Sugar Intake of Young Children in New Zealand

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Abstract

Background: Sugar intake has been linked to noncommunicable diseases such as overweight, obesity, type 2 diabetes, and dental caries in children. In New Zealand, the prevalence of child obesity is increasing, especially amongst Māori and Pasifika, and dental caries are reported in young children. Demographic characteristics and feeding practices have been linked to poor nutrition choices, including a high intake of sugar. There is currently a gap in our knowledge about the dietary intake of sugar in young New Zealand children.

Objectives: To describe total sugar intake and describe differences in total sugar intake based on anthropometry, demographic characteristics and feeding practices in New Zealand 1-3.9-year-olds.

Methods: Data from the Young Foods New Zealand study (YFNZ) were used. The current study was a cross-sectional study of young New Zealand children (n=289) aged 1-3.9 years living in Auckland, Wellington, and Dunedin. Two non-consecutive 24-hour diet recalls were administered to parents/caregivers using the triple pass method, and analysed for intake of total sugar, energy, carbohydrate, protein, fat, and fibre. Length, height was measured using a portable stadiometer for children and weight using adult weight scales. BMI z-score was calculated using World Health Organization reference data. Demographic (age, sex, ethnicity, deprivation, parental education), feeding method and food pouch use were measured using a questionnaire. Independent sample t-tests determined the differences in total sugar intake between age and sex. Analysis of Covariance Tests (ANCOVA) tests determined the differences in total sugar intake between BMI z-score classification, feeding method, and demographics.

Results: Mean (SD) total sugar intake was 67.3 (15.1) g/day which contributed 22.9 (4.4) % of total energy. Toddlers (n=108) consumed a mean total sugar intake of 65.2 (16.9) g/day which contributed 23.7 (5.1) % of total energy and pre-schoolers (n=181) consumed 68.5 (13.9) g/day which contributed 22.4 (3.8) % of total energy. Boys (n=142) consumed a mean total sugar intake of 67.8 (15.3) g/day which contributed 22.7 (4.4) % of total energy and girls (n=147) consumed 66.8 (15.0) g/day which contributed 23.1 (4.4) % of total energy. Total sugar intake (g/day) varied by BMI z-score category (p=0.004), but not % of total energy (p=0.14). Children who were obese (n=31) had a higher intake of total sugar (g/day) than normal or underweight children (n=148), 75.4 (17.3) vs 65.6 (14.9) respectively, (p=0.006), and overweight children (n=70), 69.4 (14.8), but not significantly (p=0.19).

European children (n=125) consumed 66.3 (12.7) g which contributed 22.7 (3.7) % of total energy per day. Māori children (n=75) consumed 69.7 (17.7) g/day which contributed 24.1 (5.2) % of total energy. Pasifika children (n=47) consumed 67.8 (16.0) g/day which contributed 22.4 (4.7) % of total energy. Asian/other children (n=42) consumed 65.3 (15.8) g/day which contributed 21.9 (4.0) % of total energy. Total sugar intake in g/day and % of total energy did not vary by ethnicity (p=0.25) and (p=0.07), deprivation score (p=0.57) and (p=0.25), parental education (p=0.94) and (p=0.55) or feeding method (p=0.63) and (p=0.9), respectively. Total sugar intake (g/day) varies by the number of pouches consumed (p=0.01). Children who consumed 7-14 pouches per week (n=25) had a higher total sugar intake (g/day) compared to children who consumed 1-6 pouches (n=112), 74.7 (19.6) vs 65.3 (14.3) g/day, respectively (p=0.011), but not significantly higher than children who consumed none (n=150) 67.3 (14.2) g/day, (p=0.052). % of total energy from total sugar intake varied by the number of pouches consumed (p<0.001). Children who consumed 7-14 pouches had a higher total sugar intake (% E) than children who consumed none 26.1 (5.2) vs 22.1 (4.1), respectively (p<0.001), and children who consumed 1-6 pouches 23.1 (4.1), (p=0.004).

Conclusion: In this cohort of young New Zealand children, total sugar intake contributed 22.9% to daily energy intake. Total sugar intake was higher in children classified as obese compared with children who were normal or underweight. Total sugar intake in g/day and % of total energy from total sugar was higher in children who consumed seven or more pouches per week compared with children who consumed less than seven. There were no differences in total sugar intake according to ethnicity, deprivation, parental education or feeding method.

Key words: total sugar, dietary intake, young children

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Table of Contents

List of Tables

List of Figures

List of Abbreviations

Abbreviation or Symbol	Definition
AI	Adequate intake
AMDR	Acceptable micronutrient distribution range
BLW	Baby-led weaning
BMI	Body Mass Index
BMR	Basal metabolic rate
DP	Degree of polymerisation
EAR	Estimated average requirement
ECCs	Early childhood caries
EER	Estimated energy requirement
HSR	Health star rating
kJ	Kilojoule
MJ	Megajoule
MoH	Ministry of Health
NCDs	Noncommunicable diseases
NZ	New Zealand
PAL	Physical activity level
RDI	Recommended daily intake
SSBs	Sugar-sweetened beverages
% E	Percentage of total energy intake
WHO	World Health Organization
g	Grams
g/day	Grams per day
≥	Greater than or equal to
≤	Less than or equal to
<	Less than
>	Greater than

Chapter 1. Introduction

1.1 Background

Good nutrition is critical to optimise the growth, development, and nutritional status of a young child (Dewey, 2003). A growing child requires dietary energy for tissue synthesis (Ministry of Health, 2015; Alles et al., 2014), however, many foods that children consume are high in energy which may contribute to excess energy intake. Sugar in the diet is a source of energy and has been linked to adiposity and dental caries (Te Morenga et al., 2013; Fidler Mis et al., 2017). What is unknown is how much sugar young children living in New Zealand are eating.

Worldwide obesity has nearly tripled between 1975 and 2016, with an estimated 39 million children under the age of five being classified as overweight or obese in 2020 (World Health Organization, 2021). The New Zealand Health Survey 2020/21 found that 1 in 8 children aged 2-14 years were obese (Ministry of Health, 2021b). Obesity increases the risk of noncommunicable diseases (NCDs) such as insulin resistance, metabolic syndrome, cardiovascular disease, and type 2 diabetes which are now showing in childhood (Daniels, 2009; Anderson et al., 2016). More data is needed to understand the impact of sugar intake on obesity in children.

A high frequency of sugar intake is a significant factor in the development of dental caries (Newens and Walton, 2016). Early childhood caries affects the growth, development and quality of life of many preschool children (Ministry of Health, 2008), and predisposes a child to develop adult caries (Casamassimo et al., 2009). Dental caries have an impact on quality of life including pain, irritability and disturbed sleeping patterns (Sheiham, 2006). Sucrose a common added sugar, has been shown to contribute to dental caries (Bach and Manton, 2014). Data from the New Zealand National Children's Nutrition Survey from 2002 shows sucrose consumption is mostly from beverages (26%), sugar and sweets (21%), and cakes and muffins (7%) (Ministry of Health, 2003), which all contain high amounts of sugar.

Carbohydrates are an important source of energy and nutrients for young children (National Health and Medical Research Council and Ministry of Health, 2006b). Food and nutrition guidelines recommend a varied diet by including foods from each of the food groups: (a) vegetables, (b) fruit, (c) grain foods, (d), legumes, nuts, seeds, fish, seafood, eggs, poultry, or lean red meat, and (e) milk and milk products (Ministry of Health, 2021a; Ministry of Health, 2015). Many of these foods contain carbohydrates including cereals and grains, fruits, vegetables, and dairy. However, some of the food choices being made within these

groups are processed foods which contain added sugar which may contribute to excess sugar intake. These food choices include sweetened cereals, muesli and snack bars and sweetened yoghurt. The WHO recommends that children consume no more than 10% of their total dietary energy intake as free sugars, with 5% associated with better health outcomes (World Health Organization, 2015). The WHO and New Zealand's (NZ) Ministry of Health currently do not have recommendations specific to total sugar intake.

Ethnicity, low income and parental education are predictors of sugar intake (Kranz and Siega-Riz, 2002). The National Children's Nutrition Survey 2002 reported that Pacific children had a lower total sugar intake than New Zealand European/Other (NZEO) and Māori (Ministry of Health, 2003). Whereas Jamieson and Koopu (2007), reported Māori and Pacific children consumed a chocolate bar or soda more frequently than NZEO children. Additionally, a higher proportion of Pacific children added sugar to Milo. There is no data reporting the amount or sources of total sugar intake in the toddler and pre-school age group.

High deprivation and food insecurity has been linked to poor nutrition choices in young New Zealanders (Utter, 2020; Gerritsen, 2019; Gerritsen et al., 2020). The Ministry of Health (2019), found almost one in five 2–4-year-olds in severely to moderately food-insecure households consumed fizzy drink at least three times per week compared to less than one in ten in fully to mostly secure households. Results of the National Children's Nutrition Survey 2002 found no difference in total sugar intake by NZDep2001 (Ministry of Health, 2003). However, this data is outdated, and up-to-date national data is required.

It has been suggested that education is the strongest predictor of health behaviours (Ball et al., 2008). There is no data exploring the association between parental education and sugar intake in young New Zealand children. However, in the United States of America, a lower education has been linked to the introduction of added sugar before the age of 24 months (Bably et al., 2021). In contrast, Northstone et al. (2002), from England reported mothers with a university qualification were more likely to give their toddler fruit juice.

Baby-led weaning (BLW) is an alternative feeding method from six months of age where an infant feeds themselves (D'Auria et al., 2018). At this time, infants consume finger foods (Williams Erickson et al., 2018). Concerns have been raised that these finger foods may be high in sugar as they are often family foods (Daniels et al., 2015). Additionally, infants may self-select foods higher in sugar (Langley-Evans, 2022). A topic of interest is whether this method of feeding results in a difference in food and nutrient intake in children compared to

children who are traditionally spoon fed (Williams Erickson et al., 2018). There are few studies that have investigated the association between baby-led weaning and the amount or sources of total sugar internationally or in NZ (Langley-Evans, 2022; Williams Erickson et al., 2018).

In recent years, the market for food pouches for young children has increased globally due to the convenience they offer (Westland and Crawley, 2018). In NZ, food pouches are marketed for children from the age of 4- to 18-months and over (Katiforis et al., 2021). Many of the products marketed for infants are likely to be consumed by older children (Westland and Crawley, 2018). Commercial food pouches containing ready-to-eat purées contain more total sugar than other commercial infant foods (Katiforis et al., 2021; Koletzko et al., 2019; Hutchinson et al., 2021). This is due to ingredients being mainly fruit or sweet vegetables such as apple, pear, carrot, and sweet potato (Katiforis et al., 2021; Garcia et al., 2016; Moumin et al., 2020). Pouches can be sucked or squeezed directly into a child's mouth (Koletzko et al., 2019; Koletzko et al., 2018; Katiforis et al., 2021; Westland and Crawley, 2018), which has been linked to excess energy intake (Koletzko et al., 2019; Koletzko et al., 2018; Katiforis et al., 2021). Furthermore, it has been suggested that sucking a purée may contribute to dental caries (Koletzko et al., 2018; Koletzko et al., 2019; Westland and Crawley, 2018). One study measured the frequency of pouch consumption (Lundkvist et al., 2021), and there are no studies that measure the association between commercial infant pouch consumption and total sugar intake.

Given the growing prevalence of obesity, it is particularly important to investigate the dietary intake of sugar in young children. At present, data on the consumption of total sugars in NZ children aged between 1 and 3.9 years old is lacking. The 2002 National Children's Nutrition Survey collected data on the quantity of total sugars consumed, but it only included children aged 5 to 14 years of age. Furthermore, these data are more than 20 years old. Recently, the New Zealand Health Survey 2020/21 reported on fizzy drink intake of children aged 2 years and older but did not investigate total sugar intake. It is also important to gain an understanding of total sugar intake and its associations with body weight, demographic characteristics and feeding practices.

1.2 Purpose of the Study

The purpose of this study is to measure how much total sugar New Zealand children aged 1-3.9 years are consuming.

1.3 Aim

To investigate total sugar intake of children aged 1- to 3.9-years old living in New Zealand

1.3.1 Objectives

- To describe total sugar intake of New Zealand 1- to 3.9-year-olds
- To describe the differences in total sugar intake according to BMI z-score classifications
- To describe the differences in total sugar intake according to demographic characteristics and feeding practices

1.4 Thesis Structure

This thesis is divided into four chapters. Chapter One is an introduction to the background and purpose of the study. It includes the aim, objectives, and researcher's contributions. Chapter Two is a literature review of the most up-to-date and relevant research in the field of sugar intake of young children including sugar definitions, international and New Zealand nutrition recommendations, health consequences of excess sugar intake, international and New Zealand data on dietary intake of total sugar, demographic factors associated with sugar intake and feeding practices such as baby-led weaning and the consumption of food pouches. Chapter Three is the research manuscript which includes the abstract, introduction, methods, results and discussion of findings. The final chapter, Chapter Four is the concluding chapter that states how the aim and objectives have been met, discusses the strengths and limitations, provides a final conclusion and recommendations for future research. The appendices include relevant supporting documents such as the questionnaires used in the research.

1.5 Researchers' Contributions

Table 1.1 Summary of Researchers' Contributions

Author	Contribution to Thesis
Jayshree Bhula MSc Nutrition and Dietetic student and primary researcher	Reviewed the literature, performed the statistical analysis and interpretation of the data, formulation of the results and main author of the thesis.
Professor Cath Conlon Primary academic supervisor	Assisted with ethical approval of prior research study, involved in the development and research design, assisted with statistical analysis and supervised with progression of the research process, reviewed the final thesis.
Associate Professor Kathryn Beck Academic co-supervisor	Assisted with ethical approval of prior research study, involved in the development and research design, assisted with statistical analysis and supervised with progression of the research process, reviewed the final thesis.
Professor Pamela von Hurst Academic co-supervisor	Auckland lead for the Young Foods New Zealand study. Assisted with ethical approval of prior research study, involved in the development and research design, assisted with statistical analysis and supervised with progression of the research reviewed the final thesis.
Associate Professor Jill Haszard Biostatistician	Involved in the data processing and provided the dataset used for this study.
Dr Karen Mumme Postdoctoral Research Fellow	Advisor for statistical analysis.

I would like to acknowledge the Young Foods research team:

Table 1.2 Young Foods Research Team

Joint Principal Investigators	Prof Rachael Taylor and Prof Anne-Louise Heath
Investigators	Prof Pamela von Hurst, Prof Cathryn Conlon, Assoc Prof Kathryn Beck, Assoc Prof Jillian Haszard, Assoc Prof Lisa Te Morenga, Assoc Prof Alison Meldrum and Assoc Prof Ridvan Firestone
Project Coordinators	Jenny McArthur (Dunedin) and Rebecca Paul (Auckland)
Dunedin Research Team	Bailey Bruckner, Louise Fangupo Elizabeth Fleming and Ioanna Katiforis
Auckland Research Team	Andrea Wei, Emily Jones, Kimberley Brown, Maria Casale and Rosario Jupiterwala
Wellington Research Team	Megan Healey, Veisinia Pulu and Ella Duxfield

Chapter 2. Literature Review

2.1 Introduction

This literature review explores the classification of carbohydrates, dietary energy requirements, definitions of sugar, and sugar intake recommendations. It will briefly explore the health consequences of excess sugar intake in children including obesity and dental caries. Lastly, it will report on the current intake of sugar including by BMI z-score classification, demographic factors and feeding practices. PubMed, Web of Science and Google Scholar were searched using various combinations of the search terms below (Figure 1). A manual search was also undertaken using reference lists from review articles, nutrition guidelines and World Health Organization (WHO) documents. This review was limited to literature from 1990 onwards.

Date searched: October 2021 **-** October 2022

Search criteria:

Sugar* OR “total sugar”
AND child* OR “early childhood” OR toddler OR preschool* OR “children under 5”
AND intake OR diet OR consumption OR source
AND Zealand OR Aotearoa OR NZ
AND “Free sugar” OR “added sugar” AND definition
AND “dietary guidelines”
AND obesity OR “childhood obesity” OR adiposity OR BMI OR “BMI z-score”
AND “dental caries” OR “tooth decay” OR “dental decay”
AND “nutrient deficiencies” OR “nutritional deficiencies” OR deficiencies
AND ethnicity OR deprivation OR “parent* education”
AND “baby led weaning” OR “spoon fed” OR “spoon feed”
AND food pouch OR puree

Filters: Infant: 1-23 months, Preschool Child: 2-5 years, Nutrition Dietetics, past 1 year, past 5 years, past 10 years

Electronic databases: PubMed, Web of Science, Google Scholar

Websites: New Zealand Ministry of Health, World Health Organization

Documents: Healthy Eating Guidelines for New Zealand Babies and Toddlers (0-2 years old), Food and Nutrition Guidelines for Healthy Children and Young People (Aged 2-18 years), World Health Organization Guideline: Sugars intake for adults and children

Figure 1. Search Strategy for Literature Review

2.2 Carbohydrates as an Energy Source

Carbohydrates are the main source of energy in the diet (Scientific Advisory Committee on Nutrition, 2015; Ministry of Health, 2015; National Health and Medical Research Council and Ministry of Health, 2006b). Although energy is available from other macronutrients such as fat and protein, glucose from carbohydrates provides a more efficient energy source, particularly for the brain (Ministry of Health, 2015; Scientific Advisory Committee on Nutrition, 2015).

2.2.1 Carbohydrate Classification

The primary method of classifying carbohydrates is based on chemistry (Cummings and Stephen, 2007; Scientific Advisory Committee on Nutrition, 2015; McNaught, 1996). Specifically, they can be classified by their Degree of Polymerisation (DP), characteristics of their individual units, and type of linkage (Scientific Advisory Committee on Nutrition, 2015; Cummings and Stephen, 2007; McNaught, 1996). Table 2.1 outlines the class, groups, and components of carbohydrates.

Table 2.1 Chemical Classification of Carbohydrates

Class	Sub-group	Components
Sugars (1-2 DP)	Monosaccharides (single units)	Glucose, fructose, galactose
	Disaccharides	Sucrose, lactose, maltose
Polyols (1-2 DP)		Erythritol, xylitol, mannitol, sorbitol, lactitol, isomalt, maltitol
Oligosaccharides (3-9 DP)	Malto-oligosaccharides	Maltodextrins
	Non-digestible oligosaccharides	Raffinose, stachyose, fructo-oligosaccharides, verbascose
Polysaccharides (≥10 DP)	Starch	Amylose, amylopectin, modified starches
	Non-starch polysaccharides	Cellulose, hemicellulose, pectins, hydrocolloids (gums)

The DP refers to how many monosaccharides join via glycosidic linkages to form larger molecules (di-, oligo-, and polysaccharides). Although measurable, chemical classifications of carbohydrates are not easily translated into their nutritional effects due to having different physiological properties and effects on health (Scientific Advisory Committee on Nutrition, 2015; Ministry of Health, 2015; Cummings et al., 1997). For example, glycaemic response differs between simple and complex carbohydrates where simple carbohydrates are absorbed into the bloodstream faster causing a rise in blood glucose levels. Furthermore, digestible carbohydrates are absorbed in the small intestine, compared to non-digestible carbohydrates which are fermented in the large intestine (Scientific Advisory Committee on Nutrition, 2015)

The principal monosaccharides are glucose, fructose, and galactose. Mono- and disaccharides are commonly referred to as 'simple sugars' (Sigman-Grant and Morita, 2003) due to their size. They are found naturally in fruit, sugar cane, beets, honey, and milk (Hess et al., 2012; Cummings and Stephen, 2007).

Maltodextrins are often used in food manufacturing as a sweetener or fat substitute, or for texture modification (Cummings and Stephen, 2007; Scientific Advisory Committee on Nutrition, 2015). Examples of non-digestible oligosaccharides are found in foods such as artichokes, chicory (Scientific Advisory Committee on Nutrition, 2015), peas, beans, lentils, wheat, rye, asparagus, onion, garlic and leek (Cummings and Stephen, 2007).

Polysaccharides are often referred to as 'complex carbohydrates' due to their size (Cummings et al., 1997; Asp, 1995). Starches function as energy storage in plants (Asp, 1995) and is a major carbohydrate in the human diet (Cummings et al., 1997; Asp, 1995). Non-starch polysaccharides such as cellulose and pectins provide structure to plant cell walls. Cellulose (insoluble) and pectins (soluble) provide dietary fibre which contributes to increased satiety, increased gut motility, stool formation and gut microbiota composition (Gill et al., 2021).

2.3 Definitions of Sugar

Sugars exist in many forms and are defined several ways. Whilst total sugar is easily defined (includes all free sugars as well as intact sugars from vegetables, fruits, dairy products, and grains), no universal definition of added or free sugar exists (Erickson and Slavin, 2015), making it difficult to compare data. However, there are broadly accepted definitions for free and added sugars which are outlined in Figure 2.

Figure 2 shows the difference between free and added sugar is the inclusion or exclusion of naturally occurring sugars in nonintact fruits, vegetables or honey (Mela and Woolner, 2018; Amoutzopoulos et al., 2020; Erickson and Slavin, 2015). Globally, various agencies and authorities have adopted different definitions for free and added sugar. Additionally, “sugar” is also used to describe table or white sugar (sucrose). Differing definitions often result in terms being used synonymously. The subtle differences in the definitions make it challenging to analyse dietary intake and compare studies. It has been suggested that “Globally accepted definitions are needed for consistency in intake assessments, monitoring, labelling, enforcement and consumer communication” (Mela and Woolner, 2018, p. 66).

New Zealand’s (NZ) Ministry of Health (MoH) use the term ‘added sugar’ throughout the recently updated *Healthy Eating Guidelines for New Zealand Babies and Toddlers*, and the *Food and Nutrition Guidelines for Healthy Children and Young People* (which are currently under review). For the purposes of this literature review, free and added sugars will be defined as displayed in Figure 2.

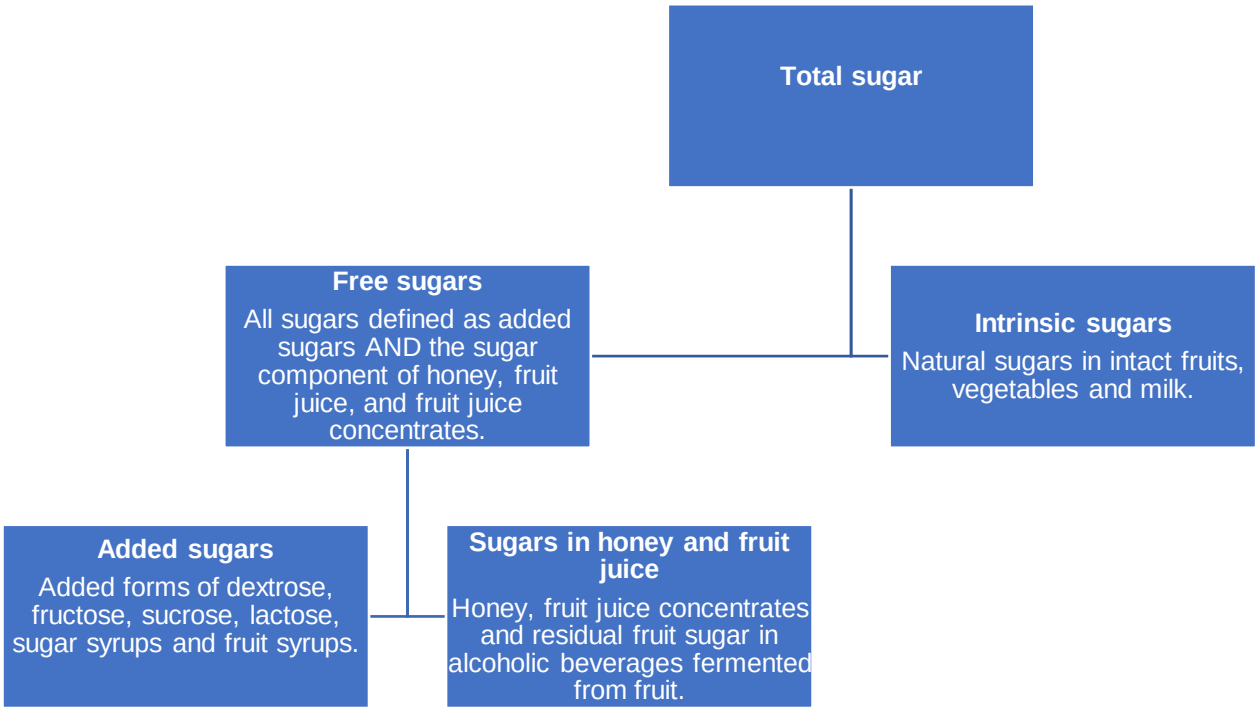

Figure 2. Definitions of Sugar (Food Standards Australia New Zealand, 2021a)

2.4 Dietary Energy Requirements

The Australian National Health and Medical Research Council (NHMRC) and NZ's MoH provide daily dietary energy nutrient reference values for young children aged one month and over. Tables 2.2 and 2.3 (National Health and Medical Research Council and Ministry of Health, 2006a), show reference values for children aged 12-24 months and 3 years. Values are provided by sex, as well as by Physical Activity Level (PAL) for children aged three years.

Table 2.2 Estimated Energy Requirements for Children Aged 12-24 Months

Age (months)	**EER (kJ/day)**	
	Boys	**Girls**
12	3,500	3,200
15	3,800	3,500
18	4,000	3,800
21	4,200	4,000
24	4,400	4,200
EER = Estimated energy requirements		

Physical Activity Level (PAL) factors incorporate a growth factor by age (National Health and Medical Research Council and Ministry of Health, 2006a). They also factor in energy required for physical activity. Physical activity level values correspond to 1.2 as bed rest, 1.6 as lightly active, and 2.2 as vigorous activity. Total estimated energy requirements (EER) are calculated by multiplying BMR by PAL.

Table 2.3 Estimated Energy Requirements for Three-year-old Children

Sex	**BMR (MJ/day)**	**PAL 1.2**	**PAL 1.4**	**PAL 1.6**	**PAL 1.8**	**PAL 2.0**	**PAL 2.2**
Boys	3.4	4.2	4.9	5.6	6.3	6.9	7.6
Girls	3.2	3.9	4.5	5.3	5.8	6.4	7.1
BMR = Basal metabolic rate; MJ = Megajoules; PAL = Physical activity level.							

These reference values allow estimation of 10% of total energy that could come from free sugars as per World Health Organization (WHO) recommendations (World Health Organization, 2015). For example, a three year old lightly active boy may need 5.6MJ/day of which 0.6MJ could be from free sugars.

2.5 Carbohydrate Recommendations

The only population group in NZ that has an Adequate Intake (AI) set for carbohydrate intake are infants (0-12 months) (National Health and Medical Research Council and Ministry of Health, 2006b). At the time of writing the carbohydrate recommendations, there was limited evidence on which to base a recommendation for the whole population. However, there is an Acceptable Macronutrient Distribution Range (AMDR) of 45-65% of total dietary energy intake from carbohydrate foods for children and adults (National Health and Medical Research Council and Ministry of Health, 2014).

Recommended sources of carbohydrate from the *Healthy Eating Guidelines for Babies and Toddlers (0-2 years)* and the *Food and Nutrition Guidelines for Healthy Children and Young People (2-18 years)* are vegetables and fruit, grain foods (iron-fortified cereals, oats, bread, rice, noodles, pasta), milk and milk products (yoghurt, cheese) and legumes (lentils, tofu, beans) (Ministry of Health, 2021a; Ministry of Health, 2015).

2.6 Sugar Recommendations

Excess sugar intake may promote a positive energy balance leading to weight gain. Excess sugars are also associated with an increased risk of developing noncommunicable diseases (NCDs) (World Health Organization, 2015). Due to emerging research on the detrimental health effects of highly processed foods, dietary guidelines worldwide are incorporating targeted advice on reducing added sugar intakes. The following section will explore recommendations for children internationally and in NZ.

2.6.1 WHO Recommendations

Currently, the WHO do not provide total dietary sugar intake recommendations. However, they recommend children limit their intake of free sugars to less than 10% of total energy intake (excluding sugars found in whole fruit, vegetables and milk), with an intake below 5% being associated with better health outcomes (World Health Organization, 2015).

The purpose of the recommendations is to provide policy makers with an evidence-based benchmark to assess their population intake against. This should assist policy makers to make informed decisions when setting public health nutrition policies, programmes and interventions with the goal of reducing the risk of dental caries and NCDs (World Health Organization, 2015).

2.6.2 International Recommendations

The WHO's recommendations are intended for international policy development. Therefore, it may be useful to consider the sugar intake guidelines for young children from other nations. Table 2.4 outlines the sugar recommendations for eleven nations. Only guidelines adopted by government departments and those written in English were reported.

Table 2.4 International Sugar Recommendations for Children

Country	Age group	Recommendation	Reference
Australia	Individuals 12m+	• Limit intake of food and drinks containing added sugars such as confectionary, sugar-sweetened soft-drinks and cordials, fruit drinks, vitamin water, energy, and sports drinks. • Discretionary choices are high in added sugars and are not an essential or necessary part of healthy dietary patterns. Eat these foods less often and in much smaller amounts, or special occasions only.	(National Health and Medical Research Council, 2013)
United States of America (USA)	Infants and toddlers (birth to 23m)	• Avoid foods and beverages with added sugar • If 100% fruit juice is provided, up to 4oz per day (after 12m)	(U.S. Department of Agriculture and U.S. Department of Health and Human Services, 2020)
	Children and adolescents (2 to 18y)	• Less than 10% of total energy from added sugars per day • If 100% fruit juice is provided, up to 4oz per day	(U.S. Department of Agriculture and U.S. Department of Health and Human Services, 2020)
United Kingdom (UK)	Infants and toddlers (birth to 23m)	• Babies do not need sugar added to their food (or cooking water)	(National Health Service, 2019b)
	Individuals 2y+	• Added sugars should not make up more than 5% of total dietary intake per day • Fruit juice and smoothies limited to 150mL/day	(National Health Service, 2019a)

Canada	Toddlers 12 to 24m	• Limit fruit juice and do not offer sweetened beverages	(Government of Canada, 2014)
	Individuals 2y+	• Prepare meals and snacks with little to no added sugar. Eat them less often and in small amounts	(Government of Canada, 2022b) (Government of Canada, 2020)
Ireland	Toddlers and children 1 to 4y	• Avoid sugary drinks • Foods high in sugar: maximum once per week and in tiny amounts	(Government of Ireland, No date)
Denmark	Individuals 2y+	• Cut down on how often you eat sweets, cakes, chocolate, ice cream, biscuits, and chips • Eat smaller portions	(Ministry of Food and The Danish Veterinary and Food Administration, 2021)
Finland	Individuals 2y+	• Sugar may cover at most 10% of the daily total energy intake • Choose food products with no more than 16g sugar per 100g	(National Institute for Health and Welfare, 2019)
Scotland	Individuals 2y+	• Average intake of free sugars not to exceed 5% of total energy	(The Scottish Government, 2016)
Malaysia	Children and adolescents (birth to 18y)	• Eat foods low in sugars • Drink beverages low in sugars • Instil a preference for less sweet taste • Choose sugar-free or less sugary products	(Ministry of Health Malaysia, 2013)

Norway	Individuals 2y+	• Avoid foods and drinks that are high in sugar • Limit the intake of foods and drinks with high energy density and low nutritional quality such as sugary drinks, candy, and snacks • Intake of added sugars should be kept below 10% E	(Norwegian Directorate of Health, No date)
Sweden	Children 1-2y	• Avoid candy, drink mixes and soft drinks for as long as possible • Buns, cookies, ice cream and other sweet products contain a lot of sugar; save them for special occasions	(Swedish Food Agency, 2021)
m = months; + = onwards; y = years; % E = percent of total energy; oz = ounce; mL/day = millilitres per day; g = grams.			

The USA, UK, Scotland, Norway, and Finland have adopted WHO recommendations (Table 2.4). None of the recommendations include a quantifiable daily intake of total, free or added sugar. Some provide supplementary guidance. For example, Finland recommends choosing products with no more than 16g of sugar per 100g, and the USA and UK provide a recommended maximum intake of juice and smoothies.

Using consistent language and definitions is key to understanding dietary recommendations. The most common guidelines are to limit or avoid food and beverages with high levels of added sugar. Advice to limit the intake of high sugar foods using terms such as 'less often', 'smaller amounts', and 'smaller portions' are subjective and could be misinterpreted. Norwegian guidelines include two differing statements. The first is an overarching statement to 'avoid' food and drinks high in sugar. The second is to 'limit' high energy density food and drinks such as sugary drinks, candy and snacks within the context of balancing energy intake with physical activity (Norwegian Directorate of Health, No date). Although the second statement has a different context, the category of foods is the same which may cause confusion.

Further, in most guidelines 'little to no added sugar' has not been quantified making it difficult to know what is acceptable. The only guidelines that offer quantification regarding pre-made products are from the UK and Canada. The UK advise how to read sugar on a nutrition information panel. That advice is any product with ≥22.5g total sugar per 100g is considered high sugar, and anything ≤5g total sugar per 100g is considered low sugar (National Health Service, 2018). Similarly, Canadian guidelines recommend consumers look for products with ≤15% daily value for total sugars, which is a new food labelling requirement to help Canadians make healthy choices (Government of Canada, 2022a). How these values were determined is not clear.

2.6.3 New Zealand Recommendations

New Zealand's MoH does not provide recommendations for total dietary sugar intake. However, guidelines for added sugar exist. These guidelines for children differ between age groups 0-2 and 2-18 years (Ministry of Health, 2021a; Ministry of Health, 2015). New Zealand's MoH recommends that babies and toddlers between 0-2 years do not consume any added sugar in home or commercially prepared foods (Ministry of Health, 2021a). This is because added sugar masks the natural flavour of food and may contribute to the development of sweet taste preferences (Ministry of Health, 2021a). The guidelines also recognise the risk of excess sugar promoting weight gain, developing NCDs and unhealthy lifetime dietary habits. The Food and Nutrition Guidelines for Healthy Children and Young

People (2-18 years) recommend that foods, snacks, and drinks are low in sugar, especially added sugar. Additionally, they recommend to limit high sugar foods and drinks to occasional consumption only (less than once a week), and to limit the offer of high sugar foods and drinks in a child's home environment (Ministry of Health, 2015).

A quantitative recommendation or definition of 'low-sugar' has not been provided in the guidelines. In fact, no quantitative guidelines for total or added sugar intake have been developed for the NZ population of any age or sex.

Interestingly, Food Standards Australia and New Zealand have a statement in the Australia New Zealand Food Standards Code that stipulates a manufacturer cannot claim that a food or beverage is low sugar if it contains more than 2.5g of sugar per 100mL of liquid or 5g of sugar per 100g of solid food (Food Standards Australia New Zealand, 2021b). It is not clear how these values were determined. There are no global guidelines as to what constitutes low sugar.

New Zealand has developed policies and interventions to reduce free sugar intake amongst children of all ages. These include updated nutrition guidelines for 0–2-year-olds (Ministry of Health, 2021a) and the Healthy Food and Drink Guidance for Early Learning Services (Ministry of Health, 2020). It also includes the voluntary initiative of water and plain milk only in schools driven by the Ministry of Education. Individual education facilities may also have their own policies.

Guidelines for Early Learning Services

Recently, NZ's MoH developed a food and drink classification system to improve the food environment in early learning services. Foods are categorised using a traffic light system (green, amber, and red items) as shown in Table 2.5.

Table 2.5 Traffic Light Criteria for Early Learning Services (Ministry of Health, 2020)

Classification	Up to 24 months	2+ years
Green	**Vegetables:** Fresh, frozen, canned, dried **Fruit:** Fresh, frozen, canned in juice **Breads and crackers:** Plain or wheatmeal bread, wraps or pita **Cereals:** Iron fortified, cereal or porridge containing ≤15g sugar per 100g and an HSR ≥3.5 **Other grains:** White rice, plain pasta, unflavoured noodles and couscous **Milk and milk products:** Breast milk or unsweetened full-fat milk, unsweetened full-fat yoghurt **Sweet condiments:** Reduced-sugar jam	**Vegetables:** Fresh, frozen, canned, dried **Fruit:** Fresh, frozen, canned in juice **Breads and crackers:** Wholegrain, multigrain, wheatmeal or wholemeal bread with ≥5g fibre and <450mg sodium per 100g, crackers with an HSR ≥3.5 **Cereals:** Wholegrain cereal or porridge containing ≤15g sugar per 100g and an HSR ≥3.5 **Other grains:** Wholegrain or brown rice, pasta and noodles, quinoa, oats, buckwheat, rye **Milk and milk products:** Unsweetened low-fat milk, reduced or low-fat products with an HSR ≥3.5 **Sweet condiments:** Reduced-sugar jam
Amber	For 0-2 year olds, only green items should be offered.	**Vegetables:** Vegetables products with an HSR ≥3.5 **Fruit:** Fruit products with an HSR ≥3.5 **Breads and crackers:** Bread products with <5g fibre and/or ≥450mg sodium per 100g, crackers with an HSR ≥3.5 **Cereals:** Cereals with an HSR ≥3.5 **Other grains:** Refined grains, white rice, plain pasta and unflavoured noodles and couscous

		Milk and milk products: Full-fat milk and milk products with an HSR ≥3.5, reduced-fat sour cream, cream cheese or cream, Lite coconut milk or coconut cream **Sweet condiments:** Standard jam and honey **Packaged snack foods:** Foods with an HSR ≥3.5 and ≤600kJ per packet **Baked items:** Packaged or unpackaged items must contain some wholemeal flour, wholegrains, and/or fruit or vegetables, contain no confectionery or icing, an HSR ≥3.5
Red	**Vegetables:** Vegetable products with an HSR <3.5 **Fruit :** Fruit products with an HSR <3.5 **Breads and crackers:** Crackers with an HSR <3.5 **Cereals:** Those that do not meet the green or amber criteria **Other grains:** Flavoured packets of grains, rice, pasta or noodles **Milk and milk products:** All sweetened milk or full-fat milk products with an HSR <3.5 **Deep-fried foods:** All deep-fried foods **Confectionery:** All confectionery **Baked items:** Those that do not meet amber criteria, contain confectionery or icing, items with an HSR <3.5 **Drinks:** Sugar-sweetened drinks, 100% fruit or vegetable juice, all smoothies	
HSR = Health star rating; g=grams; mg=milligrams; ≤=less than or equal to; ≥=greater than or equal to; <=less then; >=greater than; %=percent; kJ=kilojoules.		

Green items should make up 75% of the food and drinks available and are generally lower in added sugar. Amber items contain moderate amounts of added sugar, while red items are high in added sugar (Ministry of Health, 2020). Specifically, the guidelines for sugar intake are:

- Foods containing moderate amounts of sugar may be available in small portions (e.g., some baked goods)
- No sugar-sweetened drinks (including sweetened or flavoured milk)
- No fruit or vegetable juices (including no-sugar-added varieties)
- Breakfast cereals should contain ≤15g sugar per 100g (Ministry of Health, 2020)

Table 2.6 shows the guidelines for portions sizes of baked goods.

Table 2.6 Portion Size Guidelines for Baked Goods

Food item	Portion size
Scones, cake, and dessert	≤50g
Loaf and muffins	≤50g
Slices	≤40g
Biscuits and pikelets	≤20g
Small pastries	≤40g
Pies and quiches	≤80g

Some of these guidelines are subjective which may cause confusion. For example, baked foods are an amber item, therefore, not for everyday consumption. However, it is unclear what 'not for everyday consumption' means. Furthermore, the terms 'low', 'moderate' or 'high' have not been defined. Definitions or values could provide context regarding quantities of sugar in foods and recommended consumption frequency. These guidelines are important particularly for carbohydrates because they encourage optimal choices within the food groups and are likely to reduce overall sugar intake through limiting added sugar intake.

2.6.4 Challenges in Developing Recommendations

Recently, the European Food Safety Authority (EFSA) were asked by five European countries to review the evidence to derive a tolerable upper limit for total, added and free sugars. A tolerable upper limit is what is physiologically tolerable (EFSA Panel on Nutrition et al., 2022), or the highest level of intake before adverse health effects occur. An upper limit

was not able to be determined due to a positive linear dose-response relationship within the data (EFSA Panel on Nutrition et al., 2022). That is, as sugar intake increased there was no point where no further harm was caused due to increased intake. To develop guidelines, recommendations or quantitative reference values and complete population-wide data is needed which considers overall energy balance and nutrient adequacy (Rippe et al., 2017). Such data is lacking worldwide which explains why the WHO and Ministry of Health, New Zealand do not include recommendations on total sugar.

2.7 Health Consequences of Excess Sugar Consumption

There are many reported health consequences that are associated with excess sugar consumption, especially added or free sugar. This is because a high frequency of consumption of sugar contributes to dental caries. This section of the review will focus on obesity, dental caries, and other nutritional deficiencies as they are commonly seen in young children.

2.7.1 Obesity

Childhood malnutrition is often thought to be underweight or wasting, but it includes stunting and overweight (World Health Organization et al., 2020). Obesity increases the risk factor for NCDs (World Health Organization, 2015). Previously, many of these NCDs were only seen in adulthood, but insulin resistance, metabolic syndrome, cardiovascular disease, type 2 diabetes mellitus, and obstructive sleep apnoea are now showing in childhood (Daniels, 2009; Anderson et al., 2016). Additionally, obesity has been shown to contribute to emotional and behavioural difficulties amongst children and may reduce their quality of life (Anderson et al., 2017).

The most recent NZ Health Survey found that the prevalence of obesity among NZ children aged two to fourteen years increased from 9.5% to 12.7% between 2019 and 2021 (Ministry of Health, 2021b). This is approximately 107,000 NZ children. In children aged two to four years, prevalence has increased from 4.3% in 2019 to 6.4% in 2021 (Ministry of Health, 2021b). Amongst Māori tamariki, prevalence has increased from 13.3% in 2019 to 17.8% in 2021, with tamariki 1.66 times more likely to be obese than non-Māori (Ministry of Health, 2021b). Amongst Pasifika, prevalence has increased from 28.8% in 2019 to 35.3% in 2021, with Pasifika children 3.71 times more likely to be obese than non-Pasifika (Ministry of Health, 2021b). Conversely, between 2011/12 and 2018/19 Daniels et al. (2022), reported a reduction in the prevalence of obesity amongst 4 year old NZ children at or above the 85th, 95th and 99.7th percentile of 4.9%, 3.5% and 0.9%, respectively. Additionally, Gibb et al.

(2019), reported a decline in prevalence of 0.2% in 2010/11 and 2015/16 in 61.5% of communities included in the Ministry of Health (MoH) B4 School Check. With conflicting evidence of prevalence, it is essential that trends in prevalence and modifiable risk factors for overweight and obesity are investigated.

The link between sugar intake and obesity has been long debated and remains a controversial topic. Meta-analyses in adults conducted by the World Health Organization (2015), identified that reduced intake of free sugars was associated with a decrease in body weight, whilst an increase in free sugars was associated with an increase in body weight. In contrast, Walton et al. (2021), claims there is still great debate among experts and advisory bodies with no conclusion that excess sugar intake is directly related to obesity. A meta analyses in children showed no change in body weight when analysing intakes of foods and beverages containing sugar, however, compliance to the study protocol was low. Researchers did find that children had a greater likelihood of being overweight or obese with higher intakes of sugar-sweetened beverages (SSBs) than children with a lower intake (World Health Organization, 2015).

A systematic review and meta-analysis summarised evidence of the effects of increasing and decreasing intake of dietary sugars on body fatness in children (Te Morenga et al., 2013). No association was found between a decreased intake of SSBs or other foods containing sugars and change in BMI or BMI z-score (Te Morenga et al., 2013). However, poor compliance was noted for three of the five studies included in this analysis. Conversely, they found a significantly increased risk of overweight with higher intakes of sugar, mainly in the form of SSBs (Te Morenga et al., 2013). This analysis included 23 cohort studies, 15 of which reported a positive association between increased sugar intake and a measure of adiposity. Only four studies reported a negative association. Of note is that for these analyses, free sugars were included, not total sugar. Similarly, Linardakis et al. (2008), found that 4-7 year old children had a high BMI if they were high consumers of SSBs. Specifically, 16.4kg/m^2 for <125g/day consumers compared to 17.4kg/m^2 for >250g/day consumers, (*p for trend*=0.003).

Most analyses have used SSBs as the sugar exposures. There is little evidence investigating sources of total, free or added sugars other than SSBs and their association with measures of body fatness in children or adults.

2.7.2 Dental Caries

Early Childhood Caries (ECCs) is a health problem that affects the growth, development and quality of life of many preschool children (Ministry of Health, 2008). Early Childhood Caries

also predisposes a child to developing adult caries (Casamassimo et al., 2009). The New Zealand 2020/21 Health Survey data released by the Ministry of Health (2021c), found that in the previous 12 months, 0.6% (approximately 2,000 children) aged one to four years have had teeth removed due to decay, an abscess, infection, or gum disease. Rates have been stable over the last decade with prevalence between 0.6 to 1.1% (approximately 2,000 to 3,000 children). This indicates that whilst the problem is not worsening, it is not improving. Furthermore, no meaningful trends can be seen as the rate fluctuates year on year. Of note is a downward trend amongst Māori tamariki. In 2018, prevalence was 7.3% (approximately 17,000 children) compared with 3.8% in 2021 (approximately 9,000 children). The exact reason for this significant decrease is unknown. Improved access and uptake of professional dental care, water fluoridation or improved education and habits related to oral hygiene practices may be the reason for this improvement. Interestingly, in Māori children fizzy drink intake (at least three times per week) increased from 15% in 2018 (approximately 33,000 children) to 19.8% in 2021 (approximately 45,000 children) (Ministry of Health, 2021c).

The amount, frequency, and timing of sugar and refined carbohydrate consumption, especially sucrose (Bach and Manton, 2014; Ministry of Health, 2008) contributes to dental caries. The Growing Up in New Zealand study (New Zealand's largest longitudinal study of child development) found a strong link between sugar or refined starch and dental caries in children aged 4-7 years (Thornley et al., 2021). Nutrition survey data shows sucrose consumption is mostly from SSBs (26%), sugar and sweets (21%) and cakes and muffins (7%) in children aged 5-14 years (Ministry of Health, 2003).

Feeding practices are a risk factor for developing ECCs (Meyer and Enax, 2018; Bach and Manton, 2014). Children sleeping with bottles are at high risk because of the prolonged exposure of sugars to teeth, causing oral bacteria to produce lactic acid. This causes demineralisation of the enamel (Meyer and Enax, 2018). This also applies to sweetened beverages, for example, fruit juice. Hence, the recommendation to brush teeth twice a day, with the second time preferably after the last meal or drink.

2.7.3 Nutritional Deficiencies

High consumption of low-quality or nutrient-poor foods may displace intake of nutrient-dense foods (Alles et al., 2014). However, one systematic review found there is no evidence that excess sugar consumption results in micronutrient deficiencies (Gibson, 2007). Rather, it is the overall energy intake that predicts micronutrient deficiency (Gibson, 2007). The evidence that exists relates specifically to SSB intake. Guidelines for complementary feeding written

by Dewey (2003), on behalf of the Pan American Health Organization state that sugary drinks should be avoided because they displace the child's appetite for more nutritious foods. The exact mechanism behind this is unclear. However, a phenomenon often seen in children's feeding practices is that fluid displaces food, even if the fluid is plain milk or water. A systematic review and meta-analysis by Vartanian et al. (2007), reported an association between soft-drink consumption and lower intakes of milk and dairy products. More specifically, a one ounce decrease (29.5ml) in soft-drink consumption related to a 0.25-ounce (7ml) increase in milk consumption.

2.8 Demographic Factors Contributing to Total Sugar Intake

Ethnicity, low income and parental education are predictors of sugar intake (Kranz and Siega-Riz, 2002). Low-income consumers spend a higher proportion of their income on sugary products (Gardiner, 2016). These energy-dense foods of poor nutritional value are cheaper to buy than fruit or vegetables (Loring and Robertson, 2014). If home availability of foods is an important predictor of adolescent eating behaviour (Utter et al., 2011), the same must be true for younger children as they are highly vulnerable and have little choice in their family circumstances. The following section will briefly explore the association between ethnicity, deprivation, parental education, and total sugar intake.

2.8.1 Total Sugar Intake and Ethnicity

The data exploring the relationship between total sugar intake and ethnicity is inconsistent, particularly in New Zealand (NZ). In the United States of America (USA), dietary data collected from the National Health and Nutrition Examination Survey (NHANES) 2003-2008 (2–18-year-olds; n=2954) showed White participants consumed more total sugar (140.5g) than Black (136.1g/day) and Mexican American participants (134.8g/day) (Eicher-Miller et al., 2015). Also from the USA, Bably et al. (2021), investigated the initial introduction of added sugar to the diet in infants and toddlers from birth to 24 months (n=3835). They found that 50% Hispanic, 73% White, 84.6% African American and 92.4% other ethnicities introduced sugar before 24 months. This is contrary to nutrition advice to avoid added sugar before 24 months (U.S. Department of Agriculture and U.S. Department of Health and Human Services, 2020). These studies show that in the USA total sugar intake is similar between ethnic groups. A longitudinal study (Born in Bradford) in the United Kingdom of 12-(n=1081) and 18-month (n=1257) old White British and Pakistani children found at both ages Pakistani children were more likely to consume commercial sweet baby meals, sugar-sweetened beverages (SSBs) and pure fruit juice than White children (Sahota et al., 2016). Cultural differences in feeding practices are likely to result in different nutrient intakes

including sugar. Further exploration of these practices are required both overseas and in New Zealand.

In NZ, the results of the National Children's Nutrition Survey 2002 reported that Pacific children had a lower total sugar intake (girls 101g/day; boys 107g/day) than New Zealand European/Other (NZEO) (girls 113g/day; boys 127g/day) and Māori children (girls 124g/day; boys 132g/day) (Ministry of Health, 2003). Jamieson and Koopu (2007), studied sugar intake in children 5-14 years in New Zealand and reported Māori (50.5%) and Pacific (57.1%) children consumed a chocolate bar (p<0.001) or soda (p<0.001) four or more times per month compared to 37.1% NZEO. Additionally, they found that 50.9% of Pacific children added sugar to Milo compared to Māori (37.6%) and NZEO (26.2%) (p<0.001). In 8-12 year old New Zealand children, Smirk et al. (2021), found being of non-European ethnicity was associated with a greater SSB intake.

These studies all demonstrate inconsistent findings, particularly in NZ. Furthermore, it is important to consider cultural differences in eating behaviours to fully understand intake data. Most of the available evidence reports drink consumption as this is currently a topic of concern. Data is limited in the toddler and pre-school age group. Furthermore, data investigating total sugar by ethnicity in NZ is outdated and more recent data is needed.

2.8.2 Total Sugar Intake and Deprivation

High deprivation and food insecurity has been linked to poor nutrition choices in young New Zealanders (Utter, 2020; Gerritsen, 2019; Gerritsen et al., 2020). However, studies to date have only considered overall nutrition or few specific sources, not total sugar intake. Furthermore, few studies have investigated total sugar intake in toddlers and pre-schoolers. In the USA, socioeconomic disadvantage was associated with added sugar intake in children 2-15 years (Chi and Scott, 2019).

Currently in NZ, deprivation is measured using the NZDep18 index of deprivation (Atkinson et al., 2019). The current index is based on eight dimensions of deprivation: (1) internet access, (2) income, (3) employment status, (4) qualifications attained, (5) home ownership, (6) support, (7) living space and (8) living conditions, as well as meshblocks (Atkinson et al., 2019). These dimensions change depending on census results so previous reports of deprivation may be based on different factors. Deprivation impacts food security which occurs when there is limited or uncertain availability of nutritious and safe food, or a limited ability to acquire food safely to meet cultural needs in a socially acceptable way (Ministry of

Health, 2019). In 2019, the Ministry of Health released findings that 19% of 2–4-year-olds in severely to moderately food-insecure households consumed fizzy drink at least three times per week compared to 7.4% in fully to mostly food secure households (Ministry of Health, 2019). Utter et al. (2011), found that NZ secondary school students (n=9107; 12-18 years) living in the most deprived areas were more likely to consume chocolates (p=0.01) and soft drinks (p<0.001) as they were available at home compared to students living in more affluent areas. Results of the National Children's Nutrition Survey 2002 found no difference in total sugar intake by NZDep2001 in children aged 5-14 years (Ministry of Health, 2003). However, this data is outdated, and up-to-date national data is required.

2.8.3 Total Sugar Intake and Parental Education

It has been suggested that education is the strongest and most consistent predictor of health behaviours (Ball et al., 2008). Children are vulnerable and have little choice over their family circumstances, including food availability. Therefore, a child consumes the food available to them at home. There is no data exploring the association between parental education and sugar intake in young New Zealand children. However, there is international data that has studied this relationship. In the USA, Bably et al. (2021), investigated infants and children aged birth to 24 months (n=3835) and found that children whose parents had a high school diploma or less were introduced to added sugar earlier than children whose parents had a higher education level (p<0.001). Northstone et al. (2002), investigated drink consumption in 18-month-old children in England. Interestingly, they found that mothers with a university qualification were significantly more likely to give children water, apple, or orange juice (p<0.001). Whereas mothers with lower education (high school) were significantly more likely to give children coffee, tea, or fizzy drink (p<0.001). This shows that even mothers with a higher education still provide their toddlers drinks containing sugar. In one year old Swedish children, parental education was inversely associated with the frequency of intake of sweets and pastries and introduction of SSBs (Brekke et al., 2007). Data is needed to explore these associations amongst young children in New Zealand.

2.9 Feeding Practices Contributing to Total Sugar Intake

Common infant and toddler feeding practices such as baby-led weaning and food pouch consumption have been linked to a higher total sugar intake (Daniels et al., 2015; Lundkvist et al., 2021). The following section will briefly explore these common feeding practices internationally and in NZ.

2.9.1 Total Sugar Intake and Baby-Led Weaning

Baby-led weaning (BLW) is an alternative feeding method from six months of age where an infant feeds themselves (D'Auria et al., 2018). At this time, infants have insufficient motor skills to use utensils, therefore, foods need to be finger foods (Williams Erickson et al., 2018). This is contrary to NZ nutrition guidelines which recommend spoon-fed purées as first foods (Ministry of Health, 2021a). Concerns have been raised that these finger foods may be high in sugar as they are often family foods (Daniels et al., 2015). Additionally, infants may self-select foods higher in sugar (Langley-Evans, 2022). A topic of interest is whether this method of feeding results in a difference in food and nutrient intake in children compared to children who are traditionally spoon fed (Williams Erickson et al., 2018). There are few studies that have investigated this association (Langley-Evans, 2022; Williams Erickson et al., 2018).

2.9.2 Total Sugar Intake and Food Pouch Consumption

In NZ, food pouches are marketed for children from the age of 4- to 18-months and over (Katiforis et al., 2021). Many of the commercial products marketed for infants are likely to be consumed by older children (Westland and Crawley, 2018). Commercial food pouches containing ready-to-eat purées contain more total sugar than other commercial infant foods (Katiforis et al., 2021; Koletzko et al., 2019; Hutchinson et al., 2021). This is due to ingredients being mainly fruit or sweet vegetable purées such as apple, pear, carrot, and sweet potato (Katiforis et al., 2021; Garcia et al., 2016; Moumin et al., 2020). Garcia et al. (2016), found that total sugar was positively correlated with fruit and vegetable content and 18% of products analysed contained 15g/100g of added fruit juice. In Germany, Koletzko et al. (2019), analysed 100 complementary feeding products and found sugar content to be between 40-88.9% of total energy. Similarly, Hutchinson et al. (2021), found that fruit purées across ten European nations had the highest percentage of total sugar between 72-79%, compared to vegetable only purées containing between 10-42%. In NZ, the median total sugars found in pouches was at least three times that of other infant foods, containing 8.4g/100g (Katiforis et al., 2021).

Due to the convenience a pouch offers, often children are sucking directly from the nozzle, or it is being squeezed directly into the child's mouth (Koletzko et al., 2019; Koletzko et al., 2018; Katiforis et al., 2021; Westland and Crawley, 2018). This has been compared to drinking as there is no chewing required, therefore, may contribute to excess energy intake

(Koletzko et al., 2019; Koletzko et al., 2018; Katiforis et al., 2021). It has been suggested that sucking a purée may contribute to dental caries as the puréed texture contains no abrasive properties which may act to clean the teeth (Koletzko et al., 2018; Koletzko et al., 2019; Westland and Crawley, 2018). Furthermore, sucking sweet purées causes prolonged exposure of teeth to sugar which may contribute to dental caries (Westland and Crawley, 2018).

What is lacking is data on total dietary sugar intake from pouch consumption. Only one study measured fruit pouch consumption (Lundkvist et al., 2021). This study used data from a Swedish population-based cohort study in 18-month-old children and found that 76.5% did not consume or seldom consumed fruit pouches, with 23.5% consuming fruit pouches at least once per week (Lundkvist et al., 2021).

2.10 Current Intake of Sugars

The link between excess sugar intake and the development of NCDs is well established (World Health Organization, 2015). Therefore, it is important to understand how much sugar children are consuming. There is limited data on the intake of sugar in young NZ children and therefore this section will consider sugar intake data from international studies.

2.10.1 Dietary Intake of Total Sugar

Studies and dietary surveys which have assessed the sugar intake of children are presented in Table 2.7. Data is reported for children between the ages of 1 to 4 years only.

Table 2.7 Summary of Studies Investigating the Dietary Intake of Total Sugars

Study	Total sugar as a percentage of energy intake (% E)	Total sugars (g/day)	Total sugar (TS) estimation method	Notes
Japanese studies				
• Japanese children; 18m-6y • 18-35m n= 373 • 3-6y n= 380 **(Fujiwara et al., 2018)**	Not reported	**18-35m:** Girls: 46.1† Boys: 47.5† **3-6y:** Girls: 53† Boys: 57.5†	TS estimated using analytical data, information from similar foods, recipes, international food composition databases and 7-step method by Rand et al. (1991),	• Secondary analysis from DONGuRI (Dietary Observation and Nutrient Intake for Good Health Research in Japanese Young Children) study • 18-35m 1-day food record • 3-6y 3-day food record • Data collected 2015 • Also reported available carbohydrate, starch, sucrose, fructose, naturally occurring sugar, and free sugar
European studies				
• Finnish children; 1-3y • 1y n= 455 • 2y n= 230 • 3y n= 471 **(Kyttälä et al., 2010)**	**1y:** 5.5† **2y:** 12.2† **3y:** 13.3†	**1y:** 12† **2y:** 33† **3y:** 41†	TS estimated using Fineli Nutrition Database (FND) and Fineli Dietary Database	• Secondary analysis from the Type 1 Diabetes Prediction and Prevention Project (population-based cohort study) • 3-day food records collected 2003-05

				• Measured sucrose (defined as any added sugar eaten at the table or used as an ingredient in processed or prepared food and naturally occurring sucrose (e.g., in fruit and berries)
• Study conducted in Germany, Belgium, Italy, Poland, Spain; 12-36months • 12m n= 827 • 18m n= 717 • 24m n= 747 • 36m n= 531 **(Pawellek et al., 2017)**	Not reported	**12m:** 65.2† **18m:** 65.9† **24m:** 69.7† **36m:** 75.3†	German food composition database used in all countries; where no data was available, estimations made by comparing to similar products	• Secondary analysis from the European Childhood Obesity Project in 2009 • 3-day weighed food records collected at four time points (i.e., longitudinal study) • Natural and added sugars investigated jointly • Food items were categorised according to their food composition • Also reported added sugar
• Caucasian children in Italy; 1-3.9y • n= 148 **(Verduci et al., 2019)**	28.6†	57.2† (SS)	MètaDieta Software	• 3-day food records • Simple sugars (SS) defined as natural (including fructose and lactose), free and added sugar
• Portuguese children; <5y • n= 944 **(Marinho et al., 2020)**	28†	86.3†	TS measured using Portuguese and other food composition databases and food labels	• Secondary analysis from the National Food Nutrition, and Physical Activity Survey 2015-16 • Two 1-day food diary

				• Also reported added sugar
United Kingdom studies				
• Irish children; 1-3y • 1y n= 126 • 2y n= 124 • 3y n=126 **(Walton, 2012)**	**1y:** 26.1† **2y:** 25.1† **3y:** 24.9†	**1y:** 69.6† **2y:** 74.3† **3y:** 76†	TS from NPNS database	• Secondary study from National Preschool Nutrition Survey (NPNS) 2010-11 • 4-day weighed record
• Irish children; 3y • n= 9,793 (GUI) • n= 126 (NPNS) **(Crowe et al., 2020)**	27†	75.8†	TS from NPNS database	• Secondary analysis from Growing up in Ireland (GUI) 2010-11 and National Preschool Nutrition Survey (NPNS) 2010-11 • NPNS 4-day food weighed record • GUI used an SFQ • Also reported added sugar
Canadian studies				
• Canadian children; 1-3y • n= not reported **(Langlois and Garriguet, 2011)**	27†	101†	TS estimated using Health Canada's Canadian Nutrient File 2001b	• Secondary analysis from the Canadian Community Health Survey 2004 • One 24h recall
• Canadian children; 1.5-5y (84% Caucasian) • n= 109 **(Mahajan et al., 2021)**	Not reported	86†	TS from food ESHA Food Processor	• Secondary analysis from the Guelph Family Health Study 2014-16 • 3-day food records • Also reported added sugar

Australian studies				
• Australian children; 2-3y • n= 214 **(Linggang et al., 2016)**	25.2†	93†	TS calculated using Australian Food and Nutrient Database 2011-13	• Secondary analysis from the National Nutrition and Physical Activity Survey 2011-12 • One 24h recall • Also reported added sugar
• Australian (Adelaide) children; 12-14months • n= 828 **(Devenish et al., 2018)**	Not reported	65.3†	TS calculated using FoodWorks	• Secondary analysis from the SMILE (Study of Mother's and Infant's Life Events) study 2013-14 • Data population overrepresented in socioeconomically disadvantaged areas • One 24h recall and 2-day food records at 1y • Also reported added sugar

† = Mean.

% E = Percentage of energy; TS = Total sugars; m = months; y = years; g/day = grams per day; SS = Simple sugars; SFQ = Short food questionnaire; < = less than.

Five studies were secondary to national nutrition surveys, therefore, considered representative of their population (Marinho et al., 2020; Walton, 2012; Crowe et al., 2020; Langlois and Garriguet, 2011; Linggang et al., 2016). One of the studies used data which were overrepresented for low socioeconomic areas (Devenish et al., 2018) and two studies were nationwide, population-based studies (Fujiwara et al., 2018; Kyttälä et al., 2010). This may allow for a representative data set. However, data was collected at least six years ago with some dating as far back as 1995. This highlights the need for up-to-date data.

Total sugar includes naturally occurring sugars from fruit, vegetables, milk and grains. Therefore, it is helpful to consider this measure alongside their sources. Seven studies reported the sources of total sugar (see Table 2.8). Additionally, it may be helpful to consider measures of added or free sugar alongside total sugar. This would allow conclusions to be drawn about the proportion of total sugar from added or free sugar. Seven studies reported on both total and added sugar, although these results have not been included in Table 2.8 (Fujiwara et al., 2018; Pawellek et al., 2017; Marinho et al., 2020; Crowe et al., 2020; Mahajan et al., 2021; Linggang et al., 2016; Devenish et al., 2018).

Most dietary guidelines recommend avoiding or limiting added sugars (see Table 2.4), but no guidelines for total sugar exist. Given there are no recommendations for total sugar intake, it is difficult to compare results against a benchmark or guideline.

There are limitations to consider when reviewing these studies. Firstly, reviewing international data is not representative of the New Zealand population. Furthermore, international food composition databases may report on total sugar differently. Secondly, dietary assessment methods contribute varying intake results. Table 2.7 shows three methods: (a) 24-hour recalls, (b) food records between one and four days, and (c) food frequency questionnaires. Recalls and records can extract more detail. However, recalls rely on memory (Thompson and Subar, 2017). A food frequency questionnaire considers intake over a longer period compared to other methods (Thompson and Subar, 2017), which may impact on intake representation. Records often require participant training and take time to complete, which is burdensome. Furthermore, underreporting may occur for any method because of inaccurate or incomplete recording, or the impact of the recording process on intake (Thompson and Subar, 2017; Crowe et al., 2020; Amoutzopoulos et al., 2020).

New Zealand Research

In NZ, the only national study to investigate total sugar intake in children was the 2002 New Zealand National Children's Nutrition Survey (Ministry of Health, 2003). However, this survey was conducted in children aged 5-14 years old and there is currently very little evidence on total sugar intake of children younger than 5 years.

2.10.2 Sources of Sugar

Sugars are found naturally in fruits, vegetables, grains and milk. Due to the many adverse effects of excess sugar intake, it is important to understand the sources of sugar that contribute to total intake. Table 2.8 outlines some of the main sources of total and free/added sugar from international studies.

Table 2.8 Summary of Sources of Total, Added and Free Sugars

Study	Findings		
	Total sugar (TS)	**Free sugar (FS)**	**Added sugar (AS)**
Japanese studies			
• Japanese children; 18m-6y • 18-35m n= 373 • 3-6y n= 380 **(Fujiwara et al., 2018)**	*Reported as % contribution to TS* • Dairy products: 18-35m 22.7; 3-6y 15.6 • Fruits: 18-35m 20.9; 3-6y 16.9 • Confectionary: 18-35m 14.5; 3-6y 19.6 • Vegetables: 18-35m 10.8; 3-6y 9.7 • Sugar-sweetened beverages: 18-35m 8.9; 3-6y 11 • Sugars and jams: 18-35m 6.9; 3-6y 7.1 • Seasonings: 18-35m 5.6; 3-6y 6.4 • Other: 18-35m 9.7; 3-6y 13.6	*Reported as % contribution to FS* • Confectionary: 18-35m 33.5; 3-6y 34.4 • Sugars and jams: 18-35m 22; 3-6y 17.9 • Sugar-sweetened beverages: 18-35m 16.3; 3-6y 18.4 • Seasonings: 18-35m 12.5; 3-6y 11.6 • Other: 18-35m 15.7; 3-6y 17.7	Not reported
European studies			
• Finnish children 1-3y • 2y n= 230 • 3y n= 471 **(Kyttälä et al., 2010)**	*Reported as mean g/day* • Fruit & berries: 2y 99; 3y 110 • Vegetables: 2y 37; 3y 47 • Potatoes: 2y 47; 3y 64 • Bread: 2y 29; 3y 39 • Cereal products: 2y 237; 3y 204 • Dairy products: 2y 455; 3y 470	Not reported	*Reported as mean g/day* • Added sugar: 2y 1; 3y 1 • Sweets: 2y 4; 3y 7 • Chocolate: 2y 2; 3y 4

	• Fat spreads, oils: 2y 10; 3y 15 • Meat dishes: 2y 163; 3y 151 • Fish dishes: 2y 17; 3y 18 • Drinks: 2y 265; 3y 302 • Sweets and sugars: 2y 7; 3y 12		
• Study conducted in Germany, Belgium, Italy, Poland, Spain; 12-36months • 12m n= 827 • 18m n= 717 • 24m n= 747 • 36mn= 531 **(Pawellek et al., 2017)**	*Reported as % TS* • Milk and dairy products were the top source at 12 months of age • 80% of sugar intake was from milk & dairy products, fruit & fruit products, confectionary, breads & cereals, SSBs • Sweetened infant tea contributed the most sugar in children up to 2 years • Intake from the milk category decreased from 47% at 12 months to 19% at 96 months • Confectionary increased from 5% to 24% • SSBs increased from 2% to 6.7%	Not reported	Not reported
• Portuguese children; <5y • n= 944 **(Marinho et al., 2020)**	*Reported as % of TS* • Milk 15.9 • Fruit 15.7 • Formula 11.9 • Yoghurt 11.1	*Reported as % of FS* • Yoghurt 16.1 • Cereals 14.2 • Formula 13.9 • Sweets 13.1	*Reported as % of AS* • Yoghurt 16.8 • Cereals 14.5 • Formula 13.9 • Sweets 13.1

	• Cereals 8.2 • Sweets 5.8 • Human milk 5	• Cookies 9.8 • Milkshakes 5.5 • Cereals 4.7	• Cookies 10.4 • Milkshakes 5.8 • Cereals 5.2
United Kingdom studies			
• Irish children; 1-3y • 1y n= 126 • 2y n= 124 • 3y n=126 **(Walton, 2012)**	*Reported as % of TS* • Milk: 1y 34; 2y 22; 3y 16 • Fruit & fruit juice: 1y 27; 2y 31; 3y 31 • Yoghurt: 1y 12; 2y 10; 3y 11 • Biscuits & cakes: 1y 5; 2y 6; 3y 7 • Confectionary: 1y 2; 2y 6; 3y 8 • Beverages: 1y 3; 2y 6; 3y 6	Not reported	Not reported
• Irish children; 3y • n= 9,793 (GUI) • n= 126 (NPNS) **(Crowe et al., 2020)**	*Reported as g/day of TS* • Dairy products 22 • Fruit & vegetables 17.3 • Fruit juice & smoothies 8.7 • Confectionary 5.8	*Reported as g/day of FS* • Fruit juice & smoothies 8.4 • Dairy products 8.2 • Confectionary 5.3 • Soft drinks 4.8	Not reported
Canadian studies			
• Canadian children; 1-3y • n= not reported **(Langlois and Garriguet, 2011)**	*Reported as % TS* • Grains 11.4 • Fruit & vegetables 38 • Meat & alternatives 0.9 • Milk products 31	Not reported	Not reported

	• Other 16.5 (e.g., soft drinks, candy)		
NI = Not investigated; TS = Total sugar; FS = Free sugar; AS = Added sugar; m = months; y = years, % = percent; g/day = grams per day; < = less than. GUI – Growing Up in Ireland; NPNS = National Preschool Nutrition Survey.			

Of the seven studies that analysed total sugar sources, the largest contributors were milk or dairy products, fruit, vegetables, and cereals or grains (Fujiwara et al., 2018; Kyttälä et al., 2010; Pawellek et al., 2017; Marinho et al., 2020; Walton, 2012; Crowe et al., 2020; Langlois and Garriguet, 2011). Overall, these align with general nutritional guidelines. Further sub-categorisation of food groups such as dairy, cereals and grains would contribute valuable data on the sources of total sugar.

Sugar is often associated with unhealthy foods such as chocolate, fizzy drink, or sweets. It is evident that these foods are being consumed, despite recommendations to limit them. However, sugar can be found in foods that people perceive as healthy and are recommended to eat daily (Marinho et al., 2020). For example, in the Food and Nutrition Guidelines for Healthy Young People, yoghurt is listed as a healthy and nutritious snack (Ministry of Health, 2015). From Table 2.8, dairy products featured amongst the highest contributors to sugar intake. This highlights the importance of including free or added sugar to food labels so parents or caregivers can make a healthy choice (Devenish et al., 2019; Tierney et al., 2017).

Within the context of advising against the consumption of sugar, it is important to highlight that such foods still contribute to nutrient intake (Crowe et al., 2020). For example, cereals may be fortified with vitamins or minerals, and they contain fibre. Flavoured milk and yoghurt contain calcium and protein. For some individuals, restricting these sugar-containing foods may significantly reduce their intake of vital nutrients.

Sugar-Sweetened Beverages

Sugar-sweetened beverages contribute high dietary sugar with little nutritional value (World Health Organization, 2022). In NZ, the MoH reports on the frequency of SSB consumption in the New Zealand Health Survey. No such data is available for children under two years, perhaps because the nutrition guidelines state that infants and young children should not consume any added sugar. However, there is some data for children aged two to four years. Results from the 2020/21 survey show that 13.6% (approximately 25,000 children) consumed a fizzy drink at least once per week, and 4.8% (approximately 9,000 children) consumed fizzy drink at least three times per week (Ministry of Health, 2021c). They are often overconsumed because they do not contribute to the sensation of satiety (The New Zealand Nutrition Foundation, 2014), leading to an unhealthy diet, weight gain, increased risk of NCDs and dental caries (World Health Organization, 2015).

2.10.3 Challenges for Parents

Health conscious parents often like to make informed choices about what they buy or eat. Therefore, knowing how to read nutrition information panels might be of value to some consumers. Tierney et al. (2017), found that 97% of participants were able to identify sugars from milk, fruits and vegetables as natural sugars. However, the majority were unable to classify other sugars as natural or added. Participants selected total sugar as their second food label item of interest, indicating that added sugar may be of interest as well.

In NZ, a nutrition information panel must include energy, protein, fat, saturated fat, carbohydrate, sugars and sodium (Food Standards Australia New Zealand, 2020). The sugars portion is total sugar. Added sugar is not required to be listed. In 2018, the U.S. Food and Drug Administration (2020), changed their food labelling requirements to include added sugars as seen in Figure 4.

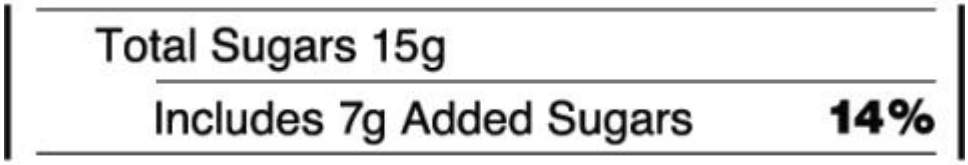

Figure 3. American Food Label for Total and Added Sugars

New Zealand has adopted a voluntary Health Star Rating (HSR) system for packaged products (Ministry for Primary Industries, 2022c). The system uses a rating scale of 0.5 to 5 stars as displayed in Figure 4. When comparing similar food products, more stars represent a healthier product.

Figure 4. Health Star Rating Label (Ministry for Primary Industries, 2022a)

As seen in Figure 4, some manufacturers may choose to display information on specific nutrients, as well as the HSR. Health Star Ratings are calculated using an online calculator

which assess risk nutrients (saturated fat, sodium, energy and total sugars), fruit, vegetables, nuts, legumes, and in some cases dietary fibre and protein (Ministry for Primary Industries, 2022b). Recently, the HSR system was updated to lower the rating for high salt or sugar food products (Ministry for Primary Industries, 2022a). However, it is unclear what the threshold is for these values.

2.11 Summary

The total sugar intake of young New Zealand children is largely unknown. Currently, no New Zealand studies have measured the total sugar intake of the 1-3.9 year age group. Studies have found an association between sugar intake and measures of adiposity. However, data is only available for sugar-sweetened beverage (SSB) exposures, not other sources of total, free or added sugar. This is also true for studies investigating total sugar intake and deprivation. There are inconsistent results from studies investigating total sugar intake and ethnicity and limited NZ data on total sugar intake and feeding method or parental education. Furthermore, there is a paucity of data on the consumption of food pouches and their contribution to total sugar intake, both internationally and NZ.

Chapter 3. Research Manuscript: Sugar Intake of Young Children in New Zealand

3.0 Abstract

Background: Consuming excess sugar has been linked to noncommunicable diseases such as obesity and dental caries in young children. In New Zealand, the prevalence of child obesity is increasing, and dental caries are being reported in young children. Demographic characteristics and feeding practices have been linked to poor nutrition choices, including high sugar intake. Therefore, it is important to measure sugar intake in young children.

Objectives: To describe total sugar intake and describe differences in total sugar intake based on anthropometry, demographic characteristics and feeding practices in New Zealand 1-3.9-year-olds.

Methods: Data were used from the Young Foods New Zealand study. Children (n=289) were aged 1-3.9 years living in Auckland, Wellington, and Dunedin. Demographic and feeding practice data were collected using a questionnaire. Two non-consecutive 24-hour diet recalls were administered to parents/caregivers using the triple pass method. Dietary data were entered into Foodworks 10 to determine nutrient intake. Length, height, and weight were measured, and BMI z-scores calculated. Statistical analyses were conducted using SPSS. Independent samples t-tests determined any differences between age, sex, and total sugar. Analysis of Covariance Tests (ANCOVA) tests determined any differences between total sugar intake and BMI z-score classification, ethnicity, deprivation, parental education, feeding methods and food pouch consumption.

Results: Mean (SD) total sugar intake was 67.3 (15.1) g/day contributing 22.9 (4.4) % of total energy (% E). Children who were obese had a higher intake of total sugar (g) than normal or underweight children 75.4 (17.3) vs 65.6 (14.9) respectively, (p=0.006), and overweight children 69.4 (14.8), but not significantly (p=0.19). Asian/other children consumed less total sugar (65.3g/day (15.8) and 21.9% E (4.0)) than European children (66.3g/day (12.7) and 22.7% E (3.7)), Māori children (69.7g/day (17.7) and 24.1% E (5.2)), and Pasifika children (67.8g/day (16.0) and 22.4% E (4.7)). Total sugar intake (% E) did not vary by BMI z-score classification (p=0.14). Total sugar in g/day and % E did not vary by ethnicity (p=0.25 and p=0.07), deprivation (p=0.57 and p=0.25), parental education (p=0.94 and p=0.55) or feeding method (p=0.63 and p=0.9). Children who consumed 7-14 pouches per week had a higher total sugar intake in g/day compared to children who consumed 1-6

pouches per week 74.7 (19.6) vs 65.3 (14.3), respectively (p=0.011) but not significantly higher than children who consumed none 67.3 (14.2), (p=0.052). Children who consumed 7-14 pouches had a higher total sugar intake (% E) than children who consumed none 26.1 (5.2) vs 22.1 (4.1), respectively (p<0.001), and children who consumed 1-6 pouches 23.1 (4.1), (p=0.004).

Conclusion: Total sugar contributed 22.9% of total energy intake. Total sugar intake differed between BMI z-score classification and food pouch consumption. Total sugar intake did not vary by ethnicity, deprivation, parental education or feeding method. Further studies should measure the intake of free and added sugars, and food sources of sugar.

Key words: total sugar, dietary intake, young children

3.1 Introduction

Good nutrition is critical to optimise the growth, development, and nutritional status of a young child (Dewey, 2003). A growing child requires dietary energy for tissue synthesis (Ministry of Health, 2015; Alles et al., 2014). However, many foods that children consume are high in dietary sugar which contributes to excess energy intake.

Carbohydrates are an important source of energy and nutrients for young children (National Health and Medical Research Council and Ministry of Health, 2006b). Recommended sources of carbohydrate are vegetables and fruit, grain foods, milk and milk products and legumes (Ministry of Health, 2021a; Ministry of Health, 2015). However, a major concern is that the food choices being made within these groups may be highly processed and contain added sugars.

A high intake of sugars, particularly free sugars, has been linked to obesity (World Health Organization, 2015) and the development of dental caries (Meyer and Enax, 2018). Childhood obesity can lead to the development of noncommunicable diseases such as insulin resistance, obstructive sleep apnoea and dyslipidaemia (Daniels, 2009; Anderson et al., 2016). In 2020, 39 million children under five have been estimated to be overweight or obese worldwide (World Health Organization, 2021). Prevalence of obesity in New Zealand (NZ) children aged two to four years has increased from 4.3% to 6.4% (Ministry of Health, 2021b). The NZ 2020/21 Health Survey found that in the previous 12 months, 0.6% (approximately 2,000 children) aged 1-4 years have had teeth removed due to decay, an abscess, infection, or gum disease (Ministry of Health, 2021c). These caries effect the life of young children including pain and infection (Bach and Manton, 2014), and may increase the risk of adult caries (Casamassimo et al., 2009).

Ethnicity, low income and parental education are predictors of sugar intake (Kranz and Siega-Riz, 2002). The National Children's Nutrition Survey 2002 reported that Pacific children had a lower total sugar intake than New Zealand European/Other (NZEO) and Māori (Ministry of Health, 2003). In contrast, Jamieson and Koopu (2007), reported Māori and Pacific children consumed chocolate or soda more frequently than NZEO children. Data is limited in the toddler and pre-school age group.

High deprivation and food insecurity has been linked to poor nutrition choices in young New Zealanders (Utter, 2020; Gerritsen, 2019; Gerritsen et al., 2020). Results of the National Children's Nutrition Survey 2002 found no difference in total sugar intake by NZDep2001 (Ministry of Health, 2003). However, more recent data has shown that 2-4 year old children

who experience severe to moderate food insecurity consume fizzy drinks more frequently than children who do not experience insecurity (Ministry of Health, 2019).

It has been suggested that education is the strongest predictor of health behaviours (Ball et al., 2008). In the United States of America, a lower education has been linked to the introduction of added sugar before the age of 24 months (Bably et al., 2021). In contrast, Northstone et al. (2002), reported mothers with a university qualification were more likely to give their toddler fruit juice. There is no NZ data exploring the association between parental education and sugar intake in young-old children.

Questions have been raised about whether the complementary feeding method of baby-led weaning results in a difference in food and nutrient intake in children compared to children who are traditionally spoon-fed (Williams Erickson et al., 2018). Baby-led weaning usually occurs from six months of age where an infant feeds themselves (D'Auria et al., 2018). Some studies have found a link between feeding method and a higher total sugar intake (Daniels et al., 2015; Lundkvist et al., 2021). However, more evidence exploring the association between total sugar intake and feeding method is needed (Langley-Evans, 2022; Williams Erickson et al., 2018).

In recent years, food pouches have become a widely consumed complementary food. In NZ, commercial food pouches are marketed for children aged 4- to 18-months and over (Katiforis et al., 2021). Many of these products marketed for infants and young children are likely to be consumed by older children (Westland and Crawley, 2018). These contain more total sugar than other commercial infant foods (Katiforis et al., 2021; Koletzko et al., 2019; Hutchinson et al., 2021) and are largely made from fruit or sweet vegetables (Katiforis et al., 2021; Garcia et al., 2016; Moumin et al., 2020) which could reinforce sweet preferences (Garcia et al., 2016). Additionally, it has been suggested that sucking a purée directly from a pouch nozzle may contribute to dental caries due to the prolonged exposure of the purée to tooth enamel (Koletzko et al., 2018; Koletzko et al., 2019; Westland and Crawley, 2018).

Currently, the World Health Organization (WHO) recommend children limit their intake of free sugars to less than 10% of total energy intake (World Health Organization, 2015). New Zealand's MoH recommends that babies and toddlers do not consume any added sugar (Ministry of Health, 2021a). The *Food and Nutrition Guidelines for Healthy Children and Young People (2-18 years)* recommend that foods and drinks are low in sugar, high sugar foods and drinks be limited to occasional consumption only, and to limit the offer of high sugar foods and drinks at home (Ministry of Health, 2015).

Total sugar intake in NZ children is not well understood. Internationally, Fujiwara et al. (2018), is the only study to compare intake between sex in the 18-35 month age group (girls 46.1g/day; boys 47.5g/day). Some studies reported intake as g/day and as a percentage of total energy (% E) (Kyttälä et al., 2010; Verduci et al., 2019; Marinho et al., 2020; Walton, 2012; Crowe et al., 2020; Langlois and Garriguet, 2011) while others reported grams per day only (Fujiwara et al., 2018; Pawellek et al., 2017; Mahajan et al., 2021; Devenish et al., 2019; Devenish et al., 2018) which can make it challenging to compare results. Intake of total sugar ranged from 12g/day (in 12 month old Finnish children) (Kyttälä et al., 2010) to 101g/day (1-3 year Canadian children) (Langlois and Garriguet, 2011) and 5.5% E (Kyttälä et al., 2010) and 28.6% E (1-3.9 year Italian children) (Verduci et al., 2019). These wide ranges may be due to methods of data collection or analyses, or other social factors such as cultural food practices or demographics.

There is limited evidence on the consumption of total sugars in New Zealand children aged between 1 and 3.9 years old. The aim of this study is to describe the amount of total sugar intake and the association between total sugar intake and BMI z-score classification, demographic variables and feeding practices in young NZ children.

3.2 Methods

3.2.1 Study Design

This cross-sectional study utilises data from the Young Foods New Zealand study to explore the total sugar intake and percentage of energy contributed to the diet from sugar in children aged 1-3.9 years living in New Zealand. Young Foods New Zealand is a multi-centre study designed to report nutrient intakes from an ethnically diverse cohort of young children in New Zealand.

3.2.2 Participants and Recruitment

Participants were recruited within the Auckland, Wellington, and Dunedin regions of New Zealand from August 2020 to February 2022. Participants attended two appointments for data collection. Parents or guardians were asked to sign a consent form at the first appointment. Ethical approval has been granted by the University of Otago Human Ethics Committee (approval number: H20/040).

Eligibility criteria were: (a) children must be aged between 1 and 3.9 years, (b) live within the Auckland, Dunedin, or Wellington regions, (c) have not participated in any study requiring diet modification, (d) parent or caregiver must be over 16 years, and (e) parent or caregiver must be able to communicate in English. Participants were screened for eligibility (online/telephone questionnaire) and if eligible an information pack was sent via email or mail. A subsequent phone call was conducted to obtain verbal consent and to schedule appointment times.

Recruitment was conducted through posters displayed at community hubs such as Plunket centres, swim centres, day care centres, playgroups, churches, and medical practices and online advertisements through Facebook and Instagram. The study design included targets for ethnicity (Māori, Pacific and Asian) and therefore recruitment was focused in specific areas with ethnically diverse populations. Snowballing recruitment strategies were also used.

3.2.3 Sample Size

A sample size of 300 participants was calculated by a Biostatistician. A sample size of 300 enables estimates of mean nutrient intake to a 95% precision level of +/- 0.1SD (standard deviations). It also allows for estimations of prevalence of inadequate intakes to a 95% precision level of +/- 6%.

3.2.4 Study Procedures and Data Collection

Two appointments one week apart were required for data collection. The first appointment was either at university research rooms, at home or any other preferred location. This visit took approximately 90-minutes. The second was an in-clinic visit that took no more than 60-minutes. During COVID-19 lockdown, some appointments were conducted online via Zoom. Participants were given a $100 The Warehouse, grocery or petrol voucher at the second visit for their time. REDCap was used to store participant data including questionnaire responses and diet recall data.

Demographic Data Collection

Demographic data was collected including age, sex, ethnicity, post code, parental education, and main caregiver. Main caregiver categories were based on the main questionnaire (see Appendix B). Children were classified as toddlers (1-1.9 years) or pre-schoolers (2-3.9 years) as defined in the Ministry of Health *Healthy Eating Guidelines for Babies and Toddlers* Ministry of Health (2021a), and *Food and Nutrition Guidelines for Healthy Children and Young People* (Ministry of Health, 2015). The *New Zealand Deprivation Index* 18 (Atkinson et al., 2019) was used to determine the level of household deprivation. Ethnicity was categorised by using a total response method (where every ethnicity was counted) and then a prioritisation method (Māori, Pacific, Asian, Other, NZ European).

Anthropometric Assessment

Anthropometrical data were collected at the first appointment including length, height and weight. Length was measured using a baby measuring mat (Seca 210), height using a portable stadiometer for children, and weight using adult weight scales. Length, height and weight measurements were taken twice to the nearest 0.1cm or 0.1kg, respectively. A third measurement was taken if there was a discrepancy of ≥0.7cm for length and height, or ≥0.1kg for weight. BMI z-scores and classifications were taken from WHO Multicentre Growth Reference Study Group and de Onis (2006), and de Onis and Lobstein (2010), Categories were underweight (<-2), healthy (≥-2 to ≤1), overweight (>1 to ≤2) and obese (>2).

Dietary Assessment

One 24-hour food recall was conducted at each appointment. Both recalls were conducted on different days of the week to capture intake variation between days. Parents or guardians were asked what their child ate and drank the day before the appointment. To assist parents or guardians with the recall, they were asked to take pictures of the child's food at the start

of each meal using a mobile phone. Consumption of food or drink was classed as any amount consumed by the child. Further details can be found in the food recall protocol (see Appendix C).

Researchers completed each recall with the parent or guardian using the triple pass method which is an adaptation of the Automated Multiple Pass Method by the United States Department of Agriculture (Blanton et al., 2006). The first pass involved the researcher recording a quick list of all food and drink consumed that the parent or guardian could remember. The second pass involved the researcher going through each item on the quick list to compile a detailed list. Researchers prompted the parent or guardian on specific details such as the time, place, description of the food, brand, amount and how the child was fed. The photos were utilised in this step as a prompt. Measurement aids (16cm x 16cm grids, 4-16cm circles, household measuring cups and spoons) were used to determine the portion consumed. The third pass involved the researcher reading the detailed list back to the parent or guardian, allowing them to fill in any missing details. This included a question regarding whether any sugar was added to food or drinks by the parent or guardian. Recipes were recorded at the end of the process, where relevant. If the child was under the care of another caregiver on the day of a 24-hour recall (e.g., at an Early Childcare Centre), those caregivers were asked to complete a separate form. Any missing information from this form was followed-up by telephone or email with that caregiver, with the parent or guardian's permission.

Feeding method and food pouch consumption data were captured using a questionnaire. Parents or caregivers were asked how their child was fed at 6 months of age and whether they used baby-led weaning. Additionally, they were asked about the frequency of home-filled and ready-to-eat pouches at the point of data collection, and the top three most commonly consumed flavours and brands (see Appendix B). Food pouch consumption categories were grouped based on the total responses to pouch frequency consumption questions in the main questionnaire (see Appendix B).

Dietary data was checked for inconsistencies or anomalies by researchers before being analysed. If any issues were found, the researcher contacted the interviewer involved in the recall which sometimes involved the interviewer contacting the participant for follow-up. The 24-hour diet recall data was entered into Foodworks 10 in Auckland by a limited number of trained researchers using standard operating procedures (see Appendix D) to ensure consistency and quality control. Data from Foodworks were used to analyse intake of total

sugar, energy, carbohydrate, protein, fat, and fibre. Intake values were reported as usual intake using the Multiple Source Method (MSM) (Harttig et al., 2011).

3.2.5 Statistical Analysis

Statistical analyses were conducted using IBM SPSS Statistics 24 software. Descriptive statistics (participant characteristics, energy, macronutrient intakes, total sugar intake, and percentage of total energy intake) were defined using mean, standard deviation, and range. Continuous data were treated as normal based on the central limit theorem which states that a sample size greater than 30 is assumed to be normally distributed (Vrbin, 2022). Independent samples t-tests were conducted to determine whether there were any differences between age, sex, and macronutrient intake (including total sugar). Analysis of Covariance Tests (ANCOVA) tests were conducted to determine whether there were any differences between total sugar intake and BMI z-score classification, pouch frequency, ethnicity, baby-led weaning, deprivation score, or parental education. Tukey's Honest Significance Difference (HSD) test was performed to analyse for specific differences between group means. A p-value <0.05 was considered significant.

3.3 Results

3.3.1 Participants

In total, 289 parents or guardians participated in the Young Foods New Zealand study and provided complete dietary data for the final analysis in this research.

The demographic characteristics of the children and their parent or main caregiver are shown in Tables 3.1 and 3.2, respectively. Table 3.1 includes current food pouch use and classification according to BMI z-score. Targets for ethnicity were achieved by targeting communities with a high proportion of Māori, Pacific and Asian people.

Table 3.1 Participant Characteristics

Child	n (%)	Mean (SD)
Age (years)	289 (100)	2.5 (0.9)
1-1.9	108 (37.4)	
2-3.9	181 (62.6)	
Sex		
Female	147 (50.9)	
Male	142 (49.1)	
Ethnicity		
European	125 (43.3)	

Māori	75 (26.0)	
Pacific	47 (16.3)	
Asian	37 (12.8)	
Other	5 (1.7)	
BMI (kg/m^2)		16.7 (1.6)
BMI z-score and classification	n=249*	
<-2 (Underweight)	1 (0.4)	
≥-2 to ≤1 (Healthy)	147 (59.0)	
>1 to ≤2 (Overweight)	70 (28.1)	
>2 (Obese)	31 (12.4)	
Main caregiver	n=288	
Mother	276 (95.8)	
Father	7 (2.4)	
Guardian	2 (0.7)	
Other	3 (1.0)	
Frequency of pouch consumption (per week)	n=287	
None	150 (52.3)	
1-6	112 (39.0)	
7-14	25 (8.7)	
Feeding method‡	n=270	
Traditionally spoon-fed	178 (65.9)	
Partial	48 (17.7)	
Baby-led weaning	44 (16.3)	

BMI = Body Mass Index; *Missing data was due to COVID-19 lockdowns which prevented physical appointments to measure height and weight. ‡ Feeding method at 6 months of age.

Most caregivers were 30-34 years of age, of European ethnicity and university educated.

Table 3.2 Parent or Caregiver Characteristics

Parent/Caregiver	n (%)	Mean (SD)
Age (years)		33.6 (5.3)
16-19	0	
20-24	15 (5.2)	
25-29	51 (17.6)	
30-34	104 (36.0)	
35-39	84 (29.1)	
40+	33 (11.4)	
Did not answer	2 (0.7)	
Ethnicity		
European	154 (53.3)	
Māori	55 (19.0)	
Pacific	40 (13.8)	
Asian	32 (11.1)	
Other	5 (1.7)	
Did not answer	3 (1.0)	
Education level		
School	55 (19.0)	
Polytech	64 (22.1)	
University	167 (57.8)	
Did not answer	3 (1.0)	

3.3.2 Dietary Intake of Total Sugar

The mean (standard deviation), median (25th percentile, 75th percentile) and range of macronutrient intakes (including total sugar) in kilojoules (kJ), grams (g) and percentage of total energy intake (% E) are presented by age categories (Table 3.3) and sex (Table 3.4).The mean total energy intake was 5030.7 (879.4) kJ/day, the mean total carbohydrate intake was 144 (28.7) g/day, and the mean total sugar intake was 67.3 (15.1) g/day.

For the 1-1.9-year age group, the mean total sugar intake was 65.2g/day and the mean total sugar intake as a percentage of total energy was 23.7%. For the 2-3.9-year age group, the mean total sugar intake was 68.5g/day and the mean total sugar intake as a percentage of total energy was 22.4%. The mean total sugar intake for boys was 67.8g/day compared to girls who had a mean total sugar intake of 66.8g/day. Boys and girls had similar mean intakes of total sugar as a percentage of total energy, 22.7% and 23.1%, respectively.

Table 3.3 Macronutrient Intake in Toddlers and pre-schoolers

	Total (n=289)			**Age (years)** 1-1.9 (n=108)			2-3.9 (n=181)			
	Mean (SD)	Median (25^{th}-75^{th})	Range	Mean (SD)	Median (25^{th}-75^{th})	Range	Mean (SD)	Median (25^{th}-75^{th})	Range	*p*-value*
Energy (kJ)	5030.7 (879.4)	4963.0 (4437.5-5567.7)	2592.3-9294.6	4670.7 (702.8)	4652.4 (4211.0-5067.3)	2599.8-6880.6	5245.6 (905.2)	5211.9 (4761.4-5814.2)	2592.3-9294.6	<0.001
Protein										
g	45.6 (10.5)	45.3 (38.2-52.8)	18.2-92.6	41.8 (9.8)	41.2 (34.5-47.7)	19.0-70.9	47.8 (10.3)	47.4 (40.8-54.6)	18.2-92.6	<0.001
% E	15.4 (2.3)	15.2 (14.0-16.7)	10.7-32.9	15.1 (2.2)	14.8 (13.7-16.8)	10.8-23.0	15.5 (2.3)	15.5 (14.3-16.6)	10.7-32.9	0.16
Carbohydrate										
g	144.0 (28.7)	144.1 (125.4-162.2)	64.5-234.9	130.9 (28.2)	130.2 (112.0-147.4)	64.5-211.1	151.8 (26.1)	150.0 (134.7-167.9)	82.9-234.9	<0.001
% E	48.7 (4.9)	49.0 (45.9-51.9)	23.3-61.9	47.4 (5.6)	47.4 (44.8-50.8)	23.3-61.9	49.4 (4.3)	49.7 (46.6-52.2)	31.8-61.0	0.002
Total sugar										
g	67.3 (15.1)	65.5 (57.2-76.5)	19.8-113.8	65.2 (16.9)	62.8 (54.8-74.5)	19.8-113.8	68.5 (13.9)	66.3 (58.9-77.6)	37.9-110.0	0.069
% E	22.9 (4.4)	22.8 (20.1-25.4)	12.1-37.3	23.7 (5.1)	23.4 (20.3-26.0)	12.1-37.3	22.4 (3.8)	22.4 (19.8-24.7)	13.9-33.0	0.023
Fibre (g)	14.0 (4.4)	13.4 (11.0-16.7)	4.3-28.0	12.5 (3.8)	12.2 (9.8-14.8)	4.3-22.1	15.0 (4.5)	14.7 (11.8-17.6)	5.0-28.0	<0.001
Fat										
g	46.1 (9.5)	45.0 (39.6-51.4)	23.2-94.0	44.2 (7.4)	43.3 (39.3-47.7)	26.7-68.8	47.2 (10.5)	46.5 (40.0-53.3)	23.2-94.0	0.006
% E	33.9 (3.8)	33.8 (31.4-36.3)	21.9-49.9	35.2 (4.0)	34.8 (32.8-37.3)	25.1-49.6	33.1 (3.5)	33.2 (30.9-35.3)	21.9-44.5	<0.001

% E = Percentage of total energy intake; SD = Standard deviation; kJ = Kilojoules; g = grams. *Independent t-test to show difference between the two age groups in macronutrient intake.

Table 3.4 Macronutrient Intake by Sex

	Total (n=289)			**Sex** Boy (n=142)			Girl (n=147)			
	Mean (SD)	Median (25^{th}-75^{th})	Range	Mean (SD)	Median (25^{th}-75^{th})	Range	Mean (SD)	Median (25^{th}-75^{th})	Range	*p*-value*
EER (kJ)[†] 12m – 24m 3y				3,500-4,400 3,400[‡]; 4,200-7,600[ǂ]			3,200-4,200 3,200[‡]; 3,900-7,100[ǂ]			
Energy (kJ)	5030.72 (879.4)	4963.0 (4437.5-5567.7)	2592.3-9294.6	5122.0 (890.9)	5053.4 (4589.7-5579.0)	2592.3-9294.6	4942.5 (861.9)	4894.9 (4313.7-5560.5)	2599.8-7745.9	0.083
Protein										
g	45.6 (10.5)	45.3 (38.2-52.8)	18.2-92.6	46.5 (10.6)	47.1 (39.1-53.7)	18.2-92.6	44.7 (10.4)	44.5 (36.7-51.4)	19.0-75.7	0.152
% E	15.4 (2.3)	15.2 (14.0-16.7)	10.7-32.9	15.4 (2.5)	15.2 (13.9-16.8)	10.8-32.9	15.3 (2.0)	15.2 (14.0-16.6)	10.7-23.0	0.691
Carbohydrate										
g	144.0 (28.7)	144.1 (125.4-162.2)	64.5-234.9	146.1 (30.0)	147.7 (128.2-165.8)	64.5-234.9	142.0 (27.3)	140.2 (124.7-160.6)	64.7-225.2	0.225
% E	48.7 (4.9)	49.0 (45.9-51.9)	23.3-61.9	48.5 (5.5)	48.6 (45.9-52.1)	23.3-61.9	48.9 (4.3)	49.3 (45.8-51.9)	34.3-61.0	0.494
Total sugar										
g	67.3 (15.1)	65.5 (57.2-76.5)	19.8-113.8	67.8 (15.3)	65.6 (58.6-76.5)	27.5-113.8	66.8 (15.0)	65.2 (56.2-76.2)	19.8-109.5	0.572
% E	22.9 (4.4)	22.8 (20.1-25.4)	12.1-37.3	22.7 (4.4)	22.6 (19.8-25.0)	12.1-36.4	23.1 (4.4)	23.0 (20.2-25.5)	12.9-37.3	0.376
Fibre (g)	14.0 (4.4)	13.4 (11.0-16.7)	4.3-28.0	14.6 (4.7)	13.9 (11.3-17.3)	4.3-28.0	13.5 (4.2)	13.2 (10.5-16.4)	4.6-23.9	0.041
Fat										
g	46.1 (9.5)	45.0 (39.6-51.4)	23.2-94.0	47.1 (9.9)	45.8 (40.9-52.4)	23.2-94.0	45.0 (9.1)	43.7 (38.5-50.9)	26.5-68.5	0.074
% E	33.9 (3.8)	33.8 (31.4-36.3)	21.9-49.9	34.1 (4.1)	34.0 (31.5-36.3)	25.1-49.9	33.9 (3.4)	33.5 (31.236.3)	21.9-41.7	0.488

EER = Estimated energy requirements; % E = Percentage of total energy intake; SD = Standard deviation; kJ = Kilojoules. g = grams.

[†]EERs differ between age groups (12m, 15m, 18m, 21m, 24m, 3y) and gender. [‡]Represents the basal metabolic rate. [ǂ]Represents the range of EER at various physical activity levels (1.2-2.2). *Independent t-test to show difference between sex in macronutrient intake.

3.3.3 Association Between Total Sugar Intake and BMI z-Score Classification

Table 3.5 shows the amount of sugar intake in grams (g) and as a percentage of total energy (% E) by BMI z-score classification. Using ANCOVA and controlling for age and sex, sugar intake (g) varies by BMI classification (p=0.004). A post-hoc (Tukey) indicates that children with obesity have a higher intake of total sugar (9.8g) than normal or underweight children (p=0.006), but not significantly higher than overweight children (p=0.19). This model explains 4% of the variation in sugar intake (g). Sugar intake (% E) did not vary by BMI classification (p=0.14).

Table 3.5 Total Sugar Intake (g) by BMI z-Score Classification

BMI z-Score classification	**Sugar intake (g) Mean (SD)**	**Total Sugar intake (% E) Mean (SD)**
Underweight (<-2) or Normal weight (≥-2 to ≤1) (n=148)	65.6 (14.9)	22.6 (3.9)
Overweight (>1 to ≤2) (n=70)	69.4 (14.8)	22.9 (4.7)
Obese (>2) (n=31)	75.4 (17.3)	24.5 (5.7)

3.3.4 Association Between Total Sugar Intake and Demographic Variables

Table 3.6 shows the amount of sugar intake in grams (g) and by percentage of total energy intake (% E) by ethnicity, deprivation score and parental education.

Table 3.6 Total Sugar Intake (g and % E) by Ethnicity, Deprivation, and Parental Education

Demographic variable	**Total Sugar intake (g) Mean (SD)**	**Total Sugar intake (% E) Mean (SD)**
Ethnicity		
European (n=125)	66.3 (12.7)	22.7 (3.7)
Māori (n=75)	69.7 (17.7)	24.1 (5.2)
Pacific (n=47)	67.8 (16.0)	22.4 (4.7)
Asian or other (n=42)	65.3 (15.8)	21.9 (4.0)
Deprivation score		
1 (n=29)	67.6 (15.3)	22.1 (3.6)
2 (n=27)	63.4 (14.3)	22.7 (4.8)

3 (n=23)	67.2 (15.8)	22.3 (3.5)
4 (n=19)	66.9 (14.0)	22.2 (3.9)
5 (n=33)	69.6 (17.6)	24.2 (5.6)
6 (n=33)	68.4 (13.9)	23.7 (3.6)
7 (n=40)	65.2 (14.3)	22.8 (4.1)
8 (n=35)	65.8 (14.6)	23.0 (4.0)
9 (n=25)	72.9 (16.1)	24.3 (5.7)
10 (n=25)	66.9 (15.9)	21.5 (4.1)
Parental Education		
School (n=55)	67.4 (14.3)	22.4 (3.7)
Polytech (n=64)	66.6 (15.1)	22.7 (4.6)
University (n=167)	67.4 (15.2)	23.1 (4.4)

Using ANCOVA and controlling for age and sex, sugar intake (g) did not vary by ethnicity (p=0.25), deprivation score (p=0.57), or parental education (p=0.94). Sugar intake (% E) did not vary by ethnicity (p=0.07), deprivation score (p=0.25) or parental education levels (p=0.55).

3.3.5 Association Between Total Sugar Intake and Feeding Practices

Table 3.7 shows the sugar intake in grams (g) and by percentage of total energy intake (% E) by feeding method.

Table 3.7 Total Sugar Intake (g and % E) by Feeding Method

Feeding method	**Total Sugar intake (g) Mean (SD)**	**Total Sugar intake (% E) Mean (SD)**
Traditionally spoon-fed (n=178)	67.8 (14.4)	22.8 (4.4)
Partial (n=48)	66.3 (16.1)	23.0 (3.8)
Baby-led weaning (n=44)	64.7 (16.0)	22.6 (4.3)

Using ANCOVA and controlling for age and gender, sugar intake (g) (p=0.63) and as a percentage of total energy (% E) does not vary between feeding method (p=0.9).

Table 3.8 shows the sugar intake in grams (g) and by percentage of total energy intake (% E) by infant food pouch consumption. Using ANCOVA and controlling for age and gender,

total sugar intake (g) varies by the number of pouches consumed (p=0.01). A post-hoc test (Tukey) indicates that children consuming 7-14 pouches per week have a higher intake of sugar (9.5g) than children consuming 1-6 pouches (p=0.01), but not significantly higher than children consuming no pouches (p=0.052). This model explains 3.1% of the variation in sugar intake (g).

Similar results were found for sugar intake (% E). Intake varies by pouch frequency (p<0.001). A post-hoc (Tukey) indicates that children who consume 7-14 pouches per week have a higher intake of sugar (% E) than children who consume no pouches (p<0.001), and those who consume 1-6 pouches (p=0.004). This model explains 6% of the variation in sugar intake (% E). Children who consume 7-14 pouches per week consume a mean difference of 4.0% more total sugar (% E) than children who consume none, and 3.0% more than children who consume 1-6 pouches per week.

Table 3.8 Total Sugar Intake (g and % E) by Food Pouch Consumption

Pouch consumption	**Total Sugar intake (g) Mean (SD)**	**Total Sugar intake (% E) Mean (SD)**
None (n=150)	67.3 (14.2)	22.1 (4.1)
1-6 (n=112)	65.3 (14.3)	23.1 (4.1)
7-14 (n=25)	74.7 (19.6)	26.1 (5.2)

3.4 Discussion

These results report the total sugar intake of 1-3.9 year old children in New Zealand. This study also described the association between total sugar intake and BMI z-score classification, demographic variables such as ethnicity, deprivation and parental education, and feeding practices such as baby-led weaning or food pouch consumption. The study population has a diverse population including Māori and Pacific children and children from a range of deprivation levels.

3.4.1 Total Sugar Intake

The mean intake of total sugar was 67.3g/day contributing 22.9% of total energy per day. It is not possible to comment on whether these align with nutritional guidelines as the guidelines only discuss added sugar intake, not total sugar. Within our population, it is interesting to note the vast range in total sugar intake which was 19.8-113.8g/day and 12.1-37.3% of total energy for the whole cohort.

In the current study, sugar intake has been categorised by age to align with *Healthy Eating Guidelines for New Zealand Babies and Toddlers (0-2 years old)*, *Food and Nutrition Guidelines for Healthy Children and Young People (Aged 2-18 years)*. We found no statistically significant difference between total sugar intake in g/day between the 1-1.9- and 2-3.9-year age groups (p=0.069). However, there was a statistically significant difference between the two age groups as a percentage of total energy (p=0.023). The older age group had a slightly lower total sugar intake as a percentage of total energy (22.4%) than the younger age group (23.7%). Walton (2012), also reported younger children consuming more total sugar as a percentage of total energy with one-year olds consuming 26.2% of total energy, and two- and three-year olds consuming 25% and 24.9% of total energy, respectively. However, in both studies this difference is minor.

We found that there was no statistically significant difference in total sugar intake as g/day or percentage of total energy between girls (p=0.572) and boys (p=0.376). Only one other study by Fujiwara et al. (2018), measured the difference in intake between boys and girls aged 18 to 35 months. They found that girls consumed 46.1g/day and boys 47.5g/day, however this difference was not significant. In the current study, girls consume 66.8g/day and boys 67.8g/day which was higher than findings from Fujiwara et al. (2018). The population studied in Fujiwara et al. (2018), and the current study were similar, but the current study included a marginally wider age range (18-35 months vs 1-3.9 years). However, the dietary assessment methods differed with Fujiwara et al. (2018) using a one day weighed diet record which may not be capture usual intake. Otherwise, the difference may reflect the predominantly wholefood diet in Japan compared to the western diet in New Zealand.

Overall differences in total sugar intake between the current study and other reported studies, include Kyttälä et al. (2010), who reported a lower intake of 12g/day for 1-year-olds, 33g/day for 2-year-olds and 41g/day for three year olds in Finland. Total sugar as a percentage of total energy was also significantly lower at 5.5%, 12.2% and 13.3%, respectively. Additionally, Verduci et al. (2019), reported 57.2g/day, however, this was analysed as simple sugars which was defined as natural (including fructose and lactose), free and added sugar. While this definition seems to encompass the total sugar definition from Food Standards Australia New Zealand (2021a), there may be nuances contributing to this difference in value.

Conversely, Langlois and Garriguet (2011), from Canada and Linggang et al. (2016), from Australia reported much higher amounts of total sugar of 101g/day and 93g/day, respectively

in children aged 1-3 years, compared to the current study. Langlois and Garriguet (2011), used 24-hour recall data for one day only and neither study utilised the multiple source method which may have resulted in data not being indicative of usual intake. Interestingly, Linggang et al. (2016) reported 25.2% total sugar intake for 2-3 year olds, which is similar to the 2-3.9 year age group in the current study. Other studies from Portugal (Marinho et al., 2020), Ireland (Walton, 2012; Crowe et al., 2020) and Canada (Mahajan et al., 2021) reported higher total sugar intake for both grams per day and as a percentage of total energy.

Pawellek et al. (2017), from Germany, Belgium, Italy, Poland, and Spain reported similar intakes to the current study for 12–24-month-old children (65.2g/day, 65.9g/day, and 69.7g/day, respectively vs 65.2g/day in 1-1.9-year-olds in the current study) but reported a higher intake of 75.3g/day for the 36-month-old children compared to 68.5g/day for 2-3.9-year-olds in the current study. Similarly, Devenish et al. (2018), from Australia reported total intake of 65.3g/day for 12-14 month old children compared to the 1-1.9 year cohort in the current study (65.2g/day).

There are limitations to consider when comparing these results from international studies to the current study. Firstly, international data is not representative of the multi-cultural New Zealand population. Furthermore, international food composition databases may report total sugar differently. Secondly, the stratification by age differed for some studies which makes it challenging to compare results. For example, Fujiwara et al. (2018), grouped children as 18-35 months or 3-6 years. Similarly, Marinho et al. (2020), and Mahajan et al. (2021), grouped children as under 5 and 1.5-5 years, respectively. It is unclear why these stratifications were chosen. In Canada, the nutrition guidelines are based on infants (birth to 11 months), toddlers (12-24 months), and individuals 2 years and over (Government of Canada, 2022b; Government of Canada, 2020; Government of Canada, 2014). Nutrition guidelines for children from Portugal and Japan were not found. The current study were based on the NZ nutrition guidelines for infants, toddlers and young people (Ministry of Health, 2021a; Ministry of Health, 2015)

It is important to consider total sugar as a percentage of total energy alongside total sugar measured in grams per day. This is because sugar contributes to total energy intake in the diet. Food and nutrition guidelines recommend a varied diet by including foods from each of the food groups: (a) vegetables, (b) fruit, (c) grain foods, (d), legumes, nuts, seeds, fish or seafood, eggs or poultry, or lean red meat, and (e) milk and milk products (Ministry of

Health, 2021a; Ministry of Health, 2015). It is important for the growth and development of children that they include adequate dietary energy from all sources.

3.4.2 Association Between Total Sugar Intake and BMI z-Score Classification

BMI z-scores are used internationally as a reference to measure and track the growth of children. They are based on a set of international data to reflect the similarities in growth between a wide range of ethnic groups. It describes how children should grow in all settings, rather than how they grow (Garza and de Onis, 2004).

We determined that total sugar intake in g/day varies by BMI classification (p=0.004). Total sugar intake is 9.8g/day higher in children with obesity than normal or underweight children. However, this model only explains 4% (r^2=0.04) of the variation in total sugar intake. Parnell et al. (2008), found that obese children aged 5-14 did not consume significantly more sugar than normal or overweight children. Additionally, in adults and children, those with the lowest intake of sugars from foods were significantly more likely to be overweight or obese (Parnell et al., 2008). The World Health Organization (2003), have suggested that factors such as physical activity, dietary fibre intake, home and school food environment and breastfeeding may promote or protect against overweight and obesity. These may be helpful to analyse alongside dietary sugar intake in future studies.

Other studies have found no association between a decreased intake of sugar-sweetened beverages (SSBs) or other foods containing sugar and change in BMI or BMI z-score (Te Morenga et al., 2013). However, Te Morenga et al. (2013), found a significant increase in the risk of overweight with higher intakes of sugar. In contrast, the current study did not find an association between total sugar intake and overweight (p=0.19). Whilst Linardakis et al. (2008), found that children who were categorised as high consumers of SSBs had a higher BMI, they did not measure BMI z-score so our results cannot be compared. These results show that the role sugar has in the development of overweight or obesity remains controversial, therefore, requires further research.

3.4.3 Association Between Total Sugar Intake and Demographic Variables

Our analyses did not find any significant differences in total sugar intake (g/day or % E) between ethnicity, deprivation score, or parental education level. There are inconsistent findings between sugar intake and ethnicity in New Zealand, so the current study adds up-to-date evidence. When considering actual intake, the range between ethnicities is minimal 65.3g/day to 69.7g/day and 21.9% of total energy to 24.1% of total energy (see Table 3.6).

The last data to be collected on deprivation was in the National Children's Nutrition Survey in 2002. However, this only looked at the 5–14-year age group. Other studies on deprivation consider the intake of sugar-sweetened beverages, not total intake. The difference between the low deprivation (1) and high deprivation (10) is minimal, 67.6g/day and 66.9g/day, and 22.1% of total energy and 21.5% of total energy, respectively (see Table 3.6).

This is the first study to consider the association between total sugar intake and parental education in young New Zealand children. Like other demographic variables, actual intake did not differ greatly. What might be considered the most unlikely group to have a low total sugar intake (school) had the same intake (g) as the university group (67.4g/day) and they had the lowest intake (% E) in the cohort (22.4%) even though only marginally.

3.4.4 Association Between Total Sugar Intake and Feeding Practices

Our analyses did not find any differences in total sugar intake (g/day or % E) between feeding method.

Concerns have been raised that food pouches may contribute to total sugar intake in young children. This is one of the few studies to report on pouch use and total sugar intake in young children. Young children who were classified as frequent pouch users (7-14 per week) did have a higher total sugar intake than less frequent pouches users. However, the number of children who frequently consumed pouches was small (n=25) and there were no statistically significant differences in sugar intake between the children who did and did not consume pouches.

We determined that total sugar intake in g/day varied by pouch consumption (p=0.01). Children who consumed 7-14 pouches per week had a higher intake of sugar in g/day than children who consumed 1-6 pouches per week (p=0.01) and consumed 9.5g more total sugar per day. Interestingly, children who consumed 7-14 pouches consumed 74.7g/day compared to children who consumed no pouches 67.3g/day. Whilst this was not statistically significant, the difference in actual intake is minimal (a difference of 7.4g).
This suggests that pouches may not add any more sugar to the diet compared to other sources in young children. More data is needed to understand what these sources are.
Additionally, we determined that total sugar intake as % E also varies by the number of pouches consumed (p<0.001).

These results are not surprising given the findings by Koletzko et al. (2019), who reported that the total sugar from food pouches contributed between 40-88.9% of total energy. Additionally, Hutchinson et al. (2021), reported between 72-79% for fruit-based pouches and between 10-42% for vegetable-based pouches.

When comparing consumers versus non-consumers in 18-month-old Swedish children, Lundkvist et al. (2021), reported that 76.5% did not consume or seldom consumed pouches compared to the current study which found 52.3% did not consume pouches. They also found that 23.5% consumed a pouch at least once per week, compared to the current study which found that 47.7%. consumed at least one pouch per week. It is important to note that Lundkvist et al. (2021), analysed intake of fruit-based pouches only.

Given the high levels of total sugar in commercial food pouches, it has been suggested that manufacturers should produce products that contain less total sugar by including a higher ratio of bitter vegetables, or perhaps some bitter vegetable only options (Hutchinson et al., 2021). However, due to commercial interests, manufacturers may be unlikely to do so.

3.4.4 Strengths and Limitations

A strength of the study was the large sample size and there was a good representation of Māori and Pasifika. A further strength was that food records were highly accurate due to the researchers having received a high level of training, following standardised operating procedures and the use of photos and the triple pass method ensured accurate detail was able to be obtained.

This is the first study in New Zealand to consider total sugar intake of the 1-3.9-year age group which is another strength. Having this data enables researchers to assess whether sugar intake for this age cohort is a topic of interest.

A limitation of this study are the COVID-19 lockdowns (particularly in Auckland) prevented some face-to-face participant appointments from going ahead. Whilst a pivot to online appointments meant food records could still be recorded, some length/height and weight information was not able to be collected. Therefore, BMI data was missing for some children (n=40). A further limitation was that the data was not available in time for the completion and submission of this thesis, therefore, we were unable to analyse free or added sugar intake, or sources of total sugar. Some bias or misreporting may have occurred during the food record data collection (e.g., under-reporting of less heathy foods, and over-reporting of healthier foods). Lastly, the current study was a secondary outcome to the Young Foods

New Zealand study which used a convenience sampling method. Therefore, the data is not nationally representative and collected data in only three cities of New Zealand.

3.4.5 Conclusion

This study is the first to measure total sugar intake in 1-3.9 year old children in New Zealand. We found an association between total sugar intake and obesity and the frequency of food pouch consumption. No associations were found between total sugar intake and ethnicity, deprivation, parental education or feeding method. We were able to measure total dietary sugar intake in 1-3.9-year-old children and the data included a good ethnic and deprivation representation. Further research is required to measure the added or free sugar intake and the sources of these sugars in a representative population.

Chapter 4. Conclusions and Recommendations

4.1 Achievement of Aims and Objectives

The overall aim of the research was to describe the total sugar intake of 1-3.9-year-old children in New Zealand. Firstly, this study found that 1-3.9-year-old children in New Zealand consume 67.3g/day of total sugar and 22.9% total sugar as a percentage of energy.

Secondly, this study found an association between total sugar intake (g) and BMI z-score classification. Excess sugar intake has been linked to adiposity (Te Morenga et al., 2013; Fidler Mis et al., 2017). Further research to determine what the food sources of sugars are would clarify whether sugars are from added or free sources, therefore, whether nutrition guidelines are being followed.

Additionally, this study found no association between total sugar intake and the demographic variables of ethnicity, deprivation, and parental education. Other studies in New Zealand have reported inconsistent findings when investigating ethnicity (Ministry of Health, 2003; Jamieson and Koopu, 2007; Smirk et al., 2021) so the current study adds to the literature. This is the first study to investigate the association between total sugar intake in children and parental education in New Zealand. Although no significant associations were found, up-to-date data on total sugar intake and demographic characteristics may contribute to the development of public health interventions by providing insight into where nutrition resources are needed or not needed.

Lastly, this study did not find any association between total sugar intake and feeding method. However, we did find an association between total sugar intake (g) and the frequency of pouch consumption. Many pouches have been found to a high sugar content as their main ingredients are fruit or sweet vegetables (Katiforis et al., 2021; Garcia et al., 2016; Moumin et al., 2020). The smooth texture and act of sucking directly from the pouch nozzle may contribute to decay (Koletzko et al., 2018; Koletzko et al., 2019; Westland and Crawley, 2018). Misleading marketing such as product names and front-of-pack graphics results in parents or caregivers believing commercial pouches to be healthy (Westland and Crawley, 2018), therefore, they may not be aware of the hidden sugar in commercial food pouches.

4.2 Research Impact

This is the first study in this age population to study total sugar intake which enhances our understanding of sugar intake in young children.

The finding that total sugar intake was associated with a high frequency intake of commercial pouch consumption could mean that many parents or caregivers are unlikely to realise the sugar content of commercial food pouches. Further nutrition education or changes to manufacturing and nutritional information labelling may be of benefit.
The learnings from this study could be used to design further large-scale studies on dietary intake and sources of sugar, especially free and added sugars.

4.3 Strengths

This study had several strengths. Firstly, the sample size was high and there was a good representation of Māori and Pasifika. There was also a good representation of deprivation. Secondly, food records were highly accurate due to the researchers having received a high level of training. Additionally, the use of photos and the triple pass method ensured accurate detail was able to be obtained. Finally, this is the first study in New Zealand to measure total sugar intake of the 1-3.9-year age group. Having this data enables researchers to study sugar intake in more depth and contributes to our understanding of sugar intake in young children.

4.4 Limitations

This study had several limitations. Firstly, the COVID-19 pandemic lockdowns (particularly in Auckland) prevented some face-to-face participant appointments from going ahead. Whilst a pivot to online appointments meant food diaries could still be recorded, some height and weight information was not able to be collected. Therefore, BMI data was missing for some children (n=40). Secondly, issues with how the 24-hour diet records were entered into Foodworks (as mixed dishes) prohibited the identification of the sources of sugar in the dataset. This limitation was beyond the control of the researcher and due to the primary aims of the wider study (Young Foods New Zealand). Currently, efforts are being made to address this limitation and in the future food sources as well as free and added sugar intake and courses will be reported. Thirdly, there was potential for some bias or underreporting during the food diary data collection due to parents or caregivers providing healthier foods if they believed the foods their children would normally eat are considered less healthy.
Lastly, the current study was a secondary outcome to the Young Foods New Zealand study which used a convenience sampling method. Therefore, the data is not nationally representative and collected data in only three cities. Additionally, the results of this study should be interpreted with some caution. Firstly, this study did not consider the intake or free or added sugar, therefore, results cannot be compared to national nutrition guidelines.

Secondly, whilst this study did find an association between total sugar intake and BMI classification, this is not a cause or effect of sugar intake.

4.5 Recommendations and Future Research

- Further research within the 1-3.9-year age group to measure total, free, and added sugar intake. Additionally, describe sources of sugars including categorising intake by food group and other food types.
- Updated New Zealand National Children's Nutrition Survey (last conducted in 2002) to gain insight into the sugar consumption of older New Zealand children. This should include dietary intake and common sources of total, free, and added sugars.
- Longitudinal research on the health outcomes of long-term total, free and added sugar intake. Findings could inform whether changes need to be made to nutrition guidelines or whether public health initiatives are needed. For example, education for parents on the sugar content of foods and serving sizes.
- Research into parent or caregiver understanding of food pouches and the sugar content that they contain could inform whether education is needed or whether changes need to be made to food labelling in New Zealand

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Appendices

Appendix A: Screening Questionnaire Young Foods New Zealand (YFNZ)

Office use only

Date:

Participant ID:

Screening questionnaire

How did you find out about this study?

- ○ Facebook
- ○ Website
- ○ Poster/flyer, please specify where you saw this: _____
- ○ Someone I know took part in the study
- ○ Friend/family member/colleague
- ○ Other, please specify: _____

Contact details

These first few questions ask about your contact details. (*Ask Q's as applicable*)

1. What is your name?

_____

2. What is the name of your child who might take part in the study?

First name: _____

Last name: _____

3. Is [*child's name*] a girl or a boy?

- ○ Girl
- ○ Boy
- ○ I would rather not say

4. How are you related to [*child's name*]?

- ○ Mother
- ○ Father
- ○ Grandparent
- ○ Guardian
- ○ Other Please state: _____

5. Are you the primary caregiver of [*baby's name*]?

- ○ Yes
- ○ No

6. What is your mobile number?

_____

7. What is your email address?

_____

8. What is your postal address?

_____
_____

(Street number and name, City, Region, Postcode)

9. Which ethnic group does your child belong to? *Select all that apply to your child.*

- ○ Māori
- ○ Pacific
- ○ New Zealand European
- ○ Other

General screening questions

The next few questions will help us tell whether you and [*child's name*] are eligible to take part in this study.

10. What is [*child's name*]'s date of birth?

_____ / _____ / _____
dd mm yyyy

IF baby is 3.9 years old or younger **(GO TO Q10)**
IF baby is older than 3.9 years **(CLOSE)**

"We're sorry but unfortunately your child is outside our age range which means you cannot take part in our study - but thank you for taking the time to get in touch with us, and all the best."

11. What is your date of birth?

_____ / _____ / _____
dd mm yyyy

OR If you would feel more comfortable doing this could you tell me whether you are 16 years of age or older?

○ Yes, I am 16 years of age or older
○ No, I am less than 16 years of age

IF respondent is 16 years of age or older **(GO TO Q11)**
IF respondent is less than 16 years of age **(CLOSE)**

"We're sorry but we need our participants to be 16 years of age or older – this means you cannot take part in our study – but thank you for taking the time to get in touch with us, and all the best."

12. Which area of New Zealand do you live in?

○ Auckland **(GO TO Q11a)**
○ Wellington **(GO TO Q11a)**
○ Dunedin **(GO TO Q11a)**
○ None of the above **(CLOSE)**

"Unfortunately we need our participants to live in the Auckland, Wellington, or Dunedin area. We're sorry but this means you cannot take part in our study - but thank you for taking the time to get in touch with us, and all the best."

12a. Which Town/City do you live in?

[*See list of eligible Town/City's for respective regions at the end of this document*]

IF respondent lives in eligible town/city **(GO TO Q12)**
IF respondent does not live in eligible town/city **(CLOSE)**

"Unfortunately we need our participants to live in the Auckland, Wellington, or Dunedin area. We're sorry but this means you cannot take part in our study - but thank you for taking the time to get in touch with us, and all the best."

13. Has [*child's name*] been in a study <u>over the last 6 months</u> where you were asked to change what they eat?

- ○ Yes **(GO TO Q12a)**
- ○ No **(GO TO Q13)**

13a. What was the name of the study?

_____
_____

13b. Please briefly describe what the study involved: (especially what changes you were asked to make to what [*child's name*] ate)

_____
_____

13c. Who was running the study?

_____
_____

RESEARCHER: Confirm whether the study baby participated in was a nutrition intervention study *[NB: See P-2b for guidance on determining this].*

- ○ Child has participated in a nutrition intervention study **(CLOSE)**
- ○ Child has not participated in a nutrition intervention study **(GO TO Q13)**

"Unfortunately we need our participants to have a child who hasn't participated in a nutrition intervention study recently. We're sorry but this means you cannot

take part in our study - thank you for taking the time to get in touch with us, and

all the best."

Childcare

We would like to know about your use of childcare with [*child's name*] - this will help with planning study visits.

14. Is [*child's name*] regularly looked after by someone other than yourself? *Please select all answers that apply.*

- ○ No **(FINISH QUESTIONNAIRE HERE; GO TO CLOSING)**
- ○ Yes, by another family member
- ○ Yes, by a nanny
- ○ Yes, they go to an early childhood centre
- ○ Yes, they go to homebased care
- ○ Yes, other Please state: ____

14a. On what days is [*child's name*] usually looked after by someone other than yourself? *Please indicate whether each day specified is for the morning or afternoon, or both.*

Monday

- ○ Yes
  - ○ AM
  - ○ PM
- ○ No

Tuesday

- ○ Yes
  - ○ AM
  - ○ PM
- ○ No

Wednesday

- ○ Yes
  - ○ AM
  - ○ PM
- ○ No

Thursday

○ Yes
- ○ AM
- ○ PM

○ No

Friday

○ Yes
- ○ AM
- ○ PM

○ No

Saturday

○ Yes
- ○ AM
- ○ PM

○ No

Sunday

○ Yes
- ○ AM
- ○ PM

○ No

14b. Any comments about childcare?

_____

Appendix B: Main Questionnaire Young Foods New Zealand (YFNZ)

Office use only

Date:

Participant ID:

Main Questionnaire

Welcome and thank you for being part of the YFNZ Study.
This questionnaire is split into 7 sections and will probably take about 15 minutes to do.
Please answer every question - *there are no right or wrong answers*.
Please ask the researchers if you have any questions – **thank you for your time**.

Section 1: Some questions about you

1. How are you related to this child?

- ○ Mother
- ○ Father
- ○ Grandparent
- ○ Guardian
- ○ Other Please state: _____

2. What is your date of birth? _____ / _____ / _____
day month year

2a. What is today's date? _____ / _____ / _____
day month year

Section 2: Some questions about your pregnancy with this child

3. Did you (or child's mother) experience any medical problems during your pregnancy?

- ○ Yes Please describe: _____
- ○ No
- ○ Don't know

4. Did you (or child's mother) take any prescribed medication during your pregnancy?

- ○ Yes
- ○ No
- ○ Don't know

*If answer is 'No' – skip [medication Qs]; go to **Question 5***

4a-i. **Medication 1:** What was the name of the prescribed medication?

_____

4a-ii. When was this prescribed medication taken? *Please select <u>all</u> that apply*.

- ○ First trimester
- ○ Second trimester
- ○ Third trimester

4a-iii. Did you (or child's mother) take any other prescribed medications during your pregnancy?

- ○ Yes
- ○ No

If answer is 'No' – skip [next Qs]

4b-i. **Medication 2:** What was the name of the prescribed medication?

_____

4b-ii. When was this prescribed medication taken? *Please select <u>all</u> that apply*.

- ○ First trimester
- ○ Second trimester
- ○ Third trimester

4b-iii. Did you (or child's mother) take any other prescribed medications during your pregnancy?

- ○ Yes
- ○ No

If answer is 'No' – skip [next Qs]

4c-i. **Medication 3:** What was the name of the prescribed medication?

_____

4c-ii. When was this prescribed medication taken? *Please select <u>all</u> that apply*.

- ○ First trimester
- ○ Second trimester
- ○ Third trimester

5. Were there any interventions during your child's birth?

- ○ Forceps were used
- ○ Caesarean birth
- ○ Other Please describe: _____
- ○ There were no interventions

6. Was your child born pre-term or term?

- ○ Preterm (less than 37 weeks gestation)
- ○ Term (37 weeks gestation or older)
- ○ I don't know

7. Is your child a girl or a boy?

- ○ Girl
- ○ Boy
- ○ I would rather not say

8. Was your child born singly, or were they a twin or multiple?

- ○ Single (one baby)
- ○ Twin (one of two babies)
- ○ Multiple (one of three or more babies)

9. Which ethnic group(s) does your child belong to? *Select all that apply to your child.*

- ○ NZ European
- ○ Māori
- ○ Samoan
- ○ Cook Island Māori
- ○ Tongan
- ○ Niuean

- ○ Chinese
- ○ Indian
- ○ other, eg Dutch, Japanese, Tokelauan. Please state: _____

10. Is your child descended from a Māori (that is, did they have a Māori birth parent, grandparent or great-grandparent, etc)?

- ○ Yes
- ○ Don't know
- ○ No

If answer is 'No' – go to Q11

10a. Do you know the name(s) of your child's iwi (tribe or tribes)?
See the Guide Notes for a list of iwi.

- ○ Yes
- ○ No

If answer is 'No' – go to Q11

10b. Enter the name(s) and region(s) of your child's iwi (tribe or tribes):
See the Guide Notes for a list of iwi.

Iwi: _____

Region: _____

Iwi: _____

Region: _____

Iwi: _____

Region: _____

Iwi: _____

Region: _____

11. Does your child have any diagnosed health conditions or disabilities?

- ○ Yes Please state: _____
- ○ No

Section 3: Your child and food

12. How was your child fed at *around 6 months of age*?

- ○ Spoon fed by an adult
- ○ Mostly spoon fed by adult, some baby feeding themselves
- ○ About half spoon fed by an adult and half baby feeding themselves
- ○ Mostly baby feeding themselves, some spoon feeding by an adult
- ○ Baby feeding themselves
- ○ Baby was not eating solids at around 6 months of age

13. Have you *ever* used baby-led weaning with your child?

- ○ I don't know what baby-led weaning is
- ○ Yes, we have followed baby-led weaning most or all of the time
- ○ Yes, we have followed baby-led weaning some of the time
- ○ Yes, we tried baby-led weaning, but we stopped
- ○ No, we did not try baby-led weaning

If answer is 'No' or 'Don't know what BLW is' – skip [next Q]

13a. How old was your child when you first tried baby-led weaning?

- ○ Less than 1 month old
- ○ 1 month old
- ○ 2 months old
- ○ 3 months old
- ○ 4 months old
- ○ 5 months old
- ○ 6 months old
- ○ 7 months old
- ○ 8 months old
- ○ 9 months old
- ○ 10 months old
- ○ 11 months old
- ○ 12 months old or older

14. Are there any traditional or cultural (family or whānau) foods you like your child to have?

- ○ Yes Please describe: _____
- ○ No

15. How knowledgeable are you of traditional **Māori** culture and lifestyle?

○	○	○	○	○
Very knowledgeable	Somewhat knowledgeable	Neutral or no response	Somewhat not knowledgeable	Not at all knowledgeable

16. How knowledgeable are you of traditional **Pacific** culture and lifestyle?

○	○	○	○	○
Very knowledgeable	Somewhat knowledgeable	Neutral or no response	Somewhat not knowledgeable	Not at all knowledgeable

17. How knowledgeable are you of **New Zealand European/Pākehā** culture and lifestyle?

○	○	○	○	○
Very knowledgeable	Somewhat knowledgeable	Neutral or no response	Somewhat not knowledgeable	Not at all knowledgeable

18. How involved are you in **Māori** culture and lifestyle?

○	○	○	○	○
Very involved	Somewhat involved	Neutral	Somewhat not involved	Not at all involved

19. How involved are you in **Pacific** culture and lifestyle?

○	○	○	○	○
Very involved	Somewhat involved	Neutral	Somewhat not involved	Not at all involved

20. How involved are you in **New Zealand European/Pākehā** culture and lifestyle?

○	○	○	○	○
Very involved	Somewhat involved	Neutral	Somewhat not involved	Not at all involved

21. How do you feel toward the **Māori** culture and lifestyle?

○	○	○	○	○
Very positive	Somewhat positive	Neutral or no response	Somewhat negative	Very negative

22. How do you feel toward the **Pacific** culture and lifestyle?

○	○	○	○	○
Very positive	Somewhat positive	Neutral or no response	Somewhat negative	Very negative

23. How do you feel toward the **New Zealand European/Pākehā** culture and lifestyle?

○	○	○	○	○
Very positive	Somewhat positive	Neutral or no response	Somewhat negative	Very negative

24. How important is it for you to maintain a **Māori** lifestyle and identity?

○	○	○	○	○
Very important	Somewhat important	Neutral or no response	Very little importance	No importance at all

25. How important is it for you to maintain a **Pacific** lifestyle and identity?

○	○	○	○	○
Very important	Somewhat important	Neutral or no response	Very little importance	No importance at all

26. How important is it for you to maintain a **New Zealand European/Pākehā** lifestyle and identity**?**

○	○	○	○	○
Very important	Somewhat important	Neutral or no response	Very little importance	No importance at all

Section 4: Your child and food pouches

The questions in this section ask about squeezable food pouches with a nozzle. Some examples are shown below. Please don't include pouches without a nozzle.

27. Has your child ever eaten food from a food pouch?

○ Yes
○ No

*If the answer is 'No' – go to [pouch dislikes; **Q43**]*

28. How often has your child eaten from a 'ready-to-eat' food pouch *in the past month*? (i.e. pouches that are filled when you buy them)

- ○ Never
- ○ More than once a day
- ○ Once a day
- ○ 5-6 times a week
- ○ 2-4 times a week
- ○ Once a week
- ○ 2-3 times a month
- ○ Once a month
- ○ Less than once a month

29. How often has your child eaten from a 'home-filled' food pouch *in the past month*? (i.e. pouches that you have to put the food in at home)

- ○ Never
- ○ More than once a day
- ○ Once a day
- ○ 5-6 times a week
- ○ 2-4 times a week
- ○ Once a week
- ○ 2-3 times a month
- ○ Once a month
- ○ Less than once a month

30. When your child has food from a food pouch, how do they get the food?

- ○ Always suck it straight from the pouch nozzle
- ○ Mostly suck it straight from the pouch nozzle, sometimes on a spoon
- ○ About half the time suck it straight from the pouch nozzle and half the time on a spoon
- ○ Mostly from a spoon, sometimes suck it straight from the pouch nozzle
- ○ Always on a spoon

If answer is 'Always on a spoon' – skip [pouch nozzle Q's: ***Q31, Q35, Q36, Q37, Q38****]*

31. When your child has food straight from a food pouch nozzle, who puts the pouch in the child's mouth?

- ○ An adult
- ○ Mostly an adult, sometimes child
- ○ About half of the time an adult and half of the time child

- ○ Mostly child, sometimes an adult
- ○ Child

32. What are the <u>three</u> most common food pouches your child eats?

32a. Brand and flavour of food pouch child <u>eats most commonly</u>:

_____

32b. How often has your child eaten this food *<u>in the past month</u>*?

- ○ Never
- ○ More than once a day
- ○ Once a day
- ○ 5-6 times a week
- ○ 2-4 times a week
- ○ Once a week
- ○ 2-3 times a month
- ○ Once a month
- ○ Less than once a month

33a. Brand and flavour of food pouch child eats <u>second most commonly</u>:

_____

33b. How often has your child eaten this food *<u>in the past month</u>*?

- ○ Never
- ○ More than once a day
- ○ Once a day
- ○ 5-6 times a week
- ○ 2-4 times a week
- ○ Once a week
- ○ 2-3 times a month
- ○ Once a month
- ○ Less than once a month

34a. Brand and flavour of food pouch child eats third most commonly

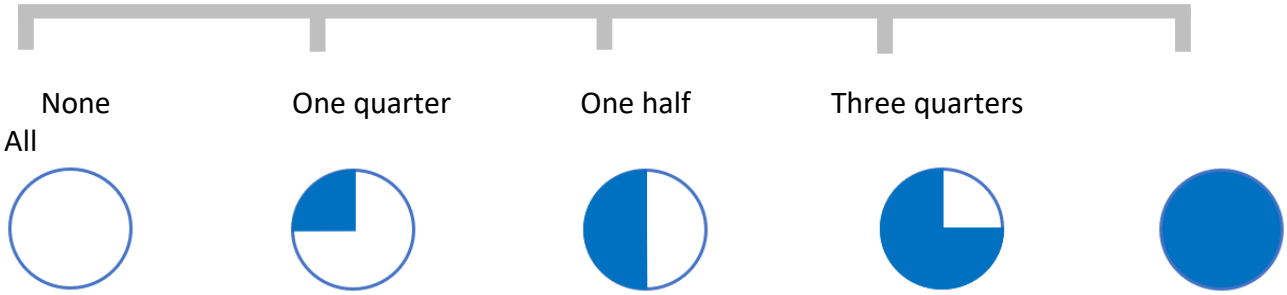
_____

34b. How often has your child eaten this food *<u>in the past month</u>*?

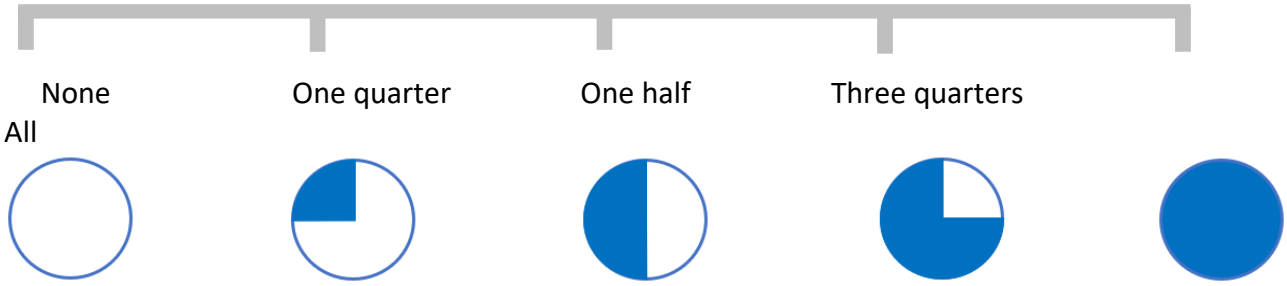
- ○ Never
- ○ More than once a day
- ○ Once a day
- ○ 5-6 times a week

- ○ 2-4 times a week
- ○ Once a week
- ○ 2-3 times a month
- ○ Once a month
- ○ Less than once a month

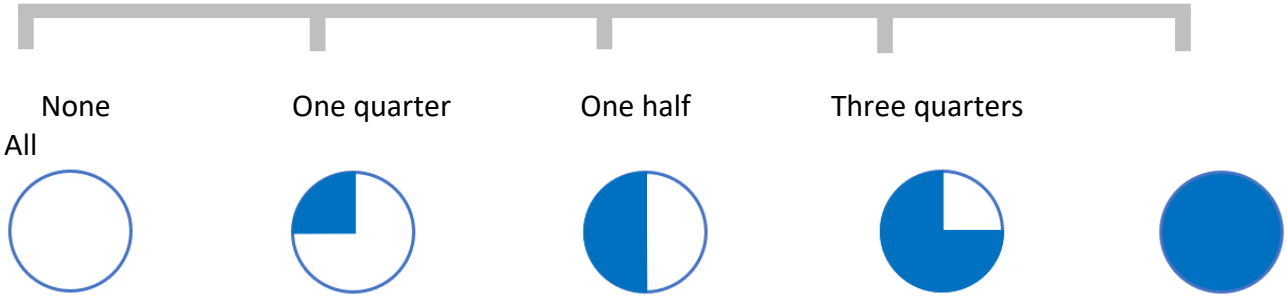
35. Out of all the food your child eats, what proportion do they eat by feeding themselves directly from a pouch (holding a pouch themselves and sucking through the nozzle)? Show this on the sliding scale:



36. Out of all the food your child eats, what proportion do they eat by *you* holding a pouch while they suck through the nozzle? Show this on the sliding scale:



37. When your child feeds themselves directly from a food pouch (holding a pouch and sucking through the nozzle), how much of it do they *usually* eat during a *single* eating occasion? Show this on the sliding scale:



If the answer is 'None' – skip Q38 and go to [pouch 'where'; Q39]

38. When your child feeds themselves directly from a food pouch (holding a pouch and sucking through the nozzle), how long do they ***usually*** spend eating it during a ***single*** eating occasion?

- ○ Less than 5 minutes
- ○ 5 to 9 minutes
- ○ 10 to 14 minutes
- ○ 15 to 19 minutes
- ○ 20 to 29 minutes

39. Where is your child usually when they are given a food pouch? *Please select the option that is the most common.*

- ○ Chair
- ○ Highchair
- ○ Floor
- ○ On someone's knee
- ○ In an early childhood centre
- ○ In homebased care
- ○ While being looked after by someone else
- ○ While in the car
- ○ While in a buggy or pram
- ○ While on the go
- ○ Other Please state: ____

40. Does your child eat from food pouches anywhere else? *Please select all options that apply.*

- ○ Chair
- ○ Highchair
- ○ Floor
- ○ On someone's knee
- ○ In an early childhood centre
- ○ In homebased care
- ○ While being looked after by someone else
- ○ While in the car
- ○ While in a buggy or pram
- ○ While on the go
- ○ Nowhere else
- ○ Other Please state: ____

41. How often do you, or another adult, sit with your child when they are eating from a food pouch?

- ○ Never

- ○ Sometimes
- ○ About half the time
- ○ Almost always
- ○ Always

42. Why do you use food pouches? *Please select <u>all</u> options that apply.*

- ○ Easy to use
- ○ Less mess
- ○ Cost less
- ○ Takes less time
- ○ Practical
- ○ I have my hands free to do other things
- ○ My child likes them
- ○ I have heard good things about them
- ○ Easy way to get fruit and vegetables into them
- ○ Easy way to get meat into them
- ○ To increase the types of food my child eats
- ○ Healthier than foods the family eats
- ○ The food in them is good for child
- ○ Organic
- ○ Doesn't waste as much food
- ○ The packaging keeps the food fresh
- ○ Safety
- ○ Other Please state: ____

43. Is there anything you do not like about using food pouches?

- ○ Yes Please state: ____
- ○ No

Section 5: Some questions about your child's teeth

44. How old was your baby or child when you first saw a tooth in their mouth? *Please think about the white tip of the tooth or the whole tooth rather than a bump or reddening*.

- ○ My child does not have any teeth
- ○ Birth
- ○ 1 month old
- ○ 2 months old
- ○ 3 months old
- ○ 4 months old
- ○ 5 months old

- ○ 6 months old
- ○ 7 months old
- ○ 8 months old
- ○ 9 months old
- ○ 10 months old
- ○ 11 months old
- ○ 12 months or older

45. Do you clean your child's teeth (or mouth if they don't have any teeth)?

- ○ Yes
- ○ No
- ○ Sometimes

If answer is 'No' – skip [next Q]

45a. How do you clean your child's teeth (or mouth if they don't have any teeth)? (e.g., brush with a soft brush, wipe with a damp cloth)

_____
_____

46. Do you do anything else to look after your child's teeth (or mouth if they don't have any teeth)?

- ○ Yes
- ○ No

If answer is 'No' – skip [next Q]

46a. What else do you do to look after your child's teeth (or mouth if they don't have any teeth)?

_____
_____

47. Do you have any concerns about your child's teeth (or mouth if they don't have any teeth)?

- ○ Yes
- ○ No

If answer is 'No' – skip [next Q]

47a. What concerns do you have about your child's teeth (or mouth if they don't have any teeth)?

_____
_____

Section 6: Some questions about supplements

48. Has your child taken any supplements in the past month?

- ○ Yes
- ○ No

*If answer is 'No' – skip [supplement Q's; go to **Section 7**]*

49. What type of supplement was it? *Please select <u>all</u> that apply.*

- ○ Multivitamin and/or multimineral
- ○ Single vitamin or mineral
- ○ Other Please specify _____

[apply skip logic as appropriate]

50a-i. **Multivitamin and/or multimineral:** How often did your child take the supplement in the past month?

- ○ More than once a day
- ○ Once a day
- ○ 5-6 times a week
- ○ 2-4 times a week
- ○ Once a week
- ○ 2-3 times a month
- ○ Once a month
- ○ Less than once a month
- ○ Regularly, but for a limited time

50a-ii.

Multivitamin and/or multimineral: Is your child currently taking this supplement?

- ○ Yes

○ No

50a-iii.

Multivitamin and/or multimineral: If you know the brand name and/or the product name please write them here. Please provide as much information about the product as possible.

_____
_____

50a-iv.

Multivitamin and/or multimineral: If you have the supplement please could the researcher take a photo of it.

[*upload photo*]

[repeat option]

51a-i. **Single vitamin or mineral**: Please tell us what vitamin or mineral it was:

_____
_____

51a-ii.

Single vitamin or mineral: How often did your child take the supplement in the past month?

○ More than once a day
○ Once a day
○ 5-6 times a week
○ 2-4 times a week
○ Once a week
○ 2-3 times a month
○ Once a month
○ Less than once a month
○ Regularly, but for a limited time

51a-iii.

Single vitamin or mineral: Is your child currently taking this supplement?

○ Yes
○ No

51a-iv.

Single vitamin or mineral: If you know the brand name and/or the product name please write them here. Please provide as much information as possible.

_____
_____

51a-v.

Single vitamin or mineral: If you have the supplement please could the researcher take a photo of it.

[*upload photo*]

[repeat option]

52a-i. **Other**: How often did your child take the supplement in the past month?

- ○ More than once a day
- ○ Once a day
- ○ 5-6 times a week
- ○ 2-4 times a week
- ○ Once a week
- ○ 2-3 times a month
- ○ Once a month
- ○ Less than once a month
- ○ Regularly, but for a limited time

52a-ii.

Other: Is your child currently taking this supplement?

- ○ Yes
- ○ No

52a-iii.

Other: If you know the brand name and/or the product name please write them here. Please provide as much information as possible.

_____
_____

52a-iv.

Other: If you have the supplement please could the researcher take a photo of it.

Section 7: Some final questions

This is a short set of questions about you and your child to help us group your answers with those of similar people for analysis purposes.

53. Which ethnic group do you belong to? *Select all that apply to you.*

- ○ NZ European
- ○ Māori
- ○ Samoan
- ○ Cook Island Māori
- ○ Tongan
- ○ Niuean
- ○ Chinese
- ○ Indian
- ○ other, eg Dutch, Japanese, Tokelauan. Please state: _____

54. Are you descended from a Māori (that is, did you have a Māori birth parent, grandparent or great-grandparent, etc)?

- ○ Yes
- ○ Don't know
- ○ No

If answer is 'No' – go to Q55

54a. Do you know the name(s) of your iwi (tribe or tribes)?
See the Guide Notes for a list of iwi.

- ○ Yes
- ○ No

If answer is 'No' – go to Q55

54b. Enter the name(s) and region(s) of your iwi (tribe or tribes):
See the Guide Notes for a list of iwi.

Iwi: _____

Region: _____

Iwi: _____

Region: _____

Iwi: _____

Region: _____

Iwi: _____

Region: _____

55. Do you currently have paid employment?

- ○ No
- ○ Yes – part-time
- ○ Yes – full-time
- ○ Paid parental leave
- ○ Unpaid parental leave

56. What is the highest level of education you have completed?

- ○ School
- ○ Polytechnic or similar
- ○ University
- ○ Other Please state: ____

57. How tall are you without shoes?

_____ cm *or* _____ feet and _____ inches

58. How much do you weigh?

_____ kg *or* _____ pounds *or* _____ stone and _____ pounds

59. How many children have you (or child's mother) given birth to (including this child)?

- ○ One
- ○ Two
- ○ Three
- ○ Four or more

60. How many *children* usually (at least half the time) live in your household (including this child)?

- ○ One
- ○ Two
- ○ Three
- ○ Four or more

61. How many *adults* usually live in your household (including yourself)?

- ○ One
- ○ Two
- ○ Three
- ○ Four or more

62. Is your child regularly looked after by someone other than yourself? *Please select <u>all</u> answers that apply.*

- ○ No
- ○ Yes, by another family member
- ○ Yes, by a nanny
- ○ Yes, they go to an early childhood centre e.g., Kohanga Reo, Pacific term? kindy, creche, daycare
- ○ Yes, they go to homebased care
- ○ Yes, other Please state: ___

If answer is 'No' – go to Q63

62a. How many hours does your child usually spend in someone else's care each week?

- ○ None
- ○ Fewer than 5 hours
- ○ 5 to 10 hours
- ○ 11 to 20 hours
- ○ 21 to 30 hours
- ○ 31 to 40 hours
- ○ More than 40 hours

63. Is your child currently being breastfed (or having expressed breast milk)?

- ○ Yes
- ○ No

Thank you very much for completing this questionnaire

Appendix C: 24h Diet Recall Protocol

Study:	YFNZ	*Version number:*	Version 5
Prepared by:	NM, LF, ALH, HD	*Date prepared:*	08/06/2020

Objective

- Capture a detailed assessment of the child's diet from the previous day, while also capturing data relevant to food pouch use and dental health.

Equipment required

Protocols:	**P-6b1: 24-h recall protocol** (this protocol) **P-6b2: Transfer 24-h recall photos** **P-6b3: Foods fed by other adults – follow up**
Documents:	**O-15: 24-h recall recording sheets** **O-16: 'Food Description Prompts' sheet** **O-37: Sheet with grids and circles** (measurement aid)
Equipment:	Measurements aids set (includes household measures, food models and **O-37: Sheet with grids and circles**) Laptop and Vodem Stapler (check plenty of staples)
Participant to provide:	Photos of eating occasions **O-12: 'Foods Fed by Other Adults' form** (if used)

Process – Before

In office:

- Ensure details are correctly recorded on ***all*** 24-h recall recording sheets (participant ID, interviewer, date, day of the week). Tick box on first page to indicate whether this is the participant's first or second recall.
- Ensure Countdown website is bookmarked on laptop

At appointment:

- Download photos following **P-6b2: Transfer 24-h recall photos**.
- Open Countdown website on laptop.
- Set out measurement aids and visuals. ***Caution*****:** This set contains dried beans which are a choking hazard for young children.

Process – During

Introduction

Invite the participant to take a seat. Explain what is going to happen during the 24-h recall interview.

"I'm going to ask you about what [*child's name*] ate and drank yesterday. We're interested in finding out everything they ate and drank, whether it was at home or away from home. So that includes snacks, drinks, water, even just having a small taste of something, as well as meals."

"A quick question before we start." (*ask illness question; record answer*)

Carry out 24-h recall interview.

Stage One: Quicklist

"First, we'll make a quick list of all the things [*child's name*] ate and drank yesterday. ***After*** we have made a list of the foods and drinks they've had, we'll go through the photos to get more details about each food and drink, like the amounts and where they had them. We can easily add to the list if you remember other things when we're looking through the photos later. At the end, we'll go back through the list one more time to make sure we have everything."

"To help you remember what [*child's name*] ate and drank, it may be useful to think about where they were, who they were with, or what they were doing yesterday. For example, going to childcare, visiting family or a friend's houses, or playing at home. Feel free to keep these activities in mind, and to say them aloud if that helps."

"So, we're going to be thinking about what [*child's name*] had yesterday – [*insert day that was yesterday*]. Let's start right at the beginning – from midnight then we'll go through the morning, afternoon and evening. What was the first thing [*child's name*] ate or drank?"

Record Quicklist – keep prompting until finished. Note: Do not go through the photos during this step (this is to avoid repetition of details).

"Sometimes people forget to tell us about drinks and snacks when we do this list."

"How much water did [*child's name*] drink yesterday?" (*record*)

"Did [*child's name*] have any [*more*] breastmilk or formula yesterday?" (*record*)

"Did [*child's name*] have any other drinks like milk or juice yesterday?" (*record*)

"How about any other snacks, like muesli bars, crackers, sweets, or desserts?" (*record*)

"Were there any other meals or snacks that [*child's name*] ate yesterday that someone else gave [*him/her*]?" (*Note this on Quick List; ask question below*)

If child consumed food/drink while in the care of another adult/in childcare:

"Do you have any information about what [*child's name*] ate or drank yesterday while in their care? For example, did this person fill out the 'Foods Fed by Other Adults' form, or did you provide food for [*child's name*] to eat while in their care?"

YES **(NOTE THIS ON QUICKLIST; GO TO DETAILED LIST)**

NO **(GO TO P-6b2: Foods Fed by Other Adults Follow Up – START AT A1; GO TO DETAILED LIST)**

Stage Two: Detailed list

"I'm now going to ask you some questions about each food and drink. We're going to work out how much of each food [*child's name*] ate and drank, where they were fed, and how they were fed. I'd also like to know whether any of the foods came from a food pouch."

"It usually works well if you click through the photos that you took on our laptop while I ask you questions about the foods and drinks eaten. Does that sound okay?"

Pull the Quicklist page from the staple and have it next to the detailed list table when going through the food/drink items, ticking off each item on the Quicklist as you go along.

"Let's start at the beginning - from one-minute past midnight yesterday morning. The first thing you remembered [*child's name*] eating/drinking was [*XXX*]." (*record*)

"What time did [*child's name*] eat/drink that? (*record*)

Complete the 'Detailed 24-h recall' form, recording each food/drink on a new line:

- **Time**. Collect time of consumption of the first mouthful of food for each meal/snack. *NB*: You may find this information by viewing the image details.
- **Place**. Collect location fed for each eating occasion – include both specific and broad place fed (e.g., highchair at home, car seat in car).
- **Description of Food/Drink**. Record the name of the food and cooking method used. Use **O-16: Food Description Prompts sheet** to guide you about specific details to obtain from certain foods and drinks. Record each food/drink item in a different row.
- **Brand**. Record the product brand (or record 'brand unknown') (*note*: to identify the brand, look at the product packaging on the photograph, in the home (visit 1), or search for the product on Countdown website). Alternatively, note if the food/drink item was 'homemade' (if so, ask for recipe – record in the 'Recipe' section).
- **Amount**. Record the amount consumed. Use size of packet information if possible (see product package). Alternatively, use bottles, dishes and utensils in the home (visit 1), or measurement aids and visuals, to help the participant estimate the portion size. *Note*: in visit 1 (home) record in the 'Notes' section of your recording sheet a description of the size of the bottle/dish/utensil (e.g., 120 mL Sippy cup), so you can refer to this to compare sizing in visit 2 (clinic).
- **Used pouch**. Tick to indicate whether food was from (stored in or served from) a food pouch (including commercial and home-filled pouches). If so, tick the option that best describes how the pouch was used:
    - Child fed self directly (i.e. child holds pouch and sucks through nozzle)
    - Adult fed child directly (i.e. adult holds pouch and child sucks through nozzle)
    - Adult fed child via spoon
    - Child fed self pouch via spoon
    - If another method was used, record this.

Probe about additions to food before moving to the next food/drink item on the Quicklist. Keep your prompts neutral, for example:

"Did they have anything with that?"

If child consumed food/drink while in the care of another adult/in childcare:

→ *If 'Foods Fed by Other Adults' form was attempted, write 'SEE FFOA FORM' on the recording sheet. Check the 'Foods Fed by Other Adults' form has been filled out correctly and completely.*

→ *If participant provided food to eat while in their care (e.g., packed lunch box), find out what food was provided and how much was sent home. Record this on the 24-h recall recording sheet.*

If you identify any significant missing information *(i.e. no data on amount eaten, Pouch Used, Fed by, and, in some cases, the brand name (e.g., to determine whether a food was iron fortified)), record this in the 'Notes' section of the recording sheet. If there is significant missing information,* ***GO TO P-6b3: Foods Fed by Other Adults Follow Up – START AT A1****.*

Stage Three: Review and probe for forgotten foods

Ask about and record:

1. *Forgotten foods/liquids*
2. *Home-filled pouch use*
3. *Salt addition*
4. *Sugar addition*
5. *Other beverages*

"Thanks for working with me to provide all that detail. We are now going to go through the list one last time to make sure we haven't missed anything. I am going to read this list back to you – please interrupt me if you remember anything else that [*child's name*] ate or drank so we can record it."

Make sure this is done slowly so the participant has an opportunity to remember each eating/drinking occasion.

1. *Review the list of foods and beverages with the participant.*
   E.g. "At 8 am, [child's name] ate a rice cracker and some peanut butter toast while in the car going to day care.

2. *Forgotten foods/liquids*
   "Is there anything you can think of that we need to add in?" (*record as necessary*)

3. *Ask about home-filled pouch use:*

Has the parent/guardian reported any pouch use

YES **(GO TO 'b')**
NO **(END)**

"Finally: we're interested to know about home-filled pouches – by that I mean pouches that you put the food in yourself at home (*show example from measurement aid set*). Were any of the pouches child had yesterday home-filled pouches?"

YES "Which ones?" (*circle and label with 'HF' beside the row*)
"Was it filled with homemade food, or ready-to-eat bought food?" (*ensure this is recorded in the 'Brand' column)*

3. *Salt addition*
   Is salt added to any foods or drinks (including on days not covered by the 24-hour recall)? If yes, was it iodised and what foods/ drinks?

4. *Sugar addition*
   Is sugar added to any foods or drinks (including on days not covered by the 24-hour recall)? If yes, what foods/ drinks?

5. *Other beverages*
   Is the child offered any drinks other than breast milk, formula, or water (things like juice, flavoured milk, soft drinks, tea, alcohol or any other drink) If yes, what drinks?

Thank the participant for their time.

Process – After

1. Staple the forms back together in the following order:
   a. Quicklist
   b. Detailed 24-h recall
   c. Recipes
   d. Notes
   e. 'Foods Fed by Other Adults' form (if applicable).

2. If follow up is required for the 24-h recall foods fed by other adults, complete follow up contact (phone call to other caregiver or email to participant) as soon after the appointment as possible (see **P-6b2: Foods fed by other adults follow up protocol**).

3. Scan all completed 24-h recall documentation and download this to the University High-Capacity Central File Storage system (*location: 24-h recall > 24-h recall documents > [area] > 1. New*) – please use the format shown below for file and folder names.

   Save files to a folder labelled in the following format:
   [*Participant ID*]_DR[*1/2*]
   E.g., YF1001AB_DR1

   Label each file with Participant ID, diet recall number, document name, and date:
   [*Participant ID*]_DR[*1/2*]_[*document name*]_[*date*]
   E.g., YF1001AB_DR1_RecordingSheet_10Jun2020

4. All 24-h recalls will be entered in Auckland for quality control and logistical purposes, following protocol **P-19: 24-h recall dietary data entry (to FoodWorks)**.

5. Download 24-h recall photos to the University High-Capacity Central File Storage system (*location: 24-h recall > 24-h recall images > [area]*) – please use the format shown below for file and folder names.

   Save files to a folder labelled in the following format:
   [*Participant ID*]_DR[*1/2*]
   E.g., YF1001AB_DR1

   Label each file with Participant ID, diet recall number, document name, and date:
   [*Participant ID*]_DR[*1/2*]_[*date*]
   E.g., YF1001AB_DR1_10Jun2020

6. Complete the **Diet Recall form** (under Main Visit 1) in REDCap – when all fields have been answered mark the form status as 'Complete'.

Appendix D: Foodworks Data Entry Protocol

Study:	YFNZ	*Version number:*	Version 2
Prepared by:	NM, LF, ALH	*Date prepared:*	23 July 2020

Objectives

- To ensure accurate and consistent entry of YFNZ 24-h recall data into FoodWorks.
- To allocate an 'item ID' and 'amount offered in grams' value to each food item reported in the 24-h recall.

Equipment required

Protocols: **P-19: 24-h recall dietary data entry** (this protocol)

Documents: **O-15: 24-h recall recording sheet**
O-12: Foods Fed by Other Adults form (if used by participant)
O-34: FoodWorks instructions
'YFNZ Codebook' excel file (access via YFNZ google docs via student desktop)
'New foods and substitutions request' excel file (access via YFNZ google docs)

Equipment: "Your" coloured pen (for annotating the 24-h recall recording sheet if needed – see below)
Computer with access to:
- Shared student desktop
- Sci-hunt-firstfoods HCS share (\\storage.hcs-p01.otago.ac.nz\sci-hunt-firstfoods)
- YFNZ FoodWorks database
- Kai-culator
- REDCap

NB: Any notes/marks added to the original 24-h recall must be in a different pen colour (e.g., pink) and the name of the person who made the notes and the date they were made must be recorded on the front of the 24-h recall recording sheet with the colour of the pen (or a scribbled sample of the colour). The colour used by each annotator should be recorded in the 'YFNZ Codebook' (see 'Codebook Instructions' sheet).

Steps - before

- Make sure you are familiar with the nature and scope of the 'YFNZ Codebook'
- 24-h recall (and follow up if necessary) has been completed.
- Move the participant's checked 24-h recall documents folder to the *Entry in progress* folder in HCS:

  FROM: *24-h recall > 24-h recall documents > [area] > 2. Not entered*
  TO: *24-h recall > 24-h recall documents > [area] > 3. Entry in progress*
- Print the participant's 24-h recall documents (recording sheet +/- Foods Fed by Other Adults form)
- Only **one person at a time** may use the shared FoodWorks database. Before opening FoodWorks, please make sure that this is your scheduled time to use FoodWorks, or that you have checked that the person who is scheduled to use FoodWorks at this time is not using it.

Steps – during

Enter 24-h recall in FoodWorks

NB1: Refer to O-34: FoodWorks instructions for specific instructions on how to use FoodWorks if needed.

NB2: Always have the 'YFNZ Codebook' open beside you when you work so it is easy to refer to (access via student desktop so that you can copy and paste default and substitute foods directly to the FoodWorks database).

1. **Open the shared YFNZ FoodWorks database via student desktop**

2. **Create a new 24-h recall record**

   a. On the toolbar, click New then click **Food Record** (this is because we need multiple days of data, and this will allow us to enter information about the day of recall).

3. **Enter general information (General tab):**

   a. **Name**: Type the name for the 24-h recall, using the following format:
   [*participant ID*]_DR[1/2]
   E.g., 'YF1234JT_DR1'

   b. **Id**: Type your initials (as recorded in the 'YFNZ Codebook') (this is important so that we can easily identify who entered the data in the future).

c. **Folder**: Click the folder drop-down and select the 'YFNZ' folder to save the record in. *NB*: You will need to create a new folder initially. To create a new folder, click the ellipsis (…) button, type the folder name (i.e. YFNZ), and click **OK**.

d. You do not need to enter other personal details (e.g., age, gender).

4. Enter information about foods in the order that they were consumed (Foods tab):
NB: It is important that foods and drinks are entered in order so that the file is an accurate reflection of the original 24-h recall – this means that (where possible) drinks should not be combined and should be entered as a single volume.

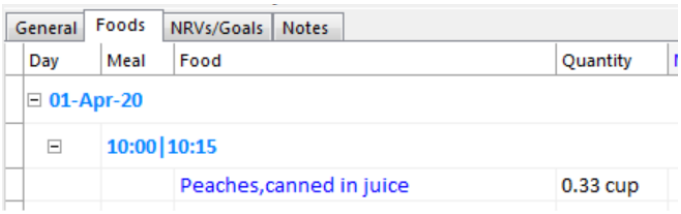
a. In the **Day** column, select the date the 24-h recall was administered.

b. In the **Meal** column, record the time started solids
[*time started as HH:MM using 24-h time*]
E.g., If a meal started at 1:00 pm, type: **13:00**

c. In the **Food** column, select the food item that best matches the food item reported in the 24-h recall; create a new recipe to select if needed (see '**Create a new recipe**' section on page 5).

Refer to **Appendix 1: Food and Quantity entry rules** for:
1. Selecting foods in FoodWorks (including the use of food DEFAULTS and SUBSTITUTIONS)
2. How to enter breastfeeding

d. In the **Quantity** column enter the quantity consumed.



Refer to **Appendix 1: Food and Quantity entry rules** for:
3. Selecting food quantities in FoodWorks (including the use of quantity estimation DEFAULTS).

e. In the **Notes** column, allocate an item ID to the food/drink item. The item ID is a unique three-digit number (starting at 001) that must be recorded for each food/drink item, because it will be used for future data linking. Subsequent food/drink items should be allocated an item ID in increments of one (i.e. 002,

003, 004). Use a vertical bar (|) and no spaces to separate the item ID from any additional notes. *NB*: there is a 50-character limit.

*****TEXT IN THE NOTES COLUMN MUST BE RECORDED IN THE FOLLOWING FORMAT*****

[*item ID*] |[*additional notes*]
E.g., 001|[*additional notes*]

Note: Please refer to Codebook for additional code to enter when "amount eaten unknown".

f. Save the 24-h recall.

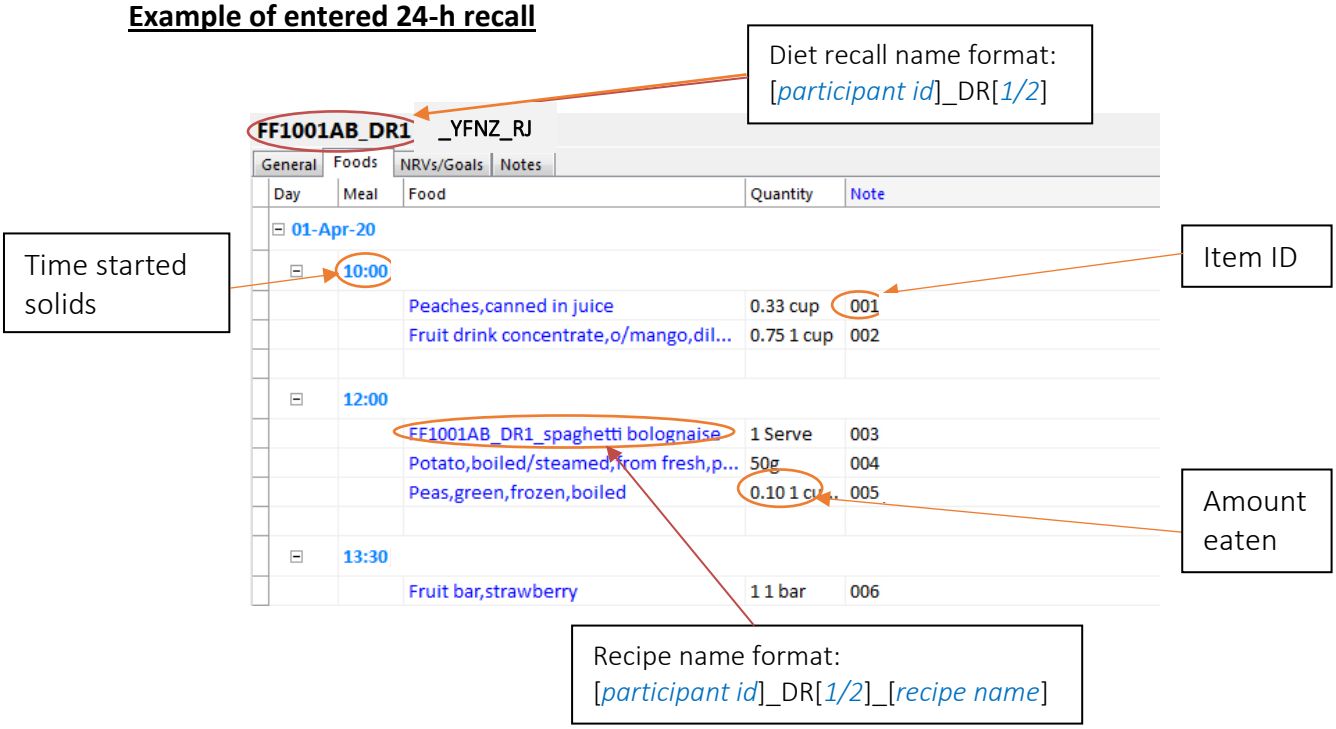
g. Repeat the steps as necessary.

5. Review and save 24-h recall

a. When all the foods and drinks have been entered to FoodWorks, double check that:
   i. All foods and drinks recorded on the 24-h recall recording sheet have been entered to the FoodWorks record
   ii. The text in the **Meal** column and **Notes** column is in the correct format (see example below)

b. Save the 24-h recall.

Example of entered 24-h recall



Create a new recipe

NB: Refer to O-34: FoodWorks instructions for specific instructions on how to create a new recipe in FoodWorks if needed.

1. **Create a new recipe**

   a. On the toolbar, click New then click **Recipe**.

2. **Enter general information (General tab):**

   a. **Name**: Type the name for the recipe, using the following format:
   [*participant ID*]_DR[1/2]_[*name of recipe*]
   E.g., 'YF1234JT_DR1_spaghetti bolognaise'

   b. **Id**: Type your initials.

   c. **Folder**: Click the folder drop-down and select the 'YFNZ recipes' folder to save the recipe in. NB: To create a new folder, click the ellipsis (…) button, type the folder name (i.e. YFNZ recipes), and click OK.

3. **Enter the ingredients for the recipe (Ingredients tab)**

   a. Enter ingredients and ingredient amounts for the whole recipe.

   b. Enter the serve weight/number of serves for the whole recipe.

   c. If the processing step for this recipe will result in a change in weight due to the loss or gain of water, then you need to set the yield. Enter the yield for the recipe using yield factors used in similar recipes in the Kai-culator database (which are based on the USDA Moisture Retention Factors (Version 4.1, 2010). If there are no similar recipes in the Kai-culator database use the USDA Moisture Retention Factors (Version 4.1, 2010) that can be found in the Kai-culator "Main menu" under "Composition data" in "Moisture factors".

   d. Set retention factors for ingredients in the recipe (see **O-34: FoodWorks instructions** – *Section 3e*).

   e. Save the recipe and return to the 24-h recall record entry. You can now start typing the recipe name (e.g., search using participant ID) in the **Food** column and select this recipe to use.

Steps - After

1. Reviewing and tracking 24-h recall entry

1. Check to make sure all items on the 24-h recall recording sheet and Foods Fed by Other Adults form have been recorded in FoodWorks in order (checking: Quicklist to Detailed list, Detailed list to FoodWorks, Foods Fed by Other Adults list to FoodWorks).
2. Check to make sure all solids start time, item IDs, and amounts eaten have been entered.
3. Ensure your name has been recorded on the front of the printed 24-h recall recording sheet with the colour of the pen which was used to make notes on the recording sheet.
4. Move participant's 24-h recall documents folder to the folder: *4. Entry complete*.
5. Scan and upload annotated documents to a new folder within the participant's 24-h recall documents folder – suffix folder name and file names with '_v2'.
6. Complete the **FoodWorks entry form** (under Diet recall 1 data entry or Diet recall 2 data entry, as appropriate) in REDCap.
    a. Leave any notes/questions/clarifications in the 'Comments field' and follow up as appropriate (e.g., "No [*new infant/child food*] in FoodWorks – added request to the New Foods and Substitutions request sheet. Emailed Rio [*DATE*].")
    b. Mark the form status as 'Complete', 'Unverified' or 'Incomplete, as appropriate – then save and exit the form.

2. Regular meetings

1. Attend regular group meetings to make decisions about substitution requests etc, and check that we are getting what we need from the 24-h recall collection.

3. Backing up the YFNZ FoodWorks database

2. Rio will back up the FoodWorks database at least once per week. To do this:
    a. Copy the FoodWorks database and save to a different location (e.g., University OneDrive).
    b. Include the date on the back-up FoodWorks database file name.
    c. Delete the previous version of the back-up FoodWorks database file from the folder.

Appendix 1

Food and Quantity entry rules

NOTE:

- A food item '**default**' is used when insufficient food information is provided to determine the exact food item (e.g., 'apple' → 'Apple,flesh & skin,raw,combined varieties') OR when no exact match is present in FoodWorks (e.g. 'The Collective Gourmet raspberry yoghurt' → 'Yoghurt,premium,assorted fruits'), but a closely related food is available.
- A food item '**substitution**' is used when there is NO food item in FoodWorks that is closely related to the food item reported in the 24-h recall (e.g., chicken bacon would have to be substituted with deli chicken).

1. Selecting Foods in FoodWorks

1. **All food items selected should have the 'pear in the square' icon OR the 'bowl and spoon' icon to their left (indicating that they are from FOODfiles 2016 or are a previously created recipe, respectively). DO NOT select foods from the 'don't use' folder.**

2. **The following rules must be followed when entering homemade and commercial baby foods:**
   - A commercial infant/child food product must be entered for all commercial baby foods reported – if the one consumed is not in FoodWorks then notify Rio (cc: Becky)
   - Homemade baby/child foods must **not** be substituted with commercial infant/child food products
   - A recipe must be created for all home-filled pouches that contain more than one ingredient. Please state "home-filled pouch" in the recipe name.

3. **Selecting foods in FoodWorks:**

   If complete food item information (e.g., brand, flavour, type) is reported:
   - Match by brand/flavour/type (e.g., light, reduced fat)
   - A peeled/flesh and unpeeled/flesh&skin option is not available for all fruits and vegetables. If the fruit and vegetable has been reported in the 24-h recall in a form that is not available, you can select the alternative form. We are assuming that where both the peeled/flesh and unpeeled/flesh&skin options for a fruit or vegetable do not exist, it is because the nutrient content is not sufficiently different and therefore it has not been analysed in its separate forms.
   - If there is no exact match, refer to the YFNZ Codebook to check for established DEFAULT rules for the food item:
     - If there is a match in the YFNZ Codebook
       - Select the DEFAULT food in FoodWorks

        - Update the YFNZ Codebook document default/substitution entry with:
            - Count of times the DEFAULT has been used
            - YFNZ participant ID for future reference
    - If there is no established DEFAULT rule, enter the food item with all possible details into the 'New foods and substitutions request' document.
    - Once an appropriate DEFAULT has been established it will be entered into the 'Default foods' sheet in the YFNZ Codebook to ensure consistent use across all YFNZ projects. The "requester(s)" will be notified of this, and will then update the diet recall of interest.

<u>If incomplete food item information is reported</u>:

- Establish which specific food item data is missing – e.g., flavour/type information supplied but no brand information (e.g., edam cheese, unknown brand) ***OR*** brand and flavour information supplied but no type (e.g., Yoplait berry yogurt, unknown whether full fat/light/sweetened etc)
- Refer to YFNZ Codebook to check for established DEFAULT rules for the food item
    - If there is a match in the YFNZ Codebook
        - Select the DEFAULT food in FoodWorks
        - Update the YFNZ Codebook document default/substitution entry with:
            - Count of times the DEFAULT has been used
            - YFNZ participant ID for future reference
    - If there is no DEFAULT rule for the food item enter the food item with all details into the 'New foods and substitutions request' document.
    - Once an appropriate DEFAULT has been established it will be entered into the 'Default foods' sheet in the YFNZ Codebook to ensure consistent use across all YFNZ projects. The "requester(s)" will be notified of this, and will then update the diet recall of interest.

<u>If there is NO food item available in FoodWorks that is closely related to the reported food item</u>:

- A SUBSTITUTION must be established.
- Check 'New foods and substitutions request' document for baby foods, infant formulas and general foods that are not available in FoodWorks.
    - For foods that have already been requested – update the request count and add the YFNZ participant ID.
    - For foods that have not been requested – add a new food request line to the 'New foods and substitutions request' document.

- Once an appropriate SUBSTITUTION has been established it must be entered into the 'Substitution foods' sheet in the YFNZ Codebook to ensure consistent use across all YFNZ projects. The "requester(s)" will be notified of this, and will then update the diet recall of interest.

4. **Entering breads**
   - Breads ***must*** come from the 'Bread: Iodine modified YFNZ' folder. If the bread match of interest has not been given an updated iodine value (i.e. is not in the 'Bread: Iodine modified YFNZ' folder), then we need to create an updated version – Kirsten Webster can provide advice on how to do this.
     NB: Will need to create the 'Bread: Iodine modified YFNZ' folder initially
   - Check the 'DEFAULTS - Bread matches' sheet in the YFNZ Codebook:
     - If there is a match in the YFNZ Codebook, select the DEFAULT bread match in FoodWorks.
     - If there is no bread match, enter the food item with all possible details into the 'New foods and substitutions request' document.
     - Once an appropriate DEFAULT has been established it will be entered into the 'Default foods' sheet in the YFNZ Codebook to ensure consistent use across all YFNZ projects. The "requester(s)" will be notified of this, and will then update the diet recall of interest.

2. How to enter breastfeeding

Each time breastfeeding is reported in the 24-h recall, it must be entered in the following format:

a) In the **Food** column, select 'YFNZ breast milk (no nutrients)'
b) In the **Quantity** column, enter '0 g' or enter the reported quantity of breast milk consumed (only for expressed breastmilk).
c) In the **Notes** column, enter '[*item ID*]|[*additional notes*]'

3. Selecting Quantities in FoodWorks

1. **If there is no quantity reported for a food item in the 24-h recall:**
   - To estimate the quantity of the food item reported:
     i. Use quantities of the food item reported to have been offered or eaten by the infant on another occasion.
     ii. Use estimation rules in the YFNZ Codebook from the 'Food quantity estimation RULES' sheet and the 'Food weight estimation DEFAULT' sheet.
        a. When a weight estimation for a food is not available in the 'Food weight estimation DEFAULTS' sheet it should be added to the 'New foods and substitutions request' document.

b. Once an estimation quantity has been established it is entered into the ‘Food weight estimation DEFAULTS’ sheet in the ‘YFNZ CODEbook’ to ensure consistent use across all YFNZ 24-h recall projects. The “requester(s)” will be notified of this and will then update the diet recall of interest.

- Make a note in the notes field regarding the entry.