# Dietary intake, household food insecurity, and their associations with anthropometric status and sociodemographic factors amongst young New Zealand children

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# Abstract

**Background:** Household food insecurity is a serious public health concern that may impact young children's dietary intake. In New Zealand (NZ), there are limited studies on young children's dietary intake. However, comprehensive dietary data is crucial to ensure that young NZ children obtain adequate energy and nutrient intakes to support their optimal growth and development. Certain sociodemographic groups are disproportionately affected by household food insecurity, which may have been reflected by the high proportion of obesity in NZ compared to other high-income countries and poor dietary consumption indicative of suboptimal nutrition.
**Aim:** Therefore, this thesis aims to describe the energy and nutrient intakes, food group consumption, and household food security status of young NZ children, their relationship, and associated correlates such as anthropometric status, ethnicity, socioeconomic status, sex, age, caregiver characteristics, and household size and structure.

**Methods:** Two 24-hour food recalls from 289 children aged 1-3 years participating in the Young Foods NZ (YFNZ) study were analysed to obtain energy, nutrient, and food group intake data. YFNZ is an observational cross-sectional study of children living in Auckland, Wellington, and Dunedin, NZ. Household food security status was measured using the NZ food security scale, a NZ-specific and validated questionnaire. NZ Index of Deprivation was utilised as a proxy measure of socioeconomic status. Anthropometric status was measured using the Body Mass Index (BMI) z-score. Data on other sociodemographic characteristics such as ethnicity, sex, age, caregiver characteristics, household size and structure were collected through online and interviewer-assisted questionnaires.

**Results:** Overall, most nutrient intake recommendations were met except for fibre, iron, calcium, and vitamin C, with a proportion of inadequacy at 54.0%, 15.2%, 3.8%, and 4.8% respectively. Additionally, high protein and saturated fat intakes were observed. Māori, Pacific, Asian, and children living in areas of high deprivation were more at risk of lower fibre intakes than their counterparts, whilst children living in areas of high deprivation had a higher fat intake than those living in low-deprived neighbourhoods.

Grains and pasta (n=276 participants), fruits (n=266), and biscuits, crackers, cakes, and desserts (n=242) were most commonly consumed. Formulae (i.e., infant and follow-on formula mixes) and mixed dishes primarily contributed to the intake of energy and most nutrients. Children who were more likely to consume dairy products and dairy-alternative products were children with healthy weight compared to those who were overweight (p=0.036), NZ European compared to Māori, Asian and Pacific children (p=0.005), and children living in areas of low deprivation compared to those who

live in highly deprived areas (p=0.014). Food insecure children were more likely to consume pies and pasties (p=0.013), potatoes, kūmara and taro (p=0.040), and beverages (i.e., all fluids except for milk and water) (p=0.011) but less likely to consume biscuits, crackers, cakes and desserts (p=0.001), vegetables (p=0.005), and nuts and seeds (p=0.004). Energy-dense and nutrient-poor foods such as sausages and processed meats; sugar, confectionery, sweet spreads; and pies and pasties were the primary contributors to Pacific children's energy intake and those living in areas of higher deprivation and food insecure households.

Over a third of young children experienced food insecurity in the past year. Being overweight, Māori or Pacific, living in areas of high deprivation; having a caregiver who was younger, not in paid employment, or had low educational attainment; living with at least two other children in the household, and living in a sole parent household were associated with household food insecurity. Compared to food-secure children, moderately food-insecure children had higher fat and saturated fat intakes, consuming 3.0 (0.2, 5.8) g/day more fat, and 2.0 (0.6, 3.5) g/day more saturated fat ($p<0.05$). Moderately and severely food insecure children had lower fibre intake, consuming 1.6 (2.8, 0.3) g/day and 2.6 (4.0, 1.2) g/day less fibre, respectively, compared to food secure children. Severely food-insecure children had three times the prevalence of inadequate calcium intakes and over three times the prevalence of inadequate vitamin C intakes compared to food-secure children.

**Conclusion:** Young NZ children consume a diet that is mostly adequate in terms of most nutrients with the exception of fibre, iron, calcium, and vitamin C. High intakes of nutrients of concern (i.e., saturated fat and protein) were detected and reported to be commonly sourced from low-cost, energy-dense, and nutrient-poor foods. The consumption of these foods mirrors the high prevalence of household food insecurity and obesity amongst young NZ children. Other sociodemographic factors closely related to poverty or low income were associated with food insecurity. Therefore, targeted policies and programmes are imperative, particularly for the most vulnerable groups, to ensure young children's optimal growth and development and attain more equitable health outcomes in NZ.

# Acknowledgments

First, I would like to express my deepest gratitude to my supervisors, Professor Pamela von Hurst, Professor Cathryn Conlon, and Professor Kathryn Beck, for their outpouring of support and for providing me with an opportunity to grow as a researcher and as an individual. Thank you for your kindness, patience, and guidance throughout my PhD journey.

I would also like to thank all the First Foods and Young Foods NZ team members in Auckland, Dunedin, and Wellington. Thank you, Maria, Kim, Emily, Becky, Andrea, and Ioanna, for the friendship. I am very proud to be part of such a caring, loving, and strong group of women.

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Most importantly, I want to extend my heartfelt thanks to all the whānau and children who participated in the Young Foods NZ study. Your participation has been instrumental in advancing our understanding of early childhood nutrition in NZ.


*The text around the logo is made up of words or phrases that mean 'thank you' in the native language of all the ethnic groups represented in our study, reflecting the diversity of young children in NZ.*

*Illustration by Gia Rose Monzales*

*The central logo is from the Young Foods NZ study*

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# List of abbreviations

| | |
|---|---|
| **ABC** | Auckland Birthweight Collaborative |
| **AI** | Adequate Intake |
| **ALA** | α-linolenic acid |
| **AMDR** | Acceptable Macronutrient Distribution Range |
| **BLISS** | Baby-Led Introduction to SolidS |
| **BMI** | Body Mass Index |
| **CHOP** | Childhood Obesity Project |
| **CNS** | Children's Nutrition Survey |
| **COVID-19** | Coronavirus disease |
| **CV** | Coefficient of Variation |
| **DHA** | Docosahexaenoic acid |
| **DNA** | Deoxyribonucleic acid |
| **DNFCS** | Dutch National Food Consumption Survey |
| **EAR** | Estimated Average Requirement |
| **EAT** | Eating Assessment in Toddlers |
| **ECC** | Early Childhood Carries |
| **EDNP** | Energy-Dense Nutrient-Poor |
| **EER** | Estimated Energy Requirement |
| **EFSA** | European Food Safety Authority |
| **FAO** | Food and Agriculture Organization |
| **FAST** | Food Access Survey Tool |
| **FFNZ** | First Foods New Zealand |
| **FFQ** | Food Frequency Questionnaire |
| **FIES** | Food Insecurity Experience Scale |
| **FITS** | Feeding Infants and Toddlers Study |
| **GDP** | Gross Domestic Product |
| **GIS** | Geographical Information Systems |
| **GUiNZ** | Growing Up in NZ |
| **GUMLi** | Growing-Up Milk–Lite |
| **IGF-1** | Insulin-like Growth Factor 1 |
| **IQ** | Intelligence Quotient |
| **kJ** | Kilojoule |
| **LA** | Linoleic Acid |
| **LDL** | Low-Density Lipoprotein |
| **MeSH** | Medical Subject Headings |
| **MFP** | Meat, Fish and Poultry |
| **MoH** | Ministry of Health |
| **MPI** | Ministry for Primary Industries |
| **MSM** | Multiple Source Method |
| **NDNS** | National Diet and Nutrition Survey |
| **NHANES** | National Health and Nutrition Examination Survey |
| **NRVs** | Nutrient Reference Values |
| **NZ** | New Zealand |
| **NZDep** | NZ Index of Deprivation |

| | |
|---|---|
| **NZiDep** | New Zealand Index of Socioeconomic Deprivation for Individuals |
| **OzFITS** | Australian Feeding Infants and Toddler Study |
| **PAL** | Physical Activity Level |
| **PEM** | Protein-Energy Malnutrition |
| **POI** | Prevention of Overweight in Infancy |
| **PRI** | Population Reference Intake |
| **RCTs** | Randomised Controlled Trials |
| **RDA** | Recommended Dietary Allowance |
| **RDI** | Recommended Dietary Intake |
| **REDCap** | Research Electronic Data Capture |
| **RNI** | Reference Nutrient Intake |
| **SAGE** | Sustainability via Active Garden Education |
| **SD** | Standard Deviation |
| **SoFIE** | Survey of Families, Income and Employment |
| **UK** | United Kingdom |
| **UL** | Upper Level of Intake |
| **UNICEF** | United Nations Children's Fund |
| **UPF** | Ultra-Processed Foods |
| **US** | United States |
| **USDA** | United States Department of Agriculture |
| **WHO** | World Health Organization |
| **WWEIA** | What We Eat in America |
| **YFNZ** | Young Foods New Zealand |

# Published conference abstracts

*Primary author*

Jupiterwala, R.; Conlon, C.; Beck, K.; Taylor, R.; Heath, A.-L.; Haszard, J.; Te Morenga, L.; Firestone, R.; Fleming, E.; Katiforis, I.; McArthur, J.; Paul, R.; Brown, K.; Casale, M.; Jones, E.; Wei, A.; Fangupo, L.; Bruckner, B.; Pulu, V.; Healy, M.; von Hurst, P. Nutrient Intakes and Associations with Socioeconomic Deprivation in Young Children Living in New Zealand. Med. Sci. Forum 2023, 18, 9. https://doi.org/10.3390/msf2023018009

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# PhD candidate's research contribution to Young Foods New Zealand study

The findings reported in this thesis are part of the Young Foods NZ study, a cross-sectional study in Auckland, Wellington, and Dunedin regions funded by the New Zealand Ministry for Primary Industries (MPI) (funding number 406047). As part of the study team, the PhD candidate's contributions are the following.

**Study-related tasks**

| Stage | PhD candidate's contribution |
|---|---|
| Recruitment | Responsible for the recruitment strategy for Young Foods NZ in Auckland, which included the promotion of the study through posters and flyers, social media advertisements, and engagement with community-based organisations. |
| Screening | Auckland contact responsible for screening and booking participants and liaising with the wider research team. |
| Data management | Oversaw the overall data management for the study through the allocation of all incoming participants from all study centres in REDCAP, reviewing and refining questionnaires, and ensuring the completeness and accuracy of all data entries. |
| Materials | Ensured the logistical requirements of the study were met by monitoring consumables' availability and liaising with the research team to ensure a stable supply and replacement of damaged equipment. |
| Protocol development | Tailored all the standard operating procedures (n=17) initially developed for a parallel study (First Foods NZ). Contributed to the development of the standard operating procedures for transferring food recall photos to study computers, supplement data conversion, and data collection during the COVID-19 lockdown. |
| Training | Underwent data collection protocol trainings facilitated by the University of Otago, which included topics on standardisation of anthropometric measurements, conducting 24-hour food recall, professional behaviour, and health and safety protocols, among others. |
| Data collection | Engaged in the overall data collection process from conducting study visits, following up with caregivers and early childhood centres for missing food recall data and photos to entering, scanning, and uploading the collected |

| | |
|---|---|
| | data to Research Electronic Data Capture (REDCAP) and the High-Capacity Storage Server hosted by the University of Otago. |
| Data collection outreach | Planned, coordinated, implemented, and evaluated a data collection outreach at the Wesley Community Centre in Auckland. |
| Data entry and processing | Undertook the dietary intake data entry to FoodWorks (including the conversion of supplement intake data), assigned food and beverage items to specific food groups, and ensured consistency in dietary data entry by regularly meeting with a small team of research assistants and experts. |
| Data quality check | Conducted comprehensive quality assurance on 24-hour food recalls for Auckland-based participants and verified the adherence to filing physical and digital datasheets according to the established protocols. |
| Data analysis | Planned the statistical analysis for each manuscript and coordinated with the Biostatistician in running the statistical tests for the study. |
| Post-study tasks | Completed tasks after the data collection phase, which included preparing data sheets and other study materials and equipment to be sent back to the University of Otago. |

The affiliations and contributions of the other study team members are outlined below.

**Core team members**

| Team member | Affiliation | Role | Contribution |
|---|---|---|---|
| Professor Pamela von Hurst | School of Sport, Exercise and Nutrition, Massey University, Auckland | Primary supervisor, Investigator | Primary supervision, conceptualisation, methodology, writing—review and editing of thesis and all manuscripts |
| Professor Cathryn Conlon | School of Sport, Exercise and Nutrition, Massey University, Auckland | Supervisor, Investigator | Supervision, conceptualisation, methodology, writing—review and editing of thesis and all manuscripts |
| Associate Professor Kathryn Beck | School of Sport, Exercise and Nutrition, Massey University, Auckland | Supervisor, Investigator | Supervision, conceptualisation, methodology, writing—review and editing of thesis and all manuscripts |

| | | | |
|---|---|---|---|
| Professor Anne-Louise Heath | Department of Human Nutrition, University of Otago, Dunedin | Principal Investigator | Conceptualisation, ethics application, funding acquisition, and review of chapter 4 manuscript |
| Professor Rachael Taylor | Department of Medicine, University of Otago, Dunedin | Principal Investigator | Conceptualisation, ethics application, funding acquisition, and review of chapter 3 and 5 manuscripts |
| Associate Professor Lisa Te Morenga | Research Centre for Hauora and Health, Massey University, Wellington | Investigator, Cultural advice | Ensured the study methodology was well-informed and provided guidance to ensure its cultural appropriateness |
| Professor Ridvan Firestone | Research Centre for Hauora and Health, Massey University, Wellington | Investigator, Cultural advice – Pacific | Ensured the study methodology was well-informed and provided guidance to ensure its cultural appropriateness, particularly for Pacific communities |
| Associate Professor Jill Haszard | Biostatistics Centre, University of Otago, Dunedin, New Zealand | Investigator, Biostatistician | Conducted formal analysis including guidance on statistical methods and presentation of results |
| Dr Claire Smith | Department of Human Nutrition, University of Otago, Dunedin | Advisor | Review of chapter 5 manuscript |

**Wider Young Foods NZ Study Team**

| Auckland | Dunedin | Wellington |
|---|---|---|
| Rebecca Paul – Project Manager [a, b, c] | Jenny McArthur – Project Manager [a] | Veisinia Pulu– Research Assistant [b] |
| Kimberley Brown – PhD student (First Foods NZ study) [b] | Elizabeth Fleming – Study Advisor (Dietary data) [d] | Megan Healy – Research Assistant [b, c] |
| Maria Casale – PhD student (First Foods NZ study) [b] | Ioanna Katiforis – Study Advisor (Dietary data) [d] | |
| Emily Jones – PhD student (First Foods NZ study) [b] | Louise Fangupo – PhD student (Young Foods NZ study) [b] | |
| Andrea Wei – Research Assistant [b, c] | Bailey Bruckner – MSc student (Young Foods NZ study) [b] | |

[a] Project administration

[b] Data collection

[c] Data entry

[d] Data entry advisor

# Chapter 1: Introduction

This chapter presents the study's context and significance, followed by the overarching aims and specific objectives, and concludes with an overview of the thesis chapters.

## Introduction

The right to food is a basic human right to which every single child is entitled. The New Zealand (NZ) government adopted and ratified the United Nations Convention on the Rights of the Child in 1993, formally acknowledging the right of each child in NZ to "adequate nutritious food" (Article 24, 2c) (1, 2). Despite this, an estimated 53,000 young children in NZ live in households with food insecurity (3). Food insecurity occurs when individuals experience limitations in terms of accessing foods that are safe and nutritionally adequate or when there is limited ability to obtain such foods by socially acceptable means (4). Child-specific consequences of food insecurity include anaemia (5), dental caries (6), high rates of hospitalisation (7) and poor nutritional status (8-10). Most of these are directly or indirectly influenced by suboptimal dietary intake and may potentially result in nutrient deficiencies.

The large number of NZ households experiencing food insecurity may have an adverse impact on the dietary intake of a substantial proportion of young NZ children. It is hypothesised that coping mechanisms such as purchasing cheaper food items, substitution (i.e., water instead of milk consumed with cereals), reducing portion size, and cooking large batches of food that can be consumed for several days may have played a role in the poor nutrition observed amongst children who live in food insecure households (11). In NZ, poor consumption patterns were reported amongst young children living in food-insecure households, including a high frequency of consumption of sugar-sweetened beverages and fast food and low adherence to nutrition guidelines in terms of fruit and vegetable intake (3). This is despite evidence from a systematic review reporting a stronger negative link between food security and diet quality for adults compared to children, citing the fact that caregivers may potentially shield their children from the impacts of food insecurity (12).

Optimal nutrition during early childhood is essential for growth and development (13). This is a crucial stage characterised by physiological and cognitive development. During this phase, there is a steady increase in height and weight (14) and rapid brain development due to its neural plasticity (15). It is also the stage where direct caregiver influence on food selection shifts into food selection based on children's self-gratification and self-selection (15). Dietary habits developed during early childhood establish dietary preferences that further contribute to health outcomes later in adulthood (16).

Early childhood includes a window of opportunity to provide energy and nutrients for optimal growth, which reduces the risk of chronic diseases in the future (17). However, young children at this crucial stage are burdened by various nutritional concerns. In most high-income countries, there is a

high prevalence of obesity amongst young children, which is indicative of excess energy intake (18-20). Despite the excess energy, the high prevalence of inadequate intake of essential nutrients such as fibre, calcium, iron, and zinc is also an issue (21-23).

Similarly, young children in NZ are impacted by the double burden of malnutrition, grappling with the consequences of being overweight or obese whilst also facing insufficient nutrient intake. According to the most recent NZ Health Survey (24), 23.1% of young children were classified as overweight or obese, which is well above the prevalence of obesity for similar age groups in other high-income countries such as the United States (US) (12.7%), United Kingdom (UK) (11%) and 26 European countries (7.9%) (25-27). Older, smaller, and regional NZ studies suggest poor intake of certain nutrients such as iron and dietary fibre and high intake of total sugars amongst young NZ children (28-30). This is reflected on the findings of the Growing Up in NZ (GUiNZ) study, a large North Island-based longitudinal study that indicated the poor adherence of young children to the Ministry of Health food and nutrition guidelines (31).

The high proportion of overweight or obese young children in NZ may be relevant to the high prevalence of food insecurity in NZ households. In lower-middle-income countries, coherent evidence points to the positive association between food insecurity and undernutrition, which exists in various forms, such as stunting (32) and underweight (33). However, due to the difference in the nature of how food insecurity is experienced in their households, children in high-income countries may manifest the negative impacts of food insecurity differently (34). A review of 14 studies from high-income countries found inconclusive evidence on the relationship between food insecurity and anthropometric status (35). However, evidence from NZ suggests a positive association between food insecurity and childhood obesity across all age groups, including young children (3).

As abovementioned, food insecurity is closely linked to young children's dietary intake. In many lower-middle-income countries such as the Philippines (36) and India (37), and low-income countries such as Zambia (38), there is a high prevalence of inadequate nutrient intake due to food insecurity as a result of the national unstable food supply and insufficient access to food at the household and individual levels (39). For most high-income countries, food insecurity is intricately linked to inequality, which has been a major threat for these nations as the gap between the socioeconomic status of the population continues to widen (40). However, there is a scarcity of recent evidence from NZ on the relationship between the nature of these inequalities and food insecurity, specifically in households with young children.

In NZ, the strongest predictor of food insecurity is income (41). Moreover, Māori and Pacific young children, along with those living in areas of high deprivation, sole-parent households, and

households with three or more children, are disproportionately impacted by food insecurity in NZ (3). Parallel to this, the 1997 National Nutrition Survey revealed that individuals living in high areas of deprivation and those of Māori and Pacific ethnicities were the most at-risk groups in terms of household food insecurity (42). The consistent pattern, where Māori and Pacific groups were observed to being at-risk to food insecurity, suggests the persistence of these disparities, indicating an intergenerational problem that requires comprehensive, systemic, and multi-faceted solutions.

Ensuring adequate nutrition in young children is one of the integral components of optimal growth and development, which is a potentially powerful tool to equalise health and socioeconomic disparities (43). Moreover, to effectively improve the dietary intake of young NZ children, policies and food-based dietary guidelines need to be formulated with a comprehensive understanding of the broader context that can impact their access to nutritious foods. Despite the need for this data, there is a lack of comprehensive food group intake data on young children in NZ. Therefore, it is not possible to determine whether young NZ children are obtaining adequate nutrition to support their optimal growth and development. The last children's national nutrition survey was conducted more than two decades ago and only included children over the age of five (44). This survey revealed a resurgence of iodine deficiency, which prompted the mandatory iodisation of salt used in bread, one of NZ's staple foods (45). This highlights the importance of evidence-based policies to pinpoint and address deficiencies and excesses. Apart from this, knowledge of food sources of energy and nutrients of concern will provide a blueprint for the formulation of food-based strategies and interventions to improve the overall dietary intake of young NZ children.

For this to happen, a robust study with well-represented samples is required to provide a solid scientific foundation to anchor policies and programmes that are aimed to improve the dietary intake and household food insecurity of young NZ children. To address this gap, this thesis has the following aims and objectives:

## Overarching aim

To determine the dietary intake and household food security status of young NZ children, their relationship, and associated correlates.

### A. Aim

To describe the energy and key nutrient intake and their associations with sex, ethnicity, and socioeconomic status of young NZ children.

**Specific Objectives**

1. To estimate the energy and key nutrient intake of young NZ children.
2. To determine the prevalence of inadequate intakes of energy and key nutrients based on Australia and NZ Nutrient Reference Values.
3. To explore differences in energy and nutrient intake based on sociodemographic characteristics such as sex, ethnicity, and socioeconomic status.

**B. Aim**

To determine energy and key nutrient intake from food groups and describe differences in the proportion of consumers and the food sources of energy in the diets of young NZ children based on anthropometric status, household food security status, and sociodemographic characteristics.

**Specific Objectives**

1. To estimate the food group contribution to energy and key nutrient intake of young NZ children.
2. To explain disparities in the proportion of consumers and food sources contributing to energy intake based on anthropometric status, household food insecurity, ethnicity, and socioeconomic status.

**C. Aim**

To assess young NZ children's household food security status and explore its relationship with energy and nutrient intake, anthropometric status, and sociodemographic factors.

**Specific Objectives**

1. To describe the household food security status of young NZ children.
2. To describe differences in household food security status by anthropometric status, ethnicity, socioeconomic status, child's age, caregiver age, education and employment status, and household size and structure.
3. To describe differences in energy and nutrient intake based on household food security status.

## Overview of the thesis

This thesis with publications has six chapters. Below is a brief overview of each section.

I. Chapter 1. Introduction – establishes the context and significance of the research, defines the aims and objectives, and describes the overall structure of the thesis.

II. Chapter 2. Literature review – provides a comprehensive review of the literature relevant to this thesis, which is subdivided into two main sections. The first section conducts an extensive analysis of the energy and key nutrients that are of particular concern for young children, discusses their current intake and food group sources, and reviews relevant sociodemographic factors. The second section discusses the concept of food insecurity, its correlates (i.e., anthropometric status), and how it is experienced and measured in NZ and globally.

III. Chapter 3 [a]. *Energy and key nutrient intakes of young New Zealand children* – the first manuscript describes the energy and key nutrient intakes of young NZ children, assesses the adequacy of intake, and explores its association with sociodemographic characteristics.

IV. Chapter 4 [a]. *Food group intake and associated correlates amongst young New Zealand children: A cross-sectional study* – the second manuscript focuses on food group consumption and how it has contributed to the energy and nutrient intakes of young children in NZ and determines its relationship with anthropometric status, household food security status, and sociodemographic factors.

V. Chapter 5 [a]. *Household food insecurity and associations with nutrient intake, anthropometric status, and sociodemographic characteristics in young NZ children* – the third manuscript focuses on the household food security status of young NZ children and how it relates to energy and nutrient intakes, anthropometric status, ethnicity, socioeconomic status, and other demographic characteristics.

VI. Chapter 6. Discussion, conclusion, and recommendations – critically analyses and interprets the study results, synthesises the main findings, discusses the study's strengths and limitations, and provides actionable recommendations, including the identification of gaps that can be further investigated by future research.

VII. Appendices – includes supplementary information to enhance the understanding of the thesis.

[a] Chapters 3-5 were composed as independent manuscripts intended for publication. Therefore, some concepts in the introduction, methodology, and discussion sections may be repeated.

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# Chapter 2: Literature review

This chapter has two main sections: dietary intake and food insecurity in young children. The first section highlights the existing literature on the dietary intake of young children globally and locally in New Zealand. This is followed by a section on food insecurity, its consequences, how it is measured, and the factors it is associated with.

## Introduction

The first section of this narrative literature review with a systematic search strategy will highlight the energy and the key nutrients considered significant for the growth and development of young children. This will also include those nutrients of public health concern, particularly for young children in NZ. Despite its significance to early childhood nutrition, other nutrients such as iodine and sodium were not examined due to well-established difficulties in accurately measuring its intake (311, 312). Evidence on the dietary intakes of young children will be reviewed, and the limitations of the methods used to determine dietary intake discussed. The second section will examine the available literature on household food insecurity, its consequences, its relationship with young children's dietary intake, and the current local and international methods used for the assessment of household food insecurity.

## Search strategy

The strategy used to identify the evidence for this review is summarised below.

Table 1. Search strategy for literature review

| | Concept | Search terms | MeSH [a] terms |
|---|---|---|---|
| **1** | **Energy and nutrient intake (multi-nutrient)** | Diet*, intake*, "dietary intake*", nutri*, "nutrient intake*", "nutritional intake*", macronutrient*, micronutrient*, "macronutrient intake*", "micronutrient intake*", eat*, feed* | Diet, nutrient intake, eating |
| **2** | **Energy and nutrient intake (single nutrient)** | Energy, "Energy intake*", "dietary energy" "calorie intake*", "caloric intake*" | Energy intake, calorie intake, caloric intake |
| | | Protein*, "dietary protein*" | Proteins, dietary proteins |
| | | Carbohydrate*, carb* "dietary carbohydrate*" | Carbohydrates, dietary carbohydrates |
| | | Sugar, "total sugar*", "dietary sugar*", sucrose, "dietary sucrose*" | Sugars, dietary sugars, sucrose, dietary sucrose |
| | | Fat*, "dietary fat*", "fatty acid*" | Fats, dietary fats, fatty acids |
| | | "Saturated fat*", "saturated fatty acid*" | Saturated fat, saturated fatty acid |
| | | Fibre, fiber, "dietary fibre*","dietary fiber*" | Dietary fiber |

| | | | |
|---|---|---|---|
| | | Iron, “dietary iron” | Iron, dietary iron |
| | | Zinc, “dietary zinc” | Zinc |
| | | Calcium, “dietary calcium” | Calcium, dietary calcium |
| | | “Vitamin C,” “ascorbic acid,” | Vitamin C, ascorbic acid |
| **3** | **New Zealand** | “New Zealand”, NZ, Aotearoa, Zealand | New Zealand |
| **4** | **Young children** | “Young child*”, child*, “pre school*”, preschool*, toddler, “aged one”, “aged two”, “aged three”, “aged under four”, “aged under five”, “aged 1”, “aged 2”, “aged 3”, “aged under 4”, “aged under 5”, “under five”, “under 5” | Child, preschool |
| **5** | **Food contributors to multi-nutrients** | Sources, Food, food group, contributors, “food contribut*” Diet*, intake, nutri*, eat, feed*, macronutrient*, micronutrient* | Food |
| **6** | **Food contributors to single nutrients** | Energy, “energy intake*”, “dietary energy” “calorie intake*”, “caloric intake*” | Energy intake, calorie intake, caloric intake |
| | | Protein*, “dietary protein*”, meat, “meat product*”, poultry, “poultry product*”, egg*, dairy, “dairy product*” | Proteins, dietary proteins, meat, meat products, poultry, poultry products, eggs, dairy products |
| | | Carbohydrate*, carb* “dietary carbohydrate*” | Carbohydrates, dietary carbohydrates |
| | | Sugar, “total sugar*”, “dietary sugar*”, sucrose, “dietary sucrose*” | Sugars, dietary sugars, sucrose, dietary sucrose |
| | | Fat*, “dietary fat*”, “fatty acid*” | Fats, dietary fats, fatty acids |
| | | “Saturated fat*”, “saturated fatty acid*” | Saturated fat, saturated fatty acid |
| | | Fibre, fiber, “dietary fibre*”, “dietary fiber*” | Dietary fiber |
| | | Iron, “dietary iron” | Iron, dietary iron |
| | | Zinc, “dietary zinc” | Zinc |
| | | Calcium, “dietary calcium” | Calcium, dietary calcium |
| | | “Vitamin C,” “ascorbic acid,” | Vitamin C, ascorbic acid |

| | | |
|---|---|---|
| **7 Food security** | "Food secur*", "food insec*", hunger, "household food insec*", "household food sec*" | Food security, food insecurity |
| **Search combinations** | **Concepts** | **Literature Review Section** |
| 1 OR 2 AND 3 AND 4 | Energy and key nutrient intakes of young NZ children | Section 1 |
| 5 OR 6 AND 4 | Food sources of energy and nutrient intakes of young children | Section 1 |
| 5 OR 6 AND 4 AND 3 | Food sources of energy and nutrient intakes of young NZ children | Section 1 |
| 1 OR 2 AND 7 AND 4 | Household food insecurity and key nutrient intakes of young children | Section 2 |
| 1 OR 2 AND 7 AND 4 AND 3 | Household food insecurity and key nutrient intakes of young NZ children | Section 2 |
| **Databases used** | Web of science [b], Scopus, Google Scholar, Discover | |
| **Duration of literature search** | September 2021- January 2023 [c] | |

[a] Medical Subject Headings (MeSH); [b] Only applicable to searches conducted between September 2021 and December 2022; [c] To account for evidence published between the completion of this review and the submission of this thesis, the same search terms were re-entered in the abovementioned databases in September 2023. This search captured two new journal articles that were then incorporated into the corresponding sections of this review.

## Nutrients of importance for young children and their food sources

### Nutrient recommendations for young children

The following sections aim to answer the question of what the nutrients that play a significant role in early childhood nutrition are, their main food sources, their recommended intake levels and the rationale behind these recommendations, and the consequences of intake inadequacies or excesses. To provide a brief background on nutrient recommendations, table 2 presents the definitions and applications of nutrient reference values (NRVs) at the population and individual levels. This shows how the NRVs are utilised in assessing the nutrient intakes of groups and individuals. Additionally, table 3 displays the Australia and NZ NRVs published in 2006 (6). Recommendations for most macronutrients are not set except for protein due to the limited data available. The recommendations for iron and calcium were established through data modelling from the Food and Agriculture Organization (FAO) and the World Health Organization (WHO), whilst zinc values were determined using the factorial approach, and vitamin C values were interpolated from recommendations for both infants and adults (6).

Table 2. Definition of nutrient reference values

| Nutrient reference value | Definition | Use of nutrient reference value | |
|---|---|---|---|
| | | **For individuals** | **For groups** |
| Estimated Average Requirement (EAR) | A daily nutrient level estimated to meet the requirements of half the healthy individuals in a particular life stage and gender group | Use to examine the probability that usual intake is inadequate | Use to estimate the prevalence of inadequate intakes within a group |
| Recommended Dietary Intake (RDI) | The average daily dietary intake level that is sufficient to meet the nutrient requirements of nearly all (97–98 per cent) healthy individuals in a particular life stage and gender group | Usual intake at or above this level has a low probability of inadequacy | Do not use to assess intakes of groups |
| Adequate Intake (AI) | The average daily nutrient intake level based on observed or experimentally-determined approximations or estimates of nutrient intake by a group (or groups) of apparently healthy people that are assumed to be adequate | Usual intake at or above this level has a low probability of inadequacy. When the AI is based on the median intakes of healthy populations, this assessment is made with less confidence | Mean usual intake at or above this level implies a low prevalence of inadequate intakes. When the AI is based on median intakes of healthy populations, this assessment is made with less confidence |
| Upper Level of Intake (UL) | The highest average daily nutrient intake level likely to pose no adverse health effects to almost all individuals in the general population. As intake increases above the UL, the potential risk of adverse effects increases | Usual intake above this level may place an individual at risk of adverse effects from excessive nutrient intake | Use to estimate the percentage of the population at potential risk of adverse effects from excessive nutrient intake |

The table above was reproduced from Food and Nutrition Board: Institute of Medicine (15) and can be found on National Health and Medical Research Council (6) pages 1 and 3

Table 3. Summary of energy and key nutrient recommendations for young NZ children aged 1-3 years

| Energy or Nutrient | Recommendations [a] | | | | | Rationale for estimate |
|---|---|---|---|---|---|---|
| | EER [b] | EAR [c] | AI [d] | RDI [e] | UL [f] | |
| Energy (kJ) | 3,200-3,500 [g]<br>3,500-3,800 [h]<br>3,800- 4,000 [i]<br>4,000-4,200 [j]<br>4,200-4,400 [k]<br>3,900-7,600 [l] | - | - | - | - | For 1-2 years old: estimates based on sex, age, weight and length<br>For 2-3 years old: estimates based on sex, age, weight, length and physical activity level |
| Fat (g) | - | - | - | - | - | Essentiality relates to type of fat |
| Protein (g) | - | 12 g (0.92 g/kg) [m] | - | 14 (1.08 g/kg) | - | Factorial method (accounted for amounts required for maintenance and growth) |
| Carbohydrates (g) | - | - | - | - | - | Limited data available to set requirements |
| Total sugars (g) | - | - | - | - | - | Not set |
| Fibre (g) | - | - | 14 | - | - | Based on median population intakes; Included an allowance for resistant starch |
| Saturated fat (g) | - | - | - | - | - | Not set |
| Iron (mg) | - | 4 | 9 | - | 20 | Based on modelling requirements; Assumption of 14% absorption (UL) |
| Zinc (mg) | - | 2.5 [n] | 3 | - | 7 | Estimates based on factorial method |
| Calcium (mg) | - | 360 [o] | 500 | - | 2,500 | Set by modelling the components of calcium requirements, including component for growth |
| Vitamin C (mg) | - | 25 | - | 35 [p] | - | Set by interpolation of adult and infant recommendations |

[a] Based on Australia and NZ Nutrient Reference Values (6); [b] Estimated Energy Requirement (EER); [c] Estimated Average Requirement (EAR); [d] Adequate Intake (AI); [e] Recommended Dietary Intake (RDI); [f] Upper Level of intake (UL); [g-l] Estimated Energy Requirement (EER) for g:12 months, h:15 months, i:18 months, j:21 months, k:24 months and l:3 years old children; [m] Coefficient of variation (CV) of 12%; [n] Coefficient of variation (CV) of 10%; [o] Coefficient of variation (CV) of 15%; [p] Coefficient of variation (CV) of 20%
Abbreviations: kilojoule (kJ), milligrams (mg), grams (g)

## Energy

Energy is essential for the maintenance of metabolic and physiologic processes, the production of heat and muscle activity (1). Maintaining energy balance is critical to sustaining growth and development in children (2). Energy balance is achieved when total energy intake equals total energy expenditure, as well as an allowance for sufficient growth without inflicting limitations that may hinder the child's biological and socioeconomic potential (3).

In the United States (US), the top three foods that contribute to the energy intake of young children (2-5 years), based on the National Health and Nutrition Examination Survey (NHANES) data, were milk (8.9%), sweet bakery products (7.6%) and grain-based mixed dishes (5.6%) (4). NZ lacks data on the food sources of energy intake amongst young children. In a study that investigated the energy intake from ultra-processed foods of 2-year-old NZ children, it was found that the major contributors to energy were yoghurt, wholemeal bread, and crackers (5). However, despite its relatively recent publication, this study's data were collected between 2009 and 2010 and only included children living in Dunedin.

Energy requirements vary amongst individuals and are generally based on age, sex, level of physical activity, and body mass (1). In NZ, the energy requirement for toddlers aged 1-2 years takes into account sex, age, weight and length, but physical activity level categories are not utilised due to the high variation in physical activity levels for this age group. For children aged 2 years or more, the Estimated Energy Requirement (EER) considers their weight, height, age, and physical activity level (6). However, the NZ Ministry of Health (MoH) (1) recommends monitoring linear growth and body mass index (BMI) increases to ensure that energy requirements are met.

Positive energy balance or excessive intake, where energy consumed is greater than energy expenditure, is the ultimate cause of overweight and obesity (7). Childhood obesity is associated with chronic diseases that can lead to disability and early death in adulthood (3). In a systematic review and meta-analysis of fifteen large longitudinal studies, it was determined that children (n=200,777) who are obese are more likely to become obese as adults compared to their counterparts with normal weight due to the strong association found between childhood obesity and adult obesity (8). Obesity in adulthood is associated with a multitude of chronic diseases, such as type 2 diabetes (9), various forms of cancer (10), and cardiovascular diseases (11).

Furthermore, the direct economic impact of obesity includes an increase in healthcare expenditure and, later on, decreased economic productivity. In 2014, obesity was estimated to have cost NZ $2.8 trillion or equivalent to 2.8% of the total global gross domestic product (GDP) (12). In NZ, childhood

obesity is a major public health concern. The recent UNICEF (13) report on child well-being outcomes ranked NZ with the second highest prevalence of overweight and obese children out of the 41 high-income countries included in the report. Obesity negatively impacts several aspects of human life, such as employment, discrimination, mental health, premature mortality, and socioeconomic status, amongst others (14). Therefore, due to the adverse health, social and economic consequences of childhood obesity, early intervention is required to decrease its prevalence in NZ, where a large proportion of the childhood population is affected.

## Fat

As the richest source of energy amongst the macronutrients, fats aid in the absorption of fat-soluble vitamins and are significant sources of essential fatty acids (16). Fat is specifically important during early childhood as it is required for neurological development and brain function, and intake during early childhood has been found to impact growth and cognition later in life (17). Apart from its primary role in brain and retina development, Docosahexaenoic acid (DHA), an omega-3 fatty acid, is also involved in the prevention of growth failure and undernutrition during the first two years of life (18).

Naturally-occurring fatty acids are primarily classified as saturated and unsaturated (poly or mono) based on their atomic structure (1). Most fat-rich foods are composed of a combination of fatty acids which include animal sources such as meat, and plant sources such as oils, nuts and seeds. There is limited data on the primary sources of fat in the diets of young children in NZ. In the US, a national survey identified that cheese (9.3%), crackers, popcorn, pretzels, chips (8.4%) and milk (7.7%) contributed to most of the total fat intake of young children (19).

No total fat intake requirement has been set for most age groups in NZ since the essentialness of fat is related to the type of fat consumed (6). Instead of setting a total fat requirement, NZ, as well as other high-income countries such as France, Belgium, the United Kingdom (UK), and the Netherlands, recommend adequate intakes (AIs) for specific essential fatty acids, including linoleic acid (LA), α-linolenic acid (ALA) and total long-chain omega-3 fatty acids (16). An international joint expert consultation found that there is ‘convincing’ evidence that a gradual reduction in total fat intake from 40-60% during 0-6 months of age to 35% of total energy is recommended for 6-24 month-old children dependent on physical activity, and from 2 years onwards, 25-35% of total energy coming from fat is recommended (18).

Excessive consumption of fat can lead to obesity as it provides more than twice the amount of energy as carbohydrates and protein per gram, and excess energy intake is the primary contributing factor to obesity (20). Along with obesity, dietary fat intake in adults is also associated with an increased risk of developing cardiovascular diseases. A meta-analysis and systematic review of 33 randomised controlled trials (RCTs) and 10 cohort studies indicated low-fat diet interventions were significantly protective of high blood pressure and high blood lipid levels, particularly total cholesterol and low-density lipoprotein (LDL) cholesterol (21).

However, it is argued that early childhood studies have heavily focused on the quantity of dietary fat, whilst dietary fat quality has not been sufficiently investigated (22). Monounsaturated and polyunsaturated fatty acids are ideal sources of dietary fat amongst young children, whereas saturated and trans fats are recommended to be restricted and completely avoided, respectively (23). Therefore, apart from the quantity of fat, the quality of fat in the diet is especially significant for young children, as various types of fat generate diverse health outcomes in young children.

## Saturated fat

For decades, saturated fat intake has been known to be associated with increased chronic heart disease risk. Despite cardiovascular disease being uncommon in young children, prevention of high saturated fat intake must begin during childhood as atherosclerosis, or the build-up of arterial plaque, starts in childhood (24). In a large randomised dietary intervention trial of 1,062 Finnish children recruited during infancy (at 7 months) and annually followed up until the age of 5 years, it was determined that cardiovascular risk factors track from early childhood through older childhood (25). In the continuation of this trial, the cohort was followed up until the age of 20 years, and it was found that lowering children's saturated fat intake resulted in significantly lower LDL cholesterol levels and coronary heart disease risk (i.e., lower blood pressure and better vascular endothelial function), especially in boys, compared to the control group (32)

However, not all saturated fats are created equal. There is 'convincing' evidence that different types of saturated fatty acids have varying effects on blood cholesterol levels (i.e., lauric, myristic and palmitic acids increase blood cholesterol concentrations, but stearic acid has no effect) (18). Most of these fatty acids occur together in foods in various concentrations. Palmitic and stearic acids are commonly found in most fats and oils, whilst myristic acid is typically found in dairy fat, and lauric acid is abundant in tropical oils such as coconut and palm oils (18). There is limited data on the major food sources of saturated fat amongst young NZ children. However, in older NZ children (5-14 years

of age), saturated fat is mainly contributed by butter, cream and cheese (26). To prevent the initiation of the cardiovascular disease process, young children are recommended to consume monounsaturated and polyunsaturated spreads rather than butter (27).

Despite the controversy over the lack of a consistent association between saturated fat intake and cardiovascular disease risk (28), there is high-quality and coherent evidence that saturated fat intake lower than 10% of total energy decreases the risk of cardiovascular disease when replaced by polyunsaturated fatty acids (29). However, it is unknown whether this recommendation can be extrapolated to young children as most studies investigating saturated fat intake and disease risk involve adult participants. Furthermore, lowering saturated fat intake to 8% of total energy intake has been found to be beneficial amongst children 2-18 years of age with a genetic predisposition to dyslipidaemia (18).

Inadequate saturated fat intake is rare, therefore its consequences have not been well studied. On the one hand, high saturated fat intake has been associated with long-term chronic conditions such as cardiovascular disease, diabetes and obesity (30, 31). Apart from cardiovascular disease risk factors tracking from early childhood, behavioural antecedents for heart disease, such as diet and physical activity, are starting to be established during this stage (33).

### Protein

Protein is fundamental for young children. Individual amino acids, which are the building blocks of protein, have been directly linked to children's growth and development. Lysine and arginine, specifically, are associated with the process of releasing growth hormones in young children (34). Apart from its functional and structural roles, protein is also involved in the synthesis of hormones, enzymes, and antibodies and can also be a source of energy for children (1).

Protein is present in food of varying quality depending on its origin (i.e., high-quality protein for animal-based food sources and low-quality protein for plant-based food sources). Most plant-based protein sources do not provide the required amount of all essential amino acids to support growth and tissue maintenance in young children (35). A significant and inverse association between total utilisable protein availability (a function of protein quality) and the prevalence of stunting has been established in an analysis of 200 countries (36). However, strategies such as increasing protein intake (an additional 30-35% for <2 years and 20-30% for 2-6 years) and combining complementary proteins may be employed to ensure adequate protein intake amongst young children (37, 38).

In NZ, there is a scarcity of studies investigating the dietary sources of protein amongst young children. In other high-income countries such as the US (2-18 years old) and Australia (9 months-5 years old), milk and milk products were reported to be the primary contributors to the dietary protein intake of young children (19, 39). In NZ, the MoH recommends limiting the consumption to 350 ml of cow's milk in a day for non-breastfed children (>1 year old) due to its high protein and low iron content, thereby potentially displacing iron-rich foods that young children need more of (40).

In young children, there is an increased requirement for protein to support new tissue formation and the maintenance of protein homeostasis (41). The Recommended Dietary Intake (RDI) for protein is 14 g/day, and the Estimated Average Requirement (EAR) is 12 g/day in NZ. This is comparable with the NRVs for the same age group in other high-income countries, such as the UK with a Reference Nutrient Intake (RNI) of 14.5 g/day (42), and the US and Canada with a Recommended Dietary Allowance (RDA) of 13g/day (43). However, compared to the NZ NRVs, which were published in 2006 (updated in 2017 for revisions only on fluoride and sodium recommendations), the UK recommendation is more up-to-date as these were published in 2016 (42). Evidence scans on dietary protein requirements have recently been undertaken by the Joint Canada-US Dietary Reference Intakes Working Group in an effort to update the current recommendations (6, 44). The evidence scans indicated that there is limited evidence that supports the acute adverse effects of high protein intake and inconclusive results in terms of its impact on chronic disease risk.

A usual consequence of chronic protein deficiency is protein-energy malnutrition (PEM). However, unlike in lower-middle-income countries where there is a high prevalence of PEM, multiple studies in high-income countries such as Italy, France, and the US reported an increased protein intake, with some young children continuously exceeding their requirements for a long period of time (3 years) (41, 45-47). As children age, there is a gradual decline in protein requirements, but the introduction of solid foods is marked by a sharp increase in dietary protein intake, specifically for infants who have been breastfed exclusively (48, 49).

Emerging evidence suggests that high protein intake during the first two years of life is linked to overweight and obesity. A large multi-national study situated in eleven sites in five European countries found that children who had higher dietary protein intake from 8 weeks, had a higher BMI compared to children with lower protein intake by the time they turned 2 years of age (49). This is consistent with a systematic review and meta-analysis of 16 studies that found protein intake during preschool (6 months-3 years) was associated with later obesity risk. It found that 15 out of 16 studies indicated positive associations between higher protein intake and a higher BMI z-score in older childhood (50).

## Carbohydrates

Carbohydrates are the most efficient source of energy for cells and play a critical role in energy metabolism and homeostasis (51). In young children, carbohydrates play a crucial role as the main energy source for the brain and have been shown to promote cognitive development amongst children by influencing attention, memory, and the processing of information (52). As humans are born with a preference for sweet tastes, carbohydrates also impact the development of food preferences in young children. The sensory systems that detect and prefer energy-dense foods that taste sweet are intensified during childhood (53).

Carbohydrates are primarily classified based on chemical composition and divided into three main groups: sugars (monosaccharides and disaccharides), oligosaccharides and polysaccharides (1). Each type of carbohydrate elicits various glycaemic and metabolic responses, which may be affected by other dietary components they are consumed with (54). In the US, young children obtain most of their carbohydrate intake from soft drinks; yeast breads and rolls; and candy, sugars and sugary foods (19). The NZ MoH recommends children consume carbohydrates that are mainly from wholegrain cereals and breads, vegetables, and legumes (1). However, there are limited data on the sources of carbohydrates in the diets of young NZ children.

Similar to fat, no dietary carbohydrate requirement has been set for young children due to the limited data available to set the NRVs (6). To be able to achieve an optimal diet to lower chronic disease risk, older children (>14 years) are recommended to consume 45-65% of their total energy from carbohydrates (1). However, there is no available data to estimate the Acceptable Macronutrient Distribution Range for younger NZ children. In Europe, the European Food Safety Authority (EFSA) recommends children 12 to <36 months old have the same macronutrient distribution (45-60% of total energy) prescribed for adults based on the impact of carbohydrates on weight and lipid profile whilst considering current intake and dietary patterns of the population (55).

Excess carbohydrate consumption can contribute to positive energy balance, weight gain and obesity (51, 54). Although there is no conclusive evidence that modifying the carbohydrate composition of the diet is a significant determinant of total energy intake, there is concrete research that supports the fact that sugar-sweetened beverage consumption does not provide the same satiety as solid forms of carbohydrates, and thus, has been associated with weight gain (51). Further discussion on the role of excess sugar consumption in the development of obesity is covered in the next section.

## Total sugars

Sugar contributes to the total energy density of diets (56). In young children, sugars play a role in neurological development as glucose, a component of sugar, is the primary source of energy for the brain (52). However, there is concern that sugar intake, particularly free sugars, may be a factor in increasing the probability of weight gain in preschool children (57, 58).

Sugar is a type of carbohydrate that occurs naturally or can be added to food (59). In Australia and NZ, "total sugar" is defined as the combination of free and intrinsic sugars. Free sugars include all "added sugars" and sugars that are components of honey and fruit juices, whilst intrinsic sugars include all sugars that are naturally occurring in whole foods such as milk, vegetables, and fruits (60). In most high-income countries, foods that are primary sources of added sugar tend to lack essential nutrients that young children need in their diets (59, 61). In NZ, commercial infant food pouches available on the market have been found to contain a significant amount of total sugar (8.4%) and almost 70% of commercial complementary foods are primarily composed of sweet-flavoured ingredients (62, 63). Young children may be exposed to these in early life, and there is an increasing presence of pouches in stores and early childcare centres (64).

Despite the limited data to set nutrient requirements for carbohydrates, the World Health Organization (65) recommends limiting free sugar intake to less than 10% of total energy intake. Young children are discouraged from consuming added sugar due to its negative impact on short and long-term health outcomes. Additionally, the development of food preferences towards sugar during early childhood has a tendency to be sustained later in the older childhood stage (66). In NZ, young children are recommended to consume foods, snacks, and drinks that are low in free sugars (1).

As abovementioned, high sugar intake has been determined to play a role in the development of obesity amongst young children. Despite RCTs showing no overall link between sugar-sweetened food and beverage consumption and weight change, a meta-analysis of prospective cohort studies in children determined a higher probability of being overweight or obese for children with the highest sugar-sweetened food and beverage intakes compared to those with the lowest consumption (56). Apart from obesity, sugar intake is strongly linked to dental caries and there is evidence of moderate quality that decreasing free sugar intake to less than 10% of total energy intake is associated with lower dental caries in children (68).

## Fibre

Dietary fibre has an important role in the promotion of the overall well-being of young children. It is associated with the promotion of better satiety and increased micronutrient intake in children (69). This is consistent with the results of a large European dietary intervention trial that indicated higher nutrient density and better diet quality of young children (13 months-9 years of age) who consumed a high-fibre diet (70). The same trial also showed a negative association between dietary fibre intake and serum total cholesterol levels in young children.

Dietary fibre includes polysaccharides, oligosaccharides and lignans and is characterised by its indigestibility and fermentation (partial or complete) in the large intestine (6). Dietary fibre inhibits the absorption of minerals such as iron, zinc and calcium as it forms complexes with these compounds, particularly phytic acid found in cereals and legumes (55). There are limited data on the current food sources of dietary fibre for young children in NZ. In the US, fruit; breads, rolls, and tortillas; and ready-to-eat cereals were the main food sources of fibre for young children aged 2-5 years (4).

There is a high variability in dietary fibre intake recommendations across the world. In NZ, 14 g/day is considered as an AI for 1-3-year-old children (6). This is similar to UK recommendations (15 g/day) for the same age group. Other countries have higher recommendations, such as the US and Canada (19 g/day), but recommendations are lower in European countries (10 g/day) (43, 71, 72). These differences are due to the variations in the definition of dietary fibre for each country, as well as the methods utilised to analyse the content of dietary fibre in food (73).

Inadequate dietary fibre intake is associated with constipation and picky eating amongst young children (74). Several reviews and studies have also determined the inverse association between fibre intake and obesity amongst young children (75, 76). On the other hand, excess fibre intake is not recommended, specifically for young children, due to their relatively small stomach size and the potential to reduce nutrient absorption, diarrhoea, and other gastrointestinal disturbances and inadequate energy intakes (1).

## Iron

Iron is a micronutrient crucial to the expansion of blood volume, increasing muscle and tissue mass, and supporting brain growth and development in young children (77). In young children, demand for iron is increased due to the major brain growth spurt in the first 2 years of life (78). Iron is also involved in the enhancement of learning and memory (79), attention and visual motor ability (80), and immune system function (81) in young children.

Iron is abundant in haem (animal) and non-haem (plant and animal) sources (6). Dietary enhancers such as the meat, fish and poultry (MFP) factor and vitamin C improve dietary iron absorption whilst inhibitors such as phytates, polyphenols and calcium impede its absorption (82). In the US and NZ, the primary source of iron is cereals (a non-haem source) comprising 22.9% and 31.4% of the total iron contributed to the diets of young children, respectively (83, 84). The MoH recommends the consumption of an iron and vitamin C-rich diet, whilst discouraging the consumption of drinking tea with meals in young children (27).

Healthy and term infants are born with adequate iron stores that can cover growth requirements for six months, and from then onwards, iron stores are depleted and the need for dietary iron is rapidly increased (85). By the second year of life, most body iron is found in the blood, followed by tissues, and a marked decrease in iron stores compared to birth is observed (86, 87). In Australia and NZ (see table 3), the EAR for iron is set at 4 mg/day and the RDI at 9 mg/day for 1-3-year-old children (6). For vegetarian children, 80% more is required due to the low bioavailability of iron in their diet (88).

Iron deficiency is one of the most rampant forms of micronutrient deficiency in the world (89). Young children are particularly at risk of iron deficiency due to their increased requirements for growth and complementary foods that are often low in iron (90). A child will still experience continuous growth during iron deficiency, but iron tissue depletion causes clinical symptoms in children such as fatigue, susceptibility to infection, decreased physical capacity, and poor cognition (91, 92). Even if treated, cohort studies indicate that iron deficiency amongst young children may result in long-lasting adverse effects on behaviour and development (93).

## Zinc

Zinc is a major structural component of bones and skeletal muscles and is a key micronutrient for the growth and development of children (6). It is associated with various growth factors such as Insulin-like Growth Factor 1 (IGF-1) which promotes growth in children (94). Other growth-specific functions of zinc include its interaction with hormones involved in bone growth and the promotion of DNA synthesis in bone cells, enhancing the effect of vitamin D on bone metabolism (95). Its role in the prevention of infection amongst young children is well-documented in the literature (96, 97).

Zinc is abundant in high-protein foods such as meat, poultry, dairy, and shellfish but can also be found in plant sources such as legumes and whole-grain cereals (6). Its absorption is enhanced by animal protein in the diet and inhibited by phytates (97). The primary dietary sources of zinc in a sample of young children (1-2 years of age) living in three South Island cities in NZ were dairy (43.6%), meat, fish, poultry, eggs and nuts (24.0%), and cereals (18.7%) (84). Currently, there is limited representative data that describes the food sources of zinc in this age group.

The EAR for zinc is 2.5 mg/day and 3 mg/day is the RDI (6). However, concerns about the unsuitability of the cut-offs utilised to define zinc deficiency amongst toddlers were raised due to the results of an intervention study that showed that despite the increase in dietary zinc intake by increasing red meat intake and zinc-fortified milk consumption, the zinc status of NZ toddlers did not increase correspondingly (98). The study also found adequate dietary zinc intakes (>3 mg/day) at baseline for both the placebo and intervention groups. Similar to NZ, it is also argued that the Upper Level of intake for zinc (7 mg/day) is set too low as it is already lower than the average amount of zinc consumed by healthy children in the US (99).

A systematic review of studies conducted in Australia and NZ classified toddlers in the at-risk group for zinc deficiency (100). Despite the metabolic changes that mothers undergo during lactation to increase the availability of zinc for breastfed infants, zinc transfer from the mother to the infant steadily declines as the child grows (101). This is exacerbated by the fact that complementary foods are relatively low in bioavailable zinc and generally include plant-based food items high in phytates, thus inhibiting optimal zinc absorption (101, 102).

Inadequate zinc intake is associated with an increased incidence of morbidity and mortality from respiratory infections and diarrhoea (103). A plethora of adverse health outcomes have been documented due to zinc deficiency amongst children. This includes growth restriction, cognitive dysfunction, visual impairment and increased severity of diseases such as pneumonia, measles and malaria (104, 105). Zinc deficiency also impacts the status of other nutrients as it impedes their

digestion and absorption which results in diarrhoea, causing the severity of malnutrition of other essential nutrients (97).

## Calcium

Calcium plays an indispensable role in the optimal growth and development of young children. This life stage is characterised by rapid skeletal growth that must be supported by adequate dietary calcium intake to achieve optimal peak bone mass, which may be protective of bone mineral disorders later in adulthood (106). Cohort studies and RCTs indicate a positive association between calcium intake and bone mineral content that is impacted by physical activity and genetics in young children (107, 108). Calcium intake in the second year of life has been shown to have the greatest correlation with bone mineral content at 5 years of age compared with calcium intake at ≤1, 3, 4 and 5 years (109). Apart from its structural function, calcium is also crucial for blood clotting, muscle contraction, nerve impulse transmission, immune response, and other enzymatic activities (110).

Calcium is found in milk and milk products, in bony fish, legumes and nuts, and its absorption is enhanced by vitamin D (6). However, other dietary components act as inhibitors such as phytates (present in cereals, legumes and nuts) and oxalates (present in tea, leafy vegetables, beetroots and seeds) (111, 112). There is limited current data on the sources of calcium amongst young NZ children's diets. In the US, young children obtain their calcium primarily from milk, cheese and flavoured milk (4).

Calcium requirements are determined by growth velocity, absorption rates, and the presence of other key nutrients such as phosphorus, protein and vitamin D (113). The EAR and RDI set for 1-3-year-old NZ children are 360 mg/d and 500 mg/day, respectively, and were determined using a balance approach (6). A systematic review of balance studies commissioned by the FAO and WHO expert group to update calcium requirements for children aged 0-4 years cited balance studies as an alternative approach to dose-response RCTs due to the latter's high maintenance costs and difficulty in dietary protocol adherence over a long period of time (114).

Inadequate calcium intake has an irreversible impact on young children's growth and development. If dietary calcium is inadequate to meet the physiological needs of the body, it is resorbed from the skeleton for the maintenance of calcium homeostasis in the blood (55). A calcium-deficient diet restricts the mineralisation of the growing bone, which, in severe cases, further leads to nutritional rickets (115). This is explained by two mechanisms. First, inadequate calcium in the diet increases the breakdown of 25(OH)D by activating 24-hydroxylase as a result of high 1,25-dihydroxy vitamin D

(1,25(OH)2D) blood concentrations (116). Second, low dietary calcium intake may increase the demand for vitamin D from another mechanism since an elevated 25(OH)D may be needed to achieve maximum absorption of calcium in the intestines.

## Vitamin C

Vitamin C primarily functions as an antioxidant, which is closely linked to its role in immune function (117). It is an essential micronutrient since humans do not have the ability to synthesise vitamin C (6). Vitamin C supports growth in children directly through the development of collagenous structures such as joints and connective tissues and indirectly through the enhancement of iron absorption (117). As abovementioned in the 'Iron' section, studies have shown that vitamin C improves the absorption of non-haem iron in the gastrointestinal tract (82).

Fruits and vegetables are rich sources of vitamin C. Amongst the excellent sources are citrus fruits, kiwi fruit, broccoli and sprouts (6). Similar to other nutrients, data on the food sources of young NZ children is scarce. In older NZ children (aged 5-14 years), non-alcoholic beverages (37%), fruit (22%), and vegetables (11%) were the primary contributors to vitamin C intake (118). However, this survey of older children was conducted more than two decades ago and may no longer reflect their intake. More recent evidence from other high-income countries, such as the UK and the US, revealed a similar pattern of beverages being the primary source of vitamin C in the diets of young children (119, 120).

In comparison to other high-income countries, vitamin C recommendations for young NZ children are relatively higher. Table 2 indicates that the RDI for vitamin C is set at 35 mg/day for the Australia NZ NRVs. In the US and Canada, the RDA is 15 mg/day whilst in European countries, the Population Reference Intake (PRI) is set at 20 mg/day (55, 121). The large differences in vitamin C intake recommendations are due to the variations in how the requirements were extrapolated for each country. Recommendations for infants and adults were extrapolated to NZ children due to the lack of data (6). The extrapolation for the Australia NZ NRVs was based on the process described by the FAO and WHO (122). On the other hand, European recommendations were based only on adult data that was isometrically scaled to the requirements of children aged 1-3 years (72).

Although extremely rare, lack of vitamin C in the diet results in scurvy, which includes symptoms such as bleeding gums, oedema, pain in the extremities, and ultimately, death (6). Subclinical vitamin C deficiency is more common even in high-income countries, as vitamin C concentrations can

decrease during acute and chronic diseases and infections (117). Emerging evidence also suggests that inadequate vitamin C intake also impacts cognitive development amongst children (123).

## Current studies reporting on energy and nutrient intakes of young children

Due to the vital role played by nutrition in early childhood growth and development, it is important that we assess children's diets at a population level. This section aims to address the question of what the current energy and nutrient intake recommendations and levels of young children in other high-income countries are, and to describe and examine the current studies that have reported on the energy and nutrient intakes of young NZ children.

### Studies in developed countries

In most high-income countries such as Australia (2 years old and above), the US (1-year-old and above), and the UK (1.5 years old and above), dietary intake data from children under the age of 5 is collected as an integral component of national nutrition surveys (124-126). Through national dietary surveillance, it enables countries to develop up-to-date and relevant nutrition policies and programmes (127). There is strong evidence from high-income countries that prevention of chronic diseases through the improvement of dietary intake alleviates the economic pressure resulting from increased healthcare spending to manage and treat these diseases (12, 128).

The four international diet surveys on young children reported in this literature review (table 4) included data collected between 2012 and 2021 from young children aged 1-3 years living in the Netherlands, the US, Australia and the UK (129-132). The primary dietary assessment tool used in these surveys were multiple 24-hour diet recalls, except for Australia, which utilised a 1-day food record for all participants and was repeated for the second time for a random subset of the study population. Almost all the studies adjusted sampling methods to ensure a nationally representative sample, except for Australia, which utilised convenience sampling resulting in a more educated and socioeconomically advantaged study sample.

When comparing these studies, there is an apparent trend of higher energy and nutrient intakes amongst young US children compared to the three other countries. On the other hand, Australian children had one of the lowest intakes of energy and most nutrients except for fibre. This may be due

to the fact that the study only involved children aged 1-2 years, and those who were likely to have intakes on the higher end of the spectrum (i.e., 2-3-year-old children) were not included in the survey. Dietary data from Australian children 2-3 years of age is available from a previous dietary survey, but it was not included in this review as it was conducted almost 16 years ago (133).

Energy and nutrient intakes of young children living in the US, UK, Australia and the Netherlands were generally adequate, with most children meeting or exceeding the recommended nutrient intake levels. In particular, young children from all countries reviewed had excess protein intake ranging from approximately 280-400% of the EAR (6, 72, 121, 134). Despite the US having the lowest EAR for iron at 3.0 mg/day compared to the UK (5.3 mg/day), the Netherlands (5.0 mg/day), and Australia (4.0 mg/day), young US children were reported to have the highest iron intake across the developed nations analysed in this review. Adequacy for other micronutrients such as zinc, vitamin C, and calcium is also achieved by all countries, with young children from the Netherlands meeting almost 250% of the EAR for calcium.

Table 4. Energy and nutrient intake of young children 1-3 years in US, Australia, UK and the Netherlands

| Energy or Nutrient | US [a, f, α] | | Australia [b, f, α] | UK [c, e, β] | Netherlands [d, e, f, μ] |
|---|---|---|---|---|---|
| | Male (n=527) | Female (n=488) | (n=475) | (n=306) | (n=672) |
| Energy (kJ) | 5,966.0 (121.0) | 5,535.0 (96.0) | 4247.0 (30.0) | 4,450.0 (100.0) | 5,200.0 [γ] |
| Fat (g) | 55.3 (1.3) | 50.9 (1.0) | 41.0 (0.3) | 41.5 (11.5) | 40.6 [δ] |
| Protein (g) | 51.6 (1.0) | 47.9 (0.8) | 40.0 (0.4) | 41.0 (10.0) | 41.0 (41.0–42.0) |
| Carbohydrates (g) | 186.0 (4.0) | 174.0 (4.0) | 116.0 (1.0) | 138.0 (36.0) | 174.0 (172.0–175.0) |
| Total sugars (g) | 92.0 (3.0) | 88.0 (3.0) | Not reported | Not reported | Not reported |
| Fibre (g) | 10.8 (0.3) | 10.7 (0.3) | 13.6 (0.2) | 10.4 (3.5) | 12.5 (12.5–13.0)[‡] |
| Saturated fat (g) | 20.2 (0.6) | 18.5 (0.5) | Not reported | 17.5 (6.1) | 15.2 [δ] |
| Iron (mg) | 9.8 (0.3) | 9.1 (0.3) | 5.9 (0.1) | 5.8 (1.8) | 5.8 (5.7–5.8) |
| Zinc (mg) | 7.4 (0.2) | 7.1 (0.1) | 5.3 (0.04) | 4.8 (1.4) | 5.7 (5.7–5.8) |
| Calcium (mg) | 954.0 (25.0) | 914.0 (23.0) | 608.0 (9.6) | 707.0 (246.0) | 700.0 (696.0–705.0) |
| Vitamin C (mg) | 67.5 (3.1) | 71.4 (4.0) | 64.0 (3.5) | Not reported | 77 (76–78) |

[a] Usual energy and nutrient intake from food and beverages of American children aged 1-3 years; What We Eat in America, National Health and Nutrition Examination Survey (WWEIA, NHANES) 2015-2018; [b] Usual energy and nutrient intake from food and beverages of Australian children aged 1-2 years, Australian Feeding Infants and Toddler Study (OzFITS) 2021 (130); [c] Usual energy and nutrient intake from food and beverages of Dutch children aged 1-3 years, Dutch National Food Consumption Survey (DNFCS) 2012–2016 (131); [d] Total energy and nutrient intake from food and beverages of British children aged 1.5-3 years, National Diet and Nutrition Survey Rolling Programme (NDNS RP) 2016/17-2018/19; [e] Employed the Englyst method for the analysis of total dietary fibre; [f] Utilised the Association of Official Analytical Chemists (AOAC) method for the analysis of total dietary fibre; [g] Abbreviations: kilojoule (kJ), milligrams (mg), grams (g), United States (US), United Kingdom (UK)

[δ] Calculated from % energy; total fat was reported as 29.4 (29.3–29.5) % total energy; saturated fat was reported as 11.0 (11.0–11.1)% total energy

[‡] Calculated from reported mean intake 2.4 (2.4–2.5) gram/megajoule

[α] Mean (Standard Error)

[β] Arithmetic mean (Standard Deviation)

[μ] Mean (95% Confidence Interval)

[γ] Median

## Studies in New Zealand

In New Zealand, there is a paucity of large-scale studies examining the dietary intake of children under 5. The most recent national survey investigating New Zealand children's dietary intake was published in 2002, almost two decades ago, and involved 5-14-year-old participants (118). Two national surveys followed in 2007 and 2008/2009, describing the dietary habits and physical activity of children and young people aged 5-24 years (135, 136).

The NZ Health Survey, an annual national survey, includes children under the age of 5 and assesses dietary habits, physical activity, anthropometric measurements, and other health outcomes of children aged 0-14 years (137). Through this survey, it was found that almost half (46.7%) of children aged 2-4 years consume fast food, and 12.4% have fizzy drinks at least once a week. The survey also indicated that only 46.1% of children met the MoH guidelines of 2 servings of fruits and 2-3 servings of vegetables per day (1, 137). These statistics exhibit a downward trend from 58.1% in the 2011/2012 survey (more than a 12-point percentage decline in 10 years) despite the country's foremost status in producing nutritionally diverse crops globally (137, 138). This exhibits the disconnect between the high availability of nutrient-dense foods in NZ and the overall low consumption of fruits and vegetables by young children.

Another notable NZ study is Growing Up in NZ (GUiNZ), a major longitudinal research set in the North Island that has investigated dietary consumption patterns such as frequency of confectionery and sugar-sweetened beverage consumption and fruit and vegetable intake of young children under the age of 5 (139). The study's findings were consistent with the NZ health survey, which revealed that over half of the cohort at the age of 4 years (n=3,281), adhered to the MoH guidelines regarding fruit consumption, and 84% (n=5,147) followed the recommendation for vegetable consumption. However, none of these surveys measured the energy or nutrient intake of young NZ children.

Through the search strategy employed in this review (see table 1), six recent studies were captured that reported on the energy and key nutrient intakes of young children (Table 5). However, most of these studies had different primary outcomes, which were validating a dietary assessment tool (140), testing the effect of fortified milk on dietary intake (142) or micronutrient status (141), assessing the effect of modifying feeding practices on nutrient intake (143), identifying nutritional risk factors for pneumonia (144), and assessing the relationship between birthweight and nutrient intake in children (145). The energy and key nutrient intakes indicated in table 5 are reported from the baseline or end intake of the control or placebo groups of the studies. In table 5, the setting and design of these studies are also enumerated.

The six studies that looked at energy and nutrient intakes of young NZ children indicate general adequacy for most nutrients investigated except for fibre. Set at 14 g/day, AI for fibre was not met in all six studies, with young children from the EAT study achieving just over half [7.9 (7.5, 8.4) g/day] of adequacy (140). Furthermore, a pattern of high protein intake was observed across six studies, with protein intake ranging from 33-46 g/day compared to the EAR of 12 g/day. In terms of micronutrient intake, all studies reported intakes that met the recommendations for iron, zinc and calcium.

Table 5. Summary of energy and key nutrient recommendations and intake of young NZ children

| Study characteristics | | EAT study [a] | Red meat/Fortified milk trial | GUMLi trial [b] | BLISS study [c] | Pneumonia case-control study | ABC study [d] |
|---|---|---|---|---|---|---|---|
| Author, year (reference) | | Watson et al., 2015 (140) | Szymlek-Gay et al., 2018 (141) | Lovell et al., 2019 (142) | Daniels et al., 2018 (146) | Gibbons, 2013 (144) | Wall et al., 2017 (145) |
| n | | 152 | 90 (control group) out of 225 total participants | 77 (control group) out of 160 total participants | 56 (control group) out of 113 total participants | 351 (control group) out of 856 total participants | 267 (control group) out of 456 total participants |
| Age (year/s) | | 1-2 | 1-1.7 | 1 | 2 | 0-5 | 3.5 |
| Design | | Cross-sectional | RCT | Double-blinded, RCT | RCT | Case-control study | Longitudinal case-control study |
| Dietary assessment tool | | EAT FFQ/5-day weighed food record | 3- day weighed food record | EAT FFQ | 3- day weighed food record | Food history and FFQ | 24-hr food record-assisted recall |
| Setting | | Dunedin, Mid Canterbury and Wellington | Otago and Southland regions | Auckland and Brisbane, Australia | Dunedin | Auckland | Auckland |
| Data collection timing | | September 2011 to April 2012 | February 2004 to December 2005 | 12 months (actual dates not indicated) | November 2012 and March 2014 | August 2002-March 2005 | 1999 to 2001 |
| **Energy or Nutrient** | **Recommendation** [h] | **Current intake** | | | | | |
| Energy (kJ) | 3,200-4,400 [i] | 3,494 (3,347, 3,647) [ǂ] | 4,119 (3,921, 4,316) [ǂ] | 4,417 (1,369) [µ] | 4,003 (3,812, 4,202) [ǂ] | 390.7 kJ/kg [δ] | 5,360 (3,905, 6,518) [ν] |
| Fat (g) | Not set | 28 (27, 30) [ǂ] | 34 (33, 35) % of total energy [ŧ] | 42 (16) [µ] | 35.7 (34.2, 37.2) [ǂ] | 45.4 [δ] | 42 (31, 54) [ν] |
| Protein (g) | 12 g/day (0.92 g/kg) [j] | 33 (32,35) [ǂ] | 16 (16, 17) % of total energy [ǂ] | 46 (16) [µ] | 37.0 (35.5, 38.6) [ǂ] | 3.5 g/kg [δ] | 45 (31, 60) [ν] |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Carbohydrates (g) | Not set | 111 (107, 116) [‡] | 50 (49, 51) % of total energy [ɬ] | 125 (41) [μ] | 122 (114, 130) [‡] | 148 [δ] | 170 (122, 219) [ν] |
| Total sugars (g) | Not set | - | - | - | - | - | 86 (59, 116) [ν] |
| Fibre (g) | 14 [k] | 7.9 (7.5, 8.4) [‡] | 8.1 (7.3, 8.9) [‡] | 11.0 (4.1) [μ] | 10.1 (9.3, 10.9) [‡] | - | 10 (7, 15) [ν] |
| Saturated fat (g) | Not set | - | 17 (16, 18) % of total energy [ɬ] | - | 14.7 (14.1, 15.3) % of total energy [‡] | - | 20 (14, 26) [ν] |
| Iron (mg) | 4.0 [j] | 5.8 (5.4, 6.2) [‡] | 4.8 (4.3, 5.3) [‡] | 8.6 (3.6) [μ] | 5.3 (3.1, 8.4) [‡] | 7.8 [δ] | 6.5 (4.6, 8.9) [ν] |
| Zinc (mg) | 2.5 [j] | 4.2 (4.0, 4.4) [‡] | 5.4 (5.1, 5.8) [‡] | 7.3 (2.5) [μ] | 4.4 (3.7, 5.4) [‡] | 6.5 [δ] | 5.8 (3.8, 7.7) [ν] |
| Calcium (mg) | 360 [j] | 556 (511, 605) [‡] | 844 (771, 916) [‡] | 762 (323) [μ] | 619 (562, 681) [‡] | 655 [δ] | 608 (383, 868) [ν] |
| Vitamin C (mg) | 25 [j] | 47.5 (42.8, 52.8)[‡] | Not reported | 90.2 (38.6) [μ] | 39.2 (35.5, 43.4) [‡] | Not reported | Not reported |

[a] Eating Assessment in Toddlers (EAT) study; [b] Growing-Up Milk–Lite (GUMLi) trial; [c] Baby-Led Introduction to SolidS (BLISS) study; [d] Auckland Birthweight Collaborative (ABC) study
[e] Abbreviations: kilojoule (kJ), milligrams (mg), grams (g); [h] Based on Australia NZ Nutrient Reference Values for children 1-3 years of age (National Health and Medical Research Council, 2006); [i] Estimated Energy Requirement (EER) in reference to 1-2 years of age children (minimum value=3,200 kJ girls at 1-year-old and maximum value=4,400 kJs boys at 2 years); [j] Estimated Average Requirement (EAR); [k] Adequate Intake (AI)
[ɬ] Values are mean (95% CI)
[‡] Values are geometric mean (95% CI)
[μ] Values are mean (±SD)
[δ] Values are mean
[ν] Values are median (25th, 75th percentile)

### Eating Assessment in Toddlers (EAT)

Situated in the South Island of NZ, the Eating Assessment in Toddlers (EAT) study's primary aim was to determine the relative validity and reproducibility of a modified FFQ in NZ toddlers as part of the Prevention of Overweight in Infancy (POI) study (147). The POI study is a 4-arm RCT that aimed to determine the impact of an intervention involving physical activity, sleep, diet, and breastfeeding on the reduction of obesity for the first 2 years of life (148).

Compared to the current recommendations, almost all nutrients examined were above the recommended intakes except for fibre, with a group mean intake that is approximately more than half (7.9 g/d) of the AI (14 g/d) (6). These findings are coherent with the results of the NZ health survey and GUiNZ on the low proportion of young children meeting the MoH guidelines for daily fruit and vegetable consumption.

Limitations of this study include:

- The sampling method used was convenience sampling
- Over-representation of participants from low-middle areas of deprivation
- Under-representation of minority ethnic groups
- Foods eaten in early childhood centres were not reported

### Red meat/Fortified milk trial

Conducted by the University of Otago, this clinical trial investigated whether increasing red meat consumption or fortified milk consumption increased dietary zinc intake and blood and hair zinc levels compared to a placebo (powdered cow's milk). At baseline, the control group (n=90) consumed 16% of total energy intake from protein or 37 g of protein daily (141). Similar patterns were observed in the GUMLi trial (46 g per day) and the FFQ validity study (33 g per day) (140, 142). These studies indicate protein intakes that are well above or almost 275-383% of the EAR for protein for 1-3-year-old children, which is 12 g/day (0.92 g/kg) and are consistent with the excessive protein consumption reported in other high-income countries such as Italy, France and the US (6, 41, 45-47). This trend apparently continues through older childhood as a national health survey in NZ reported excess dietary protein intake amongst all groups of children (5-6, 7-10 and 11-14 years of age) surveyed (149).

Participants were also found to have 34 (33,35)% of total daily energy intake contributed by fat, which is within, but on the upper end of the Acceptable Macronutrient Distribution Range of 20-35% of total energy intake (6). Compared to other high-income countries, this is similar to the daily fat intake reported in young children living in Australia (51.0 g or 31.8% of daily energy intake), the US (52.0 g or 32.9% for males and 50.1 g or 33.8% for females of daily energy intake) and the UK (41.5 g or 35.3% of daily energy intake) (124-126). On the other hand, participants in this study consumed 17% saturated fat of their total energy intake, exceeding the current recommendations for adults (<10%) (6).

Limitations of this study include:

- Over-representation of NZ European participants
- The study setting was limited to the South Island
- Reported data may no longer be an accurate representation of young children's current intake due to the date of data collection (almost two decades ago)

### Growing Up Milk Lite (GUMLi) trial

GUMLi trial was a two-arm, multisite, double-blinded RCT conducted in two countries (Australia and NZ). It aimed to assess the effect of 'low-protein young child formula' on body composition by the second year of life (150). Despite having some of the youngest participants out of the six studies investigating the nutrient intake of young NZ children, the GUMLi trial reported the highest energy intake per day. The reported mean (SD) energy intake [4417 (1369) kJ] was well over the Estimated Energy Requirement (EER) for 1-year-old girls (3,200 kJ) and boys (3,500 kJ) (6).

A major cohort study in Dunedin investigating the food intake of 669 children 12-60 months of age determined a large proportion of energy intake from ultra-processed food by using the NOVA food classification system, contributing 45% at 12 months, 42% at 24 months and 51% at 60 months (5). High consumption of ultra-processed food is strongly associated with overweight and obesity, decreased insulin sensitivity, increased blood cholesterol levels and a higher risk of developing high blood pressure amongst adults (151). Therefore, the high proportion of energy intake from ultra-processed foods may have been a contributory factor to the high prevalence of childhood obesity in NZ, as specified in the 'Energy' section above.

The GUMLi trial reported mean calcium and iron intakes almost twice the current recommendation and mean vitamin C intakes almost four times the EAR (table 5). However, with the current data

available, it is not possible to determine the prevalence of inadequacy since the proportion of participants falling below the EAR was not reported.

Limitations of this study include:

- Reported total nutrient intake per day was estimated from the FFQ data
- EAT FFQ had a complex method of estimating portion size (i.e., utilising the child's palm size to estimate volume), which makes the data prone to misreporting.

### Baby-Led Introduction to SolidS (BLISS) Study

The BLISS study is an RCT that recruited pregnant women in their third trimester who were booked into a hospital in Dunedin, New Zealand (143). The study's primary aim was to assess the impact of modified baby-led weaning on the nutrient intake and status of children. Data in table 5 is the follow-up data of the control group collected during the children's 2$^{nd}$ year of life.

The majority of energy and nutrient intakes of the participants in this study were similar to those of the EAT study, which was also conducted in the South Island of NZ. Both studies found inadequate mean dietary fibre intake and high protein intake in young NZ children. It could be noted that the values for both BLISS and EAT studies are quite close due to the similarities in the study setting and the demographic characteristics of participants (i.e., over-representation of NZ European ethnicity, under-representation of ethnic minorities and high economic status of participants). The studies were also conducted seven months apart, which may further explain the resemblance of their results.

Limitations of this study include:

- Unable to achieve the target sample size
- Low study compliance (20% of participants did not provide any food records)
- Estimation of breastmilk volume is prone to error
- Limited ethnic spread
- The high proportion of participants with university-level education

### Pneumonia case-control study

As part of a larger study on pneumonia in NZ preschool children, this case-control study aimed to identify the association between nutritional factors (i.e., nutrient intake and breastfeeding) and the risk of pneumonia amongst young children (144). Similar to the red meat/fortified milk trial, the data is not recent (2002-2005), meaning results may no longer be reflective of the current energy and nutrient intakes of young NZ children.
Due to the wide age range (0-5 years), values are significantly higher for this study compared to the first four studies analysed. As a result, all reported energy and nutrient intakes in this study are well above the current recommendations for children aged 1-3 years. The study further stratified the mean energy and nutrient intakes into two age groups (0-<2 and 2-5 years). However, the current NRVs are divided differently, with recommendations for children aged 1-3 years and 4-8 years, making it not feasible to make comparisons with the study's reported intakes.

Limitations of this study include:

- The proportion of high-income participants is almost twice that of low-income participants
- Estimation of breastmilk intake was problematic (313) as it was obtained through weighted feeding (i.e., weighing the child before and after feeds)

### Auckland Birthweight Collaborative (ABC) Study

Set in three Auckland hospitals, ABC is a longitudinal case-control study that determined the relationship between birth weight and dietary intake, measured at 3.5, 7 and 11 years (152). Similar to the above case-control study (144), nutrient intakes reported in this study are significantly higher compared to the first four studies due to the participants' older age when the data was collected. Despite this, median dietary fibre intake [10 (7, 15) g/day] was still below the AI recommended for 1-3-year-old children (14 g/day).

The study reported that all participants (100%) had a saturated fat intake >11% of total energy. This trend (100% of participants consuming >11% of total energy from saturated fat) continued when the same participants were measured at 7 and 11 years of age. This suggests the importance of optimal nutrition during early childhood as behaviours developed during this stage are sustained during the older childhood stage.

Limitations of this study include:

- Dietary data collected was only for one day
- Results may not be generalisable to the NZ population as the majority of participants are NZ European

A literature search was conducted to capture single-nutrient studies (see table 1 for the search strategy). However, all the single-nutrient studies found were part of a larger study that was collated and reported above. Overall, the NZ studies analysed in this review reflect the lack of a current and well-represented study with the primary outcome of determining the energy and nutrient intake of young NZ children.

## Sociodemographic and anthropometric factors associated with dietary intake of young children

**Global studies**

This section of the review answers the question of how the dietary intake of young children across the world and in NZ, are associated with sociodemographic characteristics and anthropometric status. In high-income countries, there is evidence that suggests that ethnicity, socioeconomic deprivation, sex, and anthropometric status are associated with young children's dietary intake. In the US, a study on Hispanic and African-American young children reported calcium and iron intakes below recommendations (153). Further comparison between these two minority ethnic groups revealed higher calcium and fibre intakes but lower added sugar consumption amongst Hispanic children compared to African-American children (154). Contrasting findings on ethnic minorities were reported in the Netherlands, where Surinamese (one of the largest ethnic groups in the country) children had higher calcium and iron intakes and lower fat, saturated fat and carbohydrate intakes than the native Dutch population (155).

Disproportionate energy and nutrient intakes are also observed in terms of socioeconomic deprivation. In the UK time trend analysis of the 2008/09-2016/17 National Diet and Nutrition Survey (NDNS), total fat intake decreased with income, whereas iron, fibre and zinc intakes increased with income for children aged 1.5-3 years (156). Similar findings were observed in US children aged 2-5 years (n=2,249), where a lower family income to poverty ratio was associated with lower calcium and

fibre intakes (157). In an analysis of the impact of 'Food Stamp' and the 'Special Supplemental Nutrition Program for Women, Infants, and Children', it was determined that supplementation of food improved young children's dietary intake (158). Compared to the control group (eligible non-participants), young children from families receiving food assistance had higher energy intake by 6.2%, iron intake by 22.5% and zinc intake by 15.7%.

The evidence for the association between sex and nutrient intake across the developed world is mixed. In a US cohort study, higher energy, carbohydrate, fat and protein but lower iron and zinc intakes were reported for boys compared to girls across three time points (27, 34 and 42 months of age) (159). However, the study's sample size was small (n=72), and the study population were all 'white' children, thus limiting its generalisability to other ethnicities. In other high-income countries such as Sweden (160), the UK (161) and France (162), no significant differences in energy and nutrient intakes were reported between the two sexes.

Poor dietary intake amongst young children in high-income countries has been characterised as conducive to the development of childhood obesity (163-166). Data from meta-regression models from 27 European countries reported a positive association between overweight or obesity and consumption of meat, soft drinks and added sugars and a negative correlation with milk and dairy intake (167). Similarly, a secondary analysis of NHANES in the US showed an increased energy intake along with increased fruit drink, juice, and fizzy drink consumption (168). As abovementioned in the 'Energy' section, a positive energy balance is the ultimate culprit of obesity.

**NZ studies**

As abovementioned, certain sociodemographic characteristics predispose young children to nutrient inadequacy. However, the results of the six studies on young NZ children's nutrient intakes (table 5) were not stratified by these characteristics. Relevant studies that have reported on nutritional status and consumption patterns may provide insight into differences in dietary intake according to sociodemographic characteristics in young NZ children.

### Ethnicity

In a cross-sectional study of children aged 6-23 months, it was found that Māori and Pacific children had a higher prevalence of iron deficiency (169). An early study explained that iron deficiency may be potentially augmented by sociocultural feeding practices in NZ, such as tea drinking in Pacific children

(170). Apart from iron, Māori and Pacific children are at risk of other micronutrient deficiencies due to the high prevalence of poor consumption patterns that may adversely impact their nutritional status. Findings from GUiNZ (n=6,032) in table 6 indicated a significantly higher proportion of Māori and Pacific children consumed unhealthy food and drinks, having fewer servings and less variety of fruits and vegetables compared to their NZ European counterparts (171). A recent study that utilised a child-specific nutrition screening tool that assesses risk factors for poor nutrition status (i.e., food group intake, fast food consumption, and eating patterns), identified non-European children as at higher nutrition risk compared with their NZ European counterparts (172).

Māori and Pacific children are likely to have a higher intake of sugar as there was a higher proportion of these children consuming soft drinks three or more times a week, almost twice the population average. Sugar intake is strongly linked to dental caries, and there is evidence of moderate quality that decreasing free sugar intake to less than 10% of total energy is associated with lower dental caries in children (68). In NZ, dental caries disproportionately affects Māori and Pacific children (173).

Table 6. Indicators of poor nutrition amongst children (at 9 months and 54 months), by ethnicity

| Indicator | Māori % | Pacific % | Asian % | European/other % | Total % |
|---|---|---|---|---|---|
| <12 months breastfeeding duration | 62.5 | 67.3 | 72.2 | 68.2 | 68.0 |
| None or less fruit served per day[a] | 24.1 | 26.6 | 20.0 | 7.7 | 13.6 |
| None or less vegetables served per day[a] | 14.5 | 22.6 | 20.8 | 6.3 | 11.1 |
| Consumption of unhealthy drinks | 54.6 | 61.1 | 47.5 | 26.6 | 37.1 |
| Consumption of unhealthy foods | 75.5 | 63.8 | 42.1 | 45.7 | 51.5 |
| Low variety of fruit[b] | 9.9 | 12.4 | 6.9 | 8.4 | 9.0 |
| Low variety of vegetables[b] | 9.8 | 11.6 | 4.6 | 5.1 | 6.5 |
| ≥3 soft drink intake per week | 22.4 | 27.8 | 10.3 | 7.1 | 12.1 |

[a]None or less than twice fruit or vegetable served per day; [b]Low variety indicates a score between 0-3 varieties of fruits or vegetables served per day; Used with permission; Excerpt from Growing Up in New Zealand (GUiNZ) study table, Nutrition indicators, by child ethnicity (171)

## Socioeconomic status

In NZ, socioeconomic status is usually proxy-measured by the NZ Index of Deprivation (NZDep). This index is derived from census data gathered every 5 years and aims to measure socioeconomic deprivation (including material and social deprivation) in mesh blocks (the smallest standard area utilised by Statistics NZ) (174). It is a widely used instrument for research, advocacy, and government

policies and programmes. Historically, the first index used in NZ was the Health and Equity Index (1985), followed by the index used in the census conducted every 5 years (NZDep 1991, 1996, 2001, 2006, and 2013), and the recently published NZDep 2018 (175). NZDep 2018 utilises eight dimensions of deprivation: communication, income, employment, qualifications, owned home, support, living space, and living condition (176).

Evidence on the association of deprivation status with the nutrient intake of young NZ children is scarce. However, the available research conducted on children indicates a clear relationship between deprivation and poor dietary habits. The 2002 National Children's Nutrition Survey reported that children from highly deprived neighbourhoods were more likely to skip breakfast or not have breakfast at home than children from neighbourhoods of low deprivation (177, 178).

Similar to ethnicity, deprivation status has been associated with soft drink intake. In the 2006/2007 NZ health survey, the prevalence of frequent (≥3 times a week) fizzy drink consumption was significantly higher amongst children (2-14 years old) who lived in areas of high deprivation. The same survey reported a higher likelihood of children living in highly deprived areas consuming fast food more frequently (≥3 times a week) in comparison to children living in areas of low deprivation (178). In a recently published paper from the GUiNZ study, children living in the most deprived neighbourhoods were reported to have poorer adherence to dietary guidelines (i.e., vegetables, fruits, bread and cereals, etc. intake) (179). The abovementioned poor dietary habits may be indicative of poor nutrient intake amongst children, especially those who live in moderately and severely deprived neighbourhoods.

### Sex

The 2002 National Children's Nutrition survey found that males have higher energy intake than females in all age groups from 5-18 years old (180). However, current data on the energy intake of young New Zealand children under five years of age is not widely available. None of the six studies in table 5 reported differences in nutrient intakes between sexes.

Evidence suggests significant differences exist between girls and boys in terms of dietary habits. In the abovementioned positive association between soft drink intake and deprivation status (2006/2007 NZ health survey), it was reported that this association was stronger for girls than boys (178). The same survey also determined that after adjusting for age, girls (85.7%) were less likely to eat breakfast at home every day compared to boys (90.0%). More recent data from the GUiNZ study

showed a higher proportion of 2-year-old boys meeting the recommendations for whole grain breads and cereals consumption compared to girls (179). However, when the total child feeding index score (a measurement of diet quality based on its adherence to the NZ National Food and Nutrition Guidelines) was compared, no significant differences were observed between the two sexes.

### Anthropometric status

There are limited studies in NZ that examine the relationship between dietary intake and anthropometric status amongst young children. A cross-sectional study on preschool children in NZ reported that after adjusting for sociodemographic factors, consumption of low-fat or reduced-fat milk was more likely for overweight children than those who had a healthy weight (181). In another study that investigated the relationship between anthropometric status and dietary intake amongst children aged 2-5 years in Dunedin, NZ, it was determined that children who were categorised as obese had higher total energy intake and energy contributed by sugars compared to their non-obese counterparts (182). However, this study was conducted in 1998-1999 amongst a limited demographic group of Pacific children living in a specific area of NZ and only involved a small number of participants (n=60). Due to the major changes in the NZ food supply since the time that this study was conducted, there is a need for more recent data from a wider range of participants across diverse geographic areas.

In summary, children of Māori and Pacific ethnicities, female sex, overweight, and those living in areas of high deprivation have a higher likelihood of having poor dietary habits compared to their counterparts. Despite this, there is a lack of stratification in the available dietary intake data on young children. Determination of these disparities is a key to understanding and finding solutions to reduce inequities and to ensure that each child in NZ, is provided with the best start in life.

## Methods of assessing dietary intake of young children

An accurate and precise assessment of young children's dietary intake is crucial to provide robust data that will inform programmes and policies to improve young children's nutrition. However, dietary assessment at this stage poses several challenges and complications that will be further discussed in this section as it answers the question on what the dietary assessment tools are used in

determining food intake and the methodologies utilised in estimating usual energy and nutrient intake of young children.

## Dietary assessment methods

In assessing usual dietary intake, it is necessary to have an accurate nutrient profile of foods and a precise estimate of the portion sizes consumed (183). However, measuring young children's usual dietary intake is particularly challenging. This is because young children, in general, have a high amount of leftovers, multiple caregivers (i.e., daycare, nanny, kindergarten, etc.), rapidly changing dietary patterns as they are introduced to new foods, and low adherence in reporting for time-poor caregivers (140). It is also important to note that due to young children's incapacity to recall, estimate and cooperate in dietary assessment protocols, they are unable to directly report their intake, and their caregivers tend to be surrogate reporters (184). As such, in considering the appropriate dietary assessment tool to use, it is important to consider these factors, as well as the strengths and limitations of these tools and the purpose of collecting dietary data.

Table 7 provides an overview of the dietary assessment methods utilised in nutrition research, particularly in the context of children. This table provides a detailed description of each tool's methodology, strengths, and limitations. Despite being the gold standard in dietary assessment, the weighed food record may not be the most appropriate for young children due to spills and regurgitation that are not captured in weighing the food consumed (185).

In large observational studies, the 24-hour food recall is often used to capture usual dietary intake considering the burden on caregivers. At the population level, two 24-hour food recalls appeared to be a valid dietary assessment tool for estimating the energy intake of young children (186). It is possible to estimate an individual's usual intake by repeating the administration of 24-hour food recalls. The number of repetitions required is dependent on the day-to-day variation in the food intake of an individual (187). One of the methods used to control this variation is the multiple source method (MSM).

Table 7. Summary of dietary assessment tools utilised for studies on children

| Dietary assessment tool | Characteristics | Data collected | Strengths | Limitations |
|---|---|---|---|---|
| Food Frequency Questionnaire (FFQ) | May be self-administered or interviewer-prompted | Usual intake for the past 1 months-1 year<br>Frequency of consumption<br>Portion size (for quantitative FFQ) | Appropriate tool for determining dietary patterns<br>Cost-effective<br>Suitable for large studies | Difficulty in quantifying actual intake<br>Subject to a higher extent of recall bias compared to 24-hour food recall<br>Culture-specific |
| 24-hour food recall | Open-ended questions<br>Interviewer-prompted | Intake for the past 24 hours | Low participant and researcher burden<br>Detailed intake data<br>Literacy of the participant is not required | May not be able to capture foods consumed episodically<br>Requires trained interviewer<br>Requires multiple passes<br>Recall and interviewer bias |
| Estimated diet record | Open-ended questions<br>Self-recorded | Recorded intake during a short period (2 to 14 days) | Interviewer is not necessary<br>Subject to a lesser extent of recall bias<br>Detailed and exact intake data | High participant burden<br>Costly<br>Multiple days are required to determine the usual intake<br>Influence of the act of recording diet on the actual intake |
| Meal observations | Researcher observes participant during mealtime | Detailed information on amounts and types of foods consumed | Subject to a lesser extent of recall bias<br>Low participant burden | High researcher burden<br>May be uncomfortable for the participant |

| | | | | |
|---|---|---|---|---|
| | | | | Influence of being observed on actual intake<br>Difficulty in recording meals eaten outside |
| Diet history | Involves extensive 1- to 2-hour interview or questionnaire | Detailed information on food preparation, food consumption and eating habits | Detailed intake data<br>Ability to capture qualitative and quantitative data | High participant/researcher burden (dependent on the method of administration) |

Derived from 'Comparison of Instruments for Dietary Assessment in Children 6 to 11 Years of Age' table (188) and review of dietary assessment methods of preschool children (189)

## The Multiple Source Method

The Multiple Source Method (MSM) is a novel statistical methodology that enables the estimation of usual intake by just collecting a few repeated short-term measurements (192). Rather than averaging multiple days of intake, MSM allows the adjustment for day-to-day variability to be able to determine the usual nutrient intake of young children (193). It is a web-based application that can be accessed online using the link https://msm.dife.de/.

The procedure for conducting MSM can be broken down into three components (194). Estimating 1) the probability of consumption of a food on a day and 2) the usual amount of food intake on days of consumption, per individual. In step 3) numbers 1 and 2 are multiplied, arriving at the equation (usual food intake on all days = probability of consumption of a food x usual amount of food intake on days of consumption). However, since MSM determines usual intake based only on either the 24-hour food recall or food record, it is suggested to supplement it with other sources of data such as FFQs, to be able to capture foods that are rarely consumed (195). In summary, MSM is a practical tool to determine young children's usual energy and nutrient intake at the population level due to its accessibility, ease of use, and sound statistical inference.

## Food composition database

An intermediate step between data collection and the determination of the adequacy of energy and nutrient intake is the utilisation of food composition databases to measure the nutrient content of foods. Food composition databases provide information on the macronutrient, micronutrient and non-nutritive substance composition of foods and have many applications in various disciplines such as food science, trade and food regulation by facilitating the formulation of nutrition labels, nutrient intake assessments and informing food policies and nutrition programmes (190). In NZ, the NZ Food Composition Database is the most recent and reliable database, which includes more than 2,700 foods and drinks and 85 food components (up to 360 for the complete version) (191). In establishing this database, robust data collection procedures were employed, including systematic sampling methods and standardised documentation procedures. Data for most foods were determined by analysis, but for a few foods, food composition data were borrowed from the US, UK or Australia (191).

## Methods of assessing nutrient intake adequacy

After determining the usual intake, it is essential to compare it with the current NRVs to determine the adequacy of the nutrient intake of an individual or a group. NRVs are utilised to assess nutrient intake adequacy for healthy individuals and population groups (refer to table 2) (187). To execute this assessment, the Estimated Average Requirement (EAR) cut-point method and full-probability approach are recommended approaches (196).

The EAR cut-point method is a population-based assessment that determines the percentage of participants within a group whose usual intakes fall below the EAR cut-point (197). On the one hand, the full probability method takes into account the requirement distribution of participants' age and sex group, which is highly relevant in the case of young children due to increased nutrient requirements such as iron (198). As an example, once usual iron intake is determined through the MSM method, the probability of inadequate usual intakes will be determined for each participant with the assumption of 14% iron bioavailability for 1-3-year-old children (6). Individual probabilities can be added for all participants to estimate the prevalence of inadequate dietary iron intake.

The full probability approach is considered more accurate since the distribution of requirements is utilised to assess the risk that the individual's intake is unable to meet the EAR (199). One of the limitations of the EAR cut-point method is the fact that some nutrients currently do not have an EAR set (200). Inadequacy of intake of these nutrients may still be assessed using AI, but instead of referring to it as "prevalence of inadequacy", it can be referred to as the "likelihood that the usual intake is below AI" (199). However, the strength of both methods (EAR cut-point method and the full probability approach) is the ability to estimate the proportion of the population at risk of inadequate intake of certain nutrients, thereby allowing authorities to identify the need for nutrient-specific interventions like supplementation and fortification programmes (196).

## Household food insecurity

This section aims to address the following questions on food insecurity: How is food security defined globally and in NZ? What are the consequences of food insecurity for young children? How is food insecurity experienced and measured around the world and in NZ? What is the relationship between dietary intake and food insecurity, and what are the other sociodemographic factors that it is associated with?

### Food security

Food security is a multi-faceted, multi-dimensional and complex state that is intertwined with socioeconomic factors such as health, sanitation, poverty, conflict, women's empowerment, and technology (201). According to the Food and Agriculture Organization (202), "food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life."

Despite the alarming statistics and its prevalence worldwide, the definition of the lack of food security, or food insecurity, has been incoherent as it is often confused with other relevant concepts such as hunger, malnutrition and food poverty. In New Zealand, the prevailing definition of food insecurity takes into account sociocultural factors, describing it as "limited or uncertain availability of nutritionally adequate and safe foods or limited ability to acquire personally acceptable foods that meet cultural needs in a socially acceptable way." (184 p11)

### Consequences of food insecurity

The health consequences of food insecurity are presented in various forms. In lower-middle-income countries, food insecurity is a risk factor for malnutrition, specifically stunting (204), whereas, in developed nations such as NZ, food insecurity is associated with developmental delays, decreased access to health care, obesity, poor health and mental and behavioural issues (201).

Households experiencing food insecurity respond through non-food (i.e., budgeting, borrowing money, obtaining an additional job, etc.) and food coping mechanisms (i.e., decreasing meal portion size, selection of cheaper and unhealthier alternatives, and skipping meals) (see Figure 1) (205, 206). It is suggested that health consequences, including nutritional status, infectious and chronic diseases,

and mental health outcomes, are predicted by the coping mechanisms adopted by individuals or households as they respond to food insecurity (207).

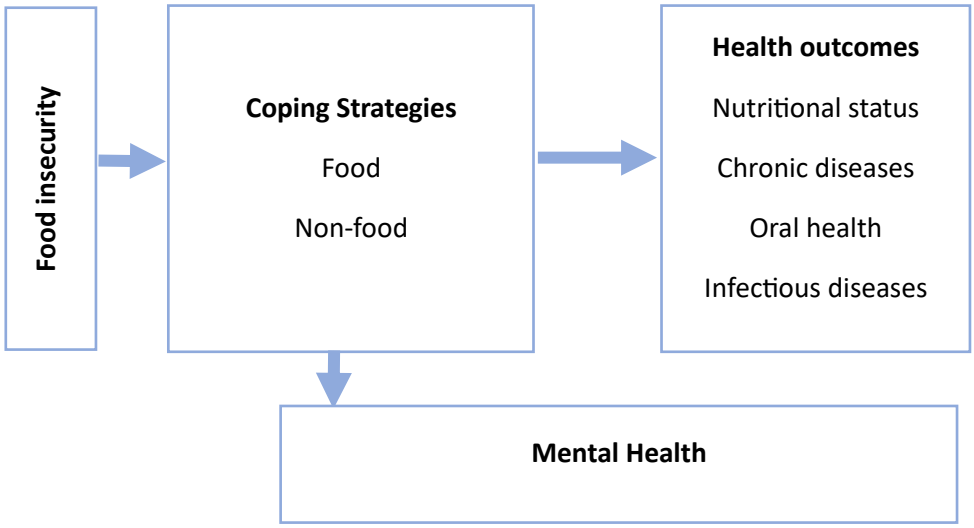


Figure 1. Conceptual framework of the link between food insecurity and health outcomes



Nutritional status

Malnutrition is an apparent consequence of food insecurity. Whilst limited quantities of food cause various forms of undernutrition, such as stunting and wasting, food insecurity is also associated with obesity, eating disorders and poor diet quality. Drivers of these associations are hypothesised to be due to (1) substituting for less expensive and energy-dense foods, (2) overeating during seasons when food is available, and (3) metabolic adjustments to offset periods of food scarcity (201). These adjustments include binge eating, storing energy efficiently, such as the accumulation of fat, and insulin resistance or impaired glucose uptake (208).

Undernutrition is a common consequence of food insecurity in lower-middle-income countries (209-212). Stunting, a chronic form of undernutrition that is characterised by a measure of at most −2 Standard Deviation (SD) for height-for-age, is closely related to food insecurity as it reflects the long-term impact of inadequate dietary intake (213). Stunting amongst children is associated with reduced learning capacity and poor school performance, eventually leading to decreased work capacity and a decline in economic productivity, which perpetuates the inter-generational cycle of deprivation (214).

Conflicting evidence exists on the association between food insecurity and obesity amongst young children. A review of observational studies conducted in high-income countries that aimed to determine the relationship between food insecurity and the weight status of young children (<4 years of age) found inconsistent results. Out of fourteen studies examined, seven found significant associations between household food insecurity and obesity, four observed no associations, and three had mixed results (215). A study that analysed data from NHANES of 3-17-year-old children in the US found significant positive associations between 'child food insecurity' and BMI for preschool children (216).

Current research indicates a complex relationship between obesity and food insecurity that may vary based on ethnicity, socioeconomic status, age and food insecurity level, as individuals experiencing mild to moderate food insecurity are most at risk of being obese, and those who are severely food insecure are at risk of being underweight (217). Other rationalisations behind these inconsistent findings were attributed to the differences in the way food insecurity is measured and the variation in cut-offs utilised in measuring outcome variables (i.e., BMI percentiles) (218). Notably, most studies exploring these associations were cross-sectional in nature, analysing two phenomena (current food insecurity status and the development of obesity) that may not occur simultaneously (8).

Chronic disease

There is consistent evidence of the potential impact of food insecurity on the prevalence and management of chronic diseases through mechanisms employed by households to cope with limited food (207). Research on adults shows positive associations between food insecurity and chronic diseases such as high cholesterol, heart disease, diabetes and metabolic syndrome (219-221). In a Canadian cross-sectional study, a significantly high prevalence of food insecurity (21.9%), more than twice the national average (9.2%), was observed in households with children who have diabetes (n=183) (222).

Aside from chronic disease prevalence, food insecurity is also associated with poor disease management. Studies suggest associations between food insecurity and indicators of poor disease management amongst adults with diabetes as indicated by increased frequency of hypoglycaemia, poor blood glucose control and increased health care utilisation (223). The abovementioned Canadian study also found that food insecurity was a significant predictor of hospitalisations and that children with diabetes living in food-insecure households have higher glycated haemoglobin concentrations (indicative of poor glycaemic control) (222). Possible explanations behind studies showing positive associations between poor chronic disease management and food insecurity are: 1) families may prioritise to meet basic needs such as food and shelter over healthcare, 2) unstable food supply may induce social disorganisation, and 3) other relevant variables that have not been measured such as substance abuse and mental health issues confounding the results (224).

Oral Health

Several studies, both in high-income and lower-middle-income countries, have found a strong association between food insecurity and the prevalence of dental carries amongst children (225-227). A recently published study analysing 2013-2014 NHANES data of 1-19-year-old children indicated that the odds of having dental caries are 3.51 (95% CI: 1.71-7.19) times greater for children with very low food security compared to their food-secure counterparts (228). However, similar to studies on food security and obesity, the studies cited above are cross-sectional and do not exhibit causation between the two phenomena.

Paediatric oral health, particularly in young children, is of great concern due to the risk of early childhood carries (ECC). Children aged 1-3 years have a distinct pattern of carries, commonly known as “nursing caries” or “baby bottle tooth decay”. These terms suggest inappropriate bottle feeding as the primary culprit, but evidence shows that this may only be one of the causes of the disease, thereby reaching a consensus to adopt the more general term of ECC (229). Consequences of ECC include loss of appetite, pain, infection, the continuation of poor oral health through to adulthood and the potential impact on nutrition and quality of life (230). ECC is strongly linked with socioeconomic status, maternal oral health, and child feeding practices, and it is hypothesised that food insecurity’s association with dental caries may be even greater amongst younger than older children due to their high dependence on adults for food selection and care (231).

Infectious disease

Inadequate intakes and poor dietary quality engendered by food insecurity are associated with micronutrient and protein-energy deficiencies that further result in a weakened immune system and delayed wound healing (232). This increases the risk of infection and other acute illnesses amongst young children living in food-insecure households. One of the most common causes of hospitalisation in young children, aged between 2 to 6 years, are infectious diseases, which may be due to poor diet (233). However, mechanisms increasing young children's vulnerability to infection due to malnutrition are not well understood (234).

A large multicentre and cohort study in the US based on 11,539 caregivers of children 3 years old and under observed a dose-response relationship between health and food insecurity status (232). In NZ, a recent study on 9-month-old infants found significant associations between food insecurity and chest infections, ear infections, gastroenteritis and other types of illnesses (235). Other factors related to food insecurity, such as poor oral health, housing issues, such as overcrowding, and poor nutrition, increase the risk of potentially avoidable hospitalisations caused by infectious diseases amongst children (236).

Mental proficiency

There is strong and consistent evidence that children living in food-insecure households have poor cognitive, behavioural and emotional development (237), a lower intelligence quotient (IQ) (238), and persistent hyperactivity or inattention (239). Exhibiting causation, a longitudinal study on 8,944 children (measured at 9 and 24 months) showed an indirect impact of food insecurity through parental depression and parenting practices on the mental proficiency of toddlers (240). The study found that highly food-insecure households tended to be more depressed and predicted less advanced mental proficiency in children at two years of age.

The strong link between food insecurity and poor mental proficiency in children may be attributed to the following potential mechanisms (239):

a. Other factors relevant to a child's psychology such as low income, may be associated with food insecurity
b. Both food insecurity and mental health may be caused by similar factors, such as parental mental distress or illness
c. Food insecurity may be an independent predictor of a child's psychological and behavioural well-being

It is also noteworthy that even when there is adequate consumption of energy and nutrients, food-insecure individuals may still be subjected to stress or anxiety because they are unable to eat in a culturally acceptable way (237). In New Zealand, charities have reported an increasing demand for food parcels, as low-income families have to rely on others for food (241). In an international scoping review involving high-income countries which included New Zealand, food bank users reported shame, stigma and embarrassment associated with the utilisation of food banks (242).

The abovementioned consequences only encompass the measurable impact of food insecurity. It is important to take note that apart from nutrition and health consequences, poor nutrition and development, brought about by food insecurity are exemplifications of social injustice (243).

## Food security in New Zealand

The four pillars of food security were briefly defined by FAO (251) as 1) the availability of food supply which is determined by food production and stock levels as well as net trade, 2) sufficient economic and physical access to food, 3) biological utilisation of food which is a determinant of an individual's nutritional status, and 4) the stability of the abovementioned pillars over time. To tackle food security in NZ, the four pillars will be used as discussion points to further describe the current food security status of the country.

### Availability

In terms of food availability, NZ is a country that refutes the common misconception placed upon high-income nations that food insecurity does not exist in these countries (244). Despite the country's foremost status in producing nutritionally-diverse crops globally, this does not translate to the food security of all NZ households (138). Persistent food insecurity is disproportionately present in children of Māori and Pacific ethnicities, living in areas of high deprivation, from low-income households, living in a single-parent household and living with more than two other children (203).

Ironically, the country imports large quantities of discretionary foods such as sugars, biscuits and chocolates, despite having an economy that is highly reliant on exporting nutritionally diverse produce such as milk and dairy, beef, lamb and fruits and vegetables (245). A recent report on the state of the NZ food supply found that the majority of available packaged foods and beverages in the

NZ market have high sugar and salt content, with only three companies able to provide a significant amount of products considered to be healthier or with a health star rating of ≥3.5 (246). The health star rating is a voluntary labelling system for packaged foods in NZ and Australia, ranking each food in 0.5 increments, with 0.5 being the least healthy and 5.0 being the most healthy (247).

Access

Despite the fact that the majority of children live in food-secure households, economic access to food is a challenge for some. Household income or lack of money was determined to be the primary cause of household food insecurity in NZ (203). A randomised controlled study called the "Spend Study", which investigated the impact of providing additional money on food expenditure to 214 low-income and food-insecure households with children (<18 years) in Dunedin, reported an increase in food spending upon intervention (248). However, the study had limitations such as the limited ethnic spread of study participants (NZ European-88.5%, Māori-3.5%, Pacific-1%, Asian-2%), inability to capture changes in purchasing patterns due to the short intervention (1-month intervention phase) and a high respondent burden in returning receipts purchased. As such, it is crucial to consider other factors that may contribute to food insecurity due to its complex nature. This also highlights the need for studies that are ethnically and geographically representative in NZ.

Physical access to food is not a significant issue for most NZ households. In a study of 136 families with children living in Wellington and Dunedin, almost all food preparers reported that physical access to a supermarket 'felt easy' and was not found to be different between low and high-income households, as well as between food-insecure and food-secure households (217). However, in a nationwide study that utilised Geographical Information Systems (GIS), higher concentrations of fast food and alcohol outlets were found to be located in neighbourhoods of higher deprivation (249). A key finding of this study is the notably better access to multinational and local fast foods in highly deprived neighbourhoods and socioeconomically disadvantaged schools (250).

Stability

Several environmental and economic factors, such as severe weather, political volatility, unemployment and inflation may impact food security (251). Despite NZ's declining and low unemployment rate compared to other high-income countries, the unemployment rate amongst Māori is still significantly high, reported as twice the national average (252). New Zealand has also recently experienced one of the biggest increases in the inflation rate (6.0%) in the past decade, and

vegetables had a 23.3% price increase in 2023 compared to last year (253). Social assistance such as benefits and tax credits may slightly affect income poverty but having an income just above the poverty threshold does not necessarily mean that a household is no longer poor since income-based poverty does not consider other relevant factors such as people having access to savings, family support, and owning a property (254).

A recent publication from GUiNZ observed a significant movement of households in and out of food insecurity by using three food hardship indicators (171). These indicators include 1) "been forced to buy cheaper food so that you could pay for other things you needed", 2) "made use of special food grants or food banks because you did not have enough money for food, and 3) "gone without fresh fruit and vegetables, so that you could pay for other things you needed"). The same report found that compared to other ethnicities, a higher proportion of Māori and Pacific households were forced to buy cheaper food to pay for other things when infants were 9 and 54 months of age. This is indicative of the persistent food insecurity experienced by Māori and Pacific children during early childhood.

Utilisation

Utilisation as a pillar of food security is described as the "utilisation of food based on knowledge and an understanding of an adequate diet to ensure a state of nutritional well-being and meet all human physiological needs" (255). It is closely related to the individual's health status and influenced by non-food inputs such as proper child care practices, knowledge of basic nutrition principles, sanitation, food storage and food processing techniques, and healthcare management (244, 256).

A pilot research project that involved ten Māori aged 20-72 years in Whakatāne and aimed to investigate food security and food sovereignty through the Māori perspective determined that poverty, the impact of colonisation, living in urban areas, dependence on supermarkets and the lack of nutrition education programmes are the primary barriers to Māori health (257). Compared to food-secure households in NZ, households experiencing low to moderate food insecurity were found to be less likely to plan meals ahead of time, but no significant differences were observed in terms of the amount of time spent preparing meals across all household food security levels (217).

Apart from the abovementioned factors affecting the utilisation of food, other non-food-related conditions impact food security in NZ households. The 2020 Canterbury Wellbeing Survey (n=2,500) set in Christchurch and surrounding areas determined that a higher proportion of participants with long-term disabilities (42.2%) live in food-insecure households compared to those without disabilities

(24.5%) (258). A recent government report on child poverty-related indicators outlined significant factors that may impact NZ children's health status, thereby affecting their utilisation of food. The report indicated that compared to other ethnicities, Māori and Pacific have the highest proportion of children living in poor housing conditions such as mould, and have higher rates of hospitalisation due to acute illnesses (236).

Ultimately, the persistence of food insecurity experienced by vulnerable groups (Māori and Pacific ethnicities, high deprivation, low-income and sole-parent households) reflects the inequities deeply anchored in the systematic issues of NZ society. The disconnect between New Zealand's prolific food supply and the significant proportion of the population experiencing food insecurity compels a more in-depth look at NZ's food security status. To enable this, a robust and well-substantiated instrument is required for measuring and discerning the different factors influencing food insecurity.

## Measurement of household food insecurity

### Methods of determining food insecurity

Earlier methods of determining food insecurity relied on proxy measures such as a measure of the proportion of the population able to meet the minimum energy requirement, food consumption surveys at the household level and child anthropometry (259). These tools were focused on determining secure access to food and less on the availability and utilisation of food, thereby undermining other relevant factors such as disease or caregiving practices that may affect nutrition despite the sufficient availability of food (207). As such, there is widespread dissatisfaction with general food security measurement scales due to criticisms of their lack of accuracy, untimeliness, imprecision and expensive data collection processes (260).

Recent progress in food security research has initiated the use of experience-based scales, which enable researchers to measure food insecurity with higher precision and validity compared to previous proxy measures (207). Experience-based scales are the only measurement method that directly quantifies food insecurity based on the perceived experiences of individuals and captures the psychosocial dimensions of food insecurity (261). One of the most common experience-based scales is the Food Insecurity Experience Scale (FIES) which is a Rasch model-based scale administered by the FAO annually since 2014 in 150 countries (262). The 8-item questionnaire which is answerable by "yes" or "no", measures the severity of food insecurity by asking participants about their lived

experience or examining food-related behaviours associated with difficulties in accessing food due to constraints in resources (263). However, despite increasing acceptance of this scale, it is important to note that experience-based scales cannot singlehandedly account for all the dimensions of food insecurity. The FAO (264) suggests utilising scales such as the FIES in combination with other tools or measures to provide a complete picture of food insecurity and to advise effective programmes and policies.

Table 8 provides a comparison of experience-based scales utilised in various countries to measure food insecurity, including the NZ Food Security Scale. Based on the table, a large variation in the length of recall (1 month, 3 months, 6 months and 12 months) can be observed which makes it difficult to make an inter-country comparison. Length of recall vary widely as the intensity, prevalence and frequency of food security indicators detected by the scale are sensitive to a specific country's socioeconomic development (261). Compared to conventional measures of food insecurity which rely on dietary intake data or anthropometry, data collection, processing and analysis of experience-based scales are inexpensive and straightforward (196). As observed in the table below, the number of questions in these scales is relatively short, ranging from 8-15 items, depending on the type of scale and the country of validation.

Table 8. Comparison of experience-based food insecurity scales

| Tool | No. of questions | Type of scale | Response categories | Length of recall | Level | Country | Use | Validated? |
|---|---|---|---|---|---|---|---|---|
| NZ [a] Food Security Scale (203) | 8 | Ordinal | Always/often, never, or sometimes | 12 months | Household-level indicator | NZ | Assesses the prevalence of household food insecurity of a population. Categorises households into three categories: mostly to fully food-secure, moderate and severe food insecurity. | Yes, NZ |
| Food Insecurity Experience Scale | 8 | Dichotomous | Yes or no | 1 month or 12 months (dependent on research priorities) | Individual-level indicator for cross-country comparisons | Global (150 countries) | Assesses the population prevalence of food insecurity, identifies vulnerable populations, and monitors the efficacy of food security policies and programs. | Yes, multi-country validation |
| Household Food Insecurity Access Scale | 18 | Mixed (Ordinal and dichotomous) | Yes or no and, if yes, then with what frequency (rarely, sometimes, or often) | 1 month | Household-level indicator | US [b] | Assesses the prevalence of household food insecurity of a population, as well as changes in food insecurity over time. | Yes, US |
| Latin American and Caribbean Food Security Scale | 15 | Dichotomous | Yes or no | 3 months | Household-level indicator | Latin American countries | Provides information about the distribution and severity of insecure food access in the population. | Yes, Latin American countries |
| Food Access Survey Tool (FAST) | 9 | Ordinal | Never, rarely, sometimes, often, or mostly | 6 months | Household-level indicator | Bangladesh | Assesses the prevalence of household food insecurity of a population. | Yes, rural Bangladesh |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Radimer/Cornell Scale | 10 | Ordinal | Not true, sometimes true or often true | None | Household, individual and child levels indicator | US | Assesses household hunger and food insecurity of families with children. | Yes, US |
| Modified Radimer/Cornell Scale[1,2,3] | Varies – 9[c], 10[d], 12[e] (dependent on country of validation) | Ordinal | Not true, sometimes true or often true | None, except for the Philippines (6 month-recall) | Household, individual and child levels indicator | Various | Assesses household hunger and food insecurity of a population. Focus varies depending on the country of validation. | Yes, adapted and validated in various countries |

[a] New Zealand (NZ); [b] United States (US); [c] Tanzania (265); [d] Malaysia (266), Philippines (267); [e] Russia (268), Iran (269)

## Measurement of household food insecurity in NZ

### NZ Food Security Scale

In NZ, a country-specific tool was developed in 1997 to measure the prevalence of household food insecurity. The experience-based tool, which is an 8-point questionnaire, has been validated (internally and externally) and extensively used in national surveys including the adult and child nutrition surveys and the annual NZ health survey (270). The NZ Food Security Scale has three response categories (always/often, sometimes, and never) and includes the following statements.

Table 9. Eight indicator statements measuring household food insecurity in New Zealand

| |
|---|
| 1. I/we can afford to eat properly. How often [have the following statements] been true for your household over the past year? |
| 2. Food runs out in my/our household due to lack of money. |
| 3. I/we eat less because of lack of money. |
| 4. The variety of food I am/we are able to eat is limited by a lack of money. |
| 5. I/we rely on others to provide food and/or money for food for my/our household when I/we don't have enough money. |
| 6. I/we make use of special food grants or food banks when I/we do not have enough money for food. |
| 7. I feel stressed because of not having enough money for food. |
| 8. I feel stressed because I can't provide the food I want for social occasions. |

These indicator statements were developed through a stepwise process that was initiated through an extensive review of the literature and proceeded by focus group discussions with Pacific, Māori, and NZ European ethnicities (271). The five key themes generated through this process were 'food insecurity', 'food inadequacy', 'coping strategies', 'alternative sources' and 'cultural issues' (272). However, the initial indicators developed were administered directly as questions and the majority of participants included in pre-testing found the questions offensive (271). As such, the questions were rewritten and administered as either verbal or written statements which increased the acceptability of the instrument to the pre-test group.

Earlier surveys that utilised these indicators did not categorise the survey respondents based on the severity of food insecurity and solely reported on the proportion of participants answering 'always/often', 'sometimes' and 'never' for each item (see table 14, studies no. 1 and 2). Several scoring systems were then developed attempting to categorise household food insecurity based on the abovementioned indicators. A summary index was created through a validity study that utilised item response analysis through the use of the Rasch model (271). The study categorised food insecurity into three levels: 1) fully/almost food secure, 2) moderate food security, and 3) low food security. The Rasch model is widely used in the development of household food insecurity scales due to its sophisticated techniques for evaluating instrument validity and reliability (273).

A recent improvement of this summary index was published by the MoH (203) which estimates the level of food insecurity experienced by the household, disaggregating respondents into three new categories: 1) fully food-secure, 2) moderately food-insecure, and 3) severely food-insecure. Compared to conventional scoring methods, the new model does not consider equal contribution for each item but considers the item's contribution based on how well it differentiates the presence or absence of food insecurity in individuals and the food insecurity level detected by each type of item response (203).

### Food security questionnaire extracted from NZiDep

Another widely used method in the determination of food security status in NZ is the utilisation of three questions extracted from the New Zealand Index of Socioeconomic Deprivation for Individuals (NZiDep). NZiDep is a validated tool derived from the same theoretical foundation as NZDep (see the socioeconomic deprivation section) that is utilised to assess an individual's socioeconomic deprivation (274). Three out of the eight questions (listed in the supplementary material of chapter 5) were utilised to determine food security status. The questions are answerable by 'yes' or 'no', and any missing data is counted as a 'no' response. Participants who answered yes to any of the three questions were classified as food insecure (258).

Table 10. Questionnaire extracted from NZiDep

| | |
|---|---|
| 1. | In the last 12 months have you personally been forced to buy cheaper food so that you could pay for other things you needed? |
| 2. | In the last 12 months have you personally made use of special food grants or food banks because you did not have enough money for food? |
| 3. | In the last 12 months have you personally gone without fresh fruit and vegetables, often, so that you could pay for other things you needed? |

This method was utilised by a nationwide survey (table 14, study no. 4), a North Island-based longitudinal study (table 14, study no. 7), and more recently, a population-based survey in the South Island. The Canterbury Wellbeing Survey is a regional rolling survey (since 2012) of 2,500 respondents from Christchurch City and Selwyn and Waimakariri districts that measured several indicators of the residents' wellbeing and, for the first time in 2020, explored food insecurity status as part of their evaluation (258).

One of the primary advantages of this method is the ease of questionnaire administration and its low participant and researcher burden. However, the three questions are considered only a subset measure of food insecurity because they do not measure whether the household has enough food available to meet cultural needs (171). As indicated in the first section, the definition of food security includes acquiring food while meeting cultural needs in a socially acceptable way. This, however, was taken into account in the development of the NZ Food Security Scale, making it a more comprehensive measurement of food insecurity in NZ.

## Measurement of child food insecurity

Most household food insecurity scales are devoid of children's perspectives and their lived experiences. These surveys primarily have adult respondents who tend to underreport child food insecurity and usually rely on household samples, missing out on children who are in the most vulnerable situations due to homelessness and institutionalisation (275). In a rapid review of 109 studies assessing child food insecurity in high-income countries, it was found that the majority (68%) of the tools used to measure food insecurity amongst children were reported by parents/caregivers and only eight studies utilised an instrument to measure food insecurity directly from children (215).

A number of studies found that food-insecure children experience negative emotional problems (276, 277), anxiety (278), poorer self-control and poorer interpersonal skills (279). However, most of the cited studies involved older children (>4 years). A UNICEF report indicated that children are able to experience and accurately report on food insecurity as young as 7 years of age (275). Little is known about the experiences of young children with food insecurity and how well this age group can express and communicate their experiences.

Therefore, caution must be employed in interpreting results as the classification of food insecure household status may not necessarily equate to the child's food security status, with research indicating that caregivers or parents may protect children from food insecurity (203, 272). A study examining the link between food security status and hair cortisol concentration (a proxy measure for chronic stress) on 32 mother-child pairs found that mothers who experience the highest perceived distress and perceived coping are those who were food insecure together with their children (280). Another study that observed dietary patterns within the household determined that a decline in children's food intake does not happen until other household members have sacrificed their own intake, indicating the presence of severe food insecurity (281).

The direct impact of food security on infants was investigated by a subcomponent of GUINZ that aimed to develop a Food Security Index for infants. The study found a significant association between food insecurity and infections (235). However, the index was not parallel to the constructs of food insecurity as previously defined by Parnell and Gray (271) and combined several coping strategies such as foodbank use, seeking help from charity, and infant nutrition indicators, including consumption of discretionary food and exclusive breastfeeding to 3 months, making it hard to pinpoint poor nutrition outcomes due to food insecurity (171).

Further research on the best approach to measuring food insecurity amongst young children is imperative. In NZ, food security indicators for adults, households, households with children and infants have been developed (235). Future instruments to aid the measurement of child food insecurity must be anchored in constructs that are derived from children's own experiences and must take into consideration different cultures and settings (275).

### Factors associated with household food insecurity

Household food insecurity is associated with several dietary and non-dietary or sociodemographic factors. An in-depth understanding of these factors and how they interact is necessary to be able to address the underlying causes of food insecurity.

## Energy and nutrient Intake

Emerging evidence suggests an association between poor energy and nutrient intake and household food insecurity (282-284). Food-secure households buy a greater variety of healthy food (285) and have more nutritionally diverse food available for consumption compared to food-insecure households (286). A primary hypothesis attributes the 'substitution' of nutrient-dense foods with energy-dense foods as an effect of household food insecurity (287).

A 2019 MoH report estimated 17.4% or 53,000 young children (0-4 years) living in food insecure households (203). This was based on the 2014/15 and 2015/16 NZ health surveys, where it was found that children living in food-insecure households tend to have low fruit and vegetable consumption and high fast food and fizzy drink intakes (see table 11). The GUiNZ study found that 12% of food-insecure infants consume one or more servings of energy-dense nutrient-poor (EDNP) foods daily (235). In a recent publication from the study's follow-up, it was determined that even after adjusting for income, mother's education and age, deprivation and household size, food hardship (a partial measure of food insecurity) and unhealthy food consumption were significantly associated (171).

Table 11. Association of food insecurity and poor nutrition indicators amongst young New Zealand children aged 2-4 years

| Nutrition indicator | % Severely-moderately food-insecure households | % Fully-mostly food-secure households | p-value |
|---|---|---|---|
| Unable to meet vegetable consumption guidelines | 33.5 | 26.6 | 0.04 |
| Unable to meet fruit consumption guidelines | 24.2 | 18.4 | 0.05 |
| Breakfast at home <5 days per week | 5.5 | 5.6 | 0.99 |
| Fast food consumption ≥3 times a week | 8.4 | 3.1 | 0.01 |
| Fizzy drinks consumption ≥3 times a week | 19.0 | 7.4 | <0.01 |

Data is from the 2014/15 and 2015/16 New Zealand Health Surveys (203)

At present, there is no known study investigating the relationship between household food insecurity and energy and nutrient intakes in young NZ children. Studies from other high-income countries are limited and mostly focus on other assessments of dietary quality (i.e. dietary diversity, food group consumption, adherence to guidelines, etc.) and older children (≥5 years old) (215, 288).

Table 12 outlines studies from high-income countries that may provide insight on the link between food insecurity and energy and nutrient intakes. Most of these studies did not find significant differences in food security status and energy and nutrient intakes. The national survey in the US did not find significant differences in the energy and nutrient intake of food-secure and food-insecure participants. Significant differences ($p<0.05$) in solid fat and added sugar intakes were only detected through sensitivity analyses that compared intakes between food-secure and very low food-secure groups (289).

Four out of the five studies listed in table 12 did not utilise comprehensive food security questionnaires and instead used short forms or modules from the primary questionnaire to assess food insecurity. Similar to most food insecurity studies on young children, all of the studies outlined in the table had parents or caregivers as proxy reporters for the young children's food insecurity status (215).

Out of all these studies, only the Southampton Women's Survey found a significant difference in energy intake between the food-secure and food-insecure groups. Most studies utilised two 24-hour diet recalls to estimate usual intakes, but the Southampton study used a food frequency questionnaire (FFQ) to determine energy intake. Despite the ability to estimate the usual frequency of consumption (see FFQ section), FFQ has been determined to overestimate energy intake amongst young children when validated against doubly labelled water (290). A NZ study investigating the validity of a semi-quantitative FFQ to estimate the dietary intakes of young NZ children observed that it overestimated energy intake when validated against a 3-day weighed food record (147).

The results of the five studies are consistent with a systematic review of US studies on the association between food insecurity and diet quality in adults and children (291). Compared to adults (50 out of 170 associations tested), there was a weaker negative association (21 out of 130 associations tested) between diet quality and food security status amongst children. The authors argue that this is due to parents or caregivers shielding their children from the impacts of food insecurity.

Table 12. Summary of studies investigating key nutrient intakes and food insecurity amongst young children

| A**uthor**, **year** (reference**)** | **Country** | **Age (years)** | **No. of participants** | **Study design** | **Dietary assessment instrument** | **Food security status measurement** | **Key nutrient/s investigated** | **Results** |
|---|---|---|---|---|---|---|---|---|
| Atkins et al., 2020 (292) | Australia | 2-5 | 783 | National survey (data from 2011–2012 National Nutrition and Physical Activity Survey) | Two 24-hour food recalls | Two questions: "Did run out of food in the last 12 months" or "Did not run out of food in the last 12 months". | Iron | Household food security status was not significantly associated with iron intake |
| Gutierrez, 2020 (293) | Phoenix, US | 2-5 | 154 | Secondary analysis of data from SAGE (Sustainability via Active Garden Education) research project | Classroom meal observations | Short Form of Food Security Survey Module in the Parent and Child Demographic Survey | Energy, saturated fat and added sugars | No significant associations were found between food security and diet quality |
| Rossen and Kobernik, 2016 (289) | US | 2-15 | 5,136 | National survey (data from 2007-2010 National Health and Nutrition Examination Survey) | Two 24-hour food recalls (1$^{st}$ recall in person and 2$^{nd}$ recall via phone interview for most participants) | US Food Security Survey Scale | Energy, protein, carbohydrates, fibre, solid fats and added sugars | No significant differences in energy and nutrient intakes in terms of food security status. |
| Pilgrim et al., 2012 (294) | UK | 3 | 1,618 | Longitudinal cohort study (Southampton Women's Survey) | FFQ (past 3 months before the interview) | Short form of the Household Food Security Scale | Energy | Food insecure children had significantly ($p<0.001$) higher energy intake 7569 (5908–8427) kJ compared to their food-secure counterparts 6410 (5506–7590) kJ |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Egeland et al., 2011 (295) | Canada | 3-5 | 388 | Targeted survey of indigenous children (data from Nunavut Inuit Child Health Survey) | Two 24-hour food recalls (2nd recall was repeated for 20% of participants) | USDA Household Food Security Survey module | Energy, protein, carbohydrates, fat, zinc and iron | No significant differences were found in the energy and key nutrient intakes between food-secure and food-insecure groups |

Abbreviations: United States (US), United Kingdom (UK), United States Department of Agriculture (USDA), Kilojoule (kJ)

## Sociodemographic factors

### Ethnicity

Since the earliest measure of food insecurity in NZ through the 1997 National Nutrition Survey, Māori and Pacific ethnicities have consistently been found to have the highest prevalence of food insecurity. Table 13 illustrates the comparison of food insecurity prevalence between Māori, Pacific, and non-Māori and non-Pacific children. This is reflective of the broader health inequalities anchored in colonisation that have been carried through generations, resulting in Māori having poorer health outcomes, education, and income (296).

Table 13. Comparison of food insecurity prevalence amongst Māori, Pacific, and non-Māori/Pacific children

| **Ethnicity** | **Food secure** | | **Food insecure** | |
|---|---|---|---|---|
| | Actual number | Proportion (%) | Actual number | Proportion (%) |
| Māori | 169,000 | 71.4 | 68,000 | 28.6 |
| Non-Māori | 575,000 | 84.4 | 107,000 | 15.6 |
| Pacific | 78,000 | 62.9 | 46,000 | 37.1 |
| Non-Pacific | 666,000 | 83.8 | 128,000 | 16.2 |

Based on 2015/2016 New Zealand Health Survey (203)

However, this situation is not unique to NZ. Across high-income countries, indigenous populations have been found to be disproportionately affected by food insecurity. In Canada, almost 70% of indigenous Inuit children (3-5 years of age) were determined to be food insecure, 25% of whom were classified as severely food insecure. American Indians in the US were found to be significantly more food insecure compared to non-American Indians across all income brackets (297). A recent Australian study determined that older Aboriginal and Torres Strait Islanders are 5-7 times more likely to be food insecure in comparison to their non-indigenous counterparts (298).

Researchers argued that the heightened risk of food insecurity amongst indigenous populations is due to the consequences of climate change and pollution on indigenous food systems, poverty and the high prevalence of chronic or nutrition-related diseases as a consequence of health inequalities (299). In particular, indigenous populations experience food shortages in three dimensions: 1) poverty and low income, 2) impediments to access to traditional foods and ancestral lands, and 3) stunted development of traditional foods (including the unequal development of colonial farming compared to indigenous farming) (257).

Similar to Māori, Pacific people suffer from a high prevalence of food insecurity. Pacific peoples are relatively new immigrants to NZ, have a strong affinity for their culture, and have a small proportion of their population unable to speak English (3% NZ-born and 13% born overseas) (300). It is hypothesised that food insecurity and ethnicity may be related, specifically in immigrant populations, due to language and other related barriers to food shopping, thus limiting food choices and increasing food costs (281). In the US, this aligns with the enhanced classic assimilation theory which considers ethnicity as a social boundary, making ethnic minority immigrants more susceptible to food insecurity than non-minority immigrants due to systemic inequalities (301).

### Socioeconomic deprivation

Coherent evidence suggests that socioeconomic status is highly intertwined with food insecurity (302, 303). As previously mentioned, income is the strongest predictor of food insecurity in NZ. Compared to rent, housing expenses and utilities, food is an expense that is highly variable and is usually compromised with a decline in disposable income (203).

In NZ, income is one of the indicators of socioeconomic deprivation measured by the NZ Index of Deprivation (NZDep). The relationship between food insecurity and NZDep has been widely researched. Table 14 outlines a summary of studies and surveys that have examined the relationship between the two variables. As predicted, an increase in the level of deprivation corresponds to a higher severity of food insecurity. However, these studies must be compared with caution due to variations in the measures of food insecurity and deprivation used. Although the most recent statistics from the 2015/2016 New Zealand Health Survey illustrate a relatively high prevalence of food insecurity amongst highly deprived households, there is a probability that the prevalence of food insecurity may have increased in moderately to highly deprived households due to the onset of the global pandemic in 2020.

During COVID-19, various non-profit organisations across NZ reported a dramatic surge in food parcel demand (304). Due to stringent government restrictions to contain COVID-19, several businesses were forced to close or downsize, resulting in a steep increase in unemployment rates, rising from 4.0% to 5.3% in the third quarter of 2020 (305). Anecdotal evidence of first-time food bank users across NZ reflects the rise of a new demographic group facing financial difficulties due to the ramifications of the global pandemic (306). As such, exploring the relationship between socioeconomic deprivation and household food insecurity will provide valuable insights into the lived experiences of vulnerable groups.

Table 14. Summary of studies investigating food insecurity and socioeconomic deprivation in NZ

| Survey, publication year (reference) | **Participants (n)** | **Age** | **Location** | **Study type** | **Measure of food insecurity** | **Measure of deprivation** (NZDep [a]) | **Results** |
|---|---|---|---|---|---|---|---|
| 1. National Nutrition Survey, 1999 (307) | 4,636 | >15 years | Across NZ [k] | National Survey | NZ Food Security Scale [b] | NZDep96 | Can 'sometimes' afford to eat properly (%):[c, d]<br>Q1 (least deprived): 5.5<br>Q2: 9.5<br>Q3: 13.5<br>Q4 (most deprived): 24.0 |
| 2. Children's Nutrition Survey, 2003 (118) | 3,275 | 5-14 | Across NZ | National Survey | NZ Food Security Scale [b] | NZDep01 | Can 'sometimes' afford to eat properly (%):[c]<br>Q1 (least deprived): 5.5<br>Q2: 9.8<br>Q3: 14.9<br>Q4: 24.3<br>Q5 (most deprived): 37.5 |
| 3. 2008/09 NZ Adult Nutrition Survey, 2011 (308) | 4,721 | >15 years | Across NZ | National Survey | NZ Food Security Scale [i] | NZDep06 | Proportion of participants with moderate food security per NZDep quintile (%):[d]<br>Q1 (least deprived): 29.0<br>Q2: 29.1<br>Q3: 33.4<br>Q4: 36.8<br>Q5 (most deprived): 41.3<br><br>Proportion of participants with low food security per NZDep quintile (%):[d]<br>Q1 (least deprived): 1.7<br>Q2: 4.0<br>Q3: 3.7 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | | | | Q4: 9.5<br>Q5 (most deprived): 18.2 |
| 4. Survey of Families, Income and Employment, 2010 (302) | 18,950 | ≥15 | Across NZ | Longitudinal survey | 3 questions adapted from NZ Index of Individual Deprivation (NziDep) | NZDep01 | Proportion of food insecure per NZDep quintile (%):<br>Q1 (least deprived): 7.3<br>Q2: 10.2<br>Q3: 16.6<br>Q4: 18.6<br>Q5 (most deprived): 26.9 |
| 5. 2015/2016 NZ Health Survey, 2019 (203) | 13,000 | ≥15 | Across NZ | Annual rolling survey | NZ Food Security Scale [j] | NZDep2013 | Proportion of food insecure per NZDep quintile (%):<br>Q1&Q2 (least deprived): 19.6<br>Q3: 17.2<br>Q4: 19.4<br>Q5 (most deprived): 43.9 |
| 6. Growing Up In NZ, 2019 (235) | 6,382 | Primary caregivers of children at 9 months | North Island | Longitudinal study | Infant Food Security Index | NZDep2006 | Proportion of food insecure per NZDep level (%):<br>NZDep 1-3 (low deprivation): 22<br>NZDep 4-7 (medium deprivation): 35<br>NZDep 8-10 (high deprivation): 43 |
| 7. Growing Up In NZ, 2020 (171) | 6,032 | Primary caregivers of children at 9 months and at 54 months | North Island | Longitudinal study | 3 questions adapted from the NZ Index of Individual Deprivation (NziDep) | NZDep2006[e] and NZDep2013[f] | Proportion of participants forced to buy cheaper food per NZDep level (%):[e, g]<br><br>NZDep 1-3 (low deprivation): 39.1<br>NZDep 4-7 (medium deprivation): 48.3<br>NZDep 8-10 (high deprivation): 59.8<br><br>Proportion of participants forced to buy cheaper food per NZDep level (%):[f, h]<br><br>NZDep 1-3 (low deprivation): 22.7<br>NZDep 4-7 (medium deprivation): 32.1 |

NZDep 8-10 (high deprivation): 52.8

[a] An area-based measure of socioeconomic deprivation in New Zealand (NZ Dep) (176); [b] An earlier version of NZ Food Security Scale where participants were not categorised based on the severity of food insecurity; [c] Response options available were 'Always' and 'Sometimes'; Response options 'Never' and 'Don't know' were not reported; [d] Mean percentage of male and female participants; [e] For data collection wave 1 collected in 2010/11; [f] For data collection wave 5 collected in 2013/14; [g] Proportion of children aged 9 months whose mother was forced to buy cheaper food to pay for other things she needed in the past year; [h] Proportion of children aged 54 months whose mother was forced to buy cheaper food to pay for other things she needed in the past year; [i] Categories based on Rasch Analysis; [j] Categories based on Item Response Theory methodology; [k] New Zealand (NZ)

### Anthropometric status

As abovementioned, in other high-income countries, the relationship between anthropometric and household food security status has been mixed. Similarly, the correlation between household food insecurity and obesity in NZ has shown varying results. Positive and independent associations were observed between household food insecurity and obesity amongst adults (1997 National Nutrition Survey), but not in older children (2002 Children's Nutrition Survey) (272). The limited data available in young children indicated a positive relationship between food insecurity and obesity, as reported by the 2015/16 NZ Health Survey (203). Table 15 presents the anthropometric status based on household food security status amongst young children aged 2-4 years in NZ. There were a higher proportion of healthy weight and a lower proportion of overweight and obese young children living in fully-mostly food-secure households compared to severely-moderately food-insecure households.

Table 15. Anthropometric status based on household food security status in young NZ children

| Anthropometric status | Proportion in severely-moderately food insecure households | Proportion in fully-mostly food-secure households |
|---|---|---|
| Healthy weight | 54.5% | 69.5% |
| Overweight but not obese | 29.7% | 18.2% |
| Obese | 12.2% | 7.2% |

Based on 2015/2016 New Zealand Health Survey (203)

A review by the Canterbury District Health Board cited that the high prevalence of obesity in food-insecure households in NZ may be due to the high availability of energy-dense and nutrient-poor foods that are cheap and occasional food shortages that may have led to several changes (i.e., cognitive, behavioural, and emotional) such as alternating periods of excessive eating and limited consumption and eating that is synchronised with the receipt of benefit payments (309). The review also noted that lower socioeconomic neighbourhoods have more fast food and may have less conducive environments to foster physical activity.

## Summary

Early childhood is a crucial period of rapid growth and development that requires optimal energy and nutrient intake. However, there is a lack of comprehensive and up-to-date data on young NZ children's dietary intake. Evidence from other high-income countries points to the disproportionate intake of young children based on their age, ethnicity, anthropometric status, and socioeconomic deprivation. Hence, stratified data is needed in pinpointing where these disparities lie. To obtain this data, a well-designed study is required to overcome the unique challenges of capturing dietary intake data from young children.

Apart from the apparent lack of nutrient intake data, there is also no study in NZ that has looked at the direct association between nutrient intake and household food insecurity. Coherent international evidence indicates the adverse consequences of household food insecurity on young children's dietary intake. Due to the current global situation (i.e., economic crisis, volatile political climate and pandemic) which threatens the four pillars of food security, households in NZ may be adversely impacted. As such, it is essential to ensure that vulnerable children are obtaining adequate nutrition as the world goes through these challenges.

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# Chapter 3: Energy and key nutrient intakes of young New Zealand children

This manuscript-style chapter presents the findings of our study on the energy and nutrient intake, and the associated sociodemographic factors amongst young children in New Zealand.

## Abstract

**Background:** Early childhood requires optimal nutrition to support rapid growth and development. Despite its importance, little is known about the current energy and nutrient intake of young children living in New Zealand (NZ).

**Aim:** To evaluate energy and nutrient intakes and describe their differences based on sex, ethnicity and socioeconomic status in young NZ children aged 1-3 years.

**Methods:** Dietary intake data for 289 children in Auckland, Wellington, and Dunedin were collected via two 24-hour food recalls. The children's sex and ethnicity were obtained, along with the NZ Index of Deprivation 2018 (NZDep2018) which was used as a proxy-measure for socioeconomic status. The multiple source method was utilised to estimate usual intakes of energy, protein, fat, saturated fat, carbohydrates, total sugars, fibre, iron, calcium, zinc, and vitamin C. The Estimated Average Requirement (EAR) cut-point method and full probability approach were used to assess the prevalence of nutrient intake inadequacy. Intakes were described with means (standard deviations) and weighted according to ethnicity and socioeconomic deprivation. The proportion of inadequate intakes were determined, and linear regression analyses were employed to examine the differences in energy and nutrient intakes based on sociodemographic characteristics.

**Results:** A general tendency of increasing prevalence of inadequate energy intake as age increased was observed. Nutrient intake recommendations were met for most nutrients except for fibre, iron, calcium, and vitamin C (proportion of inadequacy of 54.0%, 15.2%, 3.8%, and 4.8% respectively). High protein and saturated fat intakes were observed, with 100% of participants consuming protein above the EAR and 93.4% of participants consuming more than 10% of their total energy from saturated fat. No significant differences were observed in energy and nutrient intakes based on sex. Compared to NZ European children, Māori, Pacific, and Asian children had lower fibre intake, consuming 2.2 (3.4, 1.0), 1.4 (2.8, 0.1), and 2.7 (4.2, 1.2)g/day less fibre, respectively. Children living in highly deprived areas had 1.5 (2.8, 0.2)g/day less fibre intake and 3.4 (0.5, 6.3)g/day more fat intake compared to those living in areas of low deprivation.

**Conclusion:** Young NZ children had an adequate usual intake of most nutrients, except for iron and fibre, and high intakes of protein and saturated fat. Disproportionate total fat and fibre intakes were observed, putting Māori, Pacific, Asian children and children from areas of high deprivation at greater risk. Due to the crucial role of nutrition during this period, effective policies and programmes are required to address energy and nutrient intake inadequacies and excess, particularly targeting young NZ children from vulnerable sociodemographic groups.

## Introduction

Adequate energy and nutrient intakes are essential for growth and development during early childhood. This stage is characterised by rapid growth, an increase in body mass, and the development of cognitive skills and social and emotional abilities (1-3). The nutrient intake requirements per kilogram of body weight are higher in young children compared with adults, but their stomach capacity is only approximately one-third (4). It is a transition period when some autonomy over food selection becomes apparent (5), which is important as dietary habits established during the first three years of life are carried through to adulthood (6).

Despite the crucial importance of optimal nutrition during early childhood, there is limited evidence regarding the energy and nutrient intake of New Zealand (NZ) children under the age of five. Evidence from other high-income countries such as the United Kingdom (UK), United States (US), the Netherlands, and Australia, indicate adequacy of intake amongst young children for energy and most nutrients (55-58). However, excesses and shortfalls of certain nutrients such as fat, fibre, iron, and zinc were also reported.

Furthermore, the few studies assessing the dietary intake and nutrient status of young NZ children indicate that there may be differences in energy and nutrient intakes based on sex (7, 8), ethnicity (9, 10), and socioeconomic status (7). This is comparable with studies from other high-income countries which include a higher intake of protein and iron amongst American boys than girls (55), higher fat intake amongst non-Dutch participants compared to Dutch children (59), and a lower fibre intake amongst Australian children who lived in households with poor socioeconomic status (60).

Therefore, the aim of this study was to evaluate the usual energy and key nutrient (protein, fat, saturated fat, carbohydrates, total sugars, fibre, iron, calcium, zinc, and vitamin C) intakes of young children living in NZ and describe their differences based on sex, ethnicity, and socioeconomic status.

## Methods

### Study design and participants

This research is part of a larger study, Young Foods New Zealand (YFNZ), a multi-site, cross-sectional observational study conducted in Auckland, Wellington, and Dunedin between August 2020 and February 2022. Ethical approval was obtained in 2020 from the University of Otago Human Ethics Committee, project reference code H20/040. Written informed consent was obtained from the

parents/guardians. Data were collected and managed using Research Electronic Data Capture (REDCap) hosted by the University of Otago, NZ.

There was no formal sample size calculation conducted since the study's main objective was more descriptive than driven by hypothesis. The emphasis was on obtaining reliable estimates rather than achieving statistical power for hypothesis testing. Therefore, the sample size was determined based on the requirement to provide robust descriptions of the study population, rather than on achieving specific statistical significance levels. Participants were recruited through advertisements on social media, community hubs, community clinics and churches, and word of mouth. Targeted recruitment strategies (i.e., study advertisement and recruitment in Pasifika churches, visiting a Marae health centre to promote the study, and data collection outreach in an area of high socioeconomic deprivation) were employed to ensure the proportion of participants reflected the NZ population in terms of ethnicity and numbers living in areas of high deprivation. Caregivers aged ≥16 years with 1–3-year-old children, living in Auckland, Wellington, and Dunedin regions, able to communicate in English, and with infants who had not recently participated in a nutrition intervention study that may have influenced their food intake were eligible to take part.

**Data collection**

Data collection was conducted in study clinic rooms, community hubs, or participants' homes. It involved two in-person or online contacts with trained researchers over two weeks to collect the following data.

***Demographic data***

Sex and ethnicity were obtained from the main questionnaire administered during the study's first main visit. Multi-ethnic participants were assigned an ethnicity based on level 1 prioritisation outlined by the NZ Ministry of Health (11). This prioritisation method involves categorising participants with more than one ethnicity into one group based on this prioritisation order: Māori, Pacific, Asian, NZ European, and Other. The age and address of each child participant were reported by caregiver proxy through the screening questionnaire. Socioeconomic status was measured by the NZ Index of Deprivation 2018 (NZDep2018) which was determined by entering the participant's home address in an online tool from Stats NZ Geographic Data Service which assigns a meshblock for each address (12). The meshblock has an associated NZDep2018 score which is split by deciles. Socioeconomic deprivation status was classified into low (1-3), moderate (4-7), and high (8-10).

***Anthropometric data***

At the first visit, the child's weight was measured on an electronic infant scale (Seca model 354) or on an adult scale (Seca model 813) if the child could stand. For children aged less than 2 years and unable to stand, length was measured on a length mat (Seca model 210), otherwise, height was taken using a stadiometer (Seca model 213 or Wedderburn model WMHM200P). Measurements were taken in duplicates or triplicates by a trained researcher. All anthropometric equipment utilised in the study was regularly calibrated. Body Mass Index (BMI) was calculated using the formula [weight (kilogram)/ height (meter)$^2$]. BMI z-score was determined using WHO growth charts and anthropometric status were classified as underweight (BMI z-score<-2), healthy weight (BMI z-score -2 to 2), and overweight (BMI z-score>2) (52).

***Dietary intake data***

Prior to their main visits, participants were asked to take photos of all meals and snacks for 24 hours on the day before their appointment. Other caregivers such as day care staff were requested to write brief notes on the food and drinks and amounts consumed in a pre-printed form with instructions sent before main visits. During the first visit, the caregiver carried out a multiple-pass 24-hour food recall with a trained interviewer in three stages. First, a quick list of the food and drinks consumed the previous day was created. Second, the quick list was expanded into a detailed list using the photographs collected from the previous day as memory prompts. These photos were saved onto a study laptop and uploaded to the University of Otago's secure storage system. The detailed list included comprehensive information on the time and place the food or drink was consumed, cooking method (if applicable), amount consumed, recipe for mixed dishes, and brand and product names for commercial foods or drinks. This stage also involved gathering the pre-printed form previously given to other caregivers. Trained interviewers ensured that the form had been filled out correctly and completely. If not, a follow-up protocol was initiated to obtain the necessary missing information from other caregivers. Finally, the last stage of the food recall was reviewing and probing for forgotten food and drinks. The same process was undertaken during the second visit, which took place on the second week and on a different day than the first appointment to capture daily variation. Information on supplement use was captured by the main questionnaire during the first visit. Breast milk intake was estimated using 91.4 g per feed if aged between 12 and 18 months or 60.9 g per feed if older than 18 months (13). These were then multiplied by the nutrient densities for human milk from FOODFiles (14).

Dietary intake data were entered and analysed through FoodWorks software version 10 (2019, Xyris Software, Australia). Trained research assistants quality-checked all 24-hour food recalls for correctness and completion, uploaded the recording sheets to the University of Otago's secure storage system and entered all dietary intake data into FoodWorks. This software utilises the NZ food composition database and FOODfiles (15) to analyse nutrient intakes. The Multiple Source Method (MSM) (16, 17) was utilised to estimate usual nutrient intakes. Daily intakes from supplements were added subsequent to this. Supplements data were obtained from the interviewer-assisted main questionnaire (Appendix I), providing information on the frequency of supplements use, brand and product name, as well as photos of the supplements indicated. The reported frequency was assigned with a pre-determined numerical value which was then multiplied with the content of the nutrient, based on the product name or label. For iron supplements, if the equivalent elemental iron was not provided on the product label for an iron salt, the NZ formulary conversion values were utilised (53).

Statistical analysis

All statistical analysis was performed using Stata 17.0 (StataCorp, Texas). Intakes in the sample were described with means (standard deviations). These estimates were also weighted according to ethnicity and deprivation proportions from recent NZ statistics of toddlers and pre-schoolers (18) and reported with 95% confidence intervals. The proportion of the sample with inadequate intakes for protein, zinc, calcium, and vitamin C was determined using the Estimated Average Requirement (EAR) cut-point method, whilst the full probability approach at 15% bioavailability was utilised to determine the proportion of inadequacy for iron (19). Inadequacy for fibre was determined by identifying participants below the AI for fibre. The proportion of participants consuming more than 10% of their total energy intake from saturated fat was also determined. The prevalence of inadequacy for other nutrients such as carbohydrates, total fat, and sugar was not determined due to the absence of suitable recommendations for these nutrients. Weighted proportions were also estimated with 95% logit confidence intervals.

Linear regression analyses were conducted to examine differences in energy and nutrient intakes by sex, ethnicity and deprivation status. Mean differences and 95% confidence intervals were calculated and adjusted for age. A $p$ value $<0.05$ was considered statistically significant. The residuals of models were plotted and visually assessed for homoskedasticity and normality.

## Results

Out of the 628 respondents who expressed interest in the study, 601 were eligible and 290 completed the main questionnaire. Of these, 289 completed at least one 24-hour diet recall (274 completed two). More than half of the participants were living with another child in their household. The majority had a healthy weight (87.2%), but a significant proportion (12.5%) of participants were classified as overweight, and only one was underweight. The sample was diverse, with 45% New Zealand European, 26% Māori (indigenous population of New Zealand), followed by Pacific (16.3%) and Asian (12.8%) children. More than a third of participants were under two years of age, and almost half were male. There was a comparable number of participants living in areas of high deprivation (29.4%) and low deprivation (27.3%).

Table 1. Demographic characteristics of participants

| | Toddlers (12-24 months) | Pre-schoolers (25-47 months) | All |
|---|---|---|---|
| n | 108 | 181 | 289 |
| Age, mean (SD) [d] years | 1.53 (0.30) | 3.08 (0.57) | 2.50 (0.89) |
| Sex, n (%) | | | |
| Male | 51 (47.2) | 91 (50.3) | 142 (49.1) |
| Female | 57 (52.8) | 90 (49.7) | 147 (50.9) |
| Child's ethnicity[a], n (%) | | | |
| Māori | 34 (31.5) | 41 (22.7) | 75 (26.0) |
| Pacific | 18 (16.7) | 29 (16.0) | 47 (16.3) |
| Asian | 11 (10.2) | 26 (14.4) | 37 (12.8) |
| European & others | 45 (41.7) | 85 (47.0) | 130 (45.0) |
| BMI z-score[b], mean (SD) | 0.74 (1.22) | 0.72 (1.02) | 0.72 (1.09) |
| Weight status[b], n (%) | | | |
| Underweight | 1 (1.2) | 0 | 1 (0.4) |
| Healthy weight | 71 (82.6) | 146 (89.6) | 217 (87.2) |
| Overweight | 14 (16.3) | 17 (10.4) | 31 (12.5) |
| Deprivation status[c], n (%) | | | |
| 1-3 (Low) | 25 (23.2) | 54 (29.8) | 79 (27.3) |
| 4-7 (Medium) | 47 (43.5) | 78 (43.1) | 125 (43.3) |
| 8-10 (High) | 36 (33.3) | 49 (27.1) | 85 (29.4) |
| Caregiver education level, n (%) | | | |
| School | 22 (20.8) | 33 (18.3) | 55 (19.2) |
| Polytechnic | 24 (22.6) | 40 (22.2) | 64 (22.4) |
| University | 60 (56.6) | 107 (59.4) | 167 (58.4) |
| Number of other children in household, n (%) | | | |
| 0 | 26 (24.8) | 19 (10.6) | 45 (15.9) |
| 1 | 47 (44.8) | 100 (55.9) | 147 (51.8) |
| 2 | 19 (18.1) | 35 (19.6) | 54 (19.0) |
| ≥3 | 13 (12.4) | 25 (14.0) | 38 (13.4) |

[a] Prioritised ethnicity – prioritised as listed; [b] BMI z-score determined using WHO growth charts. Underweight (BMI z-score<-2); Healthy weight (BMI z-score -2 to 2); Overweight (BMI z-score>2). N=86 toddlers and N=163 pre-schoolers had anthropometric data; [c] Deprivation assessed using the NZ Index of Deprivation 2018; [d] Standard Deviation (SD)

Table 2 presents the usual energy and nutrient intake from foods, drinks and supplements of young NZ children aged 1-3 years. Inadequate energy intakes were observed amongst older age groups. The mean protein intake (45.6 g/day) was well above the EAR of 12 g/day, and all participants (100%) were above the EAR. Carbohydrates were the primary contributor to energy intake, with a mean usual intake of 144 g, providing 48.7% of total energy. This was followed by fat, contributing 33.9 % of energy, with a mean intake of 46.1 g. Most participants (93.4%) consumed more than 10% of total energy from saturated fat, and 46.0% had a likelihood that their usual intake was above the Adequate Intake (AI) for fibre.

Table 2. Energy and key nutrients intake and proportion of intake inadequacy of young NZ children aged 1-3 years old (n=289)

| Energy/nutrient | Average intake mean (SD) | Weighted average intake [a] mean (95% CI) | Classification of inadequate intake NRVs (EER[α], EAR[β] AI[γ] or UL[δ]) | % (n) of sample inadequate [b,c,d,e] | Weighted proportion of inadequacy [a] (95% CI) |
|---|---|---|---|---|---|
| Energy (boys) [α] kJ per day | | | | | |
| 12-14.9 months (n=10) | 4,646 (563) | 4,533 (4,136, 4,929) | <3,500 | 0 | - |
| 15-17.9 months (n=13) | 4,535 (456) | 4,507 (4,151, 4,863) | <3,800 | 15.4 (2) | 19.2 (3.2, 63.3) |
| 18-20.9 months (n=14) | 4,482 (543) | 4,473 (4,239, 4,707) | <4,000 | 21.4 (3) | 16.6 (3.8, 50.2) |
| 21-23.9 months (n=14) | 5,011 (708) | 5,050 (4,604, 5,495) | <4,200 | 14.3 (2) | 16.9 (3.0, 56.4) |
| 24-35.9 months (n=35) | 5,156 (1,268) | 5,131 (4,798, 5,463) | <4,400 | 28.6 (10) | 22.8 (10.6, 42.3) |
| 36- 47.9 months [f] (n=56) | 5,510 (608) | 5,477 (5,285, 5,669) | <5,600 | 57.1 (32) | 57.9 (42.6, 71.8) |
| Energy (girls) [α] kJ per day | | | | | |
| 12-14.9 months (n=16) | 4,473 (695) | 4,302 (4,059, 4,545) | <3,200 | 0 | - |
| 15-17.9 months (n=8) | 4,795 (375) | 4,712 (4,359, 5,064) | <3,500 | 0 | - |
| 18-20.9 months (n=15) | 4,790 (1,052) | 4,485 (3,686, 5,285) | <3,800 | 13.3 (2) | 18.6 (3.1, 62.2) |
| 21-23.9 months (n=18) | 4,687 (771) | 4,621 (4,329, 4,912) | <4,000 | 11.1 (2) | 10.3 (2.0, 39.5) |
| 24-35.9 months (n=39) | 4,734 (808) | 4,653 (4,409, 4,897) | <4,200 | 28.2 (11) | 27.8 (14.5, 46.5) |
| 36- 47.9 months [f] (n=51) | 5,409 (799) | 5,484 (5,211, 5,756) | <5,300 | 41.2 (21) | 40.5 (26.1, 56.8) |
| Fat | | | | | |
| g per day | 46.1 (9.5) | 46.0 (44.8, 47.1) | - | | |
| % energy from fat | 33.9 (3.8) | 34.0 (33.5, 34.5) | | | |
| Protein[β] | | | | | |
| g per day | 45.6 (10.5) | 46.0 (44.6, 47.3) | <12 | 0 | - |
| g/kg per day [g] | 3.32 (0.83) | 3.39 (3.28, 3.50) | <0.92 | 0 | - |
| % energy from protein | 15.4 (2.2) | 15.5 (15.3, 15.8) | | | |
| Carbohydrates | | | - | | |
| g per day | 144 (29) | 143 (139, 147) | | | |
| % energy from carbohydrates | 48.7 (4.9) | 48.3 (47.7, 49.0) | | | |
| Total sugar | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| g per day | 67.3 (15.2) | 66.2 (64.2, 68.2) | - | | |
| % energy from sugar | 22.9 (4.4) | 22.5 (22.0, 23.0) | | | |
| Fibre[γ] | | | | | |
| g per day | 14.0 (4.4) | 14.3 (13.7, 14.9) | <14 | 54.0 (156) | 52.1 (45.5, 58.6) |
| Saturated fat | | | | | |
| g per day | 18.9 (4.9) | 18.8 (18.1, 19.4) | - | | |
| % energy from saturated fat | 13.9 (2.6) | 13.9 (13.5, 14.2) | >10% of total energy | 93.4 (270) | 93.3 (89.2, 95.9) |
| Zinc[β] | | | | | |
| mg per day | 6.1 (1.4) | 6.2 (6.0, 6.4) | <2.5 | 0 | - |
| Calcium[β] | | | | | |
| mg per day | 695 (234) | 704 (676, 733) | <360 | 3.8 (11) | 3.3 (1.6, 6.8) |
| Iron[β] | | | | | |
| mg per day | 6.8 (2.6) | 6.8 (6.5, 7.1) | <4 | 15.2 | |
| Vitamin C[β] | | | | | |
| mg per day | 87.3 (136.9) | 87.5 (70.9, 104.2) | <25 | 4.8 (14) | 3.8 (2.0, 7.2) |

[a] Weighted by ethnicity and deprivation to more closely represent the NZ population (note that the group sizes for energy intake are small so weighted estimates should be interpreted with caution); [b] Proportion of participants below EER/EAR for dietary energy, protein, zinc and calcium intake; [c] Proportion of participants below AI for fibre; [d] Proportion of participants with >10% of total energy intake from saturated fat; [e] Calculated using the full probability approach for iron at 15% bioavailability; [f] EER was based on Physical Activity Level (PAL) of 1.6 – light activity; [g] This estimate does not include 40 participants as their weight data was unavailable

[α]EER - Estimated Energy Requirement

[β]EAR - Estimated Average Requirement for 1–3-year-old children

[γ]AI - Adequate intake for 1–3-year-old children

Abbreviations: standard deviation (SD), kilojoule (kJ), gram (g), milligram (mg), kilogram (kg)

Figure 1 displays the proportion of young NZ children who had an inadequate intake of key nutrients. Nutrient Reference Values (NRVs) have been set for these nutrients which enabled the determination of the prevalence of inadequate intakes, whereas the average probability of inadequate iron intake was determined through the full probability approach as stated in the methods section. All participants (100%) achieved adequacy for protein and zinc intakes. Of the micronutrients analysed, iron had a high average probability of inadequate intake at 15.2%, followed by vitamin C and calcium, with a prevalence of inadequacy at 4.8% and 3.8%, respectively.

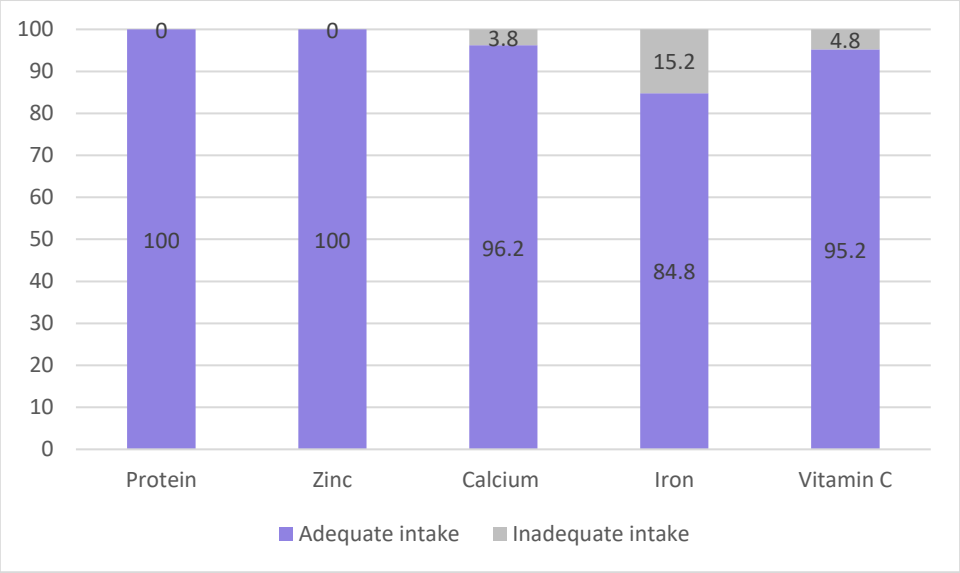


Figure 1. Proportion of inadequacy of key nutrient intake of young NZ children aged 1-3 years.

Table 3 presents the stratification of energy and macronutrient intakes based on sex, ethnicity, and deprivation status. No significant differences were found between energy and nutrient intakes based on sex. Although not statistically significant, Pacific children had the highest mean energy intake across all ethnic groups. All minority ethnic groups (Māori, Pacific and Asian children) had significantly lower fibre intake compared to NZ European children ($p<0.05$). Compared to children living in areas of low deprivation, children living in highly deprived areas had significantly higher total fat and lower fibre intake.

Table 3. Differences in energy and key macronutrient intake of young NZ children aged 1-3 years old between socio-demographic groups (n=289)

| Demographic group | n | Energy (kJ/day) | Fat (g/day) | Protein (g/day) | Carbohydrates (g/day) | Total sugar (g/day) | Fibre (g/day) | Saturated fat (g/day) |
|---|---|---|---|---|---|---|---|---|
| | | | | Mean difference (95% CI)[a] | | | | |
| Sex | | | | | | | | |
| Male | 142 | Reference | Reference | Reference | Reference | Reference | Reference | Reference |
| Female | 147 | -131 (-317, 55) | -1.7 (-3.9, 0.4) | -1.3 (-3.6, 1.0) | -2.4 (-8.5, 3.6) | -0.7 (-4.1, 2.8) | -0.9 (-1.9, 0.1) | -0.5 (-1.6, 0.6) |
| Ethnicity | | | | | | | | |
| European & others | 130 | Reference | Reference | Reference | Reference | Reference | Reference | Reference |
| Māori | 75 | -1 (-230, 229) | -0.2 (-2.9, 2.4) | -1.3 (-4.1, 1.5) | 3.2 (-4.2, 10.6) | 3.7 (-0.6, 8.0) | **-2.2 (-3.4, -1.0)** | 0.2 (-1.2, 1.6) |
| Pacific | 47 | 243 (-26, 511) | 2.9 (-0.2, 6.0) | 1.1 (-2.2, 4.4) | 7.0 (-1.6, 15.7) | 1.6 (-3.4, 6.6) | **-1.4 (-2.8, -0.1)** | 1.3 (-0.3, 2.9) |
| Asian | 37 | -95 (-390, 200) | 0.0 (-3.5, 3.4) | -0.3 (-3.9, 3.3) | -5.0 (-14.5, 4.6) | -2.3 (-7.8, 3.2) | **-2.7 (-4.2, -1.2)** | -0.5 (-2.2, 1.3) |
| Deprivation status[b] | | | | | | | | |
| 1-3 | 79 | Reference | Reference | Reference | Reference | Reference | Reference | Reference |
| 4-7 | 125 | -61 (-288, 165) | 0.3 (-2.3, 2.9) | -1.8 (-4.5, 1.0) | -2.6 (-9.9, 4.7) | 1.7 (-2.5, 5.9) | **-1.4 (-2.6, -0.2)** | 0.2 (-1.1, 1.6) |
| 8-10 | 85 | 203 (-45, 451) | **3.4 (0.5, 6.3)** | 0.7 (-2.3, 3.7) | 4.2 (-3.8, 12.3) | 3.0 (-1.6, 7.7) | **-1.5 (-2.8, -0.2)** | 1.3 (-0.2, 2.8) |

[a] Mean differences (95% CI) adjusted for age; [b] Deprivation status: low - 1-3 NZDep, moderate - 4-7 NZDep, high - 8-10 NZD

Bolded results have p<0.05

Abbreviations: kilojoule (kJ), gram (g)

Table 4 indicates the sociodemographic stratification of micronutrient intakes of young NZ children. There were no significant differences in the micronutrient intakes of young NZ children based on sex or ethnicity. Although not statistically significant, children living in moderate areas of deprivation had consistently lower micronutrient intake compared to children living in low-deprivation areas.

Table 4. Differences in key micronutrient intake of young NZ children aged 1-3 years old between demographic groups (n=289)

| **Demographic group** | **n** | **Zinc (mg[c]/day)** | **Calcium (mg/day)** | **Iron (mg/day)** | **Vitamin C (mg/day)** |
|---|---|---|---|---|---|
| | | Mean difference (95% CI)[a] | | | |
| **Sex** | | | | | |
| Male | 142 | Reference | Reference | Reference | Reference |
| Female | 147 | -0.11 (-0.42, 0.21) | 15 (-40, 69) | 0.04 (-0.57, 0.64) | -2.7 (-34.5, 29.2) |
| **Ethnicity** | | | | | |
| European and others | 130 | Reference | Reference | Reference | Reference |
| Māori | 75 | -0.22 (-0.61, 0.17) | -23 (-90, 44) | 0.15 (-0.59, 0.89) | 0.1 (-39.2, 39.3) |
| Pacific | 47 | 0.05 (-0.41, 0.51) | -19 (-97, 60) | 0.12 (-0.75, 0.99) | -30.3 (-76.3, 15.7) |
| Asian | 37 | 0.48 (-0.02, 0.98) | 19 (-68, 106) | -0.10 (-1.05, 0.86) | -21.5 (-72.1, 29.1) |
| **Deprivation status**[b] | | | | | |
| 1-3 | 79 | Reference | Reference | Reference | Reference |
| 4-7 | 125 | -0.30 (-0.69, 0.09) | -57 (-123, 9) | -0.57 (-1.30, 0.16) | -12.7 (-51.4, 26.0) |
| 8-10 | 85 | 0.00 (-0.42, 0.43) | -48 (-120, 25) | -0.41 (-1.22, 0.39) | 27.8 (-14.7, 70.2) |

[a] Mean difference (95% CI) adjusted for age; [b] Deprivation status: low-1-3 NZDep, moderate-4-7 NZDep, high- 8-10 NZD; [c] Milligram (mg)

## Discussion

This study provides data on energy and nutrient intakes in a diverse sample of young children across NZ who had comparable sociodemographic characteristics (i.e., sex and ethnicity) with the national statistics. Minority ethnic groups are well-represented, as the study's ethnic profile reflects the current NZ national statistics for children 0-4 years of age (i.e., Māori 26.0% vs 27.5% NZ population, Pacific 16.3% vs 14.3% NZ population, and Asian 12.8% vs 18.3% NZ population) (20). In terms of socioeconomic deprivation, the study sample had comparable profile with the participants of a recent study which utilised the Plunket (a well child provider in NZ) data (i.e., low deprivation 27.3% vs 31% Plunket data, moderate deprivation 43.3% vs 40% Plunket data, and high deprivation 29.4% vs 29% Plunket data) which covers 85% of 0-3 year old children in NZ (18). Overall, the results suggest

a high adequacy of intake for most nutrients except for iron and fibre. However, there are concerns regarding excess protein and saturated fat intake. Significant differences in fat intake were observed between children living in areas of high and low deprivation. Disproportionate fibre intakes were observed between ethnic and socioeconomic status groups but not between males and females.

*Energy intake*

Energy intakes showed a general increasing trend of prevalence of inadequacy as age increased for the whole study sample. However, the small sample size limits the statistical power and, therefore, generalisability to the NZ population. The mean BMI z-score (0.72) and the weight distribution (0.4% underweight, 87.2% healthy weight, and 12.5% overweight) of the participants are also not reflective of a group characterised by low energy intake since there is a negligible proportion of study sample that has been classified as underweight (0.4%). Therefore, caution must be exercised in interpreting these results.

The EERs for NZ children aged 12-35.9 months were estimated based on sex, age, weight and length, whilst physical activity was also considered for children aged 36-47.9 months. To estimate the EER for 36-47.9-month-old children, a light physical activity level at 1.6 (light activity) based on the Physical Activity Levels (PALs) outlined in the Australia NZ NRVs (21) was assumed. Evidence across NZ points to the varying levels of physical activity amongst young children (22, 23, 24). As such, the proportion of inadequacy derived for this age group may not be applicable to the entire study population. In our study, the mean energy intake of 36-47.9 months old children was 102.1% of the EER for girls and 98.4% of the EER for boys, indicating an average energy intake that is close to the recommendations. The energy intakes reported in this research are consistent with previous NZ studies on young children (25, 26, 27).

Although not statistically significant, Pacific children had the highest energy intake, followed by NZ European, Māori, and Asian children. Positive energy balance, wherein energy intake exceeds energy expenditure, is the primary determinant of overweight and obesity (21). Whilst our study did not directly measure energy expenditure, the higher energy intake observed amongst Pacific children may have potentially provide an insight to the results of the 2020/2021 NZ Health Survey which reported Pacific children having the highest proportion of obesity at 35.3% compared to Māori (17.8%), NZ European (10.3%), and Asian (6.6%) children (22). It is hypothesised that widely

available, cheap, energy-dense foods that are tasty and convenient potentially contribute to the high prevalence of obesity amongst Pacific communities in NZ (23).

*Macronutrient intake*

In agreement with previous research, the reported protein intake in this study was much higher than the current requirements (45.6 g vs 12 g). However, when expressed as a proportion of total energy, protein contributed 15.4%, which is still within the Acceptable Macronutrient Distribution Range (AMDR) of 15-25% of total energy intake from protein (24). Two NZ studies on young children had similar findings namely, the Growing-Up Milk–Lite (GUMLi) trial and the Auckland Birthweight Collaborative (ABC) study. Both reported average protein intakes of 46 g/day and 45 g/day, respectively. Studies from other high-income countries such as Italy, France and the United States (US) show consistent results of high protein intake in young children, with some consistently exceeding their intake requirements for a long period of time (i.e., 3 years) (25-28).

Emerging evidence from high-income countries indicates that excess protein consumption may potentially contribute to the risk of obesity in young children (29, 30). During early childhood, there is a slow but continuous decline in protein requirements relative to body mass but the introduction of solid foods is marked by a sharp increase in dietary protein intake (31, 32). However, the scientific panel of the European Food Safety Authority (EFSA) states that there is no conclusive evidence from the available survey data on current protein intakes that pose a long-term or short-term threat to the health of young children (33). In NZ, the Ministry of Health (MoH) does not recommend cow's milk as a drink for infants under the age of one and limits the consumption to 350 ml a day for toddlers over one year due to its high protein and low iron content (34).

The contribution of total fat intake to total energy intake was 33.9 %, which is within range but on the higher end of the AMDR for fat (20-35%) (35). However, a disproportionately high fat intake was observed amongst children living in areas of high deprivation compared to children living in areas of low deprivation. A key to this disparity may be the availability and accessibility of high-fat foods in highly deprived neighbourhoods. A nationwide study in NZ that utilised Geographical Information Systems (GIS) determined highly-deprived neighbourhoods had greater access to fast foods (36). This access is translated to the high frequency (≥3 times a week) of fast food consumption of children (aged 2-14 years) living in areas of high deprivation compared to those living in areas of low deprivation (37). Apart from the abundance of high-fat food options in their neighbourhood, young

NZ children living in areas of high deprivation have limited economic access to products that are lower in fat. Such foods tend to be more expensive than high fat options (38).

A large proportion of participants in this study reported consuming more than 10% of their energy from saturated fat. Although less than 10% of the total energy contribution from saturated fat is recommended for adults, it is unknown whether this recommendation can be extrapolated to children. For children with a genetic predisposition to dyslipidaemia, there is 'probable' evidence that lowering saturated fat intake to 8% of total energy intake may be beneficial (39). For healthy children, limiting saturated fat intake may also be advantageous due to its potential to track through older childhood and adulthood (40, 41). A 20-year Finnish cohort study (n=1,062), starting at 7 months of age, found that cardiovascular risk factors track from early to older childhood (42). In NZ, the ABC cohort study reported that all participants (100%) consumed saturated fat intake >11% of total energy at the age of 3.5 years. When participants were followed up at 7 and 11 years of age, similar findings, that is, saturated fat contributing >11% of total energy intake for all participants, were observed (43).

Low fibre intakes were observed in more than half of the participants, particularly for children of Māori, Pacific and Asian ethnicity and children living in areas of high deprivation. This is despite NZ being a major agricultural country, exporting a surplus of high-fibre produce to the world. A recent analysis revealed that NZ is exporting sufficient quantities to feed and meet the dietary guidelines for fruits (2 servings/day) for a population of 10.6 million and vegetables (5 servings/day) for a population of 2.9 million (44). This demonstrates the disconnect between the substantial production of nutrient-dense foods that are high in fibre in NZ and the low proportion of young NZ children meeting the AI for fibre.

*Micronutrient intake*

The mean iron and zinc intakes reported were relatively high, almost 2.4 times and 1.7 times the EAR, respectively. The prevalence of inadequate iron and zinc intakes observed in this study (15.2% and 0%, respectively) is comparable to the proportion determined by a case-control study (iron - 12.3 %; zinc - 1.1%) from the control group (n=351) of children aged 0-4 years in Auckland (45). However, the case-control study was conducted almost two decades ago (2002-2005) which indicates the persistent inadequacy of intake, specifically for iron. When stratified by sex, ethnicity and deprivation, no significant differences were observed in the iron intake of young NZ children.

Parallel to these findings, the World Health Organization (46) reported a sharp increase in anaemia prevalence—commonly caused by iron deficiency—in young NZ children under the age of 5 years, from 10.56 % in 2009 to 13.03 % in 2016. In a cross-sectional study of children aged 6-23 months, no differences in the prevalence of iron deficiency were observed in terms of socioeconomic status, but Māori and Pacific children had a higher prevalence of iron deficiency compared to their counterparts (9). An early study explained that iron deficiency may be potentially augmented by sociocultural feeding practices in NZ such as tea drinking in Pacific children (47).

The prevalence of inadequate vitamin C intake observed in our study was relatively low at 4.8%. Vitamin C, as well as fibre, is an essential nutrient that is closely related to fruit and vegetable intake, which is an important marker of a healthy diet. Our study found significant differences in fibre intake between various sociodemographic groups, but not for vitamin C. Current evidence in NZ align with our findings in terms of fibre intake (i.e., Māori, Pacific, those children living in areas of high deprivation had lower fruit and vegetable intakes compared to their counterparts) (10). This finding highlights the need for further investigation into the primary sources of vitamin C in the diets of young NZ children.

In this study, no participant was detected who had inadequate dietary zinc intake. However, it is argued that the current requirements for zinc are set too low. In a systematic review of Australian and NZ studies, young children were identified as one of the population groups at risk for zinc deficiency, together with adolescents, older adults, and people with chronic diseases such as diabetes (49). A randomised intervention trial found that despite increasing dietary zinc intake through the higher intake of red meat and zinc-fortified milk consumption, the zinc status of NZ toddlers did not increase accordingly (50).

Similar to zinc, mean calcium intake was high (almost twice the EAR) and the prevalence of inadequacy was generally low at 3.8 %. However, there is a risk of irreversible consequences for the growth and development of young children who have been observed to have inadequate dietary calcium intake. If intake is inadequate to meet the body's physiological needs, calcium is resorbed from the skeleton for the maintenance of blood calcium homeostasis (33). The lack of dietary calcium restricts the mineralisation of the growing bone, which, in severe cases, further leads to nutritional rickets (51).

*Strengths and limitations*

One of the major strengths of this study is the participation of demographic groups that are usually underrepresented in other NZ studies and surveys. This is the first NZ study with comprehensive dietary intake data and well-represented minority ethnic groups and participants living in areas of high deprivation compared to previous NZ studies (43, 45, 54). Despite this, our study sample cannot be considered as nationally-representative due to an urban-centred recruitment and data collection which were limited to the three major cities in NZ. This study is further limited due to 1) the inability of young children to directly report dietary intake, thus resorting to proxy reporting by caregivers, 2) incomplete or limited dietary intake data provided by other caregivers and early childhood centres, 3) the utilisation of an area-based deprivation index as a proxy measure for socioeconomic status, and 4) the inability to capture foods that were infrequently consumed since the 24-hour food recall collected dietary data from only two days. The final limitation was addressed by the utilisation of MSM which enabled the calculation of 'usual intake' of the participants.

## Conclusion

The energy and nutrient intakes of young NZ children are generally sufficient. This study found that optimal nutrition for young NZ children may be achieved by decreasing saturated fat intake whilst increasing iron and fibre intake. There were no significant differences in energy and nutrient intakes in terms of sex, but discrepancies in fat and fibre intakes were observed when the population was stratified by ethnicity and socioeconomic status. This study highlights the need for effective policies and programmes to address the health disparities that have been pervasively experienced by young children living in NZ.

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# Chapter 4: Food group intake and associated correlates amongst young New Zealand children: A cross-sectional study

This manuscript-style chapter provides evidence on the current food group intake and its contribution to energy and nutrient intake of young NZ children. Further analysis was performed to determine the correlation between food group intake (i.e., proportion of consumers and contribution to energy intake), anthropometric status, household food security status, and other sociodemographic characteristics.

## Abstract

**Background:** Despite the high rates of early childhood obesity and the prevalence of inadequate intakes of essential nutrients amongst young New Zealand (NZ) children, there is limited knowledge of their food group intake. Current evidence suggests that Māori and Pacific young children bear an inequitable burden of household food insecurity and low socioeconomic status, which is reflected in high rates of obesity and food consumption patterns that are suggestive of suboptimal nutrition.
**Aim:** Therefore, this study aims to examine the food group's contribution to energy and nutrient intakes of young NZ children. Additionally, it seeks to examine the differences in the proportions of consumers and food sources of energy based on anthropometric status, household food security status and sociodemographic characteristics.
**Methods:** A total of 289 young children aged 1-3 years living in three major NZ cities participated in the Young Foods NZ study, where dietary intake data was obtained from two 24-hour food recalls. Food, beverages, and supplements were assigned to one of the 26 constructed food group categories, that were primarily based on the 2008/09 Adult Nutrition Survey food groupings and were modified to reflect the diets of young children. Additionally, data on anthropometric status [Body Mass Index (BMI) z-score that was further classified into underweight (<-2SD), healthy weight (-2SD to 2SD), and overweight (>2SD)], household food security status, measured by the NZ food security scale (a NZ population-specific scale), and sociodemographic characteristics such as ethnicity, and socioeconomic status (proxy-measured by NZ Index of Deprivation) were obtained. Differences in the proportion of food group consumers were examined using chi-square tests whilst the differences in mean energy contribution from food groups were tested using One-way ANOVA F-test.

**Results:** The most commonly consumed food groups were grains and pasta (98% of children), fruits (94%), and biscuits, crackers, cakes, and desserts (86%). Formulae and mixed dishes primarily contributed to the intake of energy and most nutrients. Beverages (all fluids except for milk and water) were one of the major contributors to total sugar and vitamin C intake. A higher consumption of dairy products and dairy-alternative products was observed in young children with healthy weight compared to those who were overweight (p=0.036), NZ European compared to Māori, Asian and Pacific children (p=0.005), and those living in areas of low socioeconomic deprivation compared to those who live in highly deprived areas (p=0.014). Children living in food insecure households had a higher proportion of consumers of pies and pasties (p=0.013), potatoes, kūmara and taro (p=0.040), and beverages (p=0.011), but lesser proportion of consumers of biscuits, crackers, cakes and desserts (p=0.001), vegetables (p=0.005), and nuts and seeds (p=0.004). Overweight children had a higher

energy contribution from formulae compared to those who had a healthy weight (p=0.039). High-energy and nutrient-poor foods were the major contributors to the energy intake (i.e., sausages and processed meats; sugar, confectionery, and sweet spreads; and pies and pasties) amongst young children in food-insecure households, of Pacific ethnicity, and of low socioeconomic status.

**Conclusion:** This study provides evidence that highlights the urgent need for policies targeting the reduction of sugar-sweetened beverages, refined carbohydrates, and highly processed meats and the promotion of dairy products and dairy-alternative products consumption to improve the energy and nutrient intake of young NZ children. A focus on addressing systemic issues that underpin the food group intake of highly vulnerable groups is crucial to ensuring equitable access to nutritious foods for all young children in NZ.

## Introduction

Nutrition during the early years of life is one of the most crucial and fundamental factors for a child's growth and development (1). Early childhood is marked by increased nutritional requirements and the establishment of food preferences that may impact dietary choices, and thus, health outcomes in adulthood (2). In NZ, 23.1% or approximately 42,000 children aged 2-4 years were classified as overweight or obese (3). The United Nations Children's Fund (UNICEF) identified NZ as the country with the second-highest prevalence of childhood obesity across the developed world (4, 5). Childhood obesity has been associated with several comorbidities such as hypertension, diabetes, dyslipidaemia, as well as psychosocial issues such as anxiety, depression, and poor body image, amongst others (6, 7). A systematic review of 25 studies primarily conducted in high-income countries that evaluated the long-term impact of paediatric obesity on adulthood reported an increased risk of premature mortality and adult morbidity (8). Taking a broader economic perspective, the estimated cost of obesity in NZ was approximately NZ $2.8 trillion in 2014 which represents 2.8% of the total global gross domestic product (GDP) (9).

Despite the high prevalence of childhood obesity and dietary excess, there is a significant proportion of young NZ children who have inadequate intakes of nutrients such as iron, calcium, zinc and fibre (10, 11). This is further validated by the recent findings of Growing Up in New Zealand (GUiNZ) which determined the generally low adherence of young NZ children aged 2 and 4.5 years to the Ministry of Health (MoH) guidelines on food group intake (12). As such, an understanding of food sources of these nutrients, as well as those that are consumed in excess, is important to guide policy-making

and public health initiatives. However, there is currently limited comprehensive data on the food group intake of young NZ children under the age of 5 years. In some existing NZ studies, overrepresentation of NZ European ethnic groups and children from areas of low socioeconomic deprivation has been observed (13-16).

This is a matter of concern since ethnicities other than NZ European, are well represented in less healthy dietary intake patterns such as low fruit and vegetable intake (Pacific and Asian), skipping breakfast (Māori and Pacific), and frequent fizzy drinks and fast-food consumption (Māori and Pacific) (17). Furthermore, a recent NZ survey reported that young children living in areas of high socioeconomic deprivation consume fewer fruits and vegetables and more fast food and fizzy drinks compared to those from low-deprived areas (3). Aside from ethnicity and socioeconomic status, household food insecurity has been found to be associated with a detrimental pattern of food group intake in NZ. A MoH report indicated that children living in food-insecure households tend to have low fruit and vegetable consumption, and high fast food and fizzy drink intakes (18).

Therefore, evidence is required to provide insight on the relative contribution of specific foods consumed, to the diets of young NZ children, particularly in the most vulnerable groups. This data can inform broader strategies designed to ensure the health and wellbeing of young NZ children through adequate nutrition, as well as assist health professionals such as dietitians, Well Child providers, and General Practitioners in forming targeted measures to improve the energy and nutrient intakes of young children in NZ. Therefore, the objective of this study is to describe energy and key nutrients (i.e., protein, carbohydrate, total sugars, fibre, fat, saturated fat, iron, zinc, vitamin C and calcium) intake from food groups. It also aims to describe differences in the proportion of food group consumers and food group sources of energy in the diets of young NZ children based on anthropometric status, household food security status, ethnicity, and socioeconomic status.

## Methods

**Study design and participants**

Data from 289 participants aged 1-3 years who were involved in the Young Foods NZ (YFNZ) study were included in the analyses. YFNZ is an observational cross-sectional study conducted in Auckland, Wellington, and Dunedin, NZ between August 2020 and February 2022. Ethical approval was granted by the University of Otago Human Ethics Committee, project reference code H20/040. Multiple channels were utilised to promote the study and recruit participants, including social media, the

study website, community halls, clinics, churches and word of mouth. The sample included young children, with caregivers who were at least 16 years of age; residing in Auckland, Wellington, or Dunedin; who could communicate in English; and whose children had not been involved in a dietary intervention study.

**Data collection**

The following data were collected by trained researchers in two separate visits, conducted within a span of two weeks. Study visits were primarily conducted either in the participants' homes or study clinic centres across NZ. During data collection outreaches, data for some participants was collected in community halls and churches due to the participant's proximity to the venue or membership in the churches. Research Electronic Data Capture (REDCap) was utilised to collect and manage all data collected from the participants.

***Food group intake data***

Dietary intake data was obtained from two multiple pass 24-hour food recalls, conducted by trained researchers with the caregiver of each participant. To account for day-to-day variation in the estimation of usual energy and nutrient intake, the 24-hour food recalls were administered at approximately one-week intervals on different days of the week for each participant. Food groups were constructed based on the categories from the 2008/2009 Adult Nutrition Survey (19) that were adapted to reflect the diets of young children (i.e., the addition of commercial infant and toddler food, breast milk, and formulae groups). Food and beverage items were coded and classified into one of the 36 food groups by trained research assistants using FoodWorks software version 10 (2019, Xyris Software, Australia). These food groups were further collapsed into 26 groups (see table 1) based on nutritional similarity and serving the same purpose (i.e., 'snack bars' and 'snack foods' were merged as 'snacks' food group) to facilitate a more straightforward data analysis and interpretation. The food group intake was estimated in grams per day. Supplement data was added after estimating usual energy and nutrient intake using the Multiple Source Method (MSM) (20, 21). Data from the main questionnaire (Appendix I) was utilised to obtain information on the frequency of supplements use, brand, product name, and photos of the supplements. The product of the reported frequency and the nutrient content of the supplements (based on the product name or label) makeup the total supplement intake contribution. For supplements containing iron salt, the equivalent elemental iron was determined using the NZ formulary conversion values (75).

Estimation of breast milk nutrient density was obtained from the human milk composition from FOODFiles (22) and directly-consumed breast milk volume was estimated to be 91.4 g per feed for ages between 12 and 18 months or 60.9 g per feed if older than 18 months based on a national US survey of infants and toddlers (n= 3,273) (23). The contribution to energy and nutrient intakes from food groups was only reported for consumers, since including all participants (even the non-consumers) can provide a misleading average since the sample size could be much smaller than the actual study sample. This ensures that the reported energy and nutrient intake contributions are more representative of the actual consumption patterns within the study sample.

Quality control was employed across all steps of the dietary intake data processing. The first stage is the quality check conducted by trained Research Assistants on all 24-hour food recalls to ensure that they have been filled in correctly and completely. Food recalls that required further information or correction were followed up on by the researcher who conducted the interview. Once the food recalls passed the quality check, the dietary data was entered into FoodWorks, which was further quality-checked for accuracy by a different research assistant.

Table 1. Food groups classification

| **Food group** | **Abbreviated name** | **Food items within each group** |
|---|---|---|
| Grains and pasta | Grains and pasta | Rice, pasta, flour, bran and germs, oats, other grains and cereals, regular bread and rolls (plain), flat bread, pita bread, tortillas, pizza bases (plain), speciality breads, bagels, English muffins and crumpets, sweet yeast buns, other breads, wheat-based biscuits and shredded wheat, puffed or flaked dry cereal, extruded cereals, porridge and cooked cereals, bran-based cereals, toasted muesli, untoasted muesli, other breakfast cereals |
| Biscuits, crackers, cakes and desserts | Biscuits and cakes | Sweet biscuits[a], crackers, cakes, cake type desserts/gateaux include fancy rich cakes and gateaux, slices, muffins, scones, pancakes, pikelets, waffles, doughnuts, pastry, milk puddings, cheesecakes, fruit crumbles, mousse, sponge pudding/steamed pudding, sweet pies e.g., fruit or custard pies, pavlova & meringues, other puddings e.g., brandy snaps |
| Milk and milk-alternatives | Milk | Cow's milk, goat and sheep milk, milks for reconstitution, milkshakes and thick shakes, flavoured milks, soy milk, plant-based and dairy milk-alternatives |

| | | |
|---|---|---|
| Dairy products and dairy-alternative products | Dairy | Cream, sour cream, ice cream, yoghurt, other dairy products, dairy-alternative products, high fat cheese (>30 g fat/100 g), medium fat cheese (20-30 g fat/100 g), low fat cheese (<20 g fat/100 g), plant-based/vegan cheese, other cheese |
| Fats and oils | Fats and oils | Butter, butter/table spread blends, polyunsaturated table spread, monounsaturated table spread, other butter/table spreads, high saturated/monounsaturated fat, coconut oil (high saturated fat), high monounsaturated/polyunsaturated fat, high monounsaturated fat, high polyunsaturated fat, oil blends and other oils |
| Eggs and egg dishes | Eggs | Eggs, egg dishes |
| Red meats | Red meat | Beef & veal muscle meat, lamb/mutton muscle meat, bacon, ham, pork muscle meat |
| Poultry | Poultry | Chicken muscle meat, chicken processed meat, duck, turkey, other poultry |
| Sausages and processed meats | Processed meats | Sausages, luncheon, frankfurters, saveloys/cheerios[b], meatloaf, meat patties and meatballs, cured processed meats |
| Pies and pasties | Pies | Red meat pies, chicken pies, seafood pies, vegetarian/vegan meat alternative pies, vegetable pies, bacon and egg pie, pasties, savouries, sausage rolls, quiche, other pies/pasties |
| Fish and seafood | Seafood | Fin fish, shellfish and non-fin fish, fried fish in batter/coating, canned fish |
| Vegetarian/vegan meat alternatives | Meat alternatives | Vegetarian/vegan meat alternatives |
| Fruits | Fruits | Pomme fruit, berry fruit, stone fruit, citrus, tropical fruits, other fruits, dried fruit, fruit puree concentrates & fruit paste concentrates |
| Vegetables | Vegetables | Leafy greens, green beans/peas, corn, tomatoes & tomato products, orange vegetables, brassicas, onion/garlic/leeks, other vegetables, vegetables mixes, vegetable powder, vegetable juice concentrates |
| Mature legumes and pulses | Legumes | Mature legumes & pulses, mature legumes and pulse products and dishes, mature legume & pulse flours |
| Potatoes, kumara, and taro | Starchy vegetables | Potato, kūmara[c], taro |
| Nuts and Seeds | Nuts and seeds | Nuts, nut products, seeds, seed products, nut & seed mixes |
| Snacks | Snacks | Potato crisps or chips, other vegetable chips or crisps, non-vegetable chips or crisps, corn snacks including corn chips, popcorn, extruded snacks, other snack foods, including mixes, fruit break/wholemeal fruit bars (fruit wrapped in cereal-based casing), muesli[d] bars (rolled oat base), soft & hard mixed grain bars (mixed cereal base), puffed cereal bars (based on rice |

| | | |
|---|---|---|
| | | or corn), other breakfast cereal based bars, nut &/or seed bars |
| Sugar, confectionery, and sweet spreads | Sugars and sweets | Sugar, syrup, lollies[e], sweets & liquorice, chocolate & chocolate-based confectionery, sugar-based toppings, sauces & icings, ice blocks including milk or juice base, sweet spreads, other e.g., jelly, artificial sweeteners |
| Savoury sauces, condiments, herbs/spices, and other flavourings | Sauces and flavourings | Gravies & savoury meal-base sauces, condiment/side sauces, roux/white sauces, salad dressings, pickles & chutneys, dips, yeast & vegetable extracts, stocks & stock powders, salt, herbs, spices, & other flavourings |
| Beverages | Beverages | Tea, coffee, drinking chocolate, milo[f], & cereal beverages, fruit juices, vegetable juices, fruit &/or vegetable smoothies, cordials & fruit drinks, soft drinks, sports drinks, energy drinks, powdered drinks, other non-alcoholic beverages |
| Dietary supplements | Supplements | Multivitamin or minerals, meal replacements, protein supplements, carbohydrate supplements, fat supplements, mineral supplements, fat soluble (& β-carotene) vitamin supplements, water soluble vitamin supplements |
| Mixed dishes | Mixed dishes | Bread-based dishes, pasta-based dishes, rice-based dishes, casseroles/stews, soups, salads, other mixed dishes |
| Breast milk | Breast milk | Breast milk directly consumed, expressed, or mixed with food |
| Formulae | Formulae | Infant or follow-on formula mixes, or mixed with food |
| Commercial infant & toddler foods | Commercial infant & toddler foods | Infant & toddler dry cereals, infant & toddler dry snacks, infant & toddler dairy, infant & toddler wet foods |

NZ equivalent of [a]cookies, [b]cocktail sausage, [c]sweet potato, [d]granola, [e]candies, [f]brand of drinking chocolate

***Anthropometric data***

Standing height was measured using a stadiometer (Seca model 213 or Wedderburn model WMHM200P) for children more than 2 years of age and able to stand, otherwise, length was measured using a length board (Seca model 210). Height/length was taken initially in duplicates, and if the measurements disagreed by at least 0.7 cm, a third measurement was taken. If the child was unable to stand, weight was measured using an infant electronic scale (Seca model 354), otherwise, adult scales (Seca model 813) were used to measure the child's weight. Weight measurements were also taken in duplicate, and if the disagreement between the two measures was more than 0.1 kg, then the weight was taken in triplicate. Both measurements were obtained during the first study visit. Weekly calibration of height and weight equipment was conducted by trained researchers, allowing an error of ± 0.010 kg for infant scales, ± 0.10 kg for child scales, and ± 5mm for stadiometer and measuring mat. Body Mass Index (BMI) was computed by dividing the weight (kilogram) by the

square of the height (metre). Subsequently, the BMI-for-age z-scores were derived using the World Health Organization (WHO) reference data and further categorised into underweight, healthy weight, and overweight groups (74).

***Demographic data***

Sociodemographic data including sex, age, ethnicity, caregiver education, household characteristics (i.e., number of other children in the household) and socioeconomic status, were obtained from the two study questionnaires (i.e., screening, and main questionnaire). The ethnicity of participants was determined by asking the caregiver which ethnic group the child belonged to. Options included "Māori", "Pacific", "New Zealand European" ethnic groups or "Other" (if selected, caregivers were asked to specify in a text box). Participants with multiple ethnicities were categorised using 'prioritised ethnicity' which assigns each participant to a single ethnic group (24). Ethnicities were prioritised in the following order: Māori, Pacific, Asian, NZ European, and Other.

NZ Index of Deprivation (NZDep) was utilised as a proxy measure of socioeconomic status. To obtain NZDep2018, the addresses of participants were entered on the Statistics NZ Geographic Data Service online tool which automatically assigns a meshblock that corresponds to the participant's address (25). Each meshblock has an associated NZDep2018 score, divided into deciles.

***Household food security data***

A NZ-specific household food security scale was utilised to measure the food security of the children's households (26). During the first visit, caregivers were provided with eight statements, reflecting the state of their household within the past 12 months. Each statement was introduced with a blurb to explain the statement and make it more acceptable to the respondents. Caregivers were asked to respond verbally or point to a show card provided by the researcher. Responses were directly entered into REDCAP and further coded and scored. A scoring system developed by the team from the First Foods NZ (FFNZ) study, a parallel study on infants 7-10 months that was conducted alongside YFNZ, was utilised (27). Item responses were assigned points (Never=1 point, Sometimes=2 points, Often=3 points). Responses to statement 1 were reverse scored since it was phrased differently compared to the other seven statements. Based on the total score, participants were categorised into three household food security groups: food secure (22-24), moderately food insecure (19-22), and severely food insecure (<19). Participants with a total score of 22 and ≥2

affirmative responses were moderately food insecure, otherwise, participants were categorised as food secure.

**Statistical analysis**

Descriptive statistics (i.e., means, standard deviation and percentages) were utilised to describe the demographic characteristics of the study sample. The chi-squared test was utilised in examining the differences in the proportion of consumers of each food group by demographic subgroup (i.e., food secure, moderately food insecure, severely food insecure; overweight, healthy weight, etc.). Meanwhile, differences in mean energy intake from each food group across demographic subgroups were assessed using a one-way ANOVA F-test. All analyses were carried out in Stata 17.0 (Stata Corp, Texas) with statistical significance set at $p<0.05$.

## Results

A total of 290 participants completed the main questionnaire. Out of these, 289 participants provided 24-hour food recalls. Amongst the participants with food recall data, 274 had completed two food recalls, whilst the remaining 15 participants only had one food recall. The majority of the participants had a healthy weight (87.2%) and a small proportion were overweight (12.5%). Ethnic groups represented were mostly NZ European and others (45.0%), followed by Māori (26.0%), Pacific (16.3%), and Asian (12.8%). Most participants lived in households of moderate socioeconomic deprivation (43.3%), followed by high (29.4%) and low (27.3%), respectively. Most participants were food secure (64.0%), with 15.6% severely food insecure.

**Table** 2**.** Demographic characteristics of participants

| Characteristics | Toddlers (12-24 months) | Pre-schoolers (25-47 months) | All |
|---|---|---|---|
| n | 108 | 181 | 289 |
| Age, mean (SD)[a] years | 1.53 (0.30) | 3.08 (0.57) | 2.50 (0.89) |
| Sex, n (%) | | | |
| Male | 51 (47.2) | 91 (50.3) | 142 (49.1) |
| Female | 57 (52.8) | 90 (49.7) | 147 (50.9) |
| BMI z-score [b], mean (SD) | 0.74 (1.22) | 0.72 (1.02) | 0.72 (1.09) |
| Weight status [b], n (%) | | | |
| Underweight | 1 (1.2) | 0 | 1 (0.4) |
| Healthy weight | 71 (82.6) | 146 (89.6) | 217 (87.2) |

| | | | |
|---|---|---|---|
| Overweight | 14 (16.3) | 17 (10.4) | 31 (12.5) |
| Ethnicity [c], n (%) | | | |
| Māori | 34 (31.5) | 41 (22.7) | 75 (26.0) |
| Pacific | 18 (16.7) | 29 (16.0) | 47 (16.3) |
| Asian | 11 (10.2) | 26 (14.4) | 37 (12.8) |
| European & others | 45 (41.7) | 85 (47.0) | 130 (45.0) |
| Socioeconomic deprivation status [d], n (%) | | | |
| 1-3 (Low) | 25 (23.2) | 54 (29.8) | 79 (27.3) |
| 4-7 (Medium) | 47 (43.5) | 78 (43.1) | 125 (43.3) |
| 8-10 (High) | 36 (33.3) | 49 (27.1) | 85 (29.4) |
| Caregiver highest qualification, n (%) | | | |
| School | 22 (20.8) | 33 (18.3) | 55 (19.2) |
| Polytechnic | 24 (22.6) | 40 (22.2) | 64 (22.4) |
| University | 60 (56.6) | 107 (59.4) | 167 (58.4) |
| Number of other children in household, n (%) | | | |
| 0 | 26 (24.8) | 19 (10.6) | 45 (15.9) |
| 1 | 47 (44.8) | 100 (55.9) | 147 (51.8) |
| 2 | 19 (18.1) | 35 (19.6) | 54 (19.0) |
| ≥3 | 13 (12.4) | 25 (14.0) | 38 (13.4) |
| Household food insecurity status [e], n (%) | | | |
| Food secure | 59 (33.5) | 117 (66.5) | 176 (64.0) |
| Moderately food insecure | 24 (42.9) | 32 (57.1) | 56 (20.4) |
| Severely food insecure | 19 (44.2) | 24 (55.8) | 43 (15.6) |

[a] Standard Deviation (SD); [b] BMI z-score determined using WHO growth charts. Underweight (BMI z-score<-2); Healthy weight (BMI z-score -2 to 2); Overweight (BMI z-score>2). N=86 toddlers and N=163 pre-schoolers had anthropometric data; [c] Prioritised ethnicity – prioritised as listed; [d] Socioeconomic deprivation assessed using the NZ Index of Deprivation 2018; [e] Scoring system and household food security categories as described in the methods section

**Energy and nutrient intake from food groups**

Table 3 presents the average energy and nutrient intake contributed by food groups to consumers. The top five most commonly consumed food groups were 'grains and pasta' (98%), 'fruits' (94%), 'biscuits and cakes' (86%), 'mixed dishes' (85%), and 'dairy' (81%), respectively (see figure 1). In contrast, 'meat alternatives' (3%) were the least commonly consumed food group. More than half of participants consumed 'grains and pasta', 'biscuits and cakes', 'milk', 'dairy', 'fats and oils', 'fruits', 'vegetables', 'starchy vegetables', 'snacks', 'sugars and sweets', 'sauces and flavourings', and 'mixed dishes' at least once over two days.

Energy was mainly contributed by 'formulae,' 'mixed dishes,' 'grains and pasta,' 'breast milk,' and 'pies,' respectively. Most nutrients were primarily contributed by 'formulae' (10 out of 10 nutrients

examined) and ‘mixed dishes’ (8 out of 10 nutrients examined). Apart from ‘formulae’ and ‘mixed dishes,’ protein was primarily contributed by ‘poultry,’ ‘seafood,’ ’pies,’ and ‘processed meats.’ Similarly, ‘processed meats’ and ‘pies’ contributed substantially to fat and saturated fat intakes. The combined contribution of ’beverages’ and ‘sugars and sweets’ to total sugar intake is nearly equivalent to the contribution of ‘fruits’. ‘Formulae’ contributed more than seven times the iron contributed by ‘red meat.’

Table 3. Energy and nutrient intake from food groups in the diets of young NZ children (n=282)

| Food group | Consu-mers (n) | Mean contribution (SD) [a] to intake of consumers | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Energy (kJ) | Protein (g) | Fat (g) | Saturated fat (g) | Carbohy-drates (g) | Total sugars (g) | Fibre (g) | Iron (mg) | Calcium (mg) | Zinc (mg) | Vitamin C (mg) |
| Grains & pasta | 276 | ***908 (540)*** | 7.3 (4.7) | 3.3 (3.3) | 1.0 (1.4) | ***37.1 (21.2)*** | 4.3 (4.6) | ***3.7 (2.7)*** | ***2.0 (1.4)*** | 69 (74) | ***1.1 (0.7)*** | 1.4 (3.2) |
| Biscuits & cakes | 242 | 621 (486) | 2.7 (2.2) | 5.8 (5.4) | 2.7 (2.6) | ***20.7 (15.9)*** | 7.5 (8.0) | 1.0 (1.1) | 0.5 (0.7) | 27 (32) | 0.3 (0.3) | 0.4 (1.0) |
| Milk | 222 | 540 (430) | 7.1 (5.7) | 6.6 (5.5) | 3.8 (3.4) | 10.2 (8.1) | 9.7 (8.0) | 0.2 (0.7) | 0.1 (0.4) | ***270 (211)*** | 0.7 (0.6) | 0.6 (0.6) |
| Dairy | 228 | 493 (303) | 7.6 (18.5) | 6.0 (4.8) | 3.8 (3.0) | 9.5 (8.4) | 8.9 (7.9) | 0.2 (0.3) | 0.5 (5.5) | ***201 (131)*** | 0.8 (0.5) | 0.4 (1.1) |
| Fats and oils | 204 | 133 (143) | 0.0 (0.0) | 3.6 (3.9) | 1.2 (1.2) | 0.0 (0.0) | 0.0 (0.0) | 0.0 (0.0) | 0.0 (0.0) | 0 (0) | 0.0 (0.0) | 0.0 (0.0) |
| Eggs | 98 | 381 (339) | 7.3 (5.1) | 6.5 (6.5) | 2.1 (2.6) | 0.9 (2.6) | 0.6 (0.8) | 0.1 (0.5) | 0.8 (0.7) | 48 (74) | 0.6 (0.5) | 0.3 (2.0) |
| Red meat | 88 | 321 (288) | 8.3 (7.3) | 4.6 (4.6) | 1.7 (1.7) | 0.6 (2.0) | 0.1 (0.2) | 0.0 (0.1) | 0.7 (0.6) | 4 (6) | ***1.4 (1.4)*** | 0.1 (0.2) |
| Poultry | 114 | 541 (445) | ***11.8 (7.9)*** | 7.2 (7.3) | 2.0 (2.2) | 4.1 (5.1) | 0.4 (0.8) | 0.4 (0.6) | 0.5 (0.5) | 11 (12) | 0.7 (0.6) | 0.2 (0.4) |
| Processed meats | 87 | 616 (471) | ***8.7 (5.6)*** | ***10.4 (8.6)*** | ***4.2 (3.5)*** | 4.6 (4.6) | 0.6 (1.3) | 0.8 (0.9) | 0.8 (0.6) | 19 (20) | ***1.2 (1.2)*** | 0.3 (0.4) |
| Pies | 31 | ***817 (570)*** | ***8.7 (6.1)*** | ***11.5 (7.9)*** | ***5.6 (4.1)*** | 14.0 (12.5) | 1.2 (1.2) | 0.9 (0.8) | ***0.9 (0.7)*** | 54 (53) | 1.0 (0.9) | 1.4 (3.1) |
| Seafood | 36 | 367 (271) | ***8.9 (7.3)*** | 4.4 (4.2) | 1.2 (1.8) | 2.9 (4.2) | 0.4 (0.9) | 0.1 (0.2) | 0.4 (0.4) | 21 (55) | 0.3 (0.5) | 0.3 (0.5) |
| Meat alternatives | 8 | 431 (282) | 3.3 (2.0) | 6.7 (5.0) | 1.6 (1.4) | 6.8 (5.1) | 0.8 (0.5) | 1.5 (1.0) | ***1.0 (1.0)*** | 39 (50) | 0.4 (0.3) | 3.3 (5.4) |
| Fruits | 266 | 509 (336) | 1.5 (1.0) | 1.6 (4.0) | 0.3 (0.6) | ***23.5 (14.3)*** | ***20.7 (12.6)*** | ***3.4 (2.3)*** | 0.4 (0.3) | 26 (22) | 0.2 (0.2) | ***35.1 (38.3)*** |
| Vegetables | 198 | 160 (174) | 1.5 (1.6) | 1.0 (1.9) | 0.3 (0.7) | 4.7 (5.3) | 3.2 (3.0) | ***2.2 (2.0)*** | 0.4 (0.5) | 20 (21) | 0.3 (0.3) | ***12.3 (15.8)*** |
| Legumes | 38 | 177 (199) | 2.6 (3.4) | 1.3 (1.4) | 0.2 (0.3) | 4.2 (6.4) | 0.8 (1.8) | 1.6 (2.2) | 0.6 (0.8) | 21 (37) | 0.3 (0.4) | 0.6 (1.2) |

| Food group | Consu-mers (n) | Mean contribution (SD) [a] to intake of consumers | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Energy (kJ) | Protein (g) | Fat (g) | Saturated fat (g) | Carbohy-drates (g) | Total sugars (g) | Fibre (g) | Iron (mg) | Calcium (mg) | Zinc (mg) | Vitamin C (mg) |
| Starchy vegetables | 154 | 433 (386) | 1.8 (1.6) | 4.0 (4.6) | 1.2 (1.8) | 14.1 (11.9) | 1.1 (2.1) | 1.7 (1.4) | 0.4 (0.4) | 10 (19) | 0.2 (0.2) | 4.6 (6.1) |
| Nuts and seeds | 123 | 299 (463) | 2.4 (4.3) | 5.9 (9.0) | 1.0 (1.7) | 1.5 (2.6) | 0.9 (1.5) | 1.6 (2.2) | 0.3 (0.5) | 13 (27) | 0.4 (1.0) | 0.0 (0.2) |
| Snacks | 181 | 427 (358) | 1.6 (1.5) | 4.7 (4.5) | 1.4 (1.6) | 12.6 (10.9) | 2.3 (3.1) | 1.1 (1.1) | 0.4 (0.4) | 10 (12) | 0.3 (0.3) | 0.6 (0.9) |
| Sugars and sweets | 197 | 242 (314) | 0.5 (0.9) | 1.3 (2.7) | 0.7 (1.4) | 10.8 (14.0) | ***10.3 (12.8)*** | 0.1 (0.3) | 0.1 (0.2) | 10 (22) | 0.1 (0.1) | 0.5 (2.3) |
| Sauces and flavourings | 184 | 78 (213) | 0.6 (1.5) | 1.0 (4.5) | 0.2 (1.1) | 1.6 (3.3) | 1.2 (3.0) | 0.3 (0.4) | 0.5 (0.8) | 4 (13) | 0.1 (0.3) | 0.3 (0.6) |
| Beverages | 134 | 354 (287) | 2.6 (3.1) | 2.3 (3.7) | 1.2 (1.8) | 13.0 (10.0) | ***12.4 (9.7)*** | 0.6 (1.2) | 0.3 (0.5) | 88 (119) | 0.3 (0.4) | ***20.3 (30.0)*** |
| Supplements | 16 | 357 (324) | 5.2 (5.4) | 2.5 (2.4) | 0.7 (0.7) | 10.2 (10.1) | 6.6 (7.3) | 0.7 (0.8) | ***0.9 (1.2)*** | ***112 (140)*** | 0.4 (0.4) | 3.8 (4.8) |
| Mixed dishes | 241 | ***1168 (722)*** | ***14.5 (9.9)*** | ***11.1 (8.4)*** | ***4.5 (4.1)*** | ***28.5 (19.6)*** | 4.4 (3.7) | ***3.3 (2.8)*** | ***1.6 (1.4)*** | ***115 (127)*** | ***1.9 (1.6)*** | 5.1 (8.6) |
| Formulae | 41 | ***1333 (694)*** | ***9.5 (5.3)*** | ***13.1 (7.0)*** | ***6.0 (3.6)*** | ***39.4 (22.4)*** | ***27.6 (17.7)*** | ***2.5 (1.4)*** | ***5.1 (2.8)*** | ***420 (253)*** | ***2.7 (1.4)*** | ***38.4 (23.1)*** |
| Breast milk | 47 | ***864 (619)*** | 3.8 (2.7) | ***12.2 (8.7)*** | ***5.8 (4.1)*** | 20.5 (14.7) | ***20.5 (14.7)*** | 0 | 0.2 (0.1) | 101 (72) | 0.9 (0.6) | ***11.9 (8.5)*** |
| Commercial infant & toddler foods | 82 | 271 (279) | 1.6 (2.5) | 1.3 (1.8) | 0.5 (0.8) | 10.9 (10.9) | 5.8 (7.0) | 1.2 (1.4) | 0.6 (0.8) | 18 (27) | 0.3 (0.4) | 5.5 (6.4) |

[a]Standard Deviation (SD); [b]Sample size was insufficient to accurately estimate the mean (SD)

***Bolded and italicised highlight the top five food group sources (NB: Some food groups may have more than five top contributors due to instances where the fifth rank is shared)***

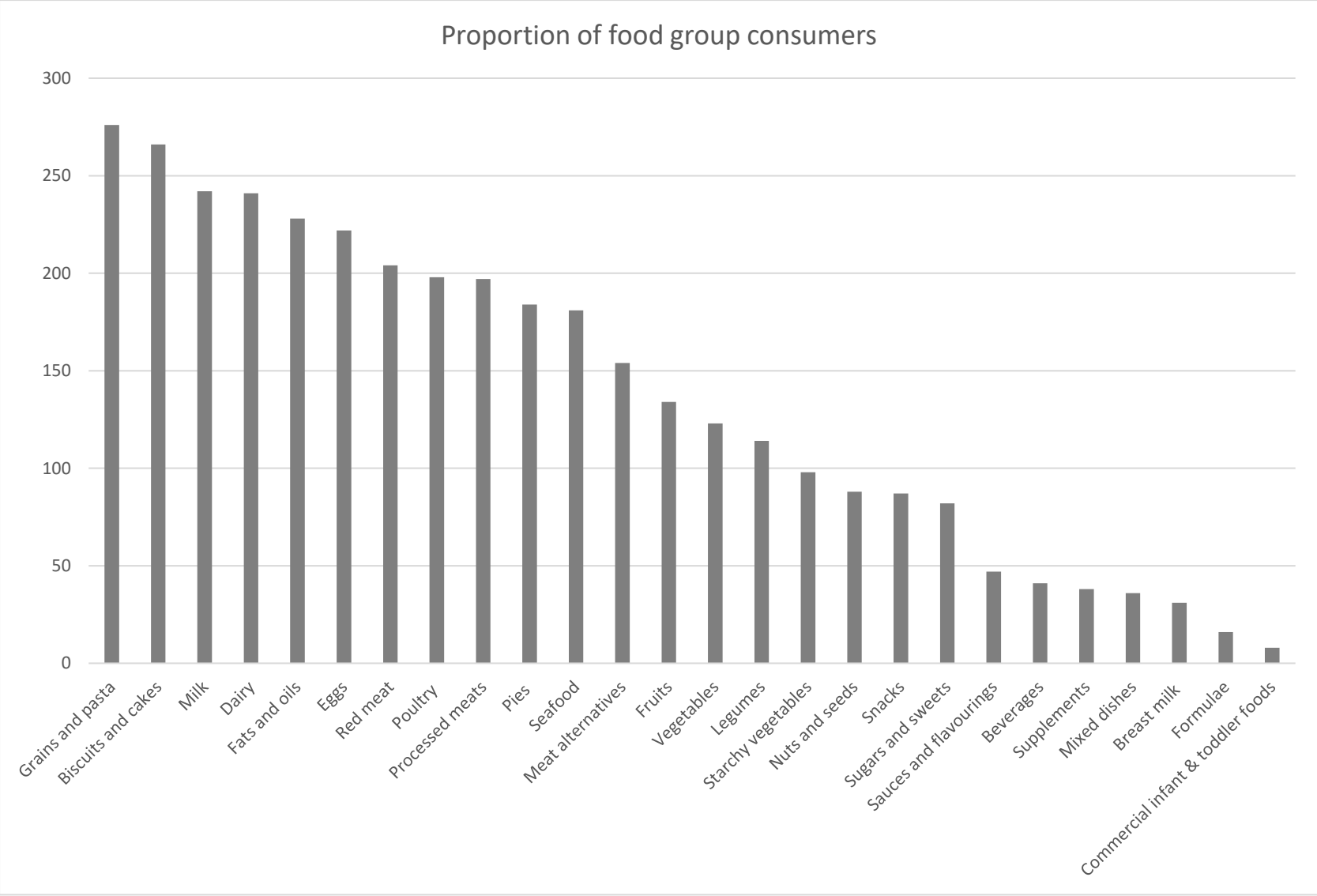


Figure 1. Proportion of consumers for each food group (arranged from highest to lowest)

**Comparison of food group consumption by anthropometric status, household food security status, and sociodemographic factors**

Supplementary table 1 presents the proportion of food group consumers based on anthropometric status. Compared to overweight children, a higher proportion of healthy-weight children consumed 'dairy' (p=0.036). No other statistically significant associations were observed in terms of other food groups.

Higher household food insecurity was associated with lower consumption of 'biscuits and cakes'(p=0.001), 'vegetables' (p=0.005), and 'nuts and seeds' (p=0.004) (supplementary table 2). Young children living in moderate food insecurity had the highest consumption of 'pies' (p=0.013) whilst those living in severely food insecure households had the highest proportion consuming 'starchy vegetables' (p=0.040), and 'beverages' (p=0.011).

Both Pacific and NZ European children had the highest proportion of 'grains and pasta' consumers (100%), followed by Māori (94.6%), and Asian (94.4%), respectively (p=0.011) (refer to supplementary table 3). The consumption of 'dairy' was found to be highest amongst NZ Europeans and the lowest for Pacific children (p=0.005). Māori had the lowest rate of consumption of 'seafood' at 2.7%. This proportion was 86% lower than that of Asian children with a consumption rate of 19.4%, the highest amongst all ethnic groups examined (p=0.008). NZ European children had the highest number of 'vegetables' and 'nuts and seeds' consumers followed by Asian, Māori, and Pacific (p<0.001). 'Beverage' consumption was the highest amongst Pacific young children (70.5%), almost double the consumption rate of NZ Europeans (38.3%) (p=0.002).

Supplementary table 4 displays food group consumption in terms of socioeconomic status. Young children living in areas of low socioeconomic deprivation had the highest consumption of 'dairy', followed by those who lived in areas of moderate and high socioeconomic deprivation, respectively (p=0.014). 'Fruits' (p=0.047) and 'meat alternatives' (p=0.042) were mostly consumed by young children in moderately deprived areas, whilst those living in areas of low socioeconomic deprivation were reported to have the lowest consumption rate out of the three socioeconomic groups.

**Comparison of food sources of energy by anthropometric status, household food security status, and sociodemographic factors**

Supplementary table 1 indicates the mean energy intake from food groups based on anthropometric status. Being overweight was shown to be significantly associated with a higher energy contribution from 'formulae' compared to those who have a healthy weight (p=0.039).

'Processed meats' contributed a considerable amount to the energy intake of moderately food insecure households, followed by severely food insecure households and food secure households, respectively (p=0.013) (supplementary table 2). Higher household food insecurity was significantly associated with higher energy contributions from 'snacks' (p=0.006), 'sugars and sweets' (p<0.001), and 'sauces and flavourings' (p<0.001).

Asian children had the lowest energy intake contribution from 'starchy vegetables' (p<0.001), 'sauces and flavourings' (p=0.015), and 'formulae' (p=0.047) (supplementary table 3). Conversely, Pacific children consistently had the highest energy intake contribution from 'poultry' (p<0.001), 'pies' (p=0.044), 'starchy vegetables' (p<0.001), 'sauces and flavourings' (p=0.015), and 'formulae' (p=0.047) across all ethnicities.

Supplementary table 4 displays the mean energy contributed by food groups based on socioeconomic status. 'Grains and pasta' contributed the highest energy intake of young children living in areas of low socioeconomic deprivation, compared with those living in moderately and highly deprived areas, respectively (p=0.015).

## Discussion

**Overall findings**

To our knowledge, this is the first study to provide comprehensive data on the food group intake and food sources of energy of a diverse sample of NZ children aged 1-3 years. The majority of children consumed 'grains and pasta', whilst 'meat alternatives' were the least consumed food group. High proportions of energy and nutrient intake were contributed by 'formulae' and 'mixed dishes'. Significant differences in the consumption and energy contribution of various food groups were observed based on anthropometric status, household food security status, ethnicity, and socioeconomic status.

**Food group consumption and their contribution to energy and key nutrients**

The three most consumed food groups by young NZ children are rich sources of carbohydrates. 'Grains and pasta,' 'fruits,' and 'biscuits and crackers' were all consumed by at least 85% of the sample. Since there is a lack of recent major surveys in NZ providing comprehensive dietary intake data and conducted in the same age group, there are a limited number of existing studies to compare our findings with. The 2002 National Children's Nutrition Survey (CNS), conducted amongst older children (aged 5 years and older), found a similar proportion of consumers of white bread and biscuits (28). The same survey indicated that only 40% of the children surveyed consumed fruit at least twice a day. This is well below our finding of 94% fruit consumers (see table 3). However, our study did not focus on the specific quantity or frequency of fruit intake; with any level of fruit consumption contributing to the overall proportion of fruit consumers.

A secondary analysis of a South Island based survey (n=188) conducted over 25 years ago, which only included non-breastfed children aged 1-2 years reported a high proportion of participants consuming white bread (28). However, this cannot be directly compared with our findings since white bread and other forms of grains such as rice, and pasta, were all aggregated under the 'grains and pasta' group for our analysis. One major difference observed was the sharp decline of more than 11 percentage points in the proportion of dairy milk consumers when compared to the South Island survey. Similar decreasing trends in dairy milk consumption amongst children have been reported in other high-income countries such as the United States (US) and Germany (29, 30). In the US, it is argued that the evidence of sugar-sweetened beverages offsetting dairy milk consumption is minimal, further suggesting that plant-based milk alternatives such as soy and almond milk may provide an explanation for the downward consumption trend as they compete with the sales of dairy milk (31). On the contrary, the observed proportion of consumers in the 'milk' group (table 3) which included dairy milk and milk alternatives (i.e., plant-based milks) in our study, was 79% (222/282) whilst the South Island survey reported 90% of dairy milk consumers. Therefore, the observed decreasing trend would have been sharper had the milk alternatives been categorised separately. This may also suggest that dairy milk consumption in NZ is more likely to be replaced by discretionary beverages or drinks that were listed under the 'beverage' group, such as sugar-sweetened beverages, coffee, and tea, rather than plant-based milks.

'Formulae', and 'mixed dishes' were the primary contributors of energy and most key nutrients for consumers. This is expected since both groups, specifically 'formulae', have relatively high energy and nutrient densities. The second primary contributor of iron was the 'grains and pasta' group

contributing an average of 2.0 (1.4) mg/day amongst consumers. However, the low bioavailability of iron from plant sources, due to anti-nutrients such as phytates chelating with iron, significantly decreases its absorption in the gastrointestinal tract (32). On the contrary, although 'red meat' contains a more readily absorbable form of iron, it was not a major source of iron in the diets of consumers, contributing only 0.7 (0.6) mg/day. Additionally, it is important to note that less than a third of the participants consumed 'red meat' (see figure 1). This possibly contributes to the low iron intake and the high prevalence of iron deficiency detected amongst young children in NZ (33-35).

Similarly, despite being a rich source of protein, 'red meat' was not a major contributor to protein intake of consumers. High protein intake has been consistently reported in previous NZ studies of young children (10, 11, 36-38). For instance, a double-blinded randomised trial aimed to assess the effect of 'low-protein young child formulae,' reported baseline protein intakes of almost four times the Estimated Average Requirement (EAR) amongst young NZ children (36). Most of the primary sources of protein, as well as other macronutrients such as fat and saturated fat, were contributed by the more processed forms of foods such as 'processed meats' and 'pies'. In a longitudinal study that involved young children living in Dunedin, NZ (n=669), it was revealed that ultra-processed foods (UPF) contributed a significant amount of energy to the diets of young children at ages 1, 2, and 5 years (13). Sausages were found to be one of the greatest contributors to energy intake from UPF at all ages. Emerging research presents the association of UPF consumption with lower diet quality, increased waist circumference, changes in blood lipid profile, and higher body mass index (BMI) amongst young children in both high-income and lower-middle-income countries (39-41).

Another notable finding of our study is the substantial contribution of 'beverages' to total sugar and vitamin C intake of consumers. As described in table 2, beverages include tea, coffee, drinking chocolate, fruit and vegetable juices, cordials, soft drinks, and other non-alcoholic beverages. This may be indicative of a significant proportion of our study sample consuming fruit juices or sugar-sweetened beverages that have been enriched or fortified with vitamin C, or vegetable juices that have sugar added. This suggests a potential overlap between the primary source of essential micronutrients (i.e., vitamin C) and the macronutrients that have been targeted for reduction due to adverse impacts on health such as total sugars (42). Therefore, limiting sugar-sweetened beverage intake and increasing whole fruit and vegetable consumption should be encouraged to increase vitamin C intake and decrease total sugar intake.

**Correlates of food group consumption in young NZ children**

*Anthropometric status*

In the comparison of groups based on anthropometric status, the lack of significant differences observed in the proportion of consumers of most food groups could be attributed to the uneven sample size of healthy weight and overweight participants. The number of overweight participants was very small (n=28), thus lacking sufficient statistical power to detect differences (43). Although slightly different in age range, the proportion of overweight participants in our study (11%) was well below the current national average of 23.1% for children aged 2-4 years (3). This is despite the fact that a substantial proportion of our participants live in areas of high socioeconomic deprivation, and are of Māori and Pacific descent, two demographic groups that are disproportionately affected by childhood obesity in NZ (44). However, the results of our study uphold this trend, since participants of Pacific ethnicity (table 6) and from areas of higher socioeconomic deprivation (table 7) were less likely to be 'dairy' consumers compared to their counterparts.

Consumption of 'dairy' was the only food group that showed a statistically significant difference between healthy and overweight participants. Similarly, the proportion of consumers consuming 'milk' was higher amongst healthy-weight participants compared to overweight participants, although this difference did not reach statistical significance. A recent systematic review and meta-analysis revealed a negative association between total dairy consumption and obesity amongst children and adolescents aged 2-21 years (45). However, this relationship was only observed from the pooled analysis of cross-sectional studies and not from the pooled analysis of prospective studies, thus limiting the establishment of causality since it is difficult to determine whether the exposure occurred prior to the outcome or vice versa.

A narrative review that analysed studies from high-income countries to determine the impact of dairy intake on early childhood weight gain, had mixed results with the majority of the studies showing both no association and an inverse association between dairy intake and obesity (46). In the few studies that presented positive associations between dairy intake and obesity, it was noted that those participants had a total protein intake of 15-20% of their energy. Therefore, the macronutrient intake distribution may play a role in the development of obesity amongst young NZ children. In a major survey of young children across NZ (n=1,329), overweight young children had higher odds of low or reduced-fat cow's milk consumption compared to those with a healthy weight (47).

*Household food security status*

Lower consumption of 'vegetables' and 'nuts and seeds' was associated with higher food insecurity. This is expected since these food groups have relatively higher costs and household food insecurity is primarily a function of income in NZ (18). Compared to food-secure households, severely food-insecure households had higher intakes of 'pies', 'starchy vegetables', and 'beverages', all of which were rich sources of carbohydrates that provide energy at a relatively cheaper cost. This is mirrored in the Growing Up in NZ (GUiNZ) study which reported that a higher frequency of consumption of energy-dense and nutrient-poor foods such as hot chips, soft drinks and sweets was associated with food insecurity at 9 months (48). A follow-up of this cohort at 4.5 years of age consistently showed a higher proportion of food-insecure children consuming soft-drinks and energy drinks more frequently compared to their food-secure counterparts (49). As such, young children from these households are at a higher risk of experiencing adverse health outcomes due to the poor quality of carbohydrates from these sources, compared to their food-secure counterparts.

*Ethnicity*

Our study revealed significant disparities in the proportion of food group consumers amongst various ethnic groups. Young NZ European children were the major consumers of 'grains and pasta,' 'dairy,' 'vegetables,' 'nuts and seeds,' 'snacks,' and 'sauces and flavourings'. Most of these food groups include nutritionally dense foods which contribute to the achievement of a nutritionally adequate and diverse diet. Conversely, children of Pacific ethnicity exhibited the highest rate of beverage consumption amongst all ethnicities, with nearly twice the proportion of NZ European children. As abovementioned, the beverage group included most fluids except for water and milk. The NZ Ministry of Health's Food and Nutrition Guidelines for children aged 0-2 years advise against the consumption of fluids other than water and milk (50). Parallel to this, the guidelines for children aged 2-18 years recommend restricting the intake of non-water and non-milk fluids such as cordial, fruit drinks, fruit juice, sports drinks, and fizzy drinks (51). This is due to the coherent evidence highlighting the association between the consumption of other beverages, specifically sugar-sweetened beverages and weight gain (52), obesity (53), and the development of dental caries (54).

Amongst 'seafood' consumers, the largest group comprised young Asian children, whereas the group with the least proportion of consumers were Māori children, having 86% fewer consumers than young Asian children. This is a stark contrast to the traditional Māori diet which had a substantial contribution of seafood (Kaimoana), especially for marae with close proximity to the sea (55). Due to

barriers to Māori food sovereignty such as the depletion of aquatic resources due to water pollution and the harvest quota imposed on seafood, its consumption has been challenging for the Māori communities in NZ (56).

*Socioeconomic status*

Children living in areas of higher socioeconomic deprivation have lower consumption rates of 'dairy'. Although a similar consumption pattern was observed for 'milk', this observation was not deemed statistically significant. As mentioned above, these products include cream, cheese, yoghurt, etc., most of which are relatively good sources of calcium. Calcium is an essential nutrient for growth and development during early childhood (57-59). Consequently, this could mean that young children living in areas of higher socioeconomic deprivation are potentially at higher risk of not reaching their full potential for growth and development.

In terms of fruit intake, our findings were not aligned with the results of the 2021/22 NZ Health Survey which determined that a higher proportion of children were able to meet the recommended amount of fruit per day as their level of socioeconomic deprivation decreased (3). Multiple factors may have contributed to this, including the fact that our study was not focused on the proportion of participants meeting the recommended amount of intake but on the proportion of consumers for each socioeconomic group instead. Also, the larger age range (i.e., children aged 2-14 years) and the wider geographic areas covered by the NZ Health survey may have played a role in this difference.

**Correlates of food sources of energy in young NZ children**

A significantly higher energy contribution from 'formulae' was observed amongst overweight children compared to those who had a healthy weight. Despite providing similar amounts of energy, this was not the case for breast milk since coherent evidence points to its protective effect against obesity later in life (60-62). A systematic review found that the higher protein content of formula may have potentially contributed to the rapid weight gain amongst infants, which is closely associated with obesity later in childhood (63). This is the "Early Protein Hypothesis", which was tested through a randomised controlled trial in five European countries called the Early Childhood Obesity Project (CHOP), which found that high milk protein intake during infancy increases the risk of

later obesity (64). However, since this is not an objective of our study, the relationship between food sources of protein and anthropometric status was not investigated.

In terms of household food security status, higher energy contributions from 'snacks,' 'sugars and sweets,' and 'sauces and flavourings' were associated with higher household food insecurity. Most of these are relatively low-cost, high-energy and nutrient-poor foods, which, if consumed in excess, are associated with obesity (65, 66). Household food insecurity has been associated with early childhood obesity in NZ. The findings of the NZ Health surveys conducted in 2014/15 and 2015/16 revealed a higher proportion of healthy-weight young children living in food-secure households than those who were overweight or obese (18). Conversely, a higher proportion of overweight or obese young children were found in households classified as severely to moderately food insecure.

Parallel to this, young children living in moderately food insecure households had the highest proportion of energy contributed by 'processed meats', almost twice as much as the energy contribution for food secure households. Higher consumption of cheaper, highly processed, and energy-dense meats such as sausages and saveloys has been observed in food insecure households compared to those that are food secure (67). These disparities may reflect the decreased financial capacity of food-insecure households to purchase low-energy and protein-rich foods such as lean meats, chicken meat, and lean minced meats.

Out of the six food groups that reached statistical significance from the comparison in terms of ethnicity, five food groups (i.e., 'poultry,' 'pies,' 'starchy vegetables,' 'sauces and flavourings,' and 'formulae') contributed the highest mean energy intake amongst Pacific young children compared to all ethnic groups examined. More than two decades ago, a birth cohort study of Pacific children in Auckland, NZ found a negative correlation between the energy density and cost of foods that Pacific mothers would still buy when the variety of foods had been limited due to a lack of financial resources (68). A cost-modelling study that analysed Pacific household diets revealed that the energy of the current Pacific household diet is well above the energy requirement of a modelled healthy diet (69). The current economic crisis may have potentially forced Pacific households to purchase low-cost high-energy foods as reflected by the 2021/22 NZ Health Survey which indicated that only 1.2% of Pacific children were able to meet the recommended amount of fruit and vegetable servings per day whilst 22.6% and 18.6% had frequent fizzy drinks and fast-food consumption, respectively (3). The high energy contribution of these food groups may be reflected in the high proportion of early childhood obesity in Pacific communities in NZ. A cross-sectional study of young Pacific children living in Dunedin found that higher energy intake was significantly associated with obesity (70). However,

data from this study was collected from a small sample within a specific region of NZ between 1998 and 1999, limiting its reliability and generalisability.

'Grains and pasta' were the only food group that exhibited a statistically significant difference in contribution to energy intake across socioeconomic groups. Children living in areas of higher socioeconomic deprivation were more likely to consume less energy from 'grains and pasta.' These food groups may potentially provide complex carbohydrates, thus increasing intakes of fibre and other essential nutrients. However, since our study only analysed the energy contribution of food groups, we were unable to identify whether highly socioeconomically deprived children consumed less quantities of 'grains and pasta' or instead opted for greater amounts of low-energy-dense 'grains and pasta.' In the abovementioned cost-modelling study, it was reported that the current diet of NZ households (based on the 2008/09 Adult Nutrition Survey and the 2002 Children's Nutrition Survey) had less amount of 'grains' when compared to the healthy modelled diet (69). Although the basis of the current diet in this study did not include the dietary intake of children under five years, this suggests the need to consume more foods from the 'grains and pasta' group to improve the overall diet quality of socioeconomically disadvantaged households.

**Strengths and limitations**

One of the primary strengths of our study is the diversity of our sample which was carefully recruited and screened to provide an adequate representation of Māori, Pacific, and young children living in areas of high socioeconomic deprivation, which is often a challenge in most NZ studies. This contributes to the generalisability of our findings to a broader population, thereby enhancing the external validity of our study. However, there are specific study limitations that warrant a discussion. For instance, since our study utilised two 24-hour food recall, foods that have been consumed habitually may not have been captured due to the limitations of our dietary assessment tool. Another limitation of our study is the use of proxy reporting by parents and other caregivers to measure the dietary intake of young children, which may be a potential source of bias, impacting the validity of our findings.

It is also important to acknowledge the limitations in the categorisation of food items into specific food groups used in our study. For instance, the protein sourced from eggs was mainly categorised under the 'eggs' group. However, eggs used as ingredients in other foods like pasta and baked goods were not disaggregated for analysis. As a result, the protein contributed by eggs within these mixed foods was not allocated to the 'eggs' category. As such, caution must be exercised when comparing

our findings with other studies that analysed the nutrient contribution of foods. Lastly, the method employed in this study to estimate directly-consumed breast milk volume was based on a national US survey, whilst the nutrient density of breast milk was obtained from a standardised nutrient profile and not based on actual participant samples. It is important to highlight the inherent variability in the volume and nutrient composition of breastmilk as it is influenced by several factors such as maternal dietary intake (71), BMI, age, and parity (72), and child-related factors such as birth weight, age, and stage of lactation (73).

## Conclusion

In conclusion, the nutrient intake of young NZ children may be improved through effective policies and programmes targeting the reduction of sugar-sweetened beverages and refined carbohydrates and the replacement of highly processed meats with lean red meats. Promotion of dairy products and their alternatives may be a prudent measure to foster healthier weights amongst young children as it was shown through our findings that their consumption was associated with healthy weights amongst young children. Relatively low-cost foods that have high energy and poor nutrient density were primary contributors to energy amongst young children living in areas of high socioeconomic deprivation, in food-insecure households, and of Pacific ethnicity. Therefore, it is imperative to focus on addressing broader health determinants such as poverty or low income for these vulnerable groups in order to overcome the disparities in nutrient intake, thereby contributing to the achievement of equitable health outcomes amongst young NZ children.

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## Supplementary tables

Supplementary table 1. Food group contribution to the diets of young NZ children aged 1-3 years old, by anthropometric status

| Food group | Consumers % | | p – value | Mean intake in consumers (kJ [a]/day) | | p-value |
|---|---|---|---|---|---|---|
| | Healthy weight (n=214) | Overweight (n=28) | | Healthy weight | Overweight | |
| Grains and Pasta | 97.7 | 96.4 | 0.526 | 930 (535) | 916 (609) | 0.900 |
| Biscuits, crackers, cakes and desserts | 88.3 | 82.1 | 0.361 | 620 (472) | 778 (710) | 0.158 |
| Milk and milk-alternatives | 80.4 | 78.6 | 0.803 | 542 (409) | 733 (611) | 0.055 |
| ***Dairy products and dairy-alternative products*** | ***84.6*** | ***67.9*** | ***0.036*** | 499 (296) | 591 (423) | 0.223 |
| Fats and oils | 73.8 | 64.3 | 0.286 | 132 (144) | 153 (176) | 0.553 |
| Eggs and egg dishes | 35.5 | 28.6 | 0.532 | 339 (299) | 508 (472) | 0.155 |
| Red meats | 30.8 | 35.7 | 0.601 | 332 (283) | 358 (427) | 0.804 |
| Poultry | 41.1 | 32.1 | 0.417 | 570 (455) | 591 (472) | 0.895 |
| Sausages and processed meats | 30.4 | 32.1 | 0.830 | 602 (429) | 783 (866) | 0.310 |
| Pies and pasties | 9.8 | 21.4 | 0.101 | 710 (581) | 932 (486) | 0.404 |
| Fish and seafood | 13.1 | 10.7 | >0.999 | 396 (260) | 312 (485) | 0.630 |
| Vegetarian/vegan meat alternatives [b] | 3.3 | 0.0 | >0.999 | - | - | - |
| Fruits | 93.9 | 96.4 | >0.999 | 530 (353) | 456 (309) | 0.301 |
| Vegetables | 69.6 | 60.7 | 0.339 | 149 (158) | 217 (266) | 0.128 |
| Mature legumes and pulses | 14.0 | 7.1 | 0.551 | 197 (214) | 15 (21) | 0.248 |

| Food group | Consumers % | | p – value | Mean intake in consumers (kJ [a]/day) | | p-value |
|---|---|---|---|---|---|---|
| | Healthy weight (n=214) | Overweight (n=28) | | Healthy weight | Overweight | |
| Potatoes, kūmara [c] and taro | 54.7 | 60.7 | 0.545 | 423 (385) | 557 (420) | 0.190 |
| Nuts and Seeds | 45.3 | 35.7 | 0.335 | 278 (475) | 356 (249) | 0.611 |
| Snacks | 63.6 | 64.3 | 0.939 | 446 (386) | 494 (236) | 0.607 |
| Sugar, confectionery, and sweet spreads | 69.6 | 71.4 | >0.999 | 246 (324) | 264 (348) | 0.820 |
| Savoury sauces, condiments, herbs/spices, and other flavourings | 65.4 | 50.0 | 0.111 | 86 (238) | 38 (38) | 0.454 |
| Beverages | 48.1 | 53.6 | 0.588 | 369 (302) | 294 (229) | 0.353 |
| Dietary supplements | 5.6 | 3.6 | >0.999 | 316 (269) | 262 (0) | 0.851 |
| Mixed dishes | 83.6 | 82.1 | 0.790 | 1,171 (726) | 1,317 (722) | 0.362 |
| Formulae | 12.6 | 14.3 | 0.766 | ***1,254 (683)*** | ***2,084 (947)*** | ***0.039*** |
| Breast milk | 16.4 | 10.7 | 0.586 | 822 (645) | 1,107 (655) | 0.468 |
| Commercial infant & toddler foods | 28.5 | 28.6 | >0.999 | 265 (283) | 225 (225) | 0.700 |

[a] Kilojoule; [b] Sample size was insufficient to accurately estimate the mean (SD); [c] NZ equivalent of sweet potato

Supplementary table 2. Food group contribution to the diets of young NZ children aged 1-3 years old, by household food insecurity status

| Food group | Consumers % | | | p – value | Mean (SD) intake in consumers (kJ[a]/day) | | | p – value |
|---|---|---|---|---|---|---|---|---|
| | Food secure (n=176) | Moderately food insecure (n=56) | Severely food insecure (n=43) | | Food secure | Moderately food insecure | Severely food insecure | |
| Grains and Pasta | 98.3 | 96.4 | 100.0 | 0.527 | 959 (533) | 799 (531) | 849 (566) | 0.121 |
| Biscuits, crackers, cakes and desserts | ***90.9*** | ***83.9*** | ***67.4*** | ***0.001*** | 633 (461) | 665 (623) | 528 (390) | 0.478 |
| Milk and milk-alternatives | 77.3 | 78.6 | 83.7 | 0.700 | 559 (402) | 561 (431) | 481 (540) | 0.614 |
| Dairy products and dairy-alternative products | 83.5 | 76.8 | 72.1 | 0.180 | 506 (313) | 454 (321) | 449 (204) | 0.461 |
| Fats and oils | 76.1 | 73.2 | 62.8 | 0.206 | 121 (120) | 162 (192) | 152 (164) | 0.208 |
| Eggs and egg dishes | 38.1 | 35.7 | 25.6 | 0.309 | 325 (310) | 503 (374) | 500 (387) | 0.054 |
| Red meats | 33.5 | 28.6 | 30.2 | 0.759 | 282 (274) | 324 (179) | 497 (395) | 0.050 |
| Poultry | 36.9 | 48.2 | 44.2 | 0.279 | 477 (329) | 607 (598) | 600 (506) | 0.324 |
| Sausages and processed meats | 30.1 | 26.8 | 32.6 | 0.816 | ***512 (384)*** | ***916 (531)*** | ***639 (620)*** | ***0.013*** |
| Pies and pasties | ***6.3*** | ***17.9*** | ***16.3*** | ***0.013*** | 797 (493) | 666 (464) | 614 (508) | 0.709 |
| Fish and seafood | 16.5 | 7.1 | 7.0 | 0.093 | 347 (274) | 593 (189) | 251 (237) | 0.178 |
| Vegetarian/vegan meat alternatives[b] | 4.0 | 1.8 | 0.0 | 0.510 | - | - | - | - |
| Fruits | 94.9 | 94.6 | 90.7 | 0.521 | 523 (338) | 539 (388) | 406 (240) | 0.117 |

| Food group | Consumers % | | | p – value | Mean (SD) intake in consumers (kJ[a]/day) | | | p – value |
|---|---|---|---|---|---|---|---|---|
| | Food secure (n=176) | Moderately food insecure (n=56) | Severely food insecure (n=43) | | Food secure | Moderately food insecure | Severely food insecure | |
| Vegetables | ***77.3*** | ***66.1*** | ***53.5*** | ***0.005*** | 155 (161) | 161 (169) | 203 (246) | 0.471 |
| Mature legumes and pulses | 16.5 | 8.9 | 4.7 | 0.076 | 173 (205) | 172 (205) | 250 (312) | 0.879 |
| Potatoes, kūmara [c] and taro | ***52.8*** | ***48.2*** | ***72.1*** | ***0.040*** | 389 (410) | 405 (261) | 567 (371) | 0.078 |
| Nuts and Seeds | ***51.1*** | ***35.7*** | ***25.6*** | ***0.004*** | 331 (514) | 214 (283) | 240 (263) | 0.541 |
| Snacks | 63.1 | 66.1 | 65.1 | 0.908 | ***364 (270)*** | ***497 (296)*** | ***583 (622)*** | ***0.006*** |
| Sugar, confectionery, and sweet spreads | 72.7 | 71.4 | 60.5 | 0.283 | ***191 (204)*** | ***219 (189)*** | ***500 (634)*** | ***<0.001*** |
| Savoury sauces, condiments, herbs/spices, and other flavourings | 68.2 | 60.7 | 55.8 | 0.245 | ***48 (83)*** | ***60 (93)*** | ***236 (512)*** | ***<0.001*** |
| Beverages | ***42.6*** | ***42.9*** | ***67.4*** | ***0.011*** | 322 (305) | 368 (221) | 395 (292) | 0.476 |
| Dietary supplements | 4.6 | 3.6 | 14.0 | 0.067 | 327 (262) | 160 (220) | 462 (424) | 0.520 |
| Mixed dishes | 86.9 | 83.9 | 79.1 | 0.398 | 1,162 (695) | 1,090 (681) | 1,274 (882) | 0.527 |
| Infant formulae | 15.9 | 12.5 | 14.0 | 0.883 | 1,212 (689) | 1,571 (568) | 1,618 (969) | 0.267 |
| Breast milk | 14.2 | 17.9 | 23.3 | 0.336 | 959 (703) | 668 (437) | 624 (290) | 0.214 |
| Commercial infant & toddler foods | 33.5 | 21.4 | 20.9 | 0.103 | 252 (239) | 319 (326) | 374 (445) | 0.412 |

[a] Kilojoule; [b] Sample size was insufficient to accurately estimate the mean (SD); [c] NZ equivalent of sweet potato

Supplementary table 3. Food group contribution to the diets of young NZ children aged 1-3 years old, by ethnicity

| Food group | Consumers % | | | | p - value | Mean intake in consumers (kJ[a]/day) | | | | p-value |
|---|---|---|---|---|---|---|---|---|---|---|
| | Māori (n=74) | Pacific (n=44) | Asian (n=36) | European & others (n=128) | | Māori | Pacific | Asian | European & others | |
| Grains and Pasta | ***94.6*** | ***100.0*** | ***94.4*** | ***100.0*** | ***0.011*** | 829 (520) | 941 (610) | 1,008 (439) | 912 (549) | 0.423 |
| Biscuits, crackers, cakes and desserts | 81.1 | 77.3 | 88.9 | 90.6 | 0.079 | ***497 (318)*** | ***735 (625)*** | ***800 (546)*** | ***603 (479)*** | ***0.016*** |
| Milk and milk-alternatives | 73.0 | 84.1 | 72.2 | 82.0 | 0.263 | 468 (520) | 540 (405) | 661 (463) | 547 (374) | 0.307 |
| Dairy products and dairy-alternative products | ***79.7*** | ***63.6*** | ***77.8*** | ***88.3*** | ***0.005*** | 499 (260) | 453 (329) | 543 (370) | 488 (302) | 0.729 |
| Fats and oils | 66.2 | 65.9 | 75.0 | 77.3 | 0.257 | 134 (109) | 186 (239) | 103 (85) | 125 (131) | 0.142 |
| Eggs and egg dishes | 37.8 | 27.3 | 36.1 | 35.2 | 0.697 | 466 (380) | 444 (474) | 492 (377) | 279 (224) | 0.053 |
| Red meats | 29.7 | 40.9 | 36.1 | 27.3 | 0.348 | 322 (211) | 454 (405) | 350 (333) | 242 (217) | 0.084 |
| Poultry | 44.6 | 45.5 | 38.9 | 36.7 | 0.623 | ***449 (425)*** | ***909 (629)*** | ***584 (346)*** | ***436 (295)*** | ***<0.001*** |
| Sausages and processed meats | 31.1 | 29.6 | 33.3 | 30.5 | 0.985 | 588 (442) | 824 (411) | 505 (414) | 598 (516) | 0.347 |
| Pies and pasties | 13.5 | 11.4 | 2.8 | 11.7 | 0.365 | ***541 (271)*** | ***1,397 (789)*** | ***1,031 (0)*** | ***794 (541)*** | ***0.044*** |
| Fish and seafood | ***2.7*** | ***15.9*** | ***19.4*** | ***15.6*** | ***0.008*** | 182 (257) | 385 (389) | 404 (315) | 366 (220) | 0.794 |
| Vegetarian/vegan meat alternatives[b] | 1.4 | 0.0 | 2.8 | 4.7 | 0.394 | - | - | - | - | - |

| Food group | Consumers % | | | | p - value | Mean intake in consumers (kJ[a]/day) | | | | p-value |
|---|---|---|---|---|---|---|---|---|---|---|
| | Māori (n=74) | Pacific (n=44) | Asian (n=36) | European & others (n=128) | | Māori | Pacific | Asian | European & others | |
| Fruits | 96.0 | 90.9 | 86.1 | 96.9 | 0.056 | 471 (275) | 516 (398) | 544 (370) | 520 (339) | 0.703 |
| Vegetables | ***62.2*** | ***47.7*** | ***69.4*** | ***82.8*** | ***<0.001*** | 173 (178) | 224 (259) | 88 (94) | 159 (161) | 0.058 |
| Mature legumes and pulses | 12.2 | 4.6 | 25.0 | 14.1 | 0.068 | 172 (190) | 38 (21) | 251 (264) | 157 (175) | 0.510 |
| Potatoes, kūmara[c] and taro | 58.1 | 63.6 | 38.9 | 53.9 | 0.143 | ***420 (382)*** | ***740 (555)*** | ***335 (293)*** | ***336 (235)*** | ***<0.001*** |
| Nuts and Seeds | ***39.2*** | ***25.0*** | ***50.0*** | ***50.8*** | ***0.018*** | 205 (239) | 231 (244) | 177 (182) | 386 (591) | 0.172 |
| Snacks | ***63.5*** | ***61.4*** | ***38.9*** | ***72.7*** | ***0.003*** | 472 (521) | 529 (282) | 383 (217) | 381 (282) | 0.197 |
| Sugar, confectionery, and sweet spreads | 70.3 | 59.1 | 72.2 | 72.7 | 0.392 | 285 (437) | 331 (378) | 199 (218) | 204 (218) | 0.182 |
| Savoury sauces, condiments, herbs/spices, and other flavourings | ***55.4*** | ***59.1*** | ***50.0*** | ***77.3*** | ***0.001*** | ***113 (347)*** | ***178 (319)*** | ***18 (22)*** | ***47 (71)*** | ***0.015*** |
| Beverages | ***52.7*** | ***70.5*** | ***41.7*** | ***38.3*** | ***0.002*** | 405 (284) | 352 (213) | 386 (346) | 305 (311) | 0.416 |
| Dietary supplements | 6.8 | 2.3 | 5.6 | 6.3 | 0.822 | 331 (257) | 4.7 (0) | 420 (35) | 401 (407) | 0.740 |
| Mixed dishes | 82.4 | 81.8 | 91.7 | 86.7 | 0.516 | 1,195 (725) | 1,215 (639) | 1,135 (755) | 1,147 (744) | 0.941 |
| Formulae | 18.9 | 6.8 | 22.2 | 12.5 | 0.143 | ***1,674 (725)*** | ***1,730 (570)*** | ***989 (577)*** | ***1,132 (620)*** | ***0.047*** |

| Food group | Consumers % | | | | p - value | Mean intake in consumers (kJ[a]/day) | | | | p-value |
|---|---|---|---|---|---|---|---|---|---|---|
| | Māori (n=74) | Pacific (n=44) | Asian (n=36) | European & others (n=128) | | Māori | Pacific | Asian | European & others | |
| Breast milk | 17.6 | 18.2 | 16.7 | 15.6 | 0.971 | 872 (666) | 940 (792) | 502 (357) | 937 (578) | 0.496 |
| Commercial infant & toddler foods | 29.7 | 18.2 | 25.0 | 33.6 | 0.252 | 382 (380) | 315 (392) | 169 (135) | 228 (194) | 0.115 |

[a] Kilojoule; [b] Sample size was insufficient to accurately estimate the mean (SD); [c] NZ equivalent of sweet potato

Supplementary table 4. Food group contribution to the diets of young NZ children aged 1-3 years old, by socioeconomic status (n=282)

| Food group | Consumers % | | | p – value | Mean intake in consumers (kJ[a]/day) | | | p-value |
|---|---|---|---|---|---|---|---|---|
| | Low (n=76) | Moderate (n=124) | High (n=82) | | Low | Moderate | High | |
| Grains and Pasta | 98.7 | 97.6 | 97.6 | >0.999 | ***1,053 (587)*** | ***884 (514)*** | ***808 (510)*** | ***0.015*** |
| Biscuits, crackers, cakes and desserts | 92.1 | 86.3 | 79.3 | 0.078 | 540 (353) | 624 (495) | 705 (578) | 0.143 |
| Milk and milk-alternatives | 81.6 | 79.8 | 74.4 | 0.501 | 500 (435) | 521 (408) | 611 (457) | 0.305 |
| Dairy products and dairy-alternative products | ***90.8*** | ***79.8*** | ***73.2*** | ***0.014*** | 511 (339) | 482 (295) | 492 (276) | 0.835 |
| Fats and oils | 73.7 | 68.6 | 76.8 | 0.410 | 101 (73) | 146 (166) | 144 (154) | 0.149 |
| Eggs and egg dishes | 36.8 | 33.9 | 34.2 | 0.904 | 363 (329) | 376 (361) | 406 (324) | 0.888 |
| Red meats | 23.7 | 34.7 | 32.9 | 0.245 | 282 (250) | 311 (295) | 363 (304) | 0.622 |
| Poultry | 36.8 | 41.9 | 41.5 | 0.756 | 506 (368) | 480 (492) | 663 (414) | 0.156 |
| Sausages and processed meats | 34.2 | 28.2 | 31.7 | 0.660 | 504 (392) | 671 (409) | 655 (603) | 0.347 |
| Pies and pasties | 10.5 | 14.5 | 6.1 | 0.176 | 692 (561) | 850 (554) | 900 (733) | 0.770 |
| Fish and seafood | 11.8 | 14.5 | 11.0 | 0.745 | 340 (269) | 333 (254) | 460 (315) | 0.503 |
| Vegetarian/vegan meat alternatives[b] | ***0.0*** | ***5.7*** | ***1.2*** | ***0.042*** | - | - | - | - |
| Fruits | ***89.5*** | ***97.6*** | ***93.9*** | ***0.047*** | 541 (332) | 512 (324) | 477 (357) | 0.519 |
| Vegetables | 75.0 | 71.8 | 63.4 | 0.248 | 173 (199) | 172 (174) | 126 (139) | 0.253 |
| Mature legumes and pulses | 13.2 | 15.3 | 11.0 | 0.681 | 71 (65) | 209 (199) | 226 (264) | 0.144 |
| Potatoes, kūmara[c] and taro | 46.1 | 53.2 | 64.6 | 0.059 | 375 (343) | 401 (355) | 511 (440) | 0.180 |
| Nuts and Seeds | 47.4 | 44.4 | 39.0 | 0.558 | 283 (289) | 377 (628) | 183 (197) | 0.163 |

| Food group | Consumers % | | | p – value | Mean intake in consumers (kJ[a]/day) | | | p-value |
|---|---|---|---|---|---|---|---|---|
| | Low (n=76) | Moderate (n=124) | High (n=82) | | Low | Moderate | High | |
| Snacks | 61.8 | 65.3 | 64.6 | 0.879 | 392 (249) | 394 (287) | 507 (504) | 0.151 |
| Sugar, confectionery, and sweet spreads | 65.8 | 71.0 | 72.0 | 0.657 | 190 (194) | 231 (337) | 301 (354) | 0.169 |
| Savoury sauces, condiments, herbs/spices, and other flavourings | 65.8 | 62.9 | 68.3 | 0.724 | 41 (70) | 68 (145) | 125 (337) | 0.112 |
| Beverages | 43.4 | 47.6 | 51.2 | 0.618 | 384 (290) | 369 (331) | 309 (209) | 0.467 |
| Dietary supplements | 6.6 | 4.0 | 7.3 | 0.514 | 473 (200) | 131 (148) | 449 (437) | 0.172 |
| Mixed dishes | 89.5 | 86.3 | 80.5 | 0.270 | 1,208 (786) | 1,070 (670) | 1,284 (725) | 0.145 |
| Formulae | 18.4 | 13.7 | 12.2 | 0.508 | 1,176 (547) | 1,306 (609) | 1,598 (966) | 0.343 |
| Breast milk | 10.5 | 16.1 | 23.2 | 0.108 | 843 (652) | 961 (711) | 778 (513) | 0.650 |
| Commercial infant & toddler foods | 29.0 | 28.2 | 30.5 | 0.940 | 245 (316) | 272 (310) | 294 (195) | 0.840 |

[a] Kilojoule; [b] Sample size was insufficient to accurately estimate the mean (SD); [c] NZ equivalent of sweet potato

# Chapter 5: Household food insecurity and associations with anthropometric status, sociodemographic characteristics and energy and nutrient intake in young NZ children

This manuscript-style chapter describes the household food security status of young children living in NZ. The association between household food insecurity and anthropometric, sociodemographic, and household characteristics was explored. This chapter was concluded by presenting the differences in energy and nutrient intake amongst different household food security groups.

## Abstract

**Background/Aim:** Although food insecurity affects a significant proportion of young children in New Zealand (NZ), evidence of its association with dietary intake and sociodemographic characteristics in this population is lacking. This study aims to assess the household food security status of young NZ children and its association with anthropometric status, sociodemographic factors, and energy and nutrient intake.

**Methods:** This study included 289 caregiver and child (1-3 years old) dyads from the same household in either Auckland, Wellington, or Dunedin, NZ. Household food security status (food secure, moderately food insecure, or severely food insecure) was determined using a validated and NZ-specific eight-item questionnaire. Anthropometric status was determined using the Body Mass Index (BMI) z-score. Sociodemographic factors (ethnicity, caregiver education, employment status, household size, and structure) were collected from questionnaires, with the NZ Index of Deprivation used as a proxy method of socioeconomic status. Dietary intake from two 24-hour diet recalls, using the multiple source method was used to determine usual dietary intake. The prevalence of inadequate nutrient intake was assessed using the Estimated Average Requirement (EAR) cut-point method and the full probability approach. A one-way ANOVA F-test was utilised to examine the differences in continuous demographic variables, and Fisher's exact test was used to assess the differences in categorical demographic variables across the household food security categories. Linear regression models were employed to assess the differences in energy and nutrient intakes based on household food security status.

**Results:** Over 30% of young NZ children experienced food insecurity in the past 12 months. Of all eight indicator statements, "the variety of foods we are able to eat is limited by a lack of money," had the highest proportion of participants responding "often" or "sometimes" (35.8%). Household food insecurity was significantly associated with being overweight ($p=0.002$); of Māori or Pacific ethnicity ($p<0.001$); living in areas of high deprivation ($p<0.001$); having a caregiver who was younger ($p<0.001$), not in paid employment ($p<0.001$) or having low educational attainment ($p<0.001$); living with at least two other children in the household ($p<0.001$), and living in a sole parent household ($p<0.001$). Moderately food insecure children exhibited higher fat and saturated fat intakes, consuming 3.0 (0.2, 5.8) g/day more fat, and 2.0 (0.6, 3.5) g/day more saturated fat compared to food secure children ($p<0.05$). Severely food-insecure children had lower g/kg/day protein intake compared to food-secure children ($p<0.05$). In comparison to food-secure children, moderately and severely food-insecure children had lower fibre intake, consuming 1.6 (2.8, 0.3) g/day and 2.6 (4.0, 1.2) g/day less fibre, respectively. No associations were found between household food insecurity and energy and micronutrient (i.e., calcium, iron, zinc and vitamin C) intake. However, severely food

insecure children had the highest prevalence of inadequate calcium (7.0%) and vitamin C (9.3%) intakes, compared with food secure children [prevalence of inadequate intakes: calcium (2.3%) and vitamin C (2.8%)].

**Conclusion:** Food insecurity was associated with being overweight and various sociodemographic factors that are closely linked with poverty or low income. Food-insecure young NZ children consume a diet that exhibits lower nutritional quality in certain measures compared to their food-secure counterparts. As such, there is an urgent need for poverty-mitigation programmes and policies to safeguard vulnerable young children from the adverse consequences of food insecurity.

## Introduction

Food security is a multi-dimensional phenomenon that is influenced by various socioeconomic factors such as poverty, health, sanitation, conflict, women's empowerment, and technology (1). A lack of food security occurs when consistent access to adequate, safe, and nutritious foods that meet dietary requirements and preferences which are essential for maintaining a healthy and active life, becomes compromised (2). When viewed at the household level, food security in high-income countries is primarily determined by poverty, resulting in insufficient access to food (3). Households experiencing food insecurity utilise both food and non-food coping strategies that may adversely impact the health outcomes of young children. Non-food coping strategies may include budgeting, borrowing money, and taking on additional jobs, whilst food coping mechanisms may involve reducing meal sizes, opting for cheaper and less healthy food options, or skipping meals altogether (4, 5).

Adverse consequences of food insecurity on the health of young children include malnutrition, poor oral health, and higher susceptibility to infectious diseases (1). Young children experiencing food insecurity may experience malnutrition at both ends of the spectrum (i.e., undernutrition and overnutrition). Undernutrition, such as stunting, wasting and being underweight is a common consequence of food insecurity primarily in lower-middle-income countries (6-10). On the other hand, there is inconclusive evidence regarding the relationship between food insecurity and overweight or obesity in young children. A higher proportion of young children with obesity living in food-insecure households compared to food-secure households has been observed in several studies in high-income countries such as the United States (US) and Canada (11-13). However, a recent review of 14 observational studies conducted in high-income countries found mixed results when examining the relationship between food insecurity and weight status in young children (<4 years) (14).

In NZ, 17.4% (n=53,000) of young children aged 0-4 years live in households with food insecurity (15). Sociodemographic factors such as ethnicity and socioeconomic status have been observed to be associated with household food insecurity amongst young NZ children. Māori children in NZ experience almost twice the rate of household food insecurity compared to non-Māori children, whereas Pacific children experience food insecurity more than twice that of their non-Pacific counterparts (15). The high proportion of Māori children experiencing household food insecurity is attributed to broader health inequities that are deeply rooted in colonisation, which has resulted in intergenerational poverty, and poorer health and education outcomes amongst Māori (16). Similarly,

Pacific people, a relatively new immigrant population to NZ, have increased vulnerability to food insecurity (17). This may be exacerbated by language barriers and the cultural responsibility to financially support their church and families living in the Islands (17, 18). Ethnic minority migrant populations may experience higher levels of food insecurity due to systemic inequalities resulting from ethnicity being a social boundary (19). Immigrants also face unique challenges such as barriers to food acquisition including limited food choices, resulting in increased food costs (20). Moreover, income is the strongest predictor of household food insecurity in NZ (15). Numerous studies in NZ have established the direct relationship between household food insecurity and poor socioeconomic status (15, 21-26). For example, in the 2014/15 and 2015/16 NZ Health Survey, it was found that the highest proportion of food insecure children live in areas of the highest deprivation (15). Apart from ethnicity and socioeconomic status, evidence in NZ and other high-income countries suggests that other sociodemographic factors such as household size and structure, child's age, caregiver age, education and employment status, may be associated with household food insecurity (15, 24, 26-28). Household food insecurity in NZ children is associated with dietary consumption patterns that are indicative of sub-optimal dietary intake. In the 2014/15 and 2015/16 NZ Health Surveys, a higher proportion of children aged 2-4 years living in food-insecure households had a significantly high frequency (≥3 times a week) of fast-food and sugar-sweetened beverage consumption, whilst a higher proportion of children living in 'fully-mostly' food secure households were able to meet the guidelines for daily vegetable consumption compared to food insecure children (15). Growing Up in NZ (GUiNZ) found a significant association between food hardship (a subset of food insecurity) and unhealthy food consumption after controlling for income, maternal education and age, deprivation, and household size (26). However, there is a clear need for comprehensive energy and nutrient intake data, as both the NZ Health Survey and GUiNZ only had crude dietary intake data based on food frequency questionnaires.

As such, the objective of this study is to assess the status of household food insecurity amongst young children in NZ (aged 1 to 3 years) and examine its association with anthropometric status, sociodemographic factors including ethnicity, socioeconomic status, child's age, caregiver age, education and employment status, household size and structure, and energy and nutrient intakes.

## Methods

**Study design and participants**

This observational cross-sectional research is under the umbrella of the Young Foods NZ study which involved a sample of 289 young NZ children aged 1-3 years who were living in Auckland, Wellington and Dunedin between August 2020 and February 2022. Ethical approval for this study was granted by the University of Otago Human Ethics Committee (project reference code H20/040).

A targeted recruitment strategy was put in place to ensure that participants from sociodemographic groups that are often underrepresented in most NZ studies were provided with the opportunity to be involved in the study. Recruitment activities included researchers attending and promoting the study in community hui (assembly or meeting) in areas of high deprivation, conducting data collection outreach in low-income communities, and putting up study posters in areas populated by minority ethnic groups. The inclusion criteria for this study were as follows: caregivers must be at least 16 years old and able to communicate in English, and children must be between the ages of 1 and 3 years, live in the vicinity of one of the three study centres, and have not recently participated in any study that required changes to their diet.

**Data collection**

Study participants were either visited at home or came to one of the three study centres or community hubs on two occasions within two weeks. To ensure comprehensive participant follow-up, scheduled text reminders and emails were employed, and a study website was developed to offer participants study information and guidance as they navigated the various aspects of the study. Due to the lockdowns and government restrictions to minimise contact and reduce the spread of coronavirus disease (COVID-19), several disruptions of the data collection were experienced, primarily in Auckland. Data collection was postponed during the government-imposed national and regional lockdowns in August 2020, February 2021, and August 2021, prohibiting data collection for a total duration of five and a half months. Trained researchers collected the following data.

***Household food insecurity data***

A NZ-specific tool comprised of eight validated indicator statements was utilised to measure household food insecurity (29). The questionnaire was verbally administered on the first main visit to

the caregiver who was provided with show cards containing response options. The caregiver could either point to the answer or respond verbally to the questions. To increase acceptability, each indicator statement was introduced with opening comments that were formulated through the focus groups conducted in the development of the questionnaire for the 1997 National Nutrition Survey in NZ (see supplementary material) (15).

***Anthropometry***

During the initial visit, the participant's weight was determined using an electronic infant scale (Seca model 354) or an adult scale (Seca model 813) if the participant was able to stand. For participants under 2 years old, length was measured on a measuring mat (Seca model 210), and height was measured using a stadiometer (Seca model 213 or Wedderburn model WMHM200P) for older participants. All measurements were taken in duplicate or triplicate by a trained researcher. Anthropometric equipment was regularly calibrated by a trained researcher throughout the duration of data collection. Body mass index (BMI) was calculated by dividing weight (kilogram) by height (metres squared) and the BMI-for-age z-scores were determined by using the WHO reference data (30). These were then grouped into underweight (<-2SD), healthy weight (-2SD to 2SD), and overweight (>2SD) categories.

***Sociodemographic data***

Sociodemographic data such as household size and structure, participant's age and sex, and caregiver's age, education level and employment status were collected through online questionnaires. Caregivers reported their child's ethnicity by selecting at least one from the following options: "Māori", "Pacific", "New Zealand European" ethnic groups or "Other". If "Other" was selected, the caregiver was prompted to a text box to specify the child's ethnicity. To measure socioeconomic status, the NZ Index of Deprivation 2018 (NZDep2018), an area-based proxy measure of socioeconomic status specific to NZ, was utilised (31). Participant's home address (gathered from the screening questionnaire) was entered in an online tool from Stats NZ Geographic Data Service which automatically assigns a meshblock for each address (11). Each meshblock has a corresponding NZDep2018 score which is divided into deciles.

***Dietary intake data***

Two 24-hour multiple-pass food recalls were administered by trained interviewers to caregivers during the two main visits. The 24-hour recall was collected on a different day of the week to capture daily variation. In preparation for each main visit, caregivers were sent a text reminder to take photos of the food and drinks that the child consumed 24 hours prior to the visit. The photos collected were used as memory prompts during the day of the visit. Participants who had other caregivers (i.e., daycare worker, nanny, or another family member) were supplied with a form to fill in, providing information about the child's meals. Trained researchers utilised tools such as measuring spoons, cups, actual-sized-grids, and circle sheets to aid in the portion estimation of the food and drinks consumed. During the administration of the multi-pass 24-hour food recalls, the form provided for other caregivers were checked and collected. The main questionnaire (Appendix I) administered during the first visit captured data on supplement use. This included information on the frequency of supplements use, brand name, product name, and photos. The reported frequency assigned to a pre-determined value, which was then multiplied to the nutrient content of the supplement, to be able to obtain the total nutrient intake from the supplement. In supplements composed of iron salt, the equivalent elemental iron was determined using the NZ formulary conversion values (75).

Breast milk intake was calculated as 91.4 g per feed for children aged 12 to 18 months, and 60.9 g per feed for those older than 18 months based on the coding rules for the estimation of breast milk volume from the 2008 Feeding Infants and Toddlers Study (FITS) (32). The values obtained were then multiplied by the nutrient densities for human milk from FOODFiles (33).

**Data analysis**

To determine household food security status from the household food security questionnaire, a categorisation method specifically developed for the First Foods NZ Study (a concurrent study) was used (34). This method involved assigning the following points based on the participant's responses to each item: Never=1 point, Sometimes=2 points, Often=3 points. Participants who answered all items were included in the analysis, whilst those with missing items or who responded "don't know" were excluded. For statement 1, reverse scoring was used since the statement was phrased in reverse compared to the seven other statements. The total score for each participant was categorised into either food secure (22-24), moderately food insecure (19-22), or severely food insecure (<19). Participants with a total score of 22 and at least two affirmative responses were

categorised as moderately food insecure. Participants with the same score and less than two affirmative responses were categorised as food secure.

The analysis of ethnicity involved using the total response method, which categorises participants who reported multiple ethnicities based on all of their reported ethnicities (1). This means that if a participant identified as both Māori and Pacific, they were counted as both Māori and Pacific simultaneously.

Data from the two 24-hour food recalls were entered and energy and key nutrients (i.e., carbohydrates, fat, saturated fat, protein, fibre, total sugar, iron, calcium, zinc, and vitamin C) were analysed using FoodWorks software version 10 (2019, Xyris Software, Australia). To estimate usual nutrient intake, the Multiple Source Method (MSM) was used (35, 36). Afterwards, daily supplement intakes were added to these estimates.

The prevalence of inadequacy was determined by the EAR cut-point method for protein, zinc, vitamin C and calcium, whilst the full probability approach was the technique used for iron. The proportion of participants consuming below the Adequate Intake (AI) for fibre was also identified.

Stata (StataCorp, Texas) was used for all statistical analyses. Descriptive statistics were presented as means (standard deviations) and proportions. To assess the differences in continuous demographic variables (i.e., age and BMI z-score), one-way ANOVA F-test was utilised. In examining the differences in categorical demographic variables (i.e., age group, sex, weight status, etc.), Fisher's exact test was used. Linear regression models were utilised to investigate the associations between household food security status and energy and nutrient intakes. Statistical significance was defined as a p value $<0.05$.

## Results

Figure 1 illustrates the progression of participants through the study. Of the 290 consented, 289 participants completed the household food insecurity questionnaire and seven were excluded due to having at least one missing item response.

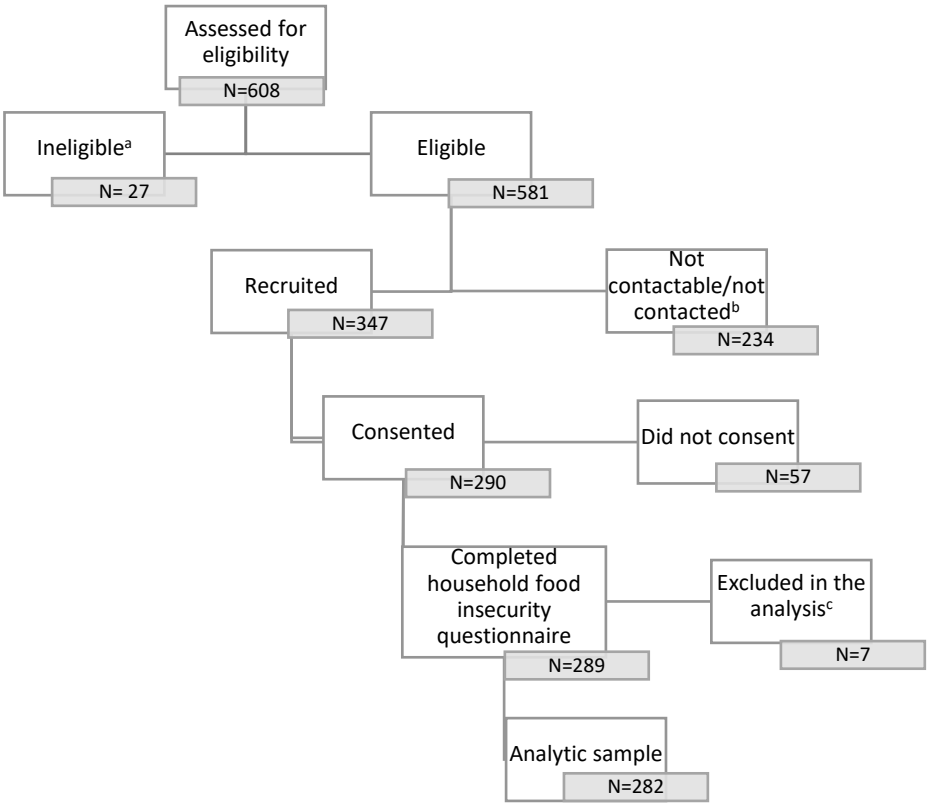


Figure 1. Participant recruitment flowchart

[a] n=9 child too old; n=1 child too young; n=17 outside of study area; [b] Some participants were not contactable/not required; [c] n=3 did not complete any item; n=2 two missing items; n=2 one missing item; no participants reported that they refused to answer any of the questions

Table 1 presents the participant demographics, along with a comparison of these demographics based on household food security status. In the past 12 months, 36% of young children in our study sample experienced food insecurity (20.4% moderate and 15.6% severely food insecure). Most children were of healthy weight (88.1%), 11.5% were overweight, and one participant (0.4%) was underweight. Almost half of the participants lived in areas of moderate deprivation (44%), with 29.1% and 27% living in areas of high and low deprivation, respectively. Most households had one other child present (52.9%) and the most common number of adults in a household was two (78.9%).

**Household food security status and anthropometric status**

A higher BMI z-score was observed amongst participants with higher levels of household food insecurity (table 1). Amongst healthy weight participants, a total of 68.6% lived in food-secure households, followed by 19.3% and 12.1% in moderately and severely food-insecure households, respectively. Households experiencing food insecurity had a higher proportion of participants who were overweight compared to those of healthy weight. For instance, 21.4% of overweight participants compared to 19.3% of healthy weight participants lived in moderately food insecure households, whilst 39.3% overweight versus 12.1% healthy weight participants lived in severely food insecure households.

**Household food security status and sociodemographic characteristics**

As indicated in table 1, significant ($p<0.05$) associations were observed between household food security status and being of Māori, Pacific and Asian ethnicities, caregiver age, employment and education, deprivation status, and household size and structure (i.e., number of other children in the household, number of adults in the household and number of people in the household).

Severe household food insecurity was observed amongst 33.8% of participants who identified as Māori, followed by 30.8% Pacific, 12.9% NZ European, 9.5% Others, and 4.8% Asian. Asian participants (83.3%) had the most food-secure households, followed by Others (69.0%), NZ European (67.2%), Pacific (35.4%), and Māori (35.2%).

The oldest caregivers were the most food-secure. The caregivers with the highest educational attainment (i.e., university-level education) had a substantially low proportion of severely food-insecure households at 3.7%, well below the proportion of those who were classified as food-secure at 77.9%. Caregivers not in paid employment had a significantly high proportion of severely food insecure households at 30.9% compared to those who were moderately food secure at 20.2%. For those who worked full time, the proportion of severely food insecure households was only at 5.1% compared to the proportion of food secure households at 74.6%.

The proportion of food-secure households with no other children was at 71.4%, much higher than the proportion of those who were severely food insecure at 11.9%. Households with three or more children had a significantly higher proportion experiencing severe food insecurity (51.5%) compared to moderately food secure (27.3%%) and food secure (21.2%) households. In households with only one adult, the proportion of severely food insecure (40.0%) is almost twice as the proportion of food secure (25.0%). In households with two to three people, the proportion of food secure (61.7%) were

more than 3.5 times than those who were severely food insecure (17.0%). Households located in areas of low deprivation had a significantly high proportion of food security (82.4%) compared to those who were severely food insecure (6.8%).

Table 1. Household food security status by anthropometric status and sociodemographic characteristics of young children in NZ

| | Total [a, i] | Household food security status [b, j] | | | p-value [c] |
|---|---|---|---|---|---|
| | | **Food secure** | **Moderately food insecure** | **Severely food insecure** | |
| n (%) | 282 | 176 (64.0) | 56 (20.4) | 43 (15.6) | |
| **Child characteristics** | | | | | |
| Age group, n (%) | | | | | 0.264 |
| Toddlers [d] | 105 | 59 (57.8) | 24 (23.5) | 19 (18.6) | |
| Young preschool children [e] | 177 | 117 (67.6) | 32 (18.5) | 24 (13.9) | |
| Age, mean (SD) [f] months | 29.9 (10.7) | 30.8 (10.9) | 27.4 (9.6) | 29.3 (10.4) | 0.106 |
| Sex, n (%) | | | | | 0.786 |
| Male | 139 (49.3) | 90 (66.2) | 26 (19.1) | 20 (14.7) | |
| Female | 143 (50.7) | 86 (61.9) | 30 (21.6) | 23 (16.5) | |
| BMI z-score [h], mean (SD) | 0.71 (1.08) | 0.51 (1.02) | 0.96 (0.91) | 1.23 (1.30) | <0.001 |
| Weight status [h], n (%) | | | | | 0.002 |
| Underweight | 1 (0.4) | 1 (100.0) | 0 | 0 | |
| Healthy weight | 214 (88.1) | 142 (68.6) | 40 (19.3) | 25 (12.1) | |
| Overweight | 28 (11.5) | 11 (39.3) | 6 (21.4) | 11 (39.3) | |
| Ethnicity [g], n (%) | | | | | |
| Māori (71) | 74 (26.2) | 25 (35.2) | 22 (31.0) | 24 (33.8) | <0.001 |
| Pacific (65) | 70 (24.8) | 23 (35.4) | 22 (33.8) | 20 (30.8) | <0.001 |
| Asian (42) | 43 (15.3) | 35 (83.3) | 5 (11.9) | 2 (4.8) | 0.015 |
| New Zealand European (201) | 203 (72.0) | 135 (67.2) | 40 (19.9) | 26 (12.9) | 0.094 |
| Others | 42 (14.9) | 29 (69.0) | 9 (21.4) | 4 (9.5) | 0.541 |
| **Caregiver characteristics** | | | | | |
| Caregiver age, mean (SD) years | 33.7 (5.3) | 34.9 (4.5) | 31.8 (5.3) | 32.1 (6.6) | <0.001 |
| Caregiver education level, n (%) | | | | | <0.001 |
| School | 55 (19.6) | 20 (41.7) | 14 (29.2) | 14 (29.2) | |
| Polytechnic | 62 (22.1) | 29 (46.8) | 11 (17.7) | 22 (35.5) | |
| University | 163 (58.2) | 127 (77.9) | 30 (18.4) | 6 (3.7) | |
| Caregiver employment, n (%) | | | | | <0.001 |
| Not in paid employment | 97 (34.8) | 46 (48.9) | 19 (20.2) | 29 (30.9) | |
| Full-time | 62 (22.2) | 44 (74.6) | 12 (20.3) | 3 (5.1) | |

| | | | | | |
|---|---|---|---|---|---|
| Part-time | 87 (31.2) | 58 (67.4) | 20 (23.3) | 8 (9.3) | |
| Paid parental leave | 11 (3.9) | 7 (63.6) | 3 (27.3) | 1 (9.1) | |
| Unpaid parental leave | 22 (7.9) | 21 (95.5) | 1 (4.5) | 0 | |
| **Household characteristics** | | | | | |
| Number of other children in household, n (%) | | | | | <0.001 |
| 0 | 43 (15.5) | 30 (71.4) | 7 (16.7) | 5 (11.9) | |
| 1 | 147 (52.9) | 108 (74.5) | 25 (17.2) | 12 (8.3) | |
| 2 | 51 (18.4) | 29 (56.9) | 14 (27.5) | 8 (15.7) | |
| ≥3 | 37 (13.3) | 7 (21.2) | 9 (27.3) | 17 (51.5) | |
| Number of adults in household, n (%) | | | | | <0.001 |
| 1 | 20 (7.2) | 5 (25.0) | 7 (35.0) | 8 (40.0) | |
| 2 | 220 (78.9) | 152 (70.0) | 41 (18.9) | 24 (11.1) | |
| 3 | 18 (6.5) | 9 (52.9) | 3 (17.6) | 5 (29.4) | |
| 4 or more | 21 (7.5) | 10 (55.6) | 3 (16.7) | 5 (27.8) | |
| Number of people in household, n (%) | | | | | <0.001 |
| 2-3 | 47 (17.0) | 29 (61.7) | 10 (21.3) | 8 (17.0) | |
| 4-5 | 177 (63.9) | 126 (72.4) | 33 (19.0) | 15 (8.6) | |
| 6 or more | 53 (19.1) | 19 (38.8) | 11 (22.4) | 19 (38.8) | |
| Socioeconomic status [i], n (%) | | | | | <0.001 |
| 1-3 (Low) | 76 (27.0) | 61 (82.4) | 8 (10.8) | 5 (6.8) | |
| 4-7 (Medium) | 124 (44.0) | 76 (63.9) | 27 (22.7) | 16 (13.4) | |
| 8-10 (High) | 82 (29.1) | 39 (47.6) | 21 (25.6) | 22 (26.8) | |

[a] n=7 excluded participants who answered 'don't know'; [b] Scoring system and household food security categories as described in the methods section; [c] p-value from a one-way ANOVA F-test for continuous variables and a Fisher's exact test for categorical variables; [d] Toddlers – 12-24 months; [e] Young preschool children – 25-47 months; [f] Standard Deviation (SD); [g] Total response ethnicity, wherein caregivers reported each ethnicity associated with the child, and each response was counted once in each ethnic group. Several participants had multiple ethnicities; therefore, the cumulative percentage exceeds 100%; [h] BMI z-score determined using WHO growth charts. Underweight (BMI z-score<-2); Healthy weight (BMI z-score -2 to 2); Overweight (BMI z-score>2). N=83 toddlers and N=160 pre-schoolers had anthropometric data; [i] Socioeconomic status assessed using the NZ Index of Deprivation 2018; [j] n=39 missing weight status; n=2 missing caregiver education; n=3 missing caregiver employment; n=4 missing number of other children in household; n=3 missing number of adults in household; n=5 missing number of people in household

**Item responses to household food insecurity questionnaire**

Figure 2 presents the responses to the eight-item household food insecurity questionnaire, providing a graphic representation of the combined proportions of "often," "sometimes," "never," and "don't know" responses to each indicator statement. Statement 4 (limited variety due to lack of money) had the highest proportion of participants (35.8%) who answered "often" or "sometimes," followed by feeling stressed due to lack of money for food (29.0%) and not being able to afford to eat properly (24.9%), respectively. On the other hand, statement 5 (relying on others to provide food or money for food) had the lowest proportion of participants (17.0%) responding affirmatively. Statements that

involved feeling stressed (i.e., those that start with “I feel stressed because…”) had the highest proportion of participants who answered, “don’t know.”

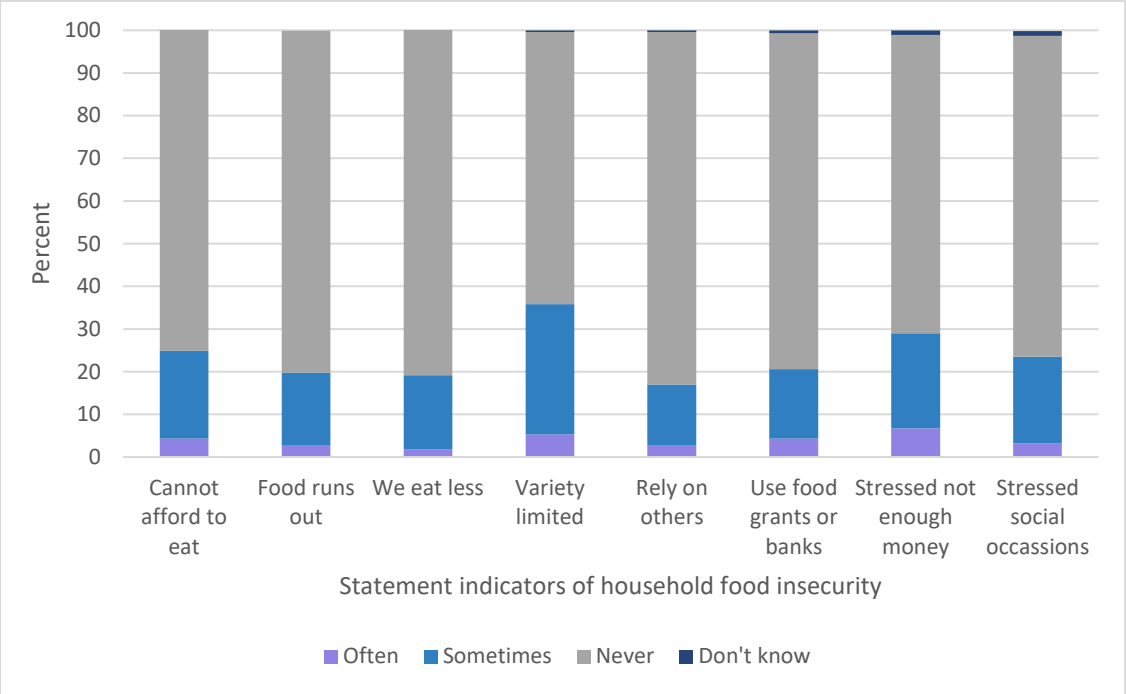


Figure 2. Item responses to household food insecurity questionnaire

Note: The first item/column has ‘Always’ instead of ‘Often’ and is reverse scored when included in the household food security total score

**Differences in energy and nutrient intake by household food security status**

The differences in usual energy and nutrient intake based on the household food security status of young NZ children are displayed in table 2. Higher fat intake was significantly associated with moderately food insecure households compared to food secure households. Participants from moderately food insecure households consumed 3.0 (0.2, 5.8) g/day more fat or 1.9 (0.8, 3.0) % more energy from fat than those who were food secure ($p<0.05$). Severely food insecure participants had a mean protein intake of 0.43 (0.71, 0.15) g/kg/day less or 0.9 (1.6, 0.1) % less energy from protein than those who were food secure ($p<0.05$). A lower proportion of energy contributed by carbohydrates and a higher proportion of energy from saturated fat were significantly associated with moderately food insecure households compared to food secure households ($p<0.05$). Usual fibre intake was lower in more food-insecure households. No significant associations were observed between micronutrient intake (i.e., iron, zinc, calcium, and vitamin C) and household food security status.

Table 2. Differences in energy and key nutrient intakes for households experiencing food insecurity (n=275)

| | **Food secure** | **Moderately food insecure** | **Severely food insecure** |
|---|---|---|---|
| | Mean (SD) | Mean difference (95% CI)[a] from food secure | Mean difference (95% CI)[a] from food secure |
| n (%) | 176 (64.0) | 56 (20.4) | 43 (15.6) |
| Energy (kJ/day) | 5045 (721) | 26 (-215, 267) | 16 (-250, 281) |
| Fat | | | |
| g/day | 45.5 (7.9) | **3.0 (0.2, 5.8)** | 0.2 (-2.9, 3.2) |
| %energy from fat | 33.4 (3.6) | **1.9 (0.8, 3.0)** | -0.1 (-1.3, 1.2) |
| Saturated fat | | | |
| g/day | 18.5 (4.3) | **2.0 (0.6, 3.5)** | -0.1 (-1.7, 1.5) |
| %energy from saturated fat | 13.6 (2.4) | **1.4 (0.7, 2.2)** | -0.1, -0.9, 0.7) |
| Protein | | | |
| g/day | 46.2 (9.3) | -0.2 (-3.1, 2.8) | -2.4 (-5.6, 0.9) |
| g/kg/day[b] | 3.39 (0.73) | -0.17 (-0.42, 0.09) | **-0.43 (-0.71, -0.15)** |
| %energy from protein | 15.5 (2.2) | -0.1 (-0.8, 0.5) | **-0.9 (-1.6, -0.1)** |
| Carbohydrates | | | |
| g/day | 146 (25) | -6 (-13, 2) | 2 (-6, 11) |
| %energy from carbohydrates | 49.0 (4.2) | **-2.0 (-3.4, -0.5)** | 0.6 (-1.0, 2.2) |
| Total sugar | | | |
| g/day | 67.2 (14.1) | 0.2 (-4.4, 4.7) | 0.5 (-4.5, 5.5) |
| %energy from sugar | 22.7 (4.0) | 0.1 (-1.2, 1.5) | 0.2 (-1.3, 1.6) |
| Fibre (g/day) | 15.0 (4.5) | **-1.6 (-2.8, -0.3)** | **-2.6 (-4.0, -1.2)** |
| Iron (mg/day) | 6.86 (1.99) | -0.38 (-1.06, 0.31) | -0.21 (-0.97, 0.54) |
| Zinc (mg/day) | 6.23 (1.21) | -0.31 (-0.71, 0.09) | -0.43 (-0.87, 0.00) |
| Calcium (mg/day) | 700 (208) | 5 (-65, 75) | -47 (-124, 30) |
| Vitamin C (mg/day) | 76.7 (52.5) | 33.1 (-9.5, 75.8) | 31.0 (-16.0, 77.9) |

[a] Mean differences (95% CI) estimated with adjustment for age. Bold results represent those that are statistically significant at $p<0.05$; [b] n=154 food secure, n=46 moderately food insecure, and n=36 severely food insecure with protein in g/kg/day.

Table 3 presents the proportion of participants with inadequate energy and nutrient intake based on household food security status. The highest proportion of participants falling below the AI for fibre was found in severely food-insecure households, whilst the lowest proportion was observed in food-secure households. Similarly, severely food-insecure participants had the highest probability of inadequate calcium and vitamin C intakes, whereas food-secure participants had the highest proportion of adequate calcium and vitamin C intakes. Participants from moderately food insecure households had the highest average probability of inadequacy for iron intake (11.7%), followed by those from severely food insecure (10.8%) and food secure (6.8%) households. No (0%) participants were observed to have inadequate protein and zinc intake.

Table 3. Proportion of inadequate energy and nutrient intake amongst young NZ children by household food security status

| | Nutrient Reference Values | Food secure | Moderately food insecure | Severely food insecure |
|---|---|---|---|---|
| | | % (n) inadequate | % (n) inadequate | % (n) inadequate |
| Energy [a] | 3,200-5,600 kJ/day [e, f] | 29.0 (51) | 35.7 (20) | 27.9 (12) |
| Protein [b] | 12 g/day | 0 | 0 | 0 |
| Protein [b] | 0.92 g/kg/day | 0 | 0 | 0 |
| Fibre [c] | 14 g/day | 44.3 (78) | 62.5 (35) | 74.4 (32) |
| Iron [d] | 4 mg/day | 6.8 | 11.7 | 10.8 |
| Zinc [b] | 2.5 mg/day | 0 | 0 | 0 |
| Calcium [b] | 360 mg/day | 2.3 (4) | 5.4 (3) | 7.0 (3) |
| Vitamin C [b] | 25 mg/day | 2.8 (5) | 8.9 (5) | 9.3 (4) |

[a] Proportion of participants below the Estimated Energy Requirement (EER); [b] Proportion of participants below the Estimated Average Requirement (EAR) for 1–3-year-old children
[c] Proportion of participants below Adequate intake (AI) for fibre for 1–3-year-old children; [d] Calculated using the full probability approach for iron at 15% bioavailability; [e] EER for boys are 3,500 kJ for 12-14.9 months, 3,800 kJ for 15-17.9 months, 4,000 kJ for 18-20.9 months, 4,200 kJ for 21-23.9 months, 4,400 kJ for 24-35.9 months and 5,600 kJ for 36- 47.9 months; EER for girls are 3,200 kJ for 12-14.9 months, 3,500 kJ for 15-17.9 months, 3,800 kJ for 18-20.9 months, 4,000 kJ for 21-23.9 months, 4,200 kJ for 24-35.9 months and 5,300 kJ for 36- 47.9 months; [f] EER was based on Physical Activity Level (PAL) of 1.6 – light activity
Abbreviations: kilojoule (kJ), gram (g), milligram (mg), kilogram (kg)

## Discussion

This study is the first to investigate energy and nutrient intake at three levels of household food insecurity in a diverse sample of young children in New Zealand, to the best of our knowledge. In this study, more than three out of 10 (36%) young NZ children experienced moderate-severe food insecurity within the last year. Food-insecure children had higher BMIs compared to their food-secure counterparts. Young children who were non-Māori and non-Pacific, of healthy weight, with older, employed and more educated caregivers, had at most one other child in the household, two adults in the household, and lived in areas of low deprivation were the most food secure. Food-insecure children consumed more fat and saturated fat, and less protein, carbohydrates, and fibre than their food-secure counterparts. No significant associations were observed between household food security status and energy and micronutrient intake. However, household food insecurity was found to be associated with inadequate intakes of calcium, iron and vitamin C.

**Prevalence of household food insecurity**

The prevalence of household food insecurity observed in this study is more than twice the proportion of food-insecure children identified by the 2015/16 NZ Health Survey which reported 17.4% of young NZ children experiencing food insecurity (37). However, despite utilising the same household food insecurity measurement tool, these differences may be due to the different scoring/categorisation system employed by the NZ Health Survey (i.e., Item Response Theory model), as well as the slightly broader age range (0-4 years of age), lower proportion of Pacific children and wider geographic areas covered by the national survey.

In terms of the item responses, the proportion of “often” and “sometimes” responses to “food runs out in our household” and “we eat less” is mirrored by the results of 2019/20, 2020/21, and 2021/22 NZ Health Surveys that were conducted parallel to the data collection period of the study (38). However, the proportion of “often” responses to the “use food grants” statement at 4.3% from the study sample was well above the national average (i.e., 1.9% for the 2019/20 and 1.7% for the 2020/21 NZ Health Surveys), further reflecting the higher proportion of lower socioeconomic status amongst our study participants (see table 1). According to the item response analysis conducted by the Ministry of Health, the “use of food grants” statement indicated the most severe food insecurity level out of all the eight indicator statements (15).

**Household food insecurity and anthropometric status**

The findings of this study suggest a significant association between household food insecurity and adiposity since a higher BMI z-score corresponds to an increase in the severity or level of household food insecurity. This is consistent with the results of the studies on young children in the USA and Canada (11-13). However, it is important to recognise that our analyses are unadjusted for confounders. Other demographic variables such as ethnicity are also associated with both weight status and food insecurity but were not accounted for in the analysis (39-41). Therefore, caution must be exercised in interpreting these results.

Furthermore, a NZ study from almost two decades ago observed a positive association between household food insecurity and obesity in adults but not in children (42). This may signify that parents are finding it more difficult to shield children from the adverse outcomes of food insecurity. A qualitative study on NZ single mothers found that they are concerned about the high cost of healthier food items, as this results in them being unable to afford fruits and vegetables, and resorting to using meats that have lower nutritional value and higher fat and salt such as processed meats and sausages (5). In agreement with this, studies in adults hypothesised that the primary factors contributing to obesity in food-insecure households include the substitution of healthy foods for cheaper and more energy-dense options, overeating during periods of high food availability, and behavioural and metabolic changes to compensate for the times when there is less food (1). Examples of these changes are binge eating, efficient energy storage such as fat accumulation, and glucose intolerance or impaired insulin sensitivity (43).

**Household food insecurity and sociodemographic factors**

The lower proportion of food-insecure young preschool children (32.4%) compared to toddlers (42.1%) in this study (table 1) is consistent with a GUiNZ report. In this report, all three food-hardship indicators measured consistently showed a lower proportion of children experiencing food hardship at 54 months compared to 9 months (26). Similarly, caregiver age exhibited the same pattern, as older caregivers were found to be the most food secure. The results of the 1997 National Nutrition Survey, although conducted more than two decades ago, also showed a linear trend in the association between age and food security. The survey found that young-middle age adults were the most food insecure and suggested this may be due to the allocation of resources to non-food expenditures such as rent, child care and healthcare costs (44). This was validated more recently by the results of the Survey of Families, Income and Employment (SoFIE) with 18,950 respondents

conducted from 2002-2010 which found the highest proportions of food insecurity amongst younger to middle age groups between 25-44 years (24).

Apart from age, caregivers who were employed and had a high level of education were found to be the least food insecure. As income is the strongest predictor of food insecurity in NZ, caregivers who have attained a lower level of education and are not in paid employment are more likely to be food insecure (37). An analysis of food costs for families in Wellington reported that for a single mother to raise two children on government benefits, almost half of her net income (after rent) must be spent on food to be able to meet the minimum nutritional requirements set by the Ministry of Health guidelines (45). These findings indicate the insufficiency of economic resources to be able to meet the basic needs of children, particularly for low-income families.

However, caregiver age, education and educational attainment were not found to be significantly associated with food insecurity in a 2010 survey conducted in Dunedin and Wellington. Despite the geographic similarity of this study (except for the inclusion of Auckland), the families interviewed in the survey had older children (≥5 years), had a higher income and were predominantly NZ European (46). In the comparisons conducted, statistically significant associations were unable to be achieved due to the decrease in sample sizes as the groups were further split into categories. However, in examining the survey results, it could be noted that a higher proportion of caregivers who were employed had higher educational attainment, and those who were 40-49 years of age were identified to be food secure.

In line with the 2015/16 NZ Health survey, our study found that food-insecure children were more likely to be of Māori and Pacific ethnicity, live in areas of high deprivation, live in a single-parent household and live with at least two other children (15). Māori and Pacific young children were the most at risk of food insecurity as the proportion of Māori and Pacific households was the highest in the moderately and severely food insecure categories. Since the earliest attempts to measure food insecurity in NZ, Māori and Pacific ethnicities have been identified as the most disadvantaged groups in terms of food security (21). A pilot project in Whakatāne that involved Māori participants recommended increased access to traditional foods and food systems as a solution to address food insecurity amongst Māori communities since indigenous peoples experience food shortages through poverty, loss of access to foods and ancestral lands, and an underdeveloped traditional food system (47). In other high-income countries, indigenous communities experience similar oppression of a basic human right, particularly, their right to food security (48). Indigenous peoples such as the Inuit in Canada, American Indians in the US, and Aboriginal and Torres Strait Islanders in Australia, were all identified as being more food insecure when compared to their non-indigenous counterparts (49-

51). The high prevalence of food insecurity in Pacific households is consistent with previous NZ studies and surveys (17, 26, 52). A birth cohort study (n=1,376) based in South Auckland reported that almost half of Pacific families experience sometimes or often running out of food (53). Food insecurity amongst Pacific households can be influenced by several sociodemographic factors such as large family size, low income, unemployment, and a high proportion of individuals relying on income-tested benefits (17).

By using the NZ Index of Deprivation (NZDep) as a proxy measure, this study found a significant association between socioeconomic status and food insecurity, as observed in prior NZ studies (15, 21-26). With this study conducted at the onset of a global pandemic, it is possible that the association between food insecurity and socioeconomic status may have been amplified for the study participants. Differences in the prevalence of household food insecurity across various socioeconomic groups could be more pronounced than previously known due to the potential increase in the prevalence of food insecurity amongst those who previously identified as food secure. In comparing the 2019/2020 and 2020/2021 NZ Health Surveys, an increase in the proportion of households accessing food grants or food banks due to a lack of money for food in the past 12 months was observed in neighbourhoods with moderate deprivation (38). These findings also provide an explanation for the higher proportion of household food insecurity detected in this study, in comparison to previous NZ studies.

Globally, the COVID-19 pandemic has led to increased poverty and decreased food security due to various interconnected factors such as strict lockdown measures, economic recession, disruption of supply chains, weakened social protection, increasing inequality, unstable food costs and production, and changes in the food environment (54). In NZ, an extraordinary surge in food parcel demand was reported by various non-profit organisations across NZ (55, 310). Across NZ, mainstream media has reported on first-time food bank users, implying the emergence of a new demographic group experiencing financial challenges as they cope with the economic pressures of the global pandemic (56). Furthermore, a sharp increase in the number of people accessing government benefits, hardship assistance payments and unemployment support was also observed during the pandemic (57).

The association between living in a sole-parent household and food insecurity is not unique in NZ with similar observations in Canada, the US, and Australia (58-60). It is argued that the increased likelihood of single-parent household to be food insecure mainly stems from economic hardship. A secondary analysis of the Canadian Community Health Survey found that the increased risk of single-parent families to be food insecure is primarily due to higher levels of poverty (61). An evaluation of

the impact of safety-net programmes in the US determined that an annual cumulative provision of $1,000 in cash or food benefits reduces the occurrence of food insecurity in single-parent households (62). In an analysis of food bank use, single-parent households were identified as the primary food bank users for two out of the three organisations examined across NZ (63). A qualitative study on single NZ mothers reported that apart from financial difficulties, other factors impacting household food security were shared parenting arrangements, health care, and the developmental changes that children undergo (i.e., growth spurts) (5).

The results of this study indicate strong associations between household size and food insecurity in multiple aspects. These include the number of adults, children, and total number of people in the household, all of which were significantly associated with household food insecurity ($p<0.001$). Contrary to the findings of this study, an observational study in Australia demonstrated that a higher number of household members was associated with food security (64). The Australian study cited that household members may pool their resources, as well as gain more access to emergency food relief, as more members may have eligibility and can physically access these services. However, due to the limitations of our study's instrument, it was not possible to identify the household composition (i.e., the proportion of adults compared to children in each household) for each participant. Knowledge of this may shed further light on the actual nature of the association between household size and food insecurity.

**Household food insecurity and energy and nutrient intakes**

Total fat intake (g/day) and the proportion of energy contributed by fat were significantly higher amongst participants living in moderately food-secure households compared to those who are food-secure. Consequently, the higher saturated fat intake observed in moderately food-insecure children, in comparison to food-secure children, is indicative of the discrepancy in dietary quality between the two groups, with food-insecure children consuming more unhealthy fats. This may potentially have public health implications since evidence suggests that cardiovascular risk markers associated with increased saturated fat intake during early childhood has been found to track in adulthood (74, 75).

The 2014/15 and 2015/16 New Zealand Health Surveys reported selected dietary habits including the frequency of fast-food consumption (≥3 times a week). The findings showed that amongst young children who were 'severely-moderately' food insecure, there was a higher prevalence of frequent fast food consumption compared to those who were 'fully-mostly' food secure (37). Fast food items in NZ have high levels of saturated fat, with almost half of the fast food meal combinations exceeding the maximum recommended amount of saturated fat intake in NZ (65). Another potential

explanation of the higher saturated fat intake in food insecure households is the higher consumption of high-fat meats (i.e., saveloys and sausages) found by a previous NZ survey in households with low-moderate food security, whereas higher consumption of lean meats (i.e., beef and veal) was reported for fully-almost food secure households (66).

On the contrary, severe food insecurity was significantly associated with lower protein intake amongst young NZ children. Of all the groups observed, severely food insecure young children had the lowest intake of protein (g/day and g/kg/day) and had the lowest proportion of energy from protein. However, the difference was not a concern since the protein intake of severely food insecure children is still well above the EAR for protein (for both g/day and g/kg/day), and no inadequate protein intakes were detected across all levels of household food insecurity.

Lower carbohydrate intake was associated with moderate food insecurity compared to food secure participants, but not severe food insecurity. However, this is the opposite for total sugar intake, indicating that the types of carbohydrates that are being consumed less by moderately food-insecure children compared with food-secure children are the more complex types of carbohydrates. In addition, fibre intake was observed to be the lowest in the most food-insecure young children. The low fibre intake of food-insecure young children compared to those who were food-secure may contribute to the perpetuation of these disparities, given the strong association between fibre intake and better nutrition and health outcomes. When the usual intake is compared to the AI for fibre (14 g/day), the same pattern is observed, as participants from food-insecure households are more likely to have fibre intake below the AI. Results from the 2007-2010 National Health and Nutrition Examination Survey (NHANES) of 5,136 children aged 2-15 years found that food-insecure children had a lower intake of whole grains compared to those who were food-secure (67). Furthermore, in the responses to the household food insecurity questionnaire, the “variety limited” item had the highest proportion of often/sometimes responses (see figure 2). This provides a further explanation for the findings of low fibre intake amongst young children who live in food-insecure households since dietary diversity is closely linked to fibre intake (68).

When compared to the EAR for calcium (360 mg/day), the proportion of children with inadequate calcium intake increased by 3.1% for moderately food insecure children and 4.7% for severely food insecure children compared to those who were food secure. It could be noted that calcium-rich foods such as milk, cheese and yoghurt, are relatively expensive. A NZ study that attempted to model the cost differential between healthy and current diets revealed that dairy made up 13% of the cost of healthy diets (69). Inadequate calcium intake during early childhood results in irreversible adverse consequences. During early childhood, there is rapid skeletal growth which requires sufficient

calcium intake to achieve optimal peak bone mass which may prevent bone mineral disorders later in adulthood (70). In young children, a positive correlation between calcium intake and bone mineral content, which is mediated by physical activity and heredity, has been found by cohort studies and randomised controlled trials (71, 72).

In observational studies on diet and food security, it is often difficult to establish correlations between dietary intake and food insecurity status due to the incongruence between the time frames. Most studies that have explored these associations attempted matching a one or two-day dietary intake assessment with the affirmations from a food insecurity questionnaire that tracks 12 months in retrospect (73). Therefore, measuring dietary intake more frequently and for a longer time frame may result in the detection of stronger associations between household food insecurity and nutrient intake (51). Despite this, significant differences in macronutrient intakes were still observed in our study.

Lastly, Growing Up in NZ (GUiNZ), a major longitudinal study in the North Island of NZ suggests persistence in food hardship (a subset measure of food insecurity) amongst young NZ children. The study found significant movement in and out of food hardship that was measured when children were 9 months and 54 months of age. It was reported that different children and households were affected by various aspects of food hardship during each phase of the study which indicates that more children are being exposed to food hardship at some point in their early childhood (26). This provides insight into the need for an ongoing intervention to support NZ families experiencing food insecurity, rather than the provision of one-time support or solutions such as food parcels and one-off food grants.

**Strengths and limitations**

Through the inclusion of underrepresented demographic groups (i.e., Māori, Pacific young children and those that are living in areas of high deprivation), this study was able to provide a valuable perspective often lacking in NZ surveys and studies. The participation of these groups was facilitated through strategic recruitment and data collection activities in areas that had a higher concentration of underrepresented groups, as well as study measures designed to retain participants.. Lastly, the use of a household food security questionnaire that was formulated and validated in NZ and has been utilised by several studies and major surveys in NZ is another advantage of this study (15, 21, 22, 29). This allowed the comparison of our study's results to other NZ studies and surveys that used the same questionnaire, specifically the responses to the eight items in the questionnaire.

The limitations of this study include (1) the utilisation of an unvalidated scoring system to categorise household food security status, (2) the use of NZDep2018 as a proxy measure of socioeconomic status, (3) the assessment of food insecurity in households, and not specifically of the child, (4) areas of recruitment and data collection were centred on urban regions of NZ, (5) the potential bias of caregivers in reporting the dietary intake of their child, (6) the utilisation of two 24-hour food recalls as a dietary assessment tool since it is unable to capture food items that were consumed periodically, and (7) statistical analyses have not been conducted to adjust for potential confounders. In addition, the exclusion of non-English speakers may have potentially introduced a bias, since language may be a barrier to accessing food. This is particularly relevant for certain ethnic minorities, such as Pacific groups, who face a higher risk of food insecurity and a significant proportion of their population with limited English proficiency (53).

## Conclusion

A high proportion of young NZ children were found to be food insecure. Children of Māori and Pacific ethnicities, having a main caregiver who was younger, not being in paid employment or having a lower level of education, those who live in areas of high deprivation, have a single parent or two or more other children in the household, were identified as the most vulnerable to food insecurity. In comparison to their food-secure counterparts, the diets of these children appear to be less healthy as they are higher in fat and saturated fat, lower in protein and carbohydrates, particularly fibre, and more likely to have inadequate calcium and vitamin C intakes. Furthermore, children from households with food insecurity were more likely to be overweight. This has implications for their growth and development as well as their future health outcomes since this is the stage when dietary habits and behaviours are established and can persist through adulthood. As such, urgent and effective interventions to address the root causes of food insecurity are required to mitigate the impact of household food insecurity on vulnerable young NZ children and ensure that they can grow and develop to be able to achieve their full potential.

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## Supplementary material

A. Introductory comments for the eight indicator statements

**Introductory blurb**

I would now like to ask you some questions about particular foods you choose, and the buying of food or gifting of food. We are interested in whether you feel you always have sufficient resources to have the food you need for yourself and the people you live with. We are not concerned with your budget, or how you spend money – we're more interested in finding out about how people get the food that they need for their household to eat and share.

You can point to the show card to indicate your answer, or you can tell me.

| Question | Introduction by interviewer | Statement and response |
|---|---|---|
| 1<br>*(show card 1)* | First of all, we know that some people can't afford to eat properly and we are interested in whether you think your household has enough money to eat properly. It's what you think eating properly is – not what I think or anyone else thinks. | We can afford to eat properly. How often has this been true for your household over the past year?<br>(1) always<br>(2) sometimes<br>(3) never<br>(4) don't know<br><br>(5) Refused |
| 2<br>*(show card 2)* | We are interested in whether you run out of basics, like bread, potatoes, etc because you do not have enough money. We are not referring to treats or special foods. | Food runs out in our household due to lack of money. How often has this been true for your household over the past year?<br>(1) often<br>(2) sometimes<br>(3) never<br>(4) don't know<br><br>(5) Refused |
| 3<br>*(show card 2)* | Now we are interested in whether a lack of money leads you to sometimes have smaller meals than you would like or whether a lack of money means there isn't enough food for seconds or you sometimes skip meals? | We eat less because of lack of money. How often has this been true for your household over the past year?<br>(1) often<br>(2) sometimes<br>(3) never<br>(4) don't know<br><br>(5) Refused |
| 4<br>*(show card 2)* | Now we are going to talk about the variety of foods you eat. By variety, we mean the number of different kinds of food you have. | The variety of foods we are able to eat is limited by a lack of money. How often |

| | | |
|---|---|---|
| | | has this been true for your household over the past year?<br>(1) often<br>(2) sometimes<br>(3) never<br>(4) don't know<br><br>(5) Refused |
| 5<br>*(show card 2)* | Some people rely on support and assistance from others for supplying their regular food, and we are interested in finding out how many people fall into this group. | We rely on others to provide food and/or money for food, for our household, when we don't have enough money. How often has this been true for your household over the past year?<br>(1) often<br>(2) sometimes<br>(3) never<br>(4) don't know<br><br>(5) Refused |
| 6<br>*(show card 2)* | Also, some people have to rely on other sources of help, such as food grants or food banks. | We make use of food grants or food banks when we do not have enough money for food. How often has this been true for your household over the past year?<br>(1) often<br>(2) sometimes<br>(3) never<br>(4) don't know<br><br>(5) Refused |
| 7<br>*(show card 2)* | We know that some people get quite stressed and worried about providing food even though they don't actually go without food. | I feel stressed because of not having enough money for food. How often has this been true for your household over the past year?<br>(1) often<br>(2) sometimes<br>(3) never<br>(4) don't know<br><br>(5) Refused |
| 8<br>*(show card 2)* | We recognise that for some people food and sharing with others is important, to the point that they don't have enough food for themselves. In this question we are only interested in social situations that are gatherings within, or outside, the household. As a result people may find themselves stressed/whakamā (embarrassed) about their koha (gift) when providing food for others. | I feel stressed because I can't provide the food I want for social occasions. How often has this been true for your household over the past year?<br>(1) often<br>(2) sometimes<br>(3) never<br>(4) don't know |

| | | |
|---|---|---|
| | | (5) Refused |

Thank you for completing these questions.

# Chapter 6: Discussion, conclusion, and recommendations

This chapter synthesises the findings of the three previous manuscripts, enumerates the strengths and limitations of our study, and presents the conclusion. This is followed by recommendations for future research and policy interventions to improve the dietary intake and household food security status of young children in NZ.

## Discussion

***Overall findings***

The main findings of this thesis address the research gap on the lack of dietary intake data and provide additional scientific evidence regarding the household food security status of young children in NZ. In the first manuscript (chapter 3), an overall adequacy of energy and nutrient intakes was reported. However, inadequate iron, fibre, calcium, and vitamin C and high saturated fat and protein intakes were detected. Lower fibre intake was reported amongst Māori, Pacific, and Asian children, whilst living in moderate-high areas of deprivation was associated with lower fibre and higher fat intake. Energy and nutrient intake did not exhibit statistically significant differences based on sex.

In chapter 4, food group consumption showed some consistency with previous NZ studies (1, 2). The majority of participants consumed grains and pasta, whilst formulae (i.e., infant and follow-on formula mixes) and mixed dishes were the main contributors to the energy intake and most nutrients of consumers. It is notable that a significant number of nutrients were primarily contributed by energy-dense and nutrient-poor foods such as pies, pasties, beverages, and processed meats. Non-NZ European, food insecure, and those with poor socioeconomic status were observed to have a higher proportion of consumers of these types of foods. Meanwhile, overweight children were less likely to consume dairy and dairy-alternative products. Conversely, formulae substantially contributed more energy to the diets of overweight children compared to their healthy-weight counterparts.

Chapter 5 reports a proportion of food-insecure households that is well above the national average. It is important to note that the data collection for our study was carried out during the height of the global pandemic, where disruption in food supply, loss of jobs, and increased use of food banks may have played a role in this above-average result (3, 4). Being overweight and having a higher BMI z-score were associated with household food insecurity. The demographic groups that are frequently burdened by poverty or low income were found to be the most vulnerable to household food insecurity. Lastly, higher fat and saturated fat intakes and lower fibre and vitamin C intakes were associated with household food insecurity.

The three manuscripts presented in this thesis provided findings that revealed important relationships between household food insecurity, sociodemographic factors, anthropometry and energy, nutrients, and food group intake. The following section will discuss how these relationships tie into a bigger picture and present the interconnectedness of these concepts.

***The bigger picture: the link between dietary intake, sociodemographic factors, anthropometric status, and household food insecurity***

Our findings are aligned with the findings of other high-income countries such as the US, Australia and Belgium, which generally reported young children having adequate intakes of the majority of the nutrients examined (5-8). This is unsurprising since most high-income countries have relatively stable and robust food systems to meet population demand. However, as abovementioned, there were excesses and inadequacies in the nutrient intakes observed. Notably, iron emerged as a significant concern, exhibiting one of the highest probabilities of inadequate intake observed.

The high prevalence of inadequate iron intake in our study is reflected in previous NZ studies that investigated the dietary intake of young children (9). However, through our study, we were able to identify the primary sources of iron (chapter 4) and pinpoint the household food security status of young children who are most at risk of inadequate iron intake (chapter 5). Next to formulae, grains and pasta were the highest contributors of iron to the diets of young children consumers. Plant-based sources of iron have low bioavailability (10). This is concerning since it suggests that despite meeting the recommendations, some young children may still be at risk of suboptimal iron intake because the source of iron they are consuming is not easily absorbed. In a South Island-based study, it was revealed that a diet including highly bioavailable iron sources was associated with increased serum ferritin (a biomarker of iron status) amongst children aged 6-24 months (11). In terms of household food security status, young children who lived in moderately food insecure households had the highest proportion of inadequate iron intakes, almost twice the prevalence of those living in food secure households. However, since dietary assessment does not assess actual iron status, biochemical tests are required to confirm if the children were truly iron deficient. Therefore, it is crucial for nutrition interventions to be focused on these households whilst promoting the intake of highly bioavailable sources of iron to effectively address inadequate iron intake.

Another significant finding of our study is the low fibre intake reported, with almost half of participants having a likelihood of usual intake below the Adequate Intake (AI) for fibre. Fibre is an important nutrient closely associated with the consumption of whole grains, fruits and vegetables and has been established to promote regular bowel movements, a healthy gut microbiome, reduce post-meal blood sugar levels, and replace energy-dense and nutrient-poor foods (12). The findings of our study suggest that fibre is the most divisive nutrient, as it served as a crucial marker of inequality in most comparisons of sociodemographic groups. Lower mean fibre intake was associated with higher food insecurity, poorer socioeconomic status, and certain ethnicities (i.e., Asian, Māori, and Pacific). Parallel to this, 'grains and pasta,' which accounted for the greatest contribution to fibre intake amongst consumers, was the only food group that exhibited a significant association with socioeconomic status. Our study found that higher energy contributions from 'grains and pasta' were associated with lower deprivation. In chapter 4, almost half of the study sample was unable to meet

the Ministry of Health (MoH) nutrition guidelines on fluid intake due to the consumption of the 'beverages' group which includes tea, coffee, and sugar-sweetened beverages (13). This is consistent with the findings of chapter 3 which indicated high sugar intake with almost half of the proportion of energy from carbohydrates contributed by total sugars. Chapter 5 shows that consumption of beverages that were predominantly sugar-sweetened was particularly evident amongst young Pacific children and those who live in severely food-insecure households, both of which have been linked to childhood obesity in NZ (14, 15). Interestingly, apart from contributing sugars, the 'beverages' group was also the primary contributor to vitamin C intake of consumers (chapter 4). This is despite young children living in severely food insecure households having the highest prevalence of inadequate vitamin C intake, across all groups (chapter 5). With this knowledge, comprehensive policies and programmes aimed at reducing sugar-sweetened beverage intake, and promotion of the consumption of vitamin C rich food sources such as fruits and vegetables, may further contribute to the achievement of optimal dietary intake amongst young NZ children.

A high saturated fat intake was observed amongst the study participants. Higher saturated fat intake was associated with moderate household food insecurity and was found to be primarily contributed by sausages, processed meats, pies, and pasties. These foods are energy-dense and have poor nutrient value, which may potentially displace nutrient-dense foods that contribute to a healthy diet. Furthermore, Pacific young children had the highest energy contribution from pies and pasties, and the lowest proportion of consumers of vegetables, nuts, and seeds, across all ethnic groups. It is important to note that saturated fat consumption has been found to track through adulthood starting from early childhood whilst evidence of the protective effect of vegetables, nuts and seeds consumption against cardiovascular diseases has been consistently reported (16-19). Consequently, this may contribute to the high incidence of cardiovascular diseases amongst Pacific adults (20). Therefore, it may be beneficial for an overburdened healthcare system to take a proactive approach by aiming to reduce saturated fat and increase the vegetable, nut, and seed intake of young NZ children, specifically for the most vulnerable groups. Thus, potentially contributing to the decline in the prevalence of cardiovascular and other chronic diseases associated with the excess consumption of saturated fat and poor consumption of vegetables, nuts, and seeds.

Since it was not directly examined, our study does not have direct evidence to support the hypothesis of substitution of nutrient-dense foods with nutrient-poor and energy-dense foods in food-insecure households (21). However, our findings suggest that a high proportion of food-insecure participants were consumers of these low-cost foods including pies, pasties, starchy vegetables, and sugar-sweetened beverages. Processed meats, snacks, sugars and sweets, and sauces contributed more energy to the diets of food-insecure children. Those who were food secure

were more likely to consume vegetables, nuts and seeds, most of which have high nutrient densities and contribute to the achievement of a healthy diet. This is reflected by qualitative studies suggesting that despite the awareness of healthy eating messages and the nutritional requirements of their children, the impact of poverty and increasing economic pressure results in the prioritisation of foods that are cheap, filling and require minimal cooking, storage cost and longer shelf life (22, 23).

In terms of anthropometric status, the proportion of overweight participants in our study sample is half the proportion reported in the NZ Health Survey (24). As previously mentioned, this is surprising since a substantial proportion of our study participants were living in highly deprived areas and were of Māori and Pacific ethnicities, both of which have been disproportionately impacted by childhood obesity in NZ. A potential explanation is the self-selecting sampling method that was used and the high proportion of caregivers (≥16 years old) with university education (58.4%) in our study compared to the national average (24.8%) for adults ≥15 years old (25). These may indicate caregivers who are more educated and have higher health-seeking behaviours compared to the average New Zealander were included in our study sample.

As abovementioned, the only food group that was negatively associated with obesity was dairy products and dairy-alternative products. Several meta-analyses and systematic reviews of observational and cohort studies from high-income countries have revealed either a null or negative association between dairy intake and adiposity (26-28). In our study, we found that 81% of children were consumers of dairy and dairy-alternative products, slightly higher than the proportion of milk and milk-alternative consumers at 79%. The MoH recommends children consume milk and milk products each day (29). However, since our study did not examine adherence to food and nutrition guidelines, (i.e., separation of milk and milk alternatives and dairy and dairy products food groups), it is difficult to gauge the proportion of our study participants meeting these recommendations. When anthropometric status was further explored in terms of food insecurity (chapter 5), an increasing BMI z-score corresponded with increasing household food insecurity. This is possible since food insecurity is primarily a function of income, and dairy and alternative products are relatively expensive.

The current dietary intake observed amongst our study participants translates to a significant proportion of young NZ children failing to meet their needs adequately. This may have been facilitated by the fact that a food-secure New Zealand is becoming increasingly out of reach. The proportion of households in our study reporting severe food insecurity is much higher than the national average, which may also be due to the high proportion of participants living in areas of higher deprivation. As cited in the literature review chapter, coherent evidence in NZ suggests that

deprivation is positively associated with food insecurity. Furthermore, our study has uncovered the substantial prevalence of food insecurity in areas with higher socioeconomic status, with 17.6% of children from areas of low deprivation experiencing moderate or severe food insecurity. Consequently, it is crucial to consider the coverage of policies and programmes targeting families in highly deprived areas since our results show that a substantial proportion of families experiencing food insecurity are living in areas of low deprivation. It is important to note that despite being closely related concepts, the NZ Index of Deprivation (NZDep) is an area-based measure of deprivation, whilst household food security status is a self-reported and experience-based tool that measures food insecurity (30, 31).

The substantial proportion of young children living in food-insecure households is a matter of grave concern. It is a disservice to young NZ children and the country's commitment to the United Nations Convention on the Rights of the Child, which includes the children's right to adequate nutritious food (32). Moreover, our study found that Māori and Pacific children, those who have a main caregiver who is younger, not in paid employment or has a lower level of education, those who live in areas of high deprivation, those who live in sole-parent households, and those who live with two or more other children in the household, are the most vulnerable to household food insecurity. In particular, the disproportionate number of Māori children living in food insecurity is a violation of the Treaty of Waitangi, a partnership between the Māori and the British Crown that guarantees equal treatment for the Māori (33). As such, a comprehensive strategy that considers the broader factors impacting household food security is imperative to uphold the rights of children, specifically those from the most vulnerable groups, and relieve them from the burden of malnutrition.

## Conclusion

Overall, this thesis provides valuable evidence on the excesses and shortfalls of young children's dietary intake, further highlighting the need to address food insecurity in NZ households. The importance of a diet that is high in iron, fibre, calcium, and vitamin C and low in saturated fat is highlighted to enable optimal dietary intake amongst young children. Encouraging the consumption of dairy products and whole fruit and vegetables may be beneficial to achieving adequate nutrient intakes, whilst the reduction of sugar-sweetened beverages and energy-dense and nutrient-poor foods such as processed meats and pies and pasties may potentially contribute to lowering chronic disease risk and childhood obesity in NZ.

This thesis is one of the first large and multicentre studies that have effectively captured dietary intake data from a significant proportion of groups that are usually underrepresented in most NZ studies. By having a large dataset, disparities in dietary intake were observed amongst at-risk groups and those living in food-insecure households were characterised, hence, offering crucial information to guide the formulation of targeted policies and programmes. As a result, contributing towards a healthier and more equal future generation in NZ.

***Strengths and limitations***

The primary strength of our study is the inclusion of a diverse sample which provided an overview of the dietary intake and food insecurity of usually underrepresented groups in previous NZ surveys and studies. Despite this, it is important to note that our study did not have a nationally-representative sample since the scope of our research only covered only three major cities in NZ. Our study also utilised convenience sampling which may have introduced a potential for self-selection bias. Our study was commissioned by the Ministry for Primary Industries (MPI) which is the end-user of this information. By utilising our dataset, MPI can undertake scientific risk assessments to ensure the safety and appropriateness of the NZ food supply for young children – an excellent example of evidence informing policy. Furthermore, our approach to collecting dietary intake data was characterised by rigorous methodologies, strengthened by comprehensive quality assurance procedures and protocols implemented prior to, during, and following the actual collection process.

Despite this, our study team faced difficulties in obtaining dietary intake information from caregivers other than parents. This was primarily due to incomplete recipes, vague descriptions of foods, and uncertainties in the amounts consumed, specifically in early childcare settings. Also, our study did not account for regional variations and only included highly urbanised cities in NZ. Another limitation is the use of a 24-hour food recall as the dietary assessment tool for our study. This does not capture food intake that is infrequently consumed. However, by utilising the Multiple Source Method (MSM), dietary data was adjusted to provide estimates of usual intake.

## Recommendations

The main findings of our study highlight the requirement for further research and the urgent need for effective intervention to break the intergenerational cycle of suboptimal nutrition in NZ.

***Future research***

The findings of our study warrant further investigation of the following:

- A significant proportion of young children with suboptimal dietary intake was detected. Therefore, an evaluation of the current effectiveness and identification of the gaps in the implementation of existing policies and programmes that are aimed at improving the dietary intake of young children in NZ are imperative.
- Further examination of the behavioural aspects of the dietary intake of young children, specifically their interactions with the mealtime environment at home and outside (i.e., early childcare centres) is required to have a full understanding of these suboptimal intakes.
- Since our study involved participants from the three main urban areas in NZ, expansion of study coverage to rural areas of NZ would provide a more complete picture of the current dietary intake and household food security status of young children.
- The challenges in dietary data collection for foods consumed by children away from home prompt the need for further exploration of more effective methods for recording the dietary intake of young children in various environments. This would therefore significantly benefit future studies on young children's dietary intake.
- Our study utilised a NZ-specific and validated household food security questionnaire that was developed in 1997 (34) and validated against the 1997 National Nutrition Survey food frequency data in 2014 (31). An enquiry on whether there is a need to update this tool, and including a closer look at food sovereignty, specifically for Māori, may reflect a more recent and comprehensive picture of food insecurity in NZ.
- Through our study, we were able to provide a quantitative measure of household food insecurity. However, an understanding of such complex concepts could be enhanced if supplemented by a qualitative study to capture the lived experiences, including the coping mechanisms and perceived solutions of food-insecure households.
- A high proportion of food-insecure young children were reported in our study. Further longitudinal studies to investigate the changes in the dietary intake of young children as they live in households that stay in or out of food insecurity are required to determine the full extent of the impact of food insecurity on their dietary intake.

***Impact***

The findings of our study support the formulation of policies and programmes targeting excesses and inadequacies in the dietary intake of young NZ children. Based on our findings which indicate a significant proportion of beverage consumption and a high contribution of total sugar intake from beverages, as well as the robust evidence on the sustained positive impact of sugar-sweetened beverage tax laws in decreasing sugar consumption across the world (38-40), policies such as sugar-sweetened beverage taxation may be a prudent approach to reduce the sugar consumption of young children.

Our study also found poorer diet quality amongst young children living in food-insecure households. As previously stated in the literature review, a randomised controlled trial of food insecure households with children in NZ revealed that providing additional money resulted in higher food expenditure upon intervention (41). In addition, data from NZ indicate that caregivers may shield children from the full impact of food insecurity (42). This suggests that offering economic relief (i.e., increasing benefits) to families at risk of household food insecurity may translate to better nutrition for young children.

Moreover, it is recommended to integrate nutrition into existing policies and programmes in NZ. Since food insecurity is a multifaceted problem, it will take a comprehensive strategy to tackle it effectively. Similar to the saying 'it takes a village to raise a child', it also takes a country to feed a child. The duty to ensure children's food security must extend beyond the household level and must also involve key stakeholders from various sectors that directly and indirectly impact children's nutrition such as politics, education, housing, trade, and the environment, amongst others. Therefore, nutrition programmes must not be siloed in the health and education ministries but must be well-incorporated and weaved into the overarching development strategy of the nation.

Lastly, our study supports the inclusion of household food security in the core content of the NZ Health Survey. The household food security scale that was used in our study and widely utilised in NZ has also been used by the MoH in the 2012/13, 2014/15, 2015/16, 2019/20, 2020/21, and 2021/22 NZ Health Surveys (24). This annual rolling survey includes a set of core questions that remain the same, along with module topics that vary from year to year (35). Household food security is currently classified as a module topic, which inconsistently appears on the survey. Other high-income countries such as the US and Canada have an established country-wide monitoring system set up to be able to measure the gains and losses in terms of food insecurity in their country (36, 37). Food insecurity is no longer mainly an issue in lower-middle-income countries. Food insecurity is a serious public health concern that threatens the dietary intake, and potentially the growth and development

of young NZ children. Therefore, a regular and national level monitoring system will benefit NZ to be able to adapt its policies and ensure food security in the country.

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# Appendices

Appendix A. Ethical approval

**H20/040**

Academic Services
Manager, Academic Committees, Mr Gary Witte

26 March 2020

Professor R Taylor
Department of Medicine
Dunedin School of Medicine
University of Otago Medical School

Dear Professor Taylor,

I am writing to let you know that, at its recent meeting, the Ethics Committee considered your proposal entitled "**Food and Nutrient Intake of Young Children in New Zealand**".

As a result of that consideration, the current status of your proposal is:- **Approved**

For your future reference, the Ethics Committee's reference code for this project is:- **H20/040**.

The comments and views expressed by the Ethics Committee concerning your proposal are as follows:-

There is an ethical imperative to ensure that you do not put others at risk of infection through your research. If your proposed project involves face-to-face interviews or focus groups, you must either adopt alternative methods for data collection or delay your research. Some alternative data collection options include eConferencing (e.g. using Zoom or other platforms) or telephone interviews with those who do not have internet access. Projects involving close physical contact (e.g. taking biological samples) will need to be postponed.

The COVID-19 situation is changing daily, so please ensure you remain up to date with the latest prevention advice from the Ministry of Health (see www.health.govt.nz/our-work/diseases-and-conditions/covid-19-novel-coronavirus) as well as COVID-19 information on the University webpage (see www.otago.ac.nz/coronavirus/index.html).

The standard conditions of approval for all human research projects reviewed and approved by the Committee are the following:

Conduct the research project strictly in accordance with the research proposal submitted and granted ethics approval, including any amendments required to be made to the proposal by the Human Research Ethics Committee.

Inform the Human Research Ethics Committee immediately of anything which may warrant review of ethics approval of the research project, including: serious or unexpected adverse effects on participants; unforeseen events that might affect continued ethical acceptability of the project; and a written report about these matters must be submitted to the Academic Committees Office by no later than the next working day after recognition of an adverse occurrence/event. Please note that in cases of adverse events an incident report should also be made to the Health and Safety Office:

http://www.otago.ac.nz/healthandsafety/index.html

Advise the Committee in writing as soon as practicable if the research project is discontinued.

Make no change to the project as approved in its entirety by the Committee, including any wording in any document approved as part of the project, without prior written approval of the Committee for any change. If you are applying for an amendment to your approved research, please email your request to the Academic Committees Office:

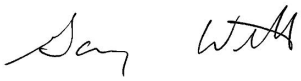
gary.witte@otago.ac.nz

jo.farrondediaz@otago.ac.nz

Approval is for up to three years from the date of this letter. If this project has not been completed within three years from the date of this letter, re-approval or an extension of approval must be requested. If the nature, consent, location, procedures or personnel of your approved application change, please advise me in writing.

The Human Ethics Committee (Health) asks for a Final Report to be provided upon completion of the study. The Final Report template can be found on the Human Ethics Web Page http://www.otago.ac.nz/council/committees/committees/HumanEthicsCommittees.html

Yours sincerely,



Mr Gary Witte
**Manager, Academic Committees**
Tel: 479 8256
Email: gary.witte@otago.ac.nz

c.c. Professor M Schultz HOD Department of Medicine

Appendix B. Young Foods New Zealand recruitment poster

# YOUNG FOODS

— New Zealand —

**Help improve the health of NZ children**

**And help health workers give parents and whānau advice they can trust**

**You will be given $100 in grocery or petrol vouchers as a thank you**

## ATTENTION: PARENTS/GUARDIANS!

**The Young Foods New Zealand Study is looking for parents and guardians from *Auckland* with children under 4 years to take part in an exciting new study when their child is 6 months to 3.9 years old. The study will look at what and how New Zealand children are being fed and how that might affect their health.**

We would like to meet with you 2 times over about two weeks. We will ask you about what your child eats and will check your child's teeth. This should take 2-3 hours in total.

**CONTACT US**

auckland@firstfoods.co.nz

0212791547

www.firstfoods.co.nz/young-foods

Type text here

*This study has ethical approval from the University of Otago Human Ethics Committee: H20/040*

# Feeding our young children – are we getting it right?

YOUNG FOODS
— New Zealand —

**We would like to invite you to take part in the Young Foods New Zealand (YFNZ) study – an exciting new project about how and what New Zealand children are being fed**

September 2020

**Investigators**

Prof Rachael Taylor, University of Otago (Dunedin)
Assoc Prof Anne-Louise Heath, University of Otago (Dunedin)
Dr Lisa Te Morenga, Victoria University (Wellington)
Assoc Prof Pamela von Hurst, Massey University (Auckland)



## Why?

We want to look at how and what young children are being fed, and what effect that has on their nutrition and health. This research will provide important information so that health professionals and policy makers can advise whānau on feeding their children. This study has ethical approval from the University of Otago Human Ethics Committee: H20/040.

## What does this study involve?

We are looking for parents or guardians from Dunedin, Auckland or Wellington with young children who are 6 months to 3.9 years of age to take part in this study. Young Foods NZ is an 'observational' study, looking at what and how young children are fed. You will **not** have to change the way you feed your child in any way or do anything different. We need to recruit a large number of families – a total of 300– so expect that the study will finish in 2022.

## What would I be asked to do?

Attend two visits when your child is between 6 months and 3.9 years old. These visits will take place over two weeks and will take 2-3 hours in total.

### First visit

This visit will take place at our Albany Massey University research center, your home, or preferred location. Our research center is a comfortable and safe place with a breastfeeding area and plenty of toys for your child. We will measure your child's weight and length/height and ask you to fill out a couple of questionnaires about your child's feeding and health. We will ask you to tell us what, and how much, your child ate the day before. Because this can be difficult to remember, we will ask you to take photos of child's food at the start of their meals and snacks the day before we visit. These are just taken on a phone or camera – we can lend you one if needed. This visit will take about one and a half hours.

### Second visit

This visit is in our clinic. One of our staff will take some photographs of your child's mouth and teeth. Then we will ask you to tell us what, and how much, your child ate the previous day (like you did for the first visit). This visit will take less than one hour.



We will ask your permission to let us access information from your child's "B4 School Check" when they are four years old so that we can see how their growth and dental health are tracking. We will need to access your child's National Health Index (NHI) number to do this.

## Who pays for the study?

This study is funded by the Ministry for Primary Industries. There is no cost for you to take part. However, as a recognition for taking part in the study we will give you a $100 voucher as a thank you.

## What if I don't want to take part in certain parts of this study?

We would really appreciate it if you could take part in all parts of the study, but know that that won't be possible for all families. You can let us know on the Consent Form whether there are any sections you already know you do not want to take part in, and you can choose not to do parts of the study after you've started, or withdraw from the study completely, if you change your mind.

## What are the benefits if I take part?

There are a number of benefits to being in the Young Foods NZ study. For example, you will:

- Know that you are helping improve the health of NZ children
- Be helping health workers give parents and whānau advice they can trust

## What are the potential risks?

We don't think there are any large risks to taking part in this study.



## What if something goes wrong?

If we find that your child has problems with their teeth, then we will let you and your dentist or dental therapist know. In the unlikely event of a physical injury as a result of taking part in this study, you would be eligible to apply for compensation from ACC. If you have private health or life insurance, you may wish to check with your insurer that taking part in this study won't affect your cover.

## What are my rights?

Deciding to take part in this study is entirely your choice. You may have a friend, family or whānau support who can help you understand the risks and benefits of this study and decide whether you would like to take part. If you choose not to take part, it will have no impact on your or your child's health care. If you choose to take part you are free to withdraw from the study at any time, you don't have to give a reason, and you wouldn't be disadvantaged in any way. You have the right to access information about yourself and your child collected as part of this study.

## How will my information be used?

Only the researchers will have access to the information. All information will be made anonymous and kept confidential, for both this study and in any future research. Group results of the project will be published, but not in a way that could identify you, your child or your family. It is possible that new research questions may arise in the future in related areas that your data could contribute to in useful and relevant ways. Please indicate on the Consent Form if you would not feel comfortable about your anonymous data being used in such future research.

## What happens after the study?

We will send you a summary of the study results when they have been published – please let us know if your address changes before then.

We will store information, including videos and images, on a secure online storage system overseen by the University of Otago for at least 10 years after your child turns 16 years old, after which time the information will be destroyed. Researchers will only have access to this information for specific study-related tasks.



## What if I have any questions?

For questions day-to-day see our contact details on our website:

www.firstfoods.co.nz/young-foods

If you have any other questions about our project either now or in the future, please feel free to contact us:

**Investigators**
Pamela von Hurst (Auckland)
09 414 0800
P.R.vonhurst@massey.ac.nz

Rachael Taylor (Dunedin)
03 470 9180
rachael.taylor@otago.ac.nz

Lisa Te Morenga (Wellington)
04 463 4757
Lisa.temorenga@vuw.ac.nz

If you want to talk to someone who isn't involved with the study, you can contact an independent health and disability advocate on:

Phone: 0800 555 050
Fax: 0800 2 SUPPORT (0800 2787 7678)
Email: advocacy@advocacy.org.nz

For Māori health support, please contact:

Turuki Health Care
Phone: 09 275 5788 (Māngere)/ 09 570 8643 (Panmure)
Email: mangere@thc.org.nz / panmure@thc.org.nz

You can also contact the University of Otago Human Ethics Committee (Health) that approved this study on:

Phone: 03 479 8256
Email: gary.witte@otago.ac.nz

# P-6b1: 24-h recall protocol

Copy no. _____

| | | | |
|---|---|---|---|
| *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)<br>**P-6b2: Transfer 24-h recall photos**<br>**P-6b3: Foods fed by other adults – follow up** |
| **Documents:** | **O-15: 24-h recall recording sheets**<br>**O-16: 'Food Description Prompts' sheet**<br>**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**)<br>Laptop and Vodem<br>Stapler (check plenty of staples) |
| **Participant to provide**: | Photos of eating occasions<br>**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*)

**<u>If child consumed food/drink while in the care of another adult/in childcare</u>:**

"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 <u>how much</u> of each food [*child's name*] ate and drank, <u>where</u> they were fed, and <u>how</u> 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 <u>the product brand</u> (or record '<u>brand unknown</u>') (*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 '<u>homemade</u>' (if so, ask for recipe – record in the 'Recipe' section).
- **Amount**. Record the amount <u>consumed</u>. 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 E. Food recall sheet

**First recall** ☐
**Second recall** ☐

YOUNG FOODS
— New Zealand —

Participant ID: _____ Interviewer: _____

Date: _____ Day of the Week: _____

| | | |
|---|---|---|
| **1.** Was the child unwell yesterday? | ☐ NO | ☐ YES |
| **1a. If unwell**, did this influence the child's appetite? | ☐ NO | ☐ YES |

## QUICK LIST

☐ _____
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**Yes**
**No** **Is salt added to any foods or drinks (including on days not covered by the 24 hour recall)? If yes, was the salt iodised and .. what foods/ drinks?**

**Yes**
**No** **Is sugar added to any foods or drinks (including on days not covered by the 24 hour recall)? If yes .. what foods/ drinks**

**Yes**
**No** **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**

**First recall** ☐
**Second recall** ☐

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**Ask about drink & snack consumption and foods fed by other adults at the end of quick list**

Participant ID: _____ Interviewer: _____

Date: _____ Day of the Week: _____

## DETAILED 24-H RECALL

| Time | Place | Description of Food/Drink | Brand | Amount consumed | Pouch used? | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | No | Yes | | | |
| | | | | | | Child fed self directly | Adult fed child directly | Adult fed child from spoon | Child fed self pouch via spoon |
| | | | | | | | | | |
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Participant ID: _____ Interviewer: _____

Date: _____ Day of the Week: _____

**RECIPES**

Participant ID: _____ Interviewer: _____

Date: _____ Day of the Week: _____

**NOTES**

| | | |
|---|---|---|
| IS FURTHER FOLLOW UP NEEDED? | ☐ NO | ☐ YES |
| RESOLVED? | ☐ NO | ☐ YES |

| | | |
|---|---|---|
| Extreme concern about completeness of recall: | ☐ NO | ☐ YES |

Appendix F. Follow up protocol for forms provided to other caregivers

# P-6b3: Foods fed by other adults follow up protocol Copy no. _____

| | | | |
|---|---|---|---|
| *Study:* | YFNZ | *Version number:* | Version 2 |
| *Prepared by:* | NM, ALH | *Date prepared:* | 08/06/2020 |

## Objective

- Obtain information about what the child ate and drank while in the care of 'other caregivers' (i.e. not parent/caregiver being interviewed) that was not obtained during the 24-h recall.

## During 24-h recall – Equipment

**Protocols:** **P-6b3: Foods fed by other adults follow up protocol** (this protocol)

**Documents:** **O-15: 24-h recall recording sheet**

## During 24-h recall – Process

A1 *"It looks like we are missing some information about [what/how much/etc] [child's name] ate while in [other caregiver's] care. Would you be happy for us to call [other caregiver] so we can get a complete record of what [child's name] ate yesterday?"*
→ YES **(CONTINUE)**
→ NO **(GO TO A2)**
→ NO – PARTICIPANT WOULD PREFER TO MAKE CONTACT **(GO TO A2a)**

A1a → IF MISSING INFORMATION FROM CHILDCARE SETTING **(GO TO A1a1**)
→ IF MISSING INFORMATION FROM ANOTHER ADULT **(GO TO A1a2)**

A1a1 CONFIRM/ASK FOR NAME OF CHILDCARE CENTER AND NAME OF THE STAFF MEMBER WHO OVERSEES CHILD IF KNOWN **(GO TO A1c)**

A1a2 CONFIRM/ASK FOR [*other caregiver's*] FIRST AND LAST NAMES

A1b *"May we have [other caregiver]'s phone number?"*
→ YES: WRITE PHONE NUMBER IN NOTES; REPEAT BACK PHONE NUMBER TO VERIFY
→ NO: "Is there another way you'd prefer we contacted them?"

A1c "*If we contact [other caregiver] and they don't feel comfortable about answering our questions about what [child's name] ate, can we say that you would be happy to talk to them to reassure them about the study?*"
→ YES **(CLOSE)**
→ NO **(NOTE THIS; CLOSE)**
**START FOLLOW UP CONTACT IMMEDIATELY AFTER APPOINTMENT**

A2 "*Would you be able to contact [other caregiver] to find out what [child's name] ate and drank when [he/she] was with them?*"
→ YES **(CONTINUE)**
→ NO **(CLOSE; RECORD FFOA FOLLOW UP CONTACT AS UNRESOLVED)**

A2a "*Excellent – thank you. I'll send you an email with the information we need right after we're finished here today. It would be great if you could get this information from [other caregiver] before he/she forgets anything – would you be able to contact that person today or tomorrow? Thank you – that would be really good.*"
MAKE NOTE TO SEND EMAIL **(CLOSE; RETURN TO P-6b1)**
**START FOLLOW UP CONTACT IMMEDIATELY AFTER APPOINTMENT**

## Follow up contact – Equipment

**Documents:** **P-6b3: Foods fed by other adults follow up protocol** (this protocol)
**P-6b1: 24-h recall protocol**
**O-12: Foods Fed by Other Adults form** (if attempted)
**O-15: 24-h recall recording sheet** (incomplete)

**Equipment:** **Laptop with access to REDCap**

## Follow up contact - Steps before

1. During the 24-h recall identify missing information about foods fed by other adults (**P-6b1**) and record this in the 'Notes' section of the recording sheet (**O-15**).
2. Only follow up about ***significant*** missing information:
    a. what the child ate/drank
    b. amount eaten
    c. whether (and how) a pouch was used
    d. in some circumstances, the brand name (e.g., to determine whether a food was iron fortified).

    You do not need to follow up about time fed or place fed.
3. Ensure you have clearly identified the significant information to follow up on before making follow up contact.
4. As soon as possible after the appointment, make follow up contact with the 'other caregiver' via phone **(START AT B1)** or with the participant via email, as appropriate.

## Follow up contact – Steps during:

### Via phone

NOTE: Attempt initial follow up contact a maximum of 5 times. If no response after the fifth attempt at initial follow up contact, record FFOA follow up contact as unresolved (on the Diet recall form (under the appropriate visit) in REDCap).

B1 *"Hello, my name is [researcher's name]. May I please speak with [other caregiver]?*
→ INITIAL CONTACT **(GO TO B1a)**
→ RESCHEDULED CONTACT **(GO TO B2)**

B1a *"Hello, my name is [researcher's name]. [Respondents name] gave me your number to talk to about what [child's full name] ate on [day of interest] while [he/she] was in your care. It's for a study that [child's name] is taking part in about what children eat called the Young Foods New Zealand study. Is now a good time to ask you a few questions about this?"*
→ YES **(GO TO B5)**
→ NO – NOT A GOOD TIME **(GO TO B4)**
→ NO – WANTS TO DISCUSS WITH PARTICIPANT **(GO TO B3)**
→ NO – REFUSED INTERVIEW **(TERMINATE; RECORD FFOA FOLLOW UP AS UNRESOLVED)**

B2 "*Hello, it's [researcher's name] here from Young Foods New Zealand. I recently contacted you to ask you about what [child's full name] ate on [day of interest] while he/she was in your care for a study about what children eat. Is now a good time for you to talk?*"
→ YES **(GO TO B5)**
→ NO – NOT A GOOD TIME **(GO TO B4)**
→ NO – WANTS TO DISCUSS WITH PARTICIPANT **(GO TO B3)**
→ NO – REFUSED INTERVIEW **(TERMINATE; RECORD FFOA FOLLOW UP AS UNRESOLVED)**

B3 "*I understand. [Respondents name] has told us they are happy for you to contact them if you have any concerns about talking to us. Would you like me to call you back after you've had the chance to talk to them?*"
→ YES **(GO TO B4)**
→ NO – REFUSED FURTHER CONTACT **(TERMINATE; RECORD FFOA FOLLOW UP AS UNRESOLVED)**

B4 "*When would be a good time to call you back?*"
NOTE TIME AND DATE **(CLOSE; START FOLLOW UP CONTACT AT B1)**

B5 → IF FOODS FED BY OTHER ADULTS FORM <u>WAS</u> ATTEMPTED **(GO TO B5a1)**
→ IF FOODS FED BY OTHER ADULTS FORM <u>WAS NOT</u> ATTEMPTED **(GO TO B5a2)**

B5a1 "*Excellent, thank you. I understand you filled in the form about what [child's name] ate while he/she was in your care on [day of interest]. There are a few things on this form I would like to ask you about.*"
GO THROUGH AND RECORD MISSING INFORMATION ON *NOTES* SHEET
ONCE ALL INFORMATION OBTAINED **(CLOSE)**

B5a2 "*Excellent, thank you. I'm interested to know everything [child's name] ate while in your care on [day of interest] – that includes snacks, drinks and water, even just having a small taste of something, as well as meals.*
*First, I'd like to make a quick list of all the things [child's name] ate and drank while in your care [on day of interest]. After that, I'll ask you to give me some more details about each food and drink, like the amounts eaten and how they were fed. I know how challenging it is to keep track of what little ones eat, so I really appreciate you helping us with this.*
*So, what was the first thing [child's name] ate while in your care [on day of interest]?*"
RECORD DIRECTLY ONTO INCOMPLETE 24-H RECALL RECORDING SHEET
COMPLETE QUICKLIST AND COLLECT ONLY <u>SIGNIFICANT</u> FURTHER DETAIL (#2 above)
ONCE INFORMATION IS OBTAINED **(CLOSE)**

**CLOSE**

*"Thank you very much for your time. You have been a great help to us for this important study. Goodbye."*

**TERMINATE**

*"Thank you very much for your time. Goodbye."*

## Via email

1. Prepare email for the participant using email template in **Appendix 1**:
    a. Foods Fed by Other Adults form attempted (see **FFOA form attempted**)
    b. Foods Fed by Other Adults form not attempted (see **FFOA form not attempted**)

    >> **If participant responds with information**: Print off the email thread and staple it to the back of the 24-h recall recording sheet.

    >> **If participant does not respond within 2 days of initial follow up contact attempt**: Send one reminder email to the participant.
        i. **If participant responds with information**: Print off the email thread and staple it to the back of the 24-h recall recording sheet.
        ii. **If no response**: Record FFOA follow up as unresolved (on the Diet recall form (under the appropriate visit) in REDCap).

# Follow up contact – Steps after

1. Make a note of each contact and attempt at contact on the **Participant Tracking Form** in REDCap – in the appropriate section of the 'Participant Contacts' section. Save and exit the form.

2. Update the **Diet Recall form** (under the appropriate visit) on REDCap:
    a. Ensure the 'Has [*the FFOA follow up*] been resolved?' field has been answered.
    b. Ensure the 'Final 24-h recall status' field has been answered. If 'Incomplete', specify the reason incomplete and type of missing information.
    c. Mark the form status as 'Complete' then save and exit the form.

3. Staple the missing information notes back to the original 24-h recall recording forms.

4. Download all 24-h recall documentation to HCS:
    - DUNEDIN: Scan all completed 24-h recall documentation and download this to the University High-Capacity Central File Storage system – please use the format shown below for file and folder names.
    - MASSEY/WELLINGTON: Scan/mail completed 24-h recall recording sheets to Otago University High-Capacity Central File Storage system – please use the format shown below for file 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_24-h recall recording sheet_10Jun2020

5. File paperwork in locked filing cabinet.

**Appendix 1**

# Foods Fed by Other Adults form attempted

**Subject: [*Child's name's*] foods and drinks while in [*other caregiver's name*]'s care yesterday ([*day dd month yyyy*])**

Dear *[Adult participant's name]*,

Thank you very much for your time taking part in the [*first/second*] visit of the Young Foods New Zealand study today.

During the visit you told me that [*child's name*] was fed by [*other caregiver*] for part of the [*day*]. We were missing some information on the [*meals/drinks*] eaten while in their care, and you kindly said you could follow up on this with [*other caregiver*] for us. Are you still happy to do this?

If so, we would really appreciate it if you could ask them the following information:

- [*Ask about missing information here*]
- [*e.g., **Cereal** – what was the brand name of this product? Was the cereal in a powder before it was made up*?]
- [*e.g., **Mango custard** – did this come from a food pouch? If yes, how was [child's name] fed the food (i.e. did they suck it straight from the pouch nozzle or was it on a spoon? And if it was straight from the nozzle who was holding the pouch?)*]
- [*e.g., **Pasta bolognaise** – around how much of this did [child's name] eat?* You can use household measures (e.g., cups or spoons) or sizes of packets (e.g., 100g pouch).
- [*etc*]

It would be great if you could contact [*other caregiver*] to get this information before [*he/she*] forgets anything – today or tomorrow would be ideal. Don't worry if it's not possible to get all this information – just getting us as much information as you can is still very useful.

If you have any questions about this, please feel free to contact me by phone (details below) or email.

Thanks again for helping us with this important study.

Kind regards,

[*Name*]
[*Role*]
[*Phone contact*]

# Foods Fed by Other Adults form not attempted

**Subject: [*Child's name*] foods and drinks while in [*other caregiver's name*]'s care yesterday ([*day dd/mm/yyyy*])**

Dear *[Adult participant's name]*,

Thank you very much for your time taking part in the [*first/second*] visit of the Young Foods New Zealand study today.

During the visit you told me that [*child's name*] was fed by [*other caregiver*] for part of the day. We were not sure what [*child's name*] ate or drank while in their care, and you kindly said you could follow up on this with [*other caregiver*] for us. Are you still happy to do this?

If so, we would really appreciate it if you could ask them the following information:

- What did [*child's name*] eat and/or drink while in [*other caregivers*] care yesterday (on [*day dd/mm/yyyy*])?

For each food or drink that was eaten, we would also like to know:

- About how much of the food or drink did [*child's name*] eat/drink? You can think about the amount in household measures (e.g., cups or spoons) or sizes of packets (e.g., 140g yoghurt pottle).
- What was the brand name of the food or drink (if applicable)?
- Who put the food or drink in [*child's name*]'s mouth? (was it an adult or the child)
- Did the food come from a food pouch? If yes, how was [*child's name*] fed the food (i.e. did they suck it straight from the pouch nozzle or was it on a spoon? And if it was straight from the nozzle who was holding the pouch?).

It would be great if you could contact [*other caregiver*] to get this information before [*he/she*] forgets anything – today or tomorrow would be ideal. Don't worry if it's not possible to get all this information – just getting us as much information as you can is still very useful.

If you have any questions about this, please feel free to contact me by phone (details below) or email.

Thanks again for helping us with this important study.

Kind regards,

[*Name*]
[*Role*]
[*Phone contact*]

YOUNG FOODS
— New Zealand —

We know how busy it can be looking after little ones – thank you very much for filling out the information on these pages. We really appreciate your support of the parents' participating in this study.

If you would like to know more about the Young Foods NZ study, our website is www.firstfoods.co.nz/young-foods

If you have any comments or questions, then feel free to contact the study on 0212791290 or auckland@firstfoods.co.nz

# Young Foods NZ

## Foods Fed by Other Adults Diary

YOUNG FOODS
— New Zealand —

"Other Caregiver" name: _____ Date: _____

Caregiver's role (e.g., family member, Early Childhood Centre staff): _____

If Early Childhood Centre staff, please state name of centre:

_____

_____ is involved in a study looking at what and how children eat. We would really appreciate it if you could write down a complete description of what s/he eats today while in your care, following the instructions on the next page. Your help in completing this diary will provide information so that health professionals and policy makers can advise parents and whānau on feeding their children.

We would like you to please:

- Step 1 & 2: Write down what food and drink was offered to the child while in your care, and write the time of the day and place they were served these items. Please list each food or drink item individually (e.g., 'bread' 'cheese' instead of 'cheese on toast') and remember to include all water, breast milk and infant formula as well.

- Step 3: Estimate how much food and drink s/he has EATEN (this might be less than they were offered). You can use household measures (e.g., cups or spoons), sizes of packets (e.g., 140g yoghurt pottle, 15g "Kids" bar).

- Step 4: Tick the option that best describes who put the food in his/her mouth. You can tick both options if it was a combined effort (like when you guide the spoon to their mouth but they help push the spoon in).

- Step 5: Tick to indicate whether food was from a food pouch. If yes, tick the option that best described how child was fed food from the pouch. *Note*: *child fed directly from pouch* means child held pouch and sucked through pouch nozzle, *adult fed child directly from pouch* means adult held pouch and child sucked through pouch nozzle.

- Step 6: If any foods eaten are recipes, please attach a copy of the recipe to this sheet, including the number of portions the recipe makes. Then in the "amount eaten" column, please record how many of these portions s/he ate e.g., ½ a portion or 2 portions.

## Recipes

Step 6: Please record the full recipe and number of portions it makes



## Here's an example of how to fill out the food diary:

| Step 1 | Step 2 | | Step 3 | Step 4 | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Time and Place | Food name | Food brand | Cooking method | Amount eaten | Was food from a food pouch? | | | | |
| | | | | | No | Yes | | | |
| | | | | | | Child fed self directly | Adult fed child directly | Adult fed child from spoon | Child fed self pouch via spoon |
| *10 am floor* | *Apple, pear and berries squeeze pouch* | *Watties* | | *1 pouch (120 g)* | | ✓ | | | |
| | *Orange flavoured fruit drink* | *Raro* | | *¾ cup* | ✓ | | | | |
| *12 noon Highchair* | *Lasagne – See Recipe* | *Homemade* | | *1 portion* | ✓ | | | | |
| | *Potato* | | *boiled* | *¾ cup* | ✓ | | | | |
| | *Peas* | | *boiled* | *10 peas* | ✓ | | | | |

Food diary:

| Step 1 | Step 2 | | | Step 3 | Step 4 | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Time & Place | Food name | Food brand | Cooking method | Amount eaten | Was food from a food pouch? | | | | |
| | | | | | No | Yes, how was food from pouch fed? | | | |
| | | | | | | Child fed self directly from pouch | Adult fed child directly from pouch | Adult fed child from spoon | Child fed self pouch via spoon |
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**Show Card 1** (for question 1)

ALWAYS

SOMETIMES

NEVER

DON'T KNOW

**Show Card 2** (for questions 2-8)

OFTEN

SOMETIMES

NEVER

DON’T KNOW

**Office use only**

**Date:**

**Participant ID:**

YOUNG FOODS
— New Zealand —

# 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 <u>*around 6 months of age*</u>?

- ○ 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 second most commonly:

_____

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

○ 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

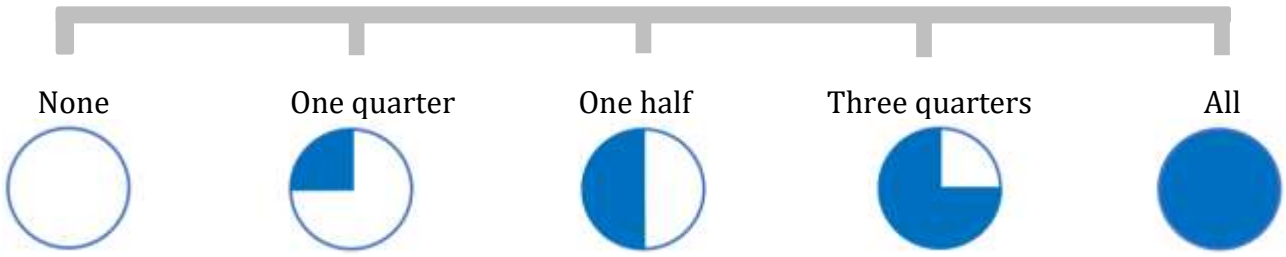
**34a.** Brand and flavour of food pouch child eats third most commonly

_____

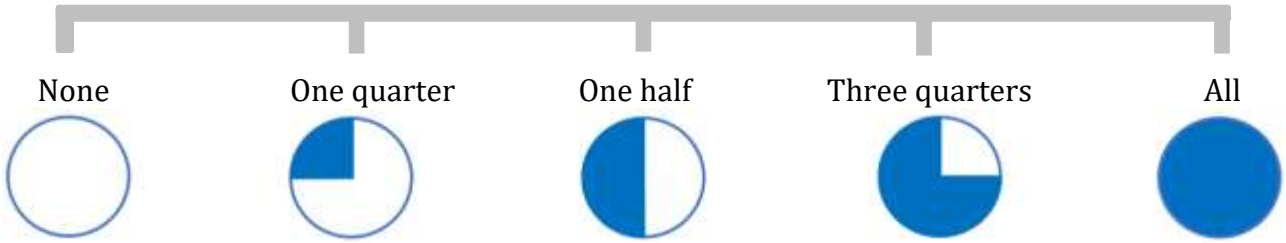
**34b.** How often has your child eaten this food *in the past month*?

○ 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

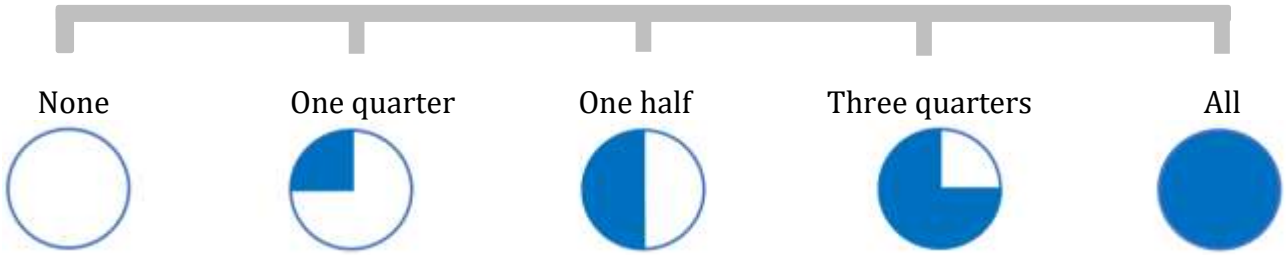
**35.** Out of all the food your child eats, what proportion do they eat by feeding themselves directly from a pouch (holding a pouch themselves and sucking through the nozzle)? Show this on the sliding scale:




**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 <u>all</u> 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.

[*upload photo*]

*[repeat option]*

## 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

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We, the student and the student's main supervisor, certify that all co-authors have consented to their work being included in the thesis and they have accepted the student's contribution as indicated below in the Statement of Originality.

| | |
|---|---|
| Student name: | Rosario Jupiterwala |
| Name and title of main supervisor: | Professor Pamela von Hurst |
| In which chapter is the manuscript/published work? | 3 |
| What percentage of the manuscript/published work was contributed by the student? | 80% |

Describe the contribution that the student has made to the manuscript/published work:

Conceptualisation, investigation, data analysis planning, visualisation, and writing—original draft preparation and further revisions.

Please select one of the following three options:

- ○ The manuscript/published work is published or in press
  Please provide the full reference of the research output:
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| | | | |
|---|---|---|---|
| Student's signature: | Rosario Jupiterwala Digitally signed by Rosario Jupiterwala Date: 2023.10.01 08:09:27 +13'00' | Main supervisor's signature: | Pamela von Hurst Digitally signed by Pamela von Hurst Date: 2023.10.08 10:05:22 +13'00' |

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| | |
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| Student name: | Rosario Jupiterwala |
| Name and title of main supervisor: | Professor Pamela von Hurst |
| In which chapter is the manuscript/published work? | 4 |
| What percentage of the manuscript/published work was contributed by the student? | 80% |

Describe the contribution that the student has made to the manuscript/published work:

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Please select one of the following three options:

- ○ **The manuscript/published work is published or in press**
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  Please provide the name of the journal:
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| | | | |
|---|---|---|---|
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| In which chapter is the manuscript/published work? | 5 |
| What percentage of the manuscript/published work was contributed by the student? | 80% |

Describe the contribution that the student has made to the manuscript/published work:

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