sugar-sweetened beverage consumption

Knowledge is defined as having information, facts, or skills which are yielded through education or experience (Trevethan, 2017). There is limited evidence on the association between healthy diet knowledge and SSB consumption in children over the age of six. A systematic review on young children (0 to 6 years) found that there is equivocal evidence on whether knowledge decreases SSB consumption, with three intervention studies finding a significantly lowered effect, and 3 finding no significant difference (Mazarello Paes et al., 2015).

Several studies have shown associations between nutritional knowledge and healthier eating behaviour in children. An Italian cross-sectional survey (n=445, 4-16 years) on children and adolescents showed that nutrition knowledge had a negative association with consumption of sugary drinks, fried food, snacking, and sweets, and had a positive association with healthy dietary habits such as consuming fruit, vegetable, fish, and pasta/rice intake (Grosso et al., 2013). Another cross-sectional survey in Iceland on 11 year old children (n=1235) showed that knowledge of the recommendations around fruit and vegetables was positively associated with increased consumption (Kristjansdottir et al., 2006).

In adults a relationship between knowledge of recommended daily calorie intake and SSB intake was identified in a cross-sectional study (Gase, Robles, Barragan, & Kuo, 2014). But another study on U.S. adults (n=3929) showed that there was no

association between knowledge of the sugar content of sports drinks and consumption (Zytnick, Park, Onufrak, Kingsley, & Sherry, 2015).

2.6 Summary

Childhood obesity is a large problem in NZ and excessive SSB consumption has been identified as a contributor to this problem. Most studies show that SSB consumption contributes to the childhood obesity problem, however, there is a lack of high-quality studies with lengthy follow up periods on the association. BF% is an effective way to study adiposity, and this measure accounts for ethnic body fat differences. NZ does not have up to date research on total beverage consumption and types of beverages that primary school aged children are consuming. Therefore, it is unknown whether beverage consumption has changed since the last comprehensive beverage consumption survey published in 2008.

There is evidence to show that multi-setting interventions are important to tackle the childhood obesity problem. Therefore, this literature review focussed on the different environments and factors which could play a role in children's SSB consumption. The home environment has been proposed to impact children's SSB consumption through parental role modelling, parental encouragement, and home availability of beverages. International research in children and NZ research in adolescents has indicated that these factors have a role in SSB consumption. As mentioned previously, children gain independence as they grow older, so the effectiveness of parental role modelling and parental encouragement could be dampened in adolescents. Integrating these techniques in interventions aimed at children of a younger age could be a key aspect in changing their behaviour, however, no research has investigated this association in younger NZ children.

Many schools in NZ are water-only schools, yet there has been no research on the association between this policy and SSB consumption in NZ. International evidence on similar policies have found an increase in water consumption, but no decrease in SSB consumption. It is also important to consider the community environment as a large proportion of NZ children consume food and drink from fast food outlets at least once per week.

Nutritional knowledge has been shown to have an association with sugary drink consumption in one relatively small observation study, thus, more research is required. Limited studies have shown an association between nutritional knowledge and healthy eating behaviours. To create interventions which target the most pressing public health issues and utilise the most effective avenues of improving NZ children's health, it is important to understand beverage consumption in this population.

Chapter 3: Manuscript

Beverage consumption in Auckland primary school children

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3.1 Abstract

Abstract: Sugar sweetened beverage (SSB) intake has been associated with childhood weight gain in some studies. It is advised that children consume plain water and plain low-fat milk daily, and that if SSB are consumed that they should be limited. The latest comprehensive New Zealand (NZ) beverage intake data in 8 to 12 year old children was published in 2008. International evidence has identified home availability, parental encouragement, socioeconomic status, and knowledge in children as factors associated with SSB intake. This cross-sectional study investigated beverage consumption in 8 to 12 year old Auckland primary school children. Beverage intake and associated factors were investigated using self-administered questionnaires. Body composition was measured using bioelectrical impedance analysis (BIA). Children (n=695, 9.9±0.7 years, 44.8% male) were recruited from 6 schools. Plain water and plain milk were consumed less than daily by 11.6% and 54.7% of the children, respectively. Soft drink and fruit juice were consumed weekly by 30.6% and 39% of the children, respectively. SSB consumption (p<0.001) had a positive association with body fat percentage (BF%) in girls. Beverage intake was positively associated with home availability (p<0.001). Receiving a lot of encouragement for healthy beverages from parents or school was inversely associated with SBB intake (p<0.001). These results identified that children may benefit from increasing their plain water and milk intake and decreasing their SSB intake. If parents limited SSB home availability and encouraged intake of healthy beverages it may contribute to a decrease in their children's SSB consumption.

Keywords: Children, obesity, sugar sweetened beverages, beverages, New Zealand, home, school

3.2 Introduction

Childhood obesity is a serious and urgent public health issue globally and nationally (Ministry of Health, 2017c; World Health Organisation, 2016). A large proportion of NZ children are overweight (21%) or obese (12%), and these rates have not changed significantly since 2011/2012 (Ministry of Health, 2017a, 2017c). This prevalence is disproportionately higher in Māori and Pacifica children, as well as those in low socioeconomic areas (Ministry of Health, 2017c).

Tackling the child obesity problem is a priority due to the many co-morbidities associated with it (Daniels, 2009; World Health Organisation, 2016). While most studies show an association between SSB consumption and weight gain, overweight, or obesity, there is a lack of high quality studies and reviews investigating this association (Keller & Della Torre, 2015). These studies commonly investigate girls and boys collectively, however, at the same body mass index (BMI) girls tend to have a higher body fat percentage (BF%) than male children (Daniels et al., 1997).

The NZ Ministry of Health recommends that children consume plain water and plain low-fat milk daily, and if SSBs are consumed that they are limited (Ministry of Health, 2012). The NZ Health Survey Annual Update (2017) publishes annual child fizzy drink intake data (Ministry of Health, 2017a). However, the latest comprehensive data (n=454) on children's intake of a range of beverages in the 8 and 12 year old age group was published in 2008 (National Research Bureau Ltd, 2008). Thus, a complete up to date picture of beverage consumption in NZ children is unknown.

Three main environments which could influence children's beverage consumption are the home, school, and community. Within these environments there are a number of factors which could potentially influence beverage intake, including home availability, parental encouragement, school policies, knowledge, and socioeconomic status (Bere et al., 2008; Bogart et al., 2017; Ezendam et al., 2010; Faught et al., 2016; Grosso et al., 2013; Heredia et al., 2016; Laurence et al., 2007; Mackay et al., 2018; Mazarello Paes et al., 2015; Ministry of Health, 2017c; Muckelbauer et al., 2009; Santiago-Torres et al., 2014; Siega-Riz et al., 2011; Singh et al., 2009; Sundborn et al., 2014; Utter et al., 2008; Van Lippevelde et al., 2013; Zahid et al., 2017).

International studies have identified an association between home availability of SSBs and higher intake in children, and NZ research has identified this association in adolescents (Bere et al., 2008; Bogart et al., 2017; Ezendam et al., 2010; Heredia et al., 2016; Sundborn et al., 2014; Utter et al., 2008). Parental encouragement has been associated with increased diet quality and positive dietary outcomes in children, but little is known about the effect of parental encouragement on beverage intake (Faught et al., 2016; Van Lippevelde et al., 2013).

Many schools in NZ have become water-only schools (only water and plain milk are available to be sold) to support healthy beverage consumption (Mansoor et al., 2017). Internationally, studies on similar school policies have identified an increase in water consumption, but not a decrease in SSBs (Laurence et al., 2007; Muckelbauer et al., 2009; Siega-Riz et al., 2011). An association between knowledge and healthy eating has been identified in children (Grosso et al., 2013), but little is known about the impact of knowledge on beverage choices in this age group.

The aim of this study is to investigate beverage consumption in 8 to 12 year old Auckland primary school children. The study will provide some insight into the factors affecting beverage intake, potentially identifying opportunities for interventions to help combat obesity in NZ children.

3.3 Method

3.3.1 Participants and recruitment

This cross-sectional observational study was a secondary outcome of the 'Children's bone study'. Schools in the Auckland region were approached to participate in this study and children aged 8 to 12 years from the schools involved were invited to take part. The inclusion criteria was year five and six children who gave consent in the participating schools. There was no exclusion criteria. Each child and their family received information sheets explaining the purpose of the study and the methods of data collection. Participation was voluntary and the children or their parents could opt out of any of the measures. The children and their parents provided informed written assent. Data was collected during August and September 2016 and 2017. A wide range of sociodemographic status and ethnicities were represented. Ethical approval was granted by the Massey Southern A Human Ethics (approval number: SOA 16/42).

3.3.2 Methodological procedures

Each child completed body composition measurements which were administered by trained personnel in the participating schools during school hours. A bioelectrical impedance analysis (BIA) (Biospace InBody 230) was used, without shoes, and in light clothing, to measure the children's BF% and weight (in kilograms (kgs)). BF% measurements using the BIA has been validated against the DXA for this group of children in yet to be published research (Delshad et al., 2018). The mean height (in metres (m)) was calculated to one decimal place from two measurements using a portable stadiometer without shoes (Seca 213). BMI was calculated from these measurements (kg/m^2). The IOTF gender and age specific child cut-offs for BMI were used (Cole & Lobstein, 2012).

3.3.3 Questionnaires

Each child was asked to complete two questionnaires, a 'food and beverage food frequency questionnaire' (FFQ), and a 'beverage knowledge and attitudes questionnaire'. These questionnaires were designed by researchers for this study and were not validated. The FFQ investigated beverage consumption frequency, home availability of beverages, and details of beverage intake in the community (outside the home and school environment). The 'beverage knowledge and attitudes' questionnaire investigated beverage knowledge, reasons for selecting drinks in the community, and parental and school encouragement of consuming healthy beverages. A parent of each participating child completed the demographics questionnaire with their child's date of birth, ethnicity, and additional information for the wider study. Children who were of a South Asian ethnicity included children who were Indian, Sri Lankan, Pakistani, and Bangladeshi. The Asian ethnicity included children who were Chinese, Japanese, Korean, and Taiwanese. The 'other' ethnicity included Middle Eastern, African, and Latin American children.

The beverages included in the FFQ were plain water, plain milk, flavoured milk, milkshake or milk drink, flavoured powdered milk drink, fruit smoothie, fruit juice, powdered fruit drink, fruit drink concentrate/cordial, soft drink, soda stream, diet drinks, energy drinks, sports drinks, flavoured water, tea, and coffee. Sugar-sweetened beverages (SSBs) were defined as beverages which contained added sugar or other caloric sweeteners, including soft drinks, sports drinks, energy drinks, flavoured milks,

flavoured water, fruit juice, and powdered or cordial fruit drinks. This excluded plain water, diet fizzy drinks, plain milk, 100% vegetable drinks, and alcoholic beverages (Riordan et al., 2017; Wetter & Hodge, 2016).

3.3.4 Statistical methods

All statistical analyses were performed using IBM SPSS statistics 24 software. The Kolmogorov-Smirnov test, Shapiro-Wilk test, and histograms were used to assess the data for normality. The non-normally distributed data was log transformed and retested for normality. However, non-parametric tests were used as the data remained non-normally distributed. Categorical variables were expressed as proportions or n(%).

Basic descriptive analyses were used to analyse participant number, age, height, weight, BF%, BMI, school deciles, and ethnicities. The prioritised approach was used to classify children who selected multiple ethnicities into one ethnicity so that the number of ethnicities was equal to the number of children who participated. The prioritisation order was as follows: Māori, Pacifica, Asian, other ethnicities, NZ European (Ministry of Health, 2010).

Basic descriptive analyses were also used for children's total beverage consumption, and beverage consumption whilst in the community. To create a grouped beverage variable and total SSB consumption variable, nominal consumption variables were scaled, and then added together. This potentially underestimated consumption as the lower value of each group beverage frequency was used, for example, the one to two times per week group was scaled to once per week. Total SSB intake included consumption frequencies from all beverages studied, with the exception of plain water, plain milk, diet drink, tea, and coffee. Total milky drinks included plain milk, flavoured milk, and milk drink. Total carbonated beverages included soft drinks, soda stream, and energy drinks.

A chi-squared test was used to investigate beverage consumption in water-only and non-water-only schools, and different levels of home availability. A Kruskal-Wallis test was used to investigate the relationship between BF% and ethnicity. The Bonferroni correction was applied in this test. A Mann-Whitney test was then completed to compare NZ European BF%s to other ethnicities. A Mann-Whitney test was also used to investigate the relationship between beverage intake and encouragement of healthy

beverage consumption, BF%, and knowledge. To assess beverage knowledge, each child was asked a series of questions about how often it was healthy to consume specific beverages and if specific beverages were sugar sweetened. The total score was calculated by each correct answer scoring the child one point, and an incorrect answer or no answer scoring the child no points. The maximum possible score was 20. A p value of <0.05 was considered significant.

3.4 Results

3.4.1 Participants

A total of 805 children were enrolled in the six participating schools, and 695 agreed to participate and were present in school on the day of testing (figure 3.1). Four of the participating schools were water-only schools (n=579), and two were not (n=116).

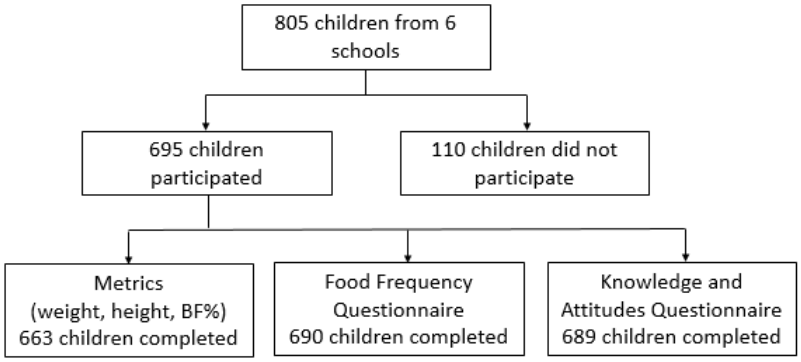

Figure 3.1 Flow chart of children involvement

The participating schools were distributed across the Auckland region in low (26.6%), medium (33.8%), and high (39.7%) decile schools. School deciles were used as a rough proxy of the children's socioeconomic status, with a low school decile representing a low socioeconomic status. A range of ethnicities were present, including European (37.6%), Pacifica (15.1%), Maori (14.9%), South Asian (14.5%), Asian (14.3%), and other (3.7%). The sample consisted of 44.8% male, and 55.2% female children, aged 9.9 ± 0.7 years (table 3.1).

Table 3.1 Baseline characteristics of all children

	Mean (SD)	Range
Age (years)	9.9 (0.7)	8 – 12
Height (m)	1.44 (0.08)	1.19 – 2.13
Weight (kg)	38.9 (11.3)	19.8 – 93.0
Body fat percentage (%)	22.7 (9.2)	7.8 – 51.6
BMI (kg/m^2)	18.7 (3.9)	12.7 – 36.8

SD, standard deviation; BMI, body mass index.

3.4.2 Beverage consumption

The total number and percentage of children who reported consuming each beverage never/less than once per week, 1 to 4 times per week, and at least 5 times per week are presented in table 3.2. Plain water and plain milk were the most commonly consumed beverages, with 88.4% and 45.3% of the children reporting consumption more than once per day. Intake of all milk-based beverages never/less than once per week was 10.1%. Soft drink and fruit juice was reported to be consumed at least once per week by 30.6% and 39% of the children, respectively. Energy drinks were not consumed weekly by 97.9%.

Table 3.2 Consumption of beverages

	Consumption of Beverages			
	Less than once/week	1 – 4 times/week	5+ times/week	No response
	n (%)	n (%)	n (%)	n
Plain water	17 (2.5)	30 (4.4)	632 (93.1)	11
Plain milk	113 (16.4)	192 (27.9)	382 (55.6)	3
Flavoured milk	540 (79.1)	102 (14.9)	41 (6.0)	7
Milkshake or milk drink	537 (78.5)	115 (16.8)	32 (4.7)	6
Fruit smoothie	542 (79.7)	111 (16.3)	27 (4.0)	4
Flavoured powdered milk drink	373 (54.4)	221 (32.2)	92 (13.4)	4
Fruit juice	411 (61.0)	207 (30.7)	56 (8.3)	16
Powdered fruit drink	563 (82.8)	78 (11.5)	39 (5.7)	10
Fruit drink concentrate/cordial	530 (78.2)	111 (16.4)	37 (5.5)	12
Soft drink	470 (69.4)	173 (25.6)	34 (5.0)	18
Soda stream	640 (94.8)	30 (4.4)	5 (0.7)	20
Diet drinks	611 (90.1)	54 (8.0)	13 (1.9)	12
Energy drinks	663 (97.9)	10 (1.5)	4 (0.6)	13
Sports drinks	634 (93.5)	34 (5.0)	10 (1.5)	12
Flavoured water	617 (91.3)	41 (6.1)	18 (2.7)	14
Tea	503 (74.1)	101 (14.9)	75 (11)	11
Coffee	650 (96.2)	17 (2.5)	9 (1.3)	14
Other drinks*	95 (57.9)	37 (22.6)	32 (19.5)	526

*sparkling water, coconut water, miso soup, yakult, iced tea, homemade honey water, kombucha, and alcohol

3.4.3 Ethnicity

A significant relationship was identified between ethnicity and total SSB consumption per week, $H(4)=92.6$, $p<0.001$. Comparisons with Bonferroni adjusted p-values showed that there was a significant difference between total SSB intake per week between NZ European children (Median (*Mdn*)=1) and Māori (*Mdn*=3) (r=-0.32,

p<0.001), Pacifica (*Mdn*=5) (*r*=-0.38, *p*<0.001), or South Asian children (*Mdn*=5.5) (*r*=-0.36, *p*<0.001), but no significant difference with Asian children (*Mdn*=1) (*r*=0.09, *p*=0.103). NZ European and Asian children had a lower total SSB consumption per week than the other ethnicities.

3.4.4 Body fat percentage

The girls who consumed SSBs at least once per week had a significantly higher BF% compared to less than once per week (*Mdn*=23% vs 19.8%) (*U*=10301, z=-3.88, *r*=-0.21, *p*<0.001). The same association was found in girls with soft drink consumption (*Mdn*=22.6% vs 19.5%) (*U*=8015, *z*=-4.71, *r*=-0.25, *p*<0.001), and fruit juice consumption (*Mdn*=22.6% vs 19.5%) (*U*=11895, *z*=-2.31, *r*=-0.12, *p*=0.021). These significant associations were not identified in boys.

A significant relationship was found between BF% and ethnicity, *H*(4), *p*<0.001). It was identified that BF% in NZ European children (*Mdn*=18.1%) was significantly different to Māori (*Mdn*=22.7%) (*r*=-0.28, *p*<0.001), Pacifica (*Mdn*=26.5%) (*r*=-0.32, *p*<0.001), and South Asian children (*Mdn*=23%) (*r*=-0.26, *p*<0.001), but was not significantly different to Asian children (*Mdn*=18.6%) (*r*=-0.06, *p*=0.103).

3.4.5 Home availability

A significant positive association was found between home availability and intake of plain milk, flavoured milk, food milk drinks, homemade smoothies, soft drinks, soda stream, diet drink, fruit juice, fruit drink, and fruit cordial. Plain milk, fruit juice, fruit cordial, fruit drink, soft drinks, and soda stream were usually available in the home for 92%, 13.4%, 12.9%, 11.2%, 9.1%, and 5.2% of the children, respectively. There was an increased likelihood of consuming these beverages at least once per week if they were usually available at home.

Plain milk intake had a positive relationship with home availability $\chi^2(1)=16.22$, p<0.001. If a child usually had plain milk available at home, the odds of them consuming plain milk at least once per week was 3.3 times more than if they never/sometimes had plain milk available at home. Of the children who consumed plain milk less than once per week, 13% and 4.6% had it available at home sometimes and never, respectively.

When intake of soft drinks was at least 5 times per week they were usually available at home for 65.6% of the children, and sometimes/never available for 34.4%. When fruit juice was consumed at least 5 times per week it was usually available in the home for half of children, and sometimes/never available for the other half.

3.4.6 Community environments

Beverages were consumed at least once per week in the community by 27.8% of the children. Beverages were reported to be consumed from fast food and other takeaway places at least once per week by 36.9% and 20.3% of the children, respectively. Beverages were also consumed at least once per week from dairies/petrol stations (15.5%) and from a supermarket (35.6%). Half (49.9%) of the beverages consumed in the community were reported to be consumed in the weekend, 22% in the evening, 19% after school, and 4% before school. Intake of beverages were most likely to be with parents/family (84.8%), but were also consumed with siblings (6.3%), friends (5.2%), or alone (1.9%).

The main reasons children gave for choosing a beverage while they were out was ‘to satisfy thirst’ and because ‘it tastes the best’, with 62.8% and 56.9% of the children selecting these options, respectively. A quarter of the children selected that they chose a beverage as ‘it’s better for me’, 19.5% selected ‘it’s what I’m allowed at home or school’, 18.1% selected ‘it was on special or the most affordable’, 12% selected that ‘it’s better than snack food’, and 6.4% selected ‘it’s what my friends chose’.

3.4.7 Water-only school policy

There were no significant differences in age, gender, height, or weight between children in the water-only and non-water-only schools. However, there were significant differences in ethnicity ($\chi^2(5)=75.72$, $p<0.001$), school decile ($\chi^2(2)=211.77$, $p<0.001$), and BF% ($U=21721$, $z=-2.60$, $r=-0.10$, $p=0.009$) between children in the two types of schools. The two non-water-only schools were both high decile schools, whereas, the four water-only schools had a combination of low, medium, and high decile schools.

Children from water-only schools consumed significantly more sugar sweetened milk drinks ($p=0.008$), juice drinks ($p<0.001$), and carbonated drinks ($p<0.001$). There was also an association found between the school water policy and intake of SSBs less than once per week vs at least once per week, $\chi^2(1)=17.52$, $p<0.001$. If a child

attended a water-only school the odds of them consuming a SSB at least once per week was 2.4 times more than if they attended a non-water-only school.

An inverse association was identified between intake of SSBs and low vs medium/high decile schools $\chi^2(1)=46.27$, $p<0.001$. If a child attended a low decile school, the odds of them consuming a SSB more than once per week was 5.3 times more than if they attended a medium/high decile school.

3.4.8 Encouragement

Most children (75%) reported that they received a lot of encouragement to consume healthy beverages from their parents, and 67% received a lot of encouragement from their school. Children who were encouraged to consume healthy beverages at home a lot had a lower intake of SSBs per week than children who were encouraged not a lot/sometimes (*Mdn*=2 vs 4) (*U*=33213, z=-3.88, r=-0.15, p<0.001). A lot of encouragement to consume healthy beverages at school also resulted in a lower SSB intake per week compared to children who were encouraged not a lot/sometimes (*Mdn*=3 vs 1) (*U*=40193, z=-3.65, r=-0.14, p<0.001).

3.4.9 Knowledge

Children who consumed SSBs less than once per week had a higher beverage knowledge score than children who consumed SSBs more than once per week (*Mdn*=18 vs 17) (*U*=34186, *z*=-6.34, *r*=-0.24, *p*<0.001).

3.5 Discussion

3.5.1 Beverage consumption and body fat percentage

This study provides an insight into beverage consumption in a group of Auckland primary school children, which helps to inform a knowledge gap existing as a result of outdated studies, or studies on limited types of beverages. Plain water is the best beverage option for children (Clinical Trials Research Unit, 2010) yet 11.6% of children reported consuming it less than once per day. This prompts the question whether children are staying adequately hydrated, and if so, what beverages were used to meet their fluid requirements. Plain milk is also recommended to be consumed daily (Ministry of Health, 2012a), however, 54% of children were not meeting this recommendation, and 16.4% consumed it less than once per week. When intake of all

milk-based beverages were combined, 10.1% of children reported intake of these less than once per week. According to the Children's National Nutrition Survey (2002), the primary source of calcium for NZ children is milk, thus these children may not be reaching their calcium recommendations (Ministry of Health, 2003). Children who do not meet their calcium requirements are at risk of a lower bone mineral density and peak bone mass (Ministry of Health, 2012a). Peak bone mass is the amount of bone mass accumulated at the end of skeletal maturation. A high peak bone mass is protective against fractures later in life (Heaney et al., 2000). As this study contained a wide ethnic diversity there are a variety of potential reasons for the irregular consumption of milk, for example, lactose intolerance.

The 2016/2017 annual Ministry of Health NZ Health Survey (n=13000, 5-14 years) identified that 61.3% of children had consumed a fizzy drink at least once in the past week. This survey categorised fizzy drinks as soft drinks, soda stream, diet drinks, and energy drinks (Ministry of Health, 2017a). A lower intake proportion (35.3%) was found when intake of the same drinks were combined in the present study.

This convenience sample of Auckland children provides an up to data analysis on beverage intake in this population group. When data on beverage intake was compared with the NZ Children's Food and Drinks survey (2008), little difference in plain water or sugar-containing carbonated beverages at least 5 times per week was identified (National Research Bureau Ltd, 2008). Consumption of all other SSBs at least 5 times per week was lower in the present survey compared to the 2008 study survey; fruit juice 8.3% vs 27%; cordials/powdered fruit drinks 5.5% vs 29%; flavoured milk 6% vs 8%; flavoured water 2.7% vs 7%; diet carbonated drinks 1.9% vs 7% (National Research Bureau Ltd, 2008).

Despite containing some vitamins and minerals, fruit juice has a high sugar content (Nicklas, O'Neil, & Fulgoni, 2015), and 39% of the children consumed it at least once per week. A recent meta-analysis on longitudinal studies (n=34470) found that 100% fruit juice intake did not significantly increase BMI in 7 to 18 year olds (Auerbach et al., 2017). However, in the present study there was a significant positive relationship between fruit juice intake at least once per week and BF% in girls. Therefore, it may be beneficial to include fruit juice in any public health initiatives that aim to reduce

consumption of SSBs. To the best of our knowledge this study is the first study to investigate a relationship between fruit juice and BF% in different genders in NZ.

Energy drinks can cause adverse physiological effects and caffeine toxicity in some individuals. Therefore, the American Academy of Pediatrics and other medical experts have recommended that children do not consume them (Harris & Munsell, 2015). The results of the present study show that this recommendation is generally met, with 97.9% of children not consuming energy drinks weekly. Coffee and tea are other sources of caffeine which the Ministry of Health guidelines recommend children under the age of 13 should avoid (Ministry of Health, 2012a). Generally, this coffee guideline is met as 96.2% of the children consumed coffee never/less than once per week. However, tea was consumed at least once per week by approximately a quarter of the children (25.9%). It is unknown whether the tea was caffeinated or un-caffeinated.

Māori, Pacifica, and South Asian girls had a significantly higher BF% than NZ European children in this study, which aligns with previous research (Duncan et al., 2009; Hudda et al., 2017). Previous research identified that East Asian girls (classified in this study as 'Asian') had a lower BF% than European girls at the same BMI, but there was no significant difference found in the present study (Duncan et al., 2009; Hudda et al., 2017).

Previous research has identified ethnic differences in fizzy drink intake, with a higher proportion of Māori and Pacifica children consuming fizzy drinks more than once per week compared to NZ European children (Ministry of Health, 2017a). These differences in ethnicity were also shown in total SSB consumption in the present study. Māori and Pacifica children have a higher rate of obesity than other ethnicities, and SSB consumption may be contributing to this problem (Ministry of Health, 2017c).

3.5.2 Home availability

A significant association between SSB intake and home availability was identified in previous international cluster randomised control and cross-sectional studies (Bere et al., 2008; Bogart et al., 2017; Ezendam et al., 2010; Heredia et al., 2016). The results from the present study suggest that this is also the case in NZ, as there was a significant relationship between home availability and consumption of all beverages.

The 2008 NZ children's food and drinks survey (n=454) looked at 8 to 12 year old children's home availability and consumption of beverages, and found that only 10% of children never drank full-sugar carbonated beverages when they were available in the home (National Research Bureau Ltd, 2008). Full-sugar carbonated beverages were consumed and available 5+ days per week in 5% and 8% of the homes, respectively. Fruit juice was consumed and available 5+ days per week in 27% and 28% of the homes, respectively (National Research Bureau Ltd, 2008). In the present study, 9.1% of the children usually had soft drinks available at home, and 12.9% usually had fruit juice available. However, 34.4% of the children who consumed soft drinks at least 5 times per week did not usually have them available at home. This suggests that children commonly consumed their soft drinks outside the home, either in the community, and/or at school if they attend a non-water-only school.

3.5.3 Community environment

Children commonly consumed beverages in the community, with 27.8% consuming a beverage at least once per week in this environment. Over a quarter of these children (28.6%) reported consumption of a beverage from a fast food or takeaway store at least once per week. Previous NZ research has shown that there is a higher concentration of convenience and takeaway stores around the most deprived schools compared to the least deprived schools (Mackay et al., 2018). The present research concurs with previous work showing that children in a higher deprivation level had a higher fizzy drink intake (Ministry of Health, 2017a). Of the children who consumed beverages outside the home, 62.8% reported their reason for choosing a drink was to satisfy their thirst. This suggests that ensuring that healthy beverage options, such as plain water and plain milk, are available to be consumed at these locations may encourage healthier beverage intake.

When beverages were consumed in the community, 84.8% of the time they were reported to be with the child's parents/family, and only 1.9% of the time they were reported to be alone. Children in this age group generally have a low disposable income and less independence than adolescents, thus may be dependent on their family to provide their beverages (Verloigne et al., 2012). Family involvement has been shown to increase the effectiveness of the intervention (Bere et al., 2008; Mazarello

Paes et al., 2015; van de Gaar et al., 2017). Therefore, interventions promoting healthy beverage consumption for the whole family could be justified.

The home and school environments are proposed to influence beverage consumption in the community, as 19.5% of children chose a drink when in the community based on what they are allowed at home or school. Furthermore, there was a significant inverse relationship between beverage knowledge scores and SSB intake. However the medians differed by only 1 point out of 20 points, with each point representing a correct answer on the questionnaire. Many studies on school SSB based interactive activities and educational sessions have shown a positive impact on SSB consumption (Tipton, 2016). Thus, school education sessions, SSB interactive activities, and having rules around healthy beverage choices from role models (Yee et al., 2017) at home and school may help reduce SSB consumption.

3.5.4 Water-only schools policy

Many Auckland schools have become water-only schools to discourage SSB consumption. Contrary to our hypothesis, children in water-only-schools had a significantly higher consumption of SSBs than non-water-only schools. This was an unexpected finding as a recent meta-analysis identified that school beverage policies resulted in a decreased habitual intake of SSBs by 0.18 servings per day (Micha et al., 2018).

A limitation of the present study was that the non-water-only schools consisted exclusively of high decile schools. Children who attended a low decile school were more likely to consume SSBs at least once per week compared to children who attended a medium/high decile school. This aligns with results of the Ministry of Health annual health survey, which identified that children at the most deprived level had a higher fizzy drink consumption (Ministry of Health, 2017a). Therefore, it is possible that the results of the present study were partially reflecting any socio-economic differences, rather than any effects of school policies.

3.5.5 Encouragement

Parental and school encouragement to make healthy beverage choices had an inverse relationship with SSB consumption. This builds on previous findings that parental encouragement of healthy foods was associated with increased diet quality,

decreased likelihood of being overweight, and increased breakfast consumption (Faught et al., 2016; Van Lippevelde et al., 2013). Previous research has shown that involving parents in interventions, regardless of whether these are educational interventions, can help to increase their effectiveness (Bere et al., 2008; Mazarello Paes et al., 2015; van de Gaar et al., 2017). Thus, parental based interventions, such as supporting them to encourage their children to consume healthy beverages, may be an effective way to increase the intake of healthier beverages.

3.5.6 Limitations

There are many ways in which parents can support healthy beverage consumption, including role modelling (Yee et al., 2017). A limitation of this study was that parental role modelling, commonly measured through parental intake, was not studied. Another limitation of this study was that it was observational and not generalisable to the NZ population due to the method of recruitment. However, the study included a large number of children across a range of ethnicities which, with the exception of Māori, were similar in proportion to the NZ population. The questionnaires also had several limitations. They were self-reported, not validated, and the way in which the questions were designed meant that exact frequencies of consumption could not be measured. This study looked at a large range of beverages in depth, however, it is acknowledged that other dietary factors contribute to body composition, as does physical activity. Future studies should include these factors to help identify the role of SSB consumption on the fatness of NZ children.

3.6 Conclusion

Compared to the most recent beverage intake statistics in the 8 to 12 year old age group, the present study identified a lower consumption of SSBs at least 5 times per week. However, children could still benefit from decreasing their SSB consumption. Children could also benefit from increasing their plain water and plain milk consumption, as a large proportion of the children consumed them less frequently than current recommendations. Health professionals and the public have placed a lot of attention on the association between obesity and soft drink consumption, however, fruit juice was also shown to have a significant positive relationship with BF% in girls. This means that including fruit juice in any actions to reduce SSBs is important.

Increasing home availability of healthy beverages, as well as, parental and school encouragement of the consumption of healthy beverages, were highlighted as three ways of increasing healthy beverage choices and decreasing SSBs. Thus, including parents in interventions could be an effective way to achieve this, as suggested in previous research. More research is needed to assess school water-only policies and their effect on SSB consumption. The children in the highest deprivation areas have the most obesogenic environment, the highest intake of SSBs, and the highest rates of obesity. Thus, interventions to decrease SSB intake should target this population. In future research it is important to include a representative sample of socio-economic groups. Also, it is timely to repeat the National Children's Nutrition Survey. It would be beneficial to investigate SSB consumption in the context of the whole diet. This would enable public health professionals to implement effective public health interventions that consider the typical diet of NZ children.

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Conflicts of interest: The authors report no conflicts of interest.

Chapter 4: Conclusions

4.1 Research problem

SSB consumption has been proposed as a potential factor contributing to the obesity problem (Keller & Della Torre, 2015). However, in 8 to 12 year old NZ children there was no recent evidence on beverage consumption, effect of SSB consumption on BF% in different genders, or factors which international evidence has shown to influence SSB consumption. These factors included home availability of beverages, encouragement to consume healthy beverages, school policies, knowledge, and socioeconomic status (Bere et al., 2008; Bogart et al., 2017; Ezendam et al., 2010; Faught et al., 2016; Grosso et al., 2013; Heredia et al., 2016; Laurence et al., 2007; Mackay et al., 2018; Mazarello Paes et al., 2015; Ministry of Health, 2017c; Muckelbauer et al., 2009; Santiago-Torres et al., 2014; Siega-Riz et al., 2011; Singh et al., 2009; Sundborn et al., 2014; Utter et al., 2008; Van Lippevelde et al., 2013; Zahid et al., 2017).

4.2 Aim, main findings and recommendations

The aim of this study was to investigate beverage consumption in 8 to 12 year old Auckland primary school children. This aim was achieved by investigating each of the following seven objectives.

4.2.1 Beverage consumption

Objective 1:

To determine the total beverage consumption and type of beverages consumed.

Main findings:

Consumption of 17 different types of beverages were investigated using a FFQ. Although the FFQ did not measure exact quantities, the results of this study propose that a large proportion of children did not meet the Ministry of Health guidelines for plain water and plain milk intake. This raises further questions about whether children are staying adequately hydrated and meeting their calcium requirements.

This study provided up to date beverage consumption data in 8 to 12 year old Auckland primary school children, and could be compared to the most recent data in the same age group from the NZ Children's Food and Drinks survey (2008). It was identified that there was little difference in the intake of plain water and sugar-containing carbonated beverages between the two studies. However, fruit juice, cordials/powdered fruit drinks, flavoured milk, flavoured water, and diet carbonated drinks consumption was lower in the present study compared to the 2008 study (National Research Bureau Ltd, 2008). Nevertheless, children would benefit from limiting their SSB intake.

Recommendations:

- Consume enough plain water and plain milk to meet the NZ Ministry of Health fluid guidelines (1.4L/day for females, 1.6L/day for males). Increase milk consumption as necessary to meet calcium recommendations, if these requirements are not being met through food (Ministry of Health, 2012a).
- Limit SSB consumption, as per the NZ Ministry of Health guidelines (Ministry of Health, 2012a)

4.2.2 Body fat percentage

Objective 2:

To determine whether there is a relationship between SSB consumption and BF%.

Main findings:

A positive association was found between SSB consumption and BF% in girls. When investigating soft drinks and fruit juice separately, these were also both positively associated with BF% in girls. No significant association was found in boys.

Recommendation:

- Include fruit juice in any public health actions to discourage SSB consumption

4.2.3 Environmental factors and beverage consumption

4.2.3.1 Socioeconomic status and ethnicity

Objective 3:

To determine whether there are demographic differences in SSB consumption.

Main findings:

School decile, as a proxy of socioeconomic status, and ethnicity were studied to investigate demographic differences in SSB consumption. Attending a medium or high decile school was associated with lower SSB consumption than attending a low decile school. The same association between socioeconomic status and fizzy drink consumption was shown in the NZ Health Survey Annual Update (2017) (Ministry of Health, 2017a).

Māori, Pacifica, and South Asian children had a significantly higher consumption of SSBs compared to NZ European children. No significant differences in SSB intake were identified between NZ European and Asian children.

Recommendations:

- Interventions to decrease SSB consumption should incorporate children of low socioeconomic areas.
- Target South Asian, Māori, and Pacifica children in interventions to decrease SSB consumption.
- Incorporating plain water or milk into school food programmes may encourage healthy beverage consumption.

4.2.3.2 Home

Objective 4:

To determine whether there is a relationship between home availability of SSBs and consumption of SSBs.

Main findings:

Home availability had a positive association with consumption of all beverages. This association concurs with international studies of this age group, and NZ studies in adolescents (Bere et al., 2008; Bogart et al., 2017; Ezendam et al., 2010; Heredia et al., 2016; Sundborn et al., 2014; Utter et al., 2008). Parents/families were also shown to influence beverage consumption through parental encouragement (section 4.2.3.5) and beverage choice when outside the home (section 4.2.3.3). This shows that families play an important part in child beverage consumption.

Previous research has indicated that parent education sessions may be an effective way of supplying parents with the information needed to provide their children with support for favourable behaviours (Burrows et al., 2008).

Recommendations:

- Increase home availability of healthy beverages (plain water and plain milk) and decrease home availability of SSBs.
- Incorporate the family and/or parents in actions to decrease SSB consumption in order to increase their effectiveness.

4.2.3.3 Community

Objective 5:

To examine beverage consumption outside of the home and school environments.

Main findings:

Over a quarter of children reported to have consumed beverages in the community at least once per week. A quarter of these children consumed a beverage from a fast food or takeaway store. A primary reason for choosing a beverage to consume was to satisfy thirst.

When outside the home 84.8% of beverages were consumed with parents/family, and 19.5% said a reason for selecting a beverage was determined by what they were allowed at home or school.

Recommendation:

- Ensure that healthy beverage options, such as plain water and plain milk, are available to be purchased at fast food / takeaway stores.

4.2.3.4 School

Objective 6:

To investigate differences in SSB consumption between water-only and non-water-only schools.

Main findings:

Contrary to our hypothesis, it was found that children from water-only-schools had a significantly higher consumption of SSBs than non-water-only schools. This may have

reflected the socioeconomic differences between schools, rather than the school policy, as the non-water-only schools exclusively consisted of high decile schools.

Recommendations:

- Based on the current evidence interventions such as providing a free water bottle to school children (Muckelbauer et al., 2009) and including interactive activities on SSB consumption into the curriculum (Tipton, 2016) could be implemented and evaluated in NZ.
- Implementing a water-only school policy NZ-wide may have dental benefits (Thornley et al., 2017) and result in increased water consumption (Laurence et al., 2007; Muckelbauer et al., 2009; Siega-Riz et al., 2011).

4.2.3.5 Knowledge & Attitudes

Objective 7:

To determine whether there is a relationship between knowledge, attitudes, and consumption of SSBs.

Main findings:

There was an inverse association between knowledge of healthy beverages and consumption of SSBs. It was also identified that parental and school encouragement to consume healthy beverages had an inverse relationship with SSB consumption.

Recommendation:

- Support parents and schools to encourage their children to consume healthy beverages, such as plain water and plain milk.
- Improve children's knowledge of the nutritional quality of beverages.

4.3 Research contribution

This study provided up to date beverage consumption data in a cohort of NZ children aged 8 to 12 years. Areas of concern in beverage consumption were identified, including low-fat plain water and plain milk intake in an alarming proportion of children, and excessive SSB intake.

Potential factors which may contribute to SSB consumption in NZ children were identified. These avenues could promote healthy beverage consumption and create a

less obesogenic environment for NZ children. Some studies had identified risk factors for higher SSB consumption in international studies, however, these factors had not been recently studied in 8 to 12 year old children in the NZ context.

The key findings of this study can help inform evidence-based, effective obesity prevention policies. Recommendations for areas of future research were also provided.

4.4 Strengths and limitations

4.4.1 Strengths

A major strength of this study was the large sample size (n=695) which encompassed a range of ethnicities similar in proportion to the NZ population, with the exception of Māori. The study also looked at a range of beverages, whereby other recent studies in NZ have exclusively looked at soft drinks (Ministry of Health, 2017a). Another strength of this study was that BF% was measured, which has an advantage over other measures of adiposity, such as BMI, as this method can account for the ethnic differences in BF%.

4.4.2 Limitations

A limitation of this study was the method of recruitment. A convenience sample was used to recruit children, who were exclusively from the Auckland area. Thus, the results are not generalisable. Another limitation was that the non-water-only schools consisted exclusively of high decile schools. Therefore, the association between SSB consumption and school water policy was potentially confounded by the socioeconomic status of the schools/students. Furthermore, only one participant was 12 years old, which means this study may have been more representable of the 8 to 11 year old age group.

The questionnaires that were used in this study also had several limitations. Firstly, beverage consumption was the only dietary data collected. This means that the contribution of SSBs to the total energy intake, or total sugar intake could not be investigated. As well as this, the exact frequency of beverage consumption could not be measured due to the way in which the questions were formatted. The way in which

the frequency of beverage consumption was estimated meant that results using the combined beverage consumption variables were potentially underestimated. Lastly, the knowledge questionnaire was not validated, thus, there was a potential for subjective analysis as the children may have interpreted the questions differently.

4.5 Recommendations for future research

- Research on the water-only school policy which ensures that each group is representable of the socioeconomic status of NZ children.
- Research investigating the relationship between parental role modelling and SSB consumption in NZ children, which has been indicated in international studies.
- When designing a beverage FFQ ensure that questions can be coded to produce exact frequencies of consumption.
- An updated edition of the 2002 NZ Children's Nutrition Survey, to investigate the contribution of SSBs to the children's total energy and total sugar intake.

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Appendices

Appendix A: Supplementary Tables

Table A.1 Home availability and beverage consumption

	Frequency of SSB consumption			
Home Availability	Less than once/week Count (%)	At least once/week Count (%)	Total Count (%)	P-value*
Plain milk				<0.001†
Never	5 (4.6)	1 (0.2)	6 (0.9)	
Sometimes	14 (13.0)	33 (5.9)	47 (7.1)	
Usually	89 (82.4)	522 (93.9)	611 (92.0)	
Flavoured milk				<0.001†
Never	302 (58.0)	12 (9.0)	314 (47.9)	
Sometimes	200 (38.4)	77 (57.5)	289 (44.1)	
Usually	19 (3.6)	45 (33.6)	64 (9.8)	
Food milk drinks				<0.001†
Never	137 (26.3)	7 (5.1)	314 (47.9)	
Sometimes	210 (40.4)	55 (39.9)	277 (42.3)	
Usually	173 (33.3)	76 (55.1)	64 (9.8)	
Homemade smoothie				<0.001†
Never	173 (32.9)	18 (13.8)	191 (29.1)	
Sometimes	240 (45.6)	49 (37.7)	289 (44.1)	
Usually	113 (21.5)	63 (48.5)	176 (26.8)	
Soft drinks				<0.001†
Never	246 (53.5)	21 (10.6)	267 (40.6)	
Sometimes	201 (43.7)	130 (65.7)	331 (50.3)	
Usually	13 (2.8)	47 (23.7)	60 (9.1)	
Diet drinks				<0.001†
Never	481 (81.3)	14 (21.5)	495 (75.3)	
Sometimes	96 (16.2)	28 (43.1)	124 (18.9)	
Usually	15 (2.5)	23 (35.4)	38 (5.8)	
Soda stream				<0.001†
Never	545 (87.9)	8 (24.2)	553 (84.7)	
Sometimes	51 (8.2)	15 (45.5)	66 (10.1)	
Usually	24 (3.9)	10 (30.3)	34 (5.2)	
Fruit juice				<0.001†
Never	211 (53.4)	46 (18.1)	257 (39.6)	
Sometimes	165 (41.8)	140 (55.1)	305 (47.0)	
Usually	19 (4.8)	68 (26.8)	87 (13.4)	
Fruit drink				<0.001†
Never	276 (50.5)	33 (29.2)	309 (46.9)	
Sometimes	213 (39.0)	63 (55.8)	276 (41.9)	
Usually	57 (10.4)	17 (15.0)	74 (11.2)	

Fruit cordial				<0.001†
Never	365 (70.5)	58 (40.8)	423 (64.1)	
Sometimes	106 (20.5)	46 (32.4)	152 (23.0)	
Usually	47 (9.1)	38 (26.8)	85 (12.9)	

*Chi^2 test was used to measure significance; †Statistically significant difference between two policies ($p<0.05$).

Table A.2 Location of beverage consumption in the community

	Consumption from these places per week		
	Less than once/week Count (%†)	1-3 times/week Count (%†)	4+ times/week Count (%†)
Fast food places	425 (63.1)	224 (33.2)	25 (3.7)
Other takeaways	534 (79.7)	117 (17.5)	19 (2.8)
Dairy / petrol station	568 (84.5)	80 (11.9)	24 (3.6)
Supermarket	371 (55.5)	238 (35.6)	59 (8.8)
Somewhere else	486 (78.8)	107 (17.3)	24 (3.9)
Total percentage	72.2%	23.2%	4.6%

† Percentage of children consumed beverages from this place at this frequency

Table A.3 When beverages were consumed in the community

	Times children consumed beverages Count (%†)
Before school	20 (3.6)
After school	107 (19.1)
In the evening	125 (22.4)
In the weekend	279 (49.9)
Other*	28 (5.0)

†Percentage of children who selected this option out of total responses;
*Other: aeroplanes, holidays, special occasions, or not specified

Table A.4 Beverages were consumed in the community with these people

	Children consuming beverages with Count (%†)
Alone	10 (1.9)
Friends	27 (5.2)
Parents/family	441 (84.8)
Siblings	33 (6.3)
Other caregiver	7 (1.3)
Other	2 (0.4)

*The children could select multiple options; †Percentage of children who selected this option out of total responses

Table A.5 Main reason for choosing a beverage when in the community

	Selected this option* Count (%†)
To satisfy thirst	431 (62.8)
Better than snack food	82 (12.0)
It's what I'm allowed at home or school	134 (19.5)
It's what my friends chose	44 (6.4)
It was on special or the most affordable	124 (18.1)
It's better for me	174 (25.4)
It tastes the best	390 (56.9)

*The children could select up to 3 reasons; †Percentage of children selected this option

Table A.6 Baseline characteristics of all participants and school policy

	School policy			
	Water-only school (n=577)	Non-water-only school (n=116)	Total (n=693)	
	Mean (SD)	Mean (SD)	Mean (SD)	P-value*
Age	9.85 (0.72)	9.93 (0.68)	9.87 (0.71)	0.455
Height (m)	1.43 (0.08)	1.45 (0.08)	1.44 (0.08)	0.135
Weight (kg)	38.8 (11.3)	39.1 (11.2)	38.91 (11.29)	0.720
Body fat percentage (%)	23.1 (9.3)	20.5 (8.1)	22.71 (9.15)	0.303
	n (%)	n (%)	n (%)	
Ethnicity				<0.001†
European	183 (35.3)	84 (80.0)	267 (42.8)	
Māori	27 (5.2)	2 (1.9)	29 (4.6)	
Pacifica	128 (24.7)	13 (12.4)	141 (22.6)	
Asian	142 (27.4)	2 (1.9)	144 (23.1)	
South East Asian	21 (4.0)	1 (1.0)	22 (3.5)	
Other	18 (3.5)	3 (2.9)	21 (3.4)	
School decile				<0.001†
Low (1-3)	184 (31.9)	0 (0.0)	184 (26.6)	
Medium (4-7)	243 (40.6)	0 (0.0)	234 (33.8)	
High (8-10)	159 (27.6)	116 (100.0)	275 (39.7)	
Gender				0.287
Male	244 (44.0)	55 (49.5)	299 (45.0)	
Female	310 (56.0)	56 (50.5)	366 (55.0)	

*Chi^2 test was used to measure significance; †Statistically significant difference between two policies ($p<0.05$).

Table A.7 Nutritional knowledge of beverages vs beverage intake

	Correct or incorrect responses when asked whether the drink is sugar sweetened		
	Incorrect/Don't know Count (%)	Correct Count (%)	P-value
Plain water			<0.001†
<Once/week	4 (0.6)	13 (1.9)	
1-4 times/week	11 (1.6)	19 (2.8)	
5+ times/week	19 (2.8)	602 (90.1)	
Plain milk			<0.001†
<Once/week	58 (7.9)	56 (8.3)	
1-4 times/week	70 (10.4)	120 (17.8)	
5+ times/week	53 (7.9)	323 (47.9)	
Fruit juice			<0.001†
<Once/week	12 (1.8)	392 (58.9)	
1-4 times/week	20 (3.0)	185 (27.8)	
5+ times/week	24 (3.6)	32 (4.8)	
Soft drink			<0.001†
<Once/week	5 (0.7)	460 (68.7)	
1-4 times/week	6 (0.9)	165 (24.6)	
5+ times/week	4 (0.6)	30 (4.5)	
Diet drink			0.202
<Once/week	28 (4.2)	575 (85.9)	
1-4 times/week	3 (0.4)	50 (7.5)	
5+ times/week	2 (0.3)	11 (1.6)	
Sports drink			0.781
<Once/week	32 (4.8)	590 (88.6)	
1-4 times/week	2 (0.3)	32 (4.8)	
5+ times/week	1 (0.2)	9 (1.4)	
Fruit smoothie			0.011†
<Once/week	51 (7.6)	483 (72.3)	
1-4 times/week	10 (1.5)	99 (14.8)	
5+ times/week	7 (1.0)	18 (2.7)	
Energy drink			0.019†
<Once/week	17 (2.5)	638 (95.4)	
1-4 times/week	0 (0.0)	10 (1.5)	
5+ times/week	1 (0.1)	3 (0.4)	
Flavoured milk			<0.001†
<Once/week	10 (1.5)	523 (77.5)	
1-4 times/week	7 (1.0)	94 (13.9)	
5+ times/week	11 (1.6)	30 (4.4)	
Meal drink			<0.001†
<Once/week	58 (8.6)	472 (70)	
1-4 times/week	33 (4.9)	79 (11.7)	
5+ times/week	19 (2.8)	13 (1.9)	

*Chi^2 test was used to measure significance; †Statistically significant difference between two policies ($p<0.05$).

Table A.8 Attitudes and SSB consumption

		Total Consumption of SSB	
		Mean (SD)	P-value*
Advertising – seen an ad for SSB recently	Agree	16.5 (2.0)	0.168
	Disagree	15.7 (3.5)	
	Don't know	15.8 (3.7)	
School encourages to drink healthy drinks	Not a lot	14.7 (2.4)	<0.001†
	Sometimes	15.3 (2.6)	
	A lot	16.2 (3.9)	
Parents encourage to drink heathy drinks	Not a lot	15.0 (3.6)	0.001†
	Sometimes	16.8 (4.4)	
	A lot	15.6 (3.2)	
How much do friends care about drinking healthy drinks	Not a lot	16.1 (3.7)	0.225
	Sometimes	15.7 (3.4)	
	A lot	16.3 (4.1)	

*Chi^2 test was used to measure significance; †Statistically significant difference between two policies ($p<0.05$).

Appendix B: Children information sheet used in 'children's bone study'

Children's Bone Study

Information Sheet for Children

We would like to invite you to take part in a study to find out the relationships between broken bones, the strength of your bones, food that is good for bone health, drink choices and preferences, exercise, sun exposure and how much muscle and fat you have.

About 600+ children around Auckland are going to take part in this study. In this study we will measure your height, waist, blood pressure, body composition, vitamin D levels, and bone density. Before you decide if you want to take part in this study, you will get to watch a video showing all the things that will happen. These same things are described below.

Height and waist measurement

We will ask you to remove your shoes so that we can measure your height. Standing height using a stadiometer, and waist circumference using a measuring tape will be measured for you.

Blood pressure

We will measure your blood pressure with automated blood pressure monitor. We will put a cuff around your arm and ask you to sit still and quiet while the cuff fills up with air and then goes down again.

BIA

You will take off your shoes and socks and stand on the machine's scale. Then grab two handles. The machine can then tell us how much you weigh, and how much of your body is muscle.

Quantitative Ultra Sound

We use this machine to measure the strength of your bones. You will bare one of your legs (no shoes or socks) and then put your heel into the machine for less than one minute. By measuring your heel bone, we will know how strong the rest of your bones are.

Finger prick blood spot

Also we need a drop of your blood in order to measure your vitamin D level. We will ask you to wash your hands with warm water. Then you will be asked to shake your hand and choose a finger for finger prick. Then we will prick the finger with a lancet and collect a full drop of blood. If you decide on the day that you don't want to do this, that is OK – just tell your teacher or one of the people doing the testing.

Questionnaire

Everyone in the class will also be asked to fill out a questionnaire about different sorts of drinks. We want to find out what you know about these drinks, and what you think about different sorts of drinks. There are no right or wrong answers, and you just need to put a tick in the boxes next to the questions. You can ask for help if you don't understand the questions, but make sure that the answers are what you think.

You do not have to take part in this study. You should only say yes if you want to. If you say yes now but change your mind later, you don't have to keep doing the study. No one will be cross with you if you don't want to do the study. You should talk to your family/whanau to help you decide. You can also ask us anything you want at any time.

If you want to take part in this study, and it is OK with your family, then please sign the consent form that your parent or caregiver has also signed. If you do not want to take part, you do not need to sign or fill out anything – just bring your envelope back to the teacher with your name, class number and school name on it.

Appendix C: Parent information sheet used in 'children's bone study'

MASSEY UNIVERSITY

The Children's Bone Study

INFORMATION SHEET FOR PARENTS

Thank you for your interest in the children's bone study. This sheet gives information on the conduct and organisation of this study, including confidentiality and data protection. It is important that you read this and are happy with the information given before agreeing to take part in the study.

Why is this research important?

Anecdotal evidence suggests that a greater number of primary school children are having more broken bones than their grandparents did. We want to find out the relationships between history of broken bones, bone mineral density, dietary intake of nutrients related to bone health, beverage choices and preferences, physical activity, sun exposure behaviours and body composition of children living in Auckland.

Who are we looking for?

We are inviting around 600+ children who are enrolled in Year 5 or 6 in Auckland primary schools and who do not have any gastrointestinal disorders or bone disease to take part in this study. Each child and at least one of the child's parents/guardians need to be able to read and comprehend English to a sufficient level that they can understand the information provided about the study and make an informed decision about whether or not they wish to participate.

What is going to happen?

Initially, the children will have a science lesson, facilitated by our specialist science teacher, on the topic of bone health. Classroom sessions will be arranged at times to suit teachers and teaching schedules, and will be designed to link with curriculum. All data collection from the children will take place in school. They will also bring home a short questionnaire about different types of drinks which the child must complete themselves. Further information will be sought from you, parents or caregivers, through two questionnaires, which your child will also bring home, along with a consent form.

One questionnaire will have questions about your child such as: Gender, date of birth, ethnicity, and information about any broken bones your child has had. Also history of sun exposure/sun protection practices, physical activity and type of sports your child plays. The

second questionnaire is a food frequency questionnaire to find out about your child's milk/dairy product consumption, other beverage choices, and other dietary sources of calcium. These questionnaires will take approximately twenty (20) minutes to complete. You will only need to complete these questionnaires once.

All data collection from the children will take place in school. The children will have measurements made to determine their body composition (level of muscle and fat), and a finger prick blood spot to measure vitamin D levels. We will also measure the bone density of their heel bone using the quantitative ultra sound (QUS), and their blood pressure.

All the children in the class will be shown a short video which will explain all the things that will happen during the study. Your child will have the opportunity to ask both his/her teacher and the specialist teacher who is part of the study team, any questions about the study.

If you and your child decide against participating in the study, your child will still be involved in all the classroom activities associated with the study. There is no obligation to be part of the study, but we do ask that your child returns the envelope with the form in it.

Height and waist measurement

We will ask your child to remove his/her shoes due to measuring his/her height. Standing height using a stadiometer, and waist circumference using a measuring tape will be measured for each child.

Blood pressure

We will measure your child blood pressure with automated blood pressure monitor.

BIA (above left)

BIA is a method for measuring body composition. This machine is used to tell us how much fat and muscle mass your child has on his/her body. This test will take only a few minutes and won't hurt at all. We will ask your child to remove her/his shoes and socks, Stand on the machine's scale. Then hold the two handles for a few seconds (as in the picture). A very tiny electrical current passes through the body, but you cannot feel anything.

Quantitative Ultra Sound (QUS – above right)
Quantitative ultrasound is a radiation-free technique for providing a proxy for bone mineral density by determining how rapidly sound travels through the bone. We will ask your child to bare one of his/her legs (no shoes or socks) and then put his/her heel into the machine for less than one minute.

Finger prick blood spot
We will ask children to wash their hands with warm water. Then they will asked to shake their hand and choose a finger for finger prick. Then we will prick the finger with a lancet and collect a full drop of blood.


Who will see the information about your child?
All information about your child will be stored in a locked filing cabinet accessed by the research team only. No names or any other information that could be used to identify your child will be used in any publication.

We are required to keep any data that may be medically relevant for your child in the future for ten years. All electronic data will be stored password-protected on the University's secure server. For the first 5 years we will store any paper copies of data in a locked filing cabinet within a locked office. For the remainder of the time, data will be stored in a secure archive in boxes labelled by barcode only. This data will be accessible by nominated staff only. After the mandatory storage time has passed, all data filed on paper will be shredded and electronic data will be deleted from our computer records and databases.

Would your child like to take part?
<u>If "YES"</u>
If your child would like to take part in this study and you are happy for them to do so, please sign the attached consent form and ask your child to return it to their teacher.

<u>If "NO"</u>
If you do not want your child to participate or your child does not want to take part in this study then you do not need to complete or sign anything, just send the envelope full of forms back to class with your child. Your child will still take part in the special science lesson, but we will not collect any data from, or about, your child.

What are the benefits and risks of taking part in this study?

- You will receive a brief report summarising the main findings of the project via mail or email.
- The principal benefit of taking part in this study is that you will contribute to a study and our understanding of bone mineral density, dietary intake of nutrients related to bone health, beverage choices and preferences, physical activity, sun exposure behaviours and body composition of children.
- It is not envisaged that there will be any discomforts or risks to the participants as a result of participation, other than the minor discomfort of the finger prick blood test.
- If you have any specific requirements including cultural requirements or concerns about the project, or about being a participant, please contact a member of the research team to discuss.

Who is funding the research?

This is funded by a grant from the Massey University Research Fund.

What are my rights and the rights of my child?

We respect your rights and your child's rights to:

- refuse to answer any particular question or take part in any testing (finger prick blood spot, QUS or BIA)
- withdraw from the study at any time
- ask further questions about the study that occur to you during your participation
- provide information on the understanding that it is completely confidential to the researchers. All information is collected confidentially, and it will not be possible to identify you or your child in any reports that are prepared from the study
- be given access to a summary of the findings from the study when it is concluded.

Compensation for Injury

In the unlikely event that physical injury results from your child's participation in this study, you should visit a treatment provider to make a claim to ACC as soon as possible. ACC cover and entitlements are not automatic and your claim will be assessed by ACC in accordance with the Compensation Act 2001. If your claim is accepted, ACC must inform you of your entitlements, and must help you access those entitlements. Entitlements may include, but not be limited to, treatment costs, travel costs for rehabilitation, loss of earnings, and/or lump sum for permanent impairment. Compensation for mental trauma may also be included, but only if this is incurred as a result of physical injury.

If your ACC claim is not accepted you should immediately contact the researcher. The researcher will initiate processes to ensure you receive compensation equivalent to that to which you would have been entitled had ACC accepted your claim from Massey University.

If you have any questions please contact Dr Pamela von Hurst who will be happy to discuss the project in more detail.

Contact details:

Dr Pamela von Hurst
School of Food and Nutrition, College of Health
Massey University
Email P.R.vonHurst@massey.ac.nz
Phone (09) 213 6657

This project has been reviewed and approved by the Massey University Human Ethics Committee: Southern A, Application 16/42 If you have any concerns about the conduct of this research, please contact Mr Jeremy Hubbard, Chairperson, Massey University Human Ethics Committee: Southern A, telephone 64 9 414 0800 x 63487. email humanethicsoutha@massey.ac.nz.

Appendix D: Food frequency questionnaire used in 'children's bone study'

Children's Bone Study
Food frequency Questionnaire

Complete this questionnaire with help from your Mum, Dad or other family member.
Put a tick ☑ in the box which best tells HOW OFTEN you eat the food or drinks listed below

1. Milk (not flavoured) – one glass serving size

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day

2. What kind of milk do you usually drink? Place a ☑ in the box

Standard milk (dark blue)	Trim (green)	Mega Milk (orange)
Low Fat (light blue)	Extra calcium (yellow)	Other milk (please name below)

3. Flavoured milk – one glass serving size

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day

4. Milk shake or milk drink eg Up and Go

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day

5. Yoghurt or dairy food dessert – one pot or one cup serving size

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day

6. Ice cream – one cup serving size

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day

7. Fruit Smoothie eg Simply Squeezed, Meadow Fresh Yoghurt Smoothie

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day

8. Fruit Smoothie eg Simply Squeezed, Meadow Fresh Yoghurt Smoothie

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day

9. Flavoured milk drink made from powder eg Milo, Nesquik, hot chocolate

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day

9a. With flavoured milk drinks made from powder eg Milo, Nesquik or hot chocolate, do you you use?

All milk	½ milk	1/4 or less milk

9b. With flavoured milk drinks made from powder eg Milo, Nesquik or hot chocolate, do you add sugar?

Yes	No	Not applicable

10. Cottage cheese – half a cup serving size

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day

11. Broccoli – half a cup serving size

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day

12. Tofu – half a cup serving size

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day

13. Bread – two slices serving size

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day

14. Juice eg fresh orange juice, juices such as McCoys, Robinsons, Keri

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day

15. Powdered fruit drink eg Refresh, Raro

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day

16. Fruit drink from concentrate or cordial eg Just Juice, Ribena

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day

17. Standard soft drinks or other fizzy drinks eg Coke, Lemonade, Fanta, Mountain Dew

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day

18. Soda stream

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day

19. Diet drinks / Artificially sweetened drinks eg Diet Coke, Coke Zero

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day

20. Energy drinks eg V, Red Bull, Monster, Demon

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day

21. Sports drinks eg Gatorade, Powerade, E2

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day

22. Plain Water including tap water or bottled water like Pump, H2go, Water for Everyone water

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day

23. Flavoured water / Vitamin Water like Mizone, H2go Zero water, Zero (flavoured) Water, Coconut water, Mizone, Loaded water

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day

24. Tea

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day

24a. If you drink tea, do you add milk?

Yes	No	Not applicable

24b. If you drink tea, do you add sugar?

Yes	No	Not applicable

25. Coffee

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day

25a. If you drink coffee, do you add milk?

Yes	No	Not applicable

25b. If you drink coffee, do you add sugar?

Yes	No	Not applicable

26. "Other drinks" group. If you often have another drink that is not listed, give the name and tick how often you have it.
Drink _____

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day

During the last 7 days, how often did you drink any of the following?

	None in last 7 days	1-3 times a week	4-5 times a week	Once a day	2 or more times a day
27. Milk, plain/unflavoured					
28. Chocolate milk or other flavoured milk					
29. Standard soft drinks or other fizzy drinks (eg Coke, Sprite, Fanta)					
30. Diet drinks / Artificially sweetened drinks eg Diet Coke, Coke Zero					
31. Juice eg fresh orange juice, juices such as McCoys, Robinsons, Keri					

32. Fruit drinks (Ribena, Raro, Just juice, etc - not 100% juice)					
33. Fruit drink from concentrate or cordial eg Just Juice, Ribena					
34. Tap water					
35. Plain bottled water eg Pump, H2go					
36. Flavoured water					

During the last 7 days, did you get a drink from any of these places?

	None in last 7 days	1-3 times a week	4-5 times a week	Once a day	2 or more times a day
37. A fast food place (eg McDonalds, KFC, Burger King, Subway, Pizza Hut)					
38. Other takeaways or fast-food shops (fish & chips, Chinese takeaways)					
39. Dairy or petrol stations					
40. Supermarket					

41. Somewhere else					

42. If you answered yes above, when did you get the drink?

Before school	After school	In the evening
In the weekend	Other (please list)	

43. Were you?

Alone	With friends	With parents or family
With brother or sister	With other caregiver	Other (please list below)

How often are the following available to eat or drink at home ?

	Never	Sometimes	Usually	Always
44. Milk				
45. Flavoured milk				
46. Food milk drinks eg Milo, Nesquk, Up and Smoothies (purchased)				
47. Smoothie (made at home)				

48. Fizzy drinks or soft drinks eg Coke, Lemonade				
49. Artificially sweetened or diet drinks eg Diet Coke, Coke Zero				
50. Soda stream drink made at home				
51. Fruit juice eg McCoys, Robinsons, Keri				
52. Fruit drink eg Just Juice, Ribena				
53. Fruit cordial eg Raro, Refresh				

Appendix E: Knowledge and attitudes questionnaire used in 'children's bone study'

What do you think about drinks?

Some drinks are better for you and are okay to drink everyday while some should be had less often, on special occasions or not at all.

Can you identify which category each drink would be in?
Put a tick ☑ in the box you think fits best.

There are no right or wrong answers – we just want to know what you think, so please give the answer that best explains what <u>you</u> think, not what others think

	Drink everyday or most days	Drink sometimes	Drink on special occasions	Not at all	Don't know
1. Fruit juice or fruit drinks 					
2. Fizzy drinks eg Coke, Sprite, Fanta 					
3. Tea or coffee 					

	Drink everyday or most days	Drink sometimes	Drink on special occasions	Not at all	Don't know
4. Artificially sweetened / Diet fizzy drinks eg Diet Coke, Coke Zero 					
5. Water (bottled or tap) 					
6. Sports drinks / sports waters / flavoured waters 					
7. Plain milk / soy milk / almond milk 					

	Drink everyday or most days	Drink sometimes	Drink on special occasions	Not at all	Don't know
8. Fruit Smoothies 					
9. Energy drinks 					
10. Flavoured milk 					
11. Flavoured milk drinks eg Milo, Nesquik, Up & Go  					

12. Put the following drinks in order with number 1 being the most healthy and number 5 being the least healthy

Some drinks have sugar added to make them sweet, whilst some drinks are naturally sweet or have no sugar added. Can you identify what category each drink would be in? Put a tick ☑ in the box you think fits best.

	Sugar sweetened drink. Has sugar added	Naturally sweet drinks	Non-sweetened drink. No sugar added	Don't know
13. Fruit juice or fruit drink 				
14. Fizzy drinks eg Coke, Sprite, Fanta 				

	Sugar sweetened drink. Has sugar added	Naturally sweet drinks	Non-sweetened drink. No sugar added	Don't know
15. Artificially sweetened / Diet fizzy drinks eg Diet Coke, Coke Zero 				
16. Fruit Smoothies from a shop 				
17. Sports drinks / sports waters / flavoured waters 				

	Sugar sweetened drink. Has sugar added	Naturally sweet drinks	Non-sweetened drink. No sugar added	Don't know
18. Plain milk 				
19. Meal drinks eg Milo, Nesquik, Up & Go  				
20. Energy drinks  				

	Sugar sweetened drink. Has sugar added	Naturally sweet drinks	Non-sweetened drink. No sugar added	Don't know
21. Flavoured milk 				

Think back to when you last chose a drink when out. What are the main reasons you chose it? You can tick ☑ up to 3 answers. One or two answers are ok if there are only one or two reasons from the list below.

22. To satisfy thirst	
23. Better than snack food	
24. It's what I'm allowed at home or school	
25. It's what my friends chose	
26. It was on special or the most affordable	
27. It's better for me	
28. It tastes the best	

29. How many sugary drinks do you think are healthy to drink in one week?

Please tick ☑

0	1-2	3-4	5-7	8-14	15+

30. How much do you care about drinking healthy drinks? Please tick ☑

Not a lot	Sometimes	A lot

31. How much do your friends care about drinking healthy drinks? Please tick ☑

Not a lot	Sometimes	A lot

32. Are you encouraged to drink healthy drinks at home? Please tick ☑

Not a lot	Sometimes	A lot

33. How much does your school encourage you to drink healthy drinks? Please tick ☑

Not a lot	Sometimes	A lot

Tick ☑ whether you agree, disagree or don't know with the following statements

34. Drinking a sugar-sweetened drink increases my energy intake

Disagree	Agree	Don't know

35. I feel full after drinking a sugar-sweetened drink

Disagree	Agree	Don’t know

36. I’ve seen an ad for sugar-sweetened drinks on tv or on a sign recently

Disagree	Agree	Don’t know

Thank you very much for filling out this questionnaire.

Please check that you have answered all questions.

Have a great day! ☺

Appendix F: Demographics questionnaire used in 'children's bone study'

Date.....

The Children's Bone Study

This questionnaire asks about your child's demographic details, fracture history, sun exposure, and physical activity levels

To be completed by parent or guardian

Thank you for participating in this study, if you have any questions please feel free to discuss them with the researcher.

Principal Investigator:

Dr Pamela von Hurst, School of Food and Nutrition, Massey University

Email: p.r.vonhurst@massey.ac.nz

All information you provide will remain strictly confidential

Participant Demographics

First Name of your child

Family Name of your child

Date of birth of your child

Address

Phone (home)

Phone (mobile)

Email

Which ethnic group or groups does your child belong to? (Please √ all that apply)

New Zealand European	□
Maori	□
Pacific	□ Please specify _____
South Asian	□
Chinese	□
Korean	□
Southeast Asian	□ Please specify _____
Other ethnicity	□ Please specify _____

How would you describe your child skin colour? (Please √ one)

☐	Fair	Easily burns in the sun, doesn't tan
☐	Medium	Can burn, but tans after some sun exposure
☐	Olive	Rarely gets sunburnt, becomes quite tanned in summer
☐	Brown	Light to medium brown, very rarely gets sunburnt
☐	Dark	Very dark brown, never gets sunburnt

Is your child taking any medication or supplements? Please list

---

Does your child have any chronic illness (for example, asthma) or food allergy? Please list

---

Participant fracture history

Has your child ever been diagnosed with any bone fracture (broken bone)?

□ Yes (Please put the details in the table)

□ No (go to next page)

Which bone For instance: upper right arm, lower left leg	Age when it happened	How did it happen For instance: Fell out of a tree, fell off skateboard, was doing a cartwheel
1.		
2.		
3.		
4.		
5.		
6.		

Does your child have brothers and/or sisters who have also had a bone fracture?

□ Yes □ No or □ No siblings

If yes, please note the details below:

Gender of sibling:..... Age when fractured:

Location of fracture .....

A large part of how strong our bones are is determined by our genes. Therefore, family history provides important information about the health of your child's bones.

Do any other family members have a history of broken bones or osteoporosis?

If so, please provide details over the page of relationship to child, the type of problem and approximate age when it occurred/emerged.

Sun light exposure

How many hours each day does your child usually spend outside in summer?

During school time.....

During weekends and holidays .....

Which part of his/her body is usually exposed to the sunlight?

□ Only face
□ Only arms
□ Face and arms
□ Only legs
□ Arms and legs
□ Face, arms, and legs

Does he/she use sunscreen cream?

□ Yes - all year round □ Yes - only in summer
□ No (go to next page)

If "Yes" how often does he/she use it?

□ Always
□ Some times
□ Rarely
□ Never

To which part of his/her body does he/she apply sunscreen?

□ Only face
□ Only arms
□ Face and arms
□ Only legs
□ Arms and legs
□ Face, arms, and legs

Physical Activity Levels

Does your child walk to school?

□ Yes - approximately how far, or how long does the walk take?
……

□ No

Does your child play sport or some other kind of physical activity like dance?

□ Yes

□ No

What kind of activity?

How many times each week does he/she do this activity?

How many hours is he/she active for each time?

Anything else you would like to tell us about your child?

Appendix G: *Nutrients* journal requirements

For more information refer to: https://www.mdpi.com/journal/nutrients/instructions

Manuscript Submission Overview

Types of Publications

Nutrients has no restrictions on the length of manuscripts, provided that the text is concise and comprehensive. Full experimental details must be provided so that the results can be reproduced. *Nutrients* requires that authors publish all experimental controls and make full datasets available where possible (see the guidelines on Supplementary Materials and references to unpublished data).

Manuscripts submitted to *Nutrients* should neither been published before nor be under consideration for publication in another journal. The main article types are as follows:

- *Articles:* Original research manuscripts. The journal considers all original research manuscripts provided that the work reports scientifically sound experiments and provides a substantial amount of new information. Authors should not unnecessarily divide their work into several related manuscripts, although Short *Communications* of preliminary, but significant, results will be considered. Quality and impact of the study will be considered during peer review.
- *Reviews:* These provide concise and precise updates on the latest progress made in a given area of research. Systematic reviews should follow the PRISMA guidelines.
- *Case reports:* Case reports present detailed information on the symptoms, signs, diagnosis, treatment (including all types of interventions), and outcomes of an individual patient. Case reports usually describe new or uncommon conditions that serve to enhance medical care or highlight diagnostic approaches.

Manuscript Preparation

General Considerations

- **Research manuscripts** should comprise:
    - Front matter: Title, Author list, Affiliations, Abstract, Keywords
    - Research manuscript sections: Introduction, Materials and Methods, Results, Discussion, Conclusions (optional).
    - Back matter: Supplementary Materials, Acknowledgments, Author Contributions, Conflicts of Interest, References.
- **Review manuscripts** should comprise the front matter, literature review sections and the back matter. The template file can also be used to prepare the front and back matter of your review manuscript. It is not necessary to follow the remaining structure. Structured reviews and meta-analyses should use the same structure as research articles and ensure they conform to the PRISMA guidelines.

- **Case reports** should include a succinct introduction about the general medical condition or relevant symptoms that will be discussed in the case report; the case presentation including all of the relevant de-identified demographic and descriptive information about the patient(s), and a description of the symptoms, diagnosis, treatment, and outcome; a discussion providing context and any necessary explanation of specific treatment decisions; a conclusion briefly outlining the take-home message and the lessons learned.
- **Graphical abstract:** Authors are encouraged to provide a graphical abstract as a self-explanatory image to appear alongside with the text abstract in the Table of Contents. Figures should be a high quality image in any common image format. Note that images displayed online will be up to 11 by 9 cm on screen and the figure should be clear at this size.
- **Abbreviations** should be defined in parentheses the first time they appear in the abstract, main text, and in figure or table captions and used consistently thereafter.
- **SI Units** (International System of Units) should be used. Imperial, US customary and other units should be converted to SI units whenever possible
- **Accession numbers** of RNA, DNA and protein sequences used in the manuscript should be provided in the Materials and Methods section. Also see the section on Deposition of Sequences and of Expression Data.
- **Equations:** If you are using Word, please use either the Microsoft Equation Editor or the MathType add-on. Equations should be editable by the editorial office and not appear in a picture format.
- **Research Data and supplementary materials:** Note that publication of your manuscript implies that you must make all materials, data, and protocols associated with the publication available to readers. Disclose at the submission stage any restrictions on the availability of materials or information. Read the information about Supplementary Materials and Data Deposit for additional guidelines.
- **Preregistration:** Where authors have preregistered studies or analysis plans, links to the preregistration must be provided in the manuscript.
- **Guidelines and standards:** MDPI follows standards and guidelines for certain types of research. See https://www.mdpi.com/editorial_process for further information.

Front Matter

These sections should appear in all manuscript types

- **Title:** The title of your manuscript should be concise, specific and relevant. It should identify if the study reports (human or animal) trial data, or is a systematic review, meta-analysis or replication study. When gene or protein names are included, the abbreviated name rather than full name should be used.
- **Author List and Affiliations:** Authors' full first and last names must be provided. The initials of any middle names can be added. The PubMed/MEDLINE standard format is used for affiliations: complete address information including city, zip code, state/province, country, and all email addresses. At least one author should be designated as corresponding author, and his or her email address and other details

should be included at the end of the affiliation section. Please read the criteria to qualify for authorship.

- **Abstract:** The abstract should be a total of about 200 words maximum. The abstract should be a single paragraph and should follow the style of structured abstracts, but without headings: 1) Background: Place the question addressed in a broad context and highlight the purpose of the study; 2) Methods: Describe briefly the main methods or treatments applied. Include any relevant preregistration numbers, and species and strains of any animals used. 3) Results: Summarize the article's main findings; and 4) Conclusion: Indicate the main conclusions or interpretations. The abstract should be an objective representation of the article: it must not contain results which are not presented and substantiated in the main text and should not exaggerate the main conclusions.
- **Keywords:** Three to ten pertinent keywords need to be added after the abstract. We recommend that the keywords are specific to the article, yet reasonably common within the subject discipline.

Research Manuscript Sections

- **Introduction:** The introduction should briefly place the study in a broad context and highlight why it is important. It should define the purpose of the work and its significance, including specific hypotheses being tested. The current state of the research field should be reviewed carefully and key publications cited. Please highlight controversial and diverging hypotheses when necessary. Finally, briefly mention the main aim of the work and highlight the main conclusions. Keep the introduction comprehensible to scientists working outside the topic of the paper.
- **Materials and Methods:** They should be described with sufficient detail to allow others to replicate and build on published results. New methods and protocols should be described in detail while well-established methods can be briefly described and appropriately cited. Give the name and version of any software used and make clear whether computer code used is available. Include any pre-registration codes.
- **Results:** Provide a concise and precise description of the experimental results, their interpretation as well as the experimental conclusions that can be drawn.
- **Discussion:** Authors should discuss the results and how they can be interpreted in perspective of previous studies and of the working hypotheses. The findings and their implications should be discussed in the broadest context possible and limitations of the work highlighted. Future research directions may also be mentioned. This section may be combined with Results.
- **Conclusions:** This section is not mandatory, but can be added to the manuscript if the discussion is unusually long or complex.
- **Patents:** This section is not mandatory, but may be added if there are patents resulting from the work reported in this manuscript.

Back Matter

- **Supplementary Materials:** Describe any supplementary material published online alongside the manuscript (figure, tables, video, spreadsheets, etc.). Please indicate the name and title of each element as follows Figure S1: title, Table S1: title, etc.
- **Acknowledgments:** All sources of funding of the study should be disclosed. Clearly indicate grants that you have received in support of your research work and if you received funds to cover publication costs. Note that some funders will not refund article processing charges (APC) if the funder and grant number are not clearly and correctly identified in the paper. Funding information can be entered separately into the submission system by the authors during submission of their manuscript. Such funding information, if available, will be deposited to FundRef if the manuscript is finally published.
- **Author Contributions:** Each author is expected to have made substantial contributions to the conception or design of the work; or the acquisition, analysis, or interpretation of data; or the creation of new software used in the work; or have drafted the work or substantively revised it; AND has approved the submitted version (and version substantially edited by journal staff that involves the author's contribution to the study); AND agrees to be personally accountable for the author's own contributions and for ensuring that questions related to the accuracy or integrity of any part of the work, even ones in which the author was not personally involved, are appropriately investigated, resolved, and documented in the literature.
  For research articles with several authors, a short paragraph specifying their individual contributions must be provided. The following statements should be used "Conceptualization, X.X. and Y.Y.; Methodology, X.X.; Software, X.X.; Validation, X.X., Y.Y. and Z.Z.; Formal Analysis, X.X.; Investigation, X.X.; Resources, X.X.; Data Curation, X.X.; Writing – Original Draft Preparation, X.X.; Writing – Review & Editing, X.X.; Visualization, X.X.; Supervision, X.X.; Project Administration, X.X.; Funding Acquisition, Y.Y.", please turn to the CRediT taxonomy for the term explanation. For more background on CRediT, see here. "**Authorship must include and be limited to those who have contributed substantially to the work. Please read the section concerning the criteria to qualify for authorship carefully**".
- **Conflicts of Interest:** Authors must identify and declare any personal circumstances or interest that may be perceived as inappropriately influencing the representation or interpretation of reported research results. If there is no conflict of interest, please state "The authors declare no conflict of interest." Any role of the funding sponsors in the choice of research project; design of the study; in the collection, analyses or interpretation of data; in the writing of the manuscript; or in the decision to publish the results must be declared in this section. *Nutrients* does not publish studies funded by the tobacco industry. Any projects funded by pharmaceutical or food industries must pay special attention to the full declaration of funder involvement. If there is no role, please state "The sponsors had no role in the design, execution, interpretation, or writing of the study".
- **References:** References must be numbered in order of appearance in the text (including table captions and figure legends) and listed individually at the end of the manuscript. We recommend preparing the references with a bibliography software package, such as EndNote, ReferenceManager or Zotero to avoid typing mistakes

and duplicated references. We encourage citations to data, computer code and other citable research material. If available online, you may use reference style 9. below.

- Citations and References in Supplementary files are permitted provided that they also appear in the main text and in the reference list.

In the text, reference numbers should be placed in square brackets [ ], and placed before the punctuation; for example [1], [1–3] or [1,3]. For embedded citations in the text with pagination, use both parentheses and brackets to indicate the reference number and page numbers; for example [5] (p. 10). or [6] (pp. 101–105).