Feeding and Dietary Practices of New Zealand Infants: An Observational Study

FIRST FOODS

— New Zealand —

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ABSTRACT

Background: Nutrition and early-life feeding practices have short and long-term impacts on the quality and longevity of life. The importance of optimal nutrition during infancy is recognised worldwide and evidence-based infant feeding recommendations have been developed to promote infant health, growth, development, and the establishment of healthy eating behaviours. Currently, there is limited evidence on infant nutrition and feeding practices in New Zealand (NZ), with gaps in our knowledge about what infants are being fed, adherence to the Ministry of Health (MoH) 'Healthy Eating Guidelines for New Zealand Babies and Toddlers (0–2 years old)', and the prevalence of concerning feeding behaviours (CFB).

Aim: To 1) investigate the contributions that key foods and food groups make to the dietary intake of NZ infants, 2) investigate infant adherence to key dietary indicators as recommended by the MoH's 'Healthy Eating Guidelines for New Zealand Babies and Toddlers (0–2 years old)', and 3) determine the prevalence of parent-reported concerning infant feeding behaviours and associated demographic characteristics and feeding practices of NZ infants between 7.0 and 10.0 months of age.

Methods: The observational First Foods NZ (FFNZ) study recruited 625 ethnically diverse infants (aged 7.0 to 10.0 months) living in Auckland and Dunedin between July 2020 and February 2022. Caregivers who were 16 years or older, spoke English, and had not recently participated in a nutritional intervention that may have influenced their infant's diet were invited to attend two study visits. Appointments were conducted in the participant's home, available research centre, or via Zoom (during Covid19 restrictions for second appointment only) and included two 24-hour diet recalls and demographic and feeding questionnaires. Diet recall data were analysed through FoodWorks (Version 10, Xyris Software, Australia) using the NZ Food Composition Database FOODfiles™ 2018 Version 01, and foods were allocated food and food group codes using the FFNZ coding system. Counts of foods and food groups consumed were analysed for at least one and both diet recall days, where available. Key indicators from the MoH's 'Healthy Eating Guidelines for New Zealand Babies and Toddlers (0–2 years old)' that were measurable from FFNZ data and applied to those aged 7.0 to 10.0 months were extracted from questionnaire data, or where stated from 24-hour recalls. Recommendations analysed included exclusive breastfeeding to 'around' six months of age (defined as '5 months' or '6 months', being the age when something other than breast milk, i.e. either another drink, or solid foods, was first introduced); current breastfeeding; the introduction of solid foods 'around' six months of age" (defined

as ‘5 months’ or ‘6 months’ when the first solid food was introduced); the introduction of puréed foods and spoon-feeding when starting solid foods; offering of iron-rich foods (meat, poultry, fish, seafood, and iron fortified infant cereals), vegetables, and fruit as first foods; the daily offering of MoH food groups (24-hour recall data; vegetables, fruit, grain foods, milk and milk products, and meat and protein-rich foods); no salt and sugar added to meals (specific 24-hour recall question); avoidance of inappropriate drinks (specific 24-hour recall question; beverages other than breast milk, formula, or water such as cow’s milk as a drink, other milk, juice, soft drinks, tea, and alcohol); and use of self-feeding when developmentally appropriate. Logistic regression was then used to estimate odds ratios, 95% confidence intervals, and p-values for associated sociodemographic characteristics and key indicators. After their second appointment, caregivers were emailed a final questionnaire, which included the Paediatric Eating Assessment Tool (PediEAT). Feeding behaviours were categorised according to the total PediEAT and subscale scores (physiologic symptoms, problematic mealtime behaviours, selective/restrictive eating, and oral processing). Scores were categorised as ‘concern’ and ‘no concern’ using the PediEAT scoring system. Unpaired t-tests and the chi-squared tests determined associations between PediEAT scores and infant and caregiver sociodemographic characteristics. Logistic regression, adjusted by infant age and deprivation, determined associations between PediEAT scores and food groups consumed during both diet recalls. Data were analysed using Stata software (StataCorp, Texas) and Microsoft Excel (version 16.66).

Results: Written consent was obtained from 625 caregivers. Data from the demographic and feeding questionnaire were available from all infants (n=625). All caregivers completed at least one diet recall. A second diet recall was available from 614 infants. PediEAT results were available for 554 term infants.

Most infants consumed vegetables (96.2% of infants), fruit (91.8%), grain foods (90.4%), milk and milk products (64.0%), and meat and protein-rich foods (84.3%) at least once during the two 24-hour diet recall days. Commercial infant foods (CIF) were consumed by 78.1% and discretionary foods by 56.3% of infants at least once. The proportion of infants who consumed vegetables (63.2%), fruit (53.9%), grain foods (49.5%), milk and milk products (38.6%), meat and protein-rich foods (31.8%), CIF (41.8%), and discretionary foods (16.1%) on both diet recall days was lower. Overall, only 6.5% of infants met guidelines for the daily consumption of the MoH food groups. The ten most common foods consumed were carrot, banana, bread, brassicas, kumara, extruded commercial infant snacks, pumpkin, apple, potato, and commercial infant pouches.

Breastfeeding was initiated by 97.2% of mothers, and 37.8% of infants were exclusively breastfed to around six months. At the time of participation, 66.2% of infants were breastfed. Most infants met guidelines for introducing solid foods, including the age of introduction (75.4%), offering iron-rich foods as first foods (88.3%), providing puréed textures (80.3%) and spoon-feeding (74.1%). Self-feeding at the time of participation was common (86.9%). Most met guidelines for avoiding inappropriate beverages (93.9%) and adding salt (76.5%) and sugar (90.6%) to foods. Typically, infants with caregivers who were younger, higher educated, not currently working, primiparous, and living in low deprivation were more likely to meet the guidelines.

Feeding behaviour scores were higher than PediEAT norm-reference values and 17.3% of infants were categorised with 'concern' feeding behaviours. 'Concern' scores were highest for selective/restrictive eating (29.2%), problematic mealtime behaviours (21.5%), and physiologic symptoms (13.7%) subscales. Mothers who were primiparous and highly educated caregivers were more likely to report 'concern' total PediEAT scores. Primiparous mothers and caregivers with higher education, that did not use early child education centres, and had infants of NZ Asian infant ethnicity were more likely to report problematic mealtime behaviours. Infants characterised as of 'concern' had significantly lower odds of consuming 'vegetables' and 'meat and protein-rich foods' and were more likely to consume 'CIF'. Infants with problematic mealtime behaviours had a lower odds of consuming 'discretionary foods' and were more likely to be still breastfeeding.

Conclusion: This research provides evidence on infant food and food group intake, adherence to key MoH infant feeding guidelines, and the prevalence of parent-reported infant feeding behaviours and associated demographic characteristics and feeding practices from an ethnically diverse group of NZ infants from Auckland and Dunedin. Infants were shown to consume a range of foods within the MoH food groups at least once during the study. However, only 6.5% of infants consumed all five food groups during both recalls. Grain foods, milk and milk products, and meat and protein-rich foods were the least commonly consumed food groups when investigating those consumed on both recall days, increasing the risk of nutritional deficiencies. Most infants met guidelines for introducing solid foods and avoiding inappropriate beverages and adding salt and sugar to meals, although the prevalence of exclusive breastfeeding to 'around' six months, however, continues to be low, particularly for first-time mothers. As seen previously, sociodemographic characteristics were also associated with adherence, identifying key groups (primiparous mothers, lower educated caregivers, those living with multiple children, and those living in areas of high deprivation) that require additional support. Finally, CFB were prevalent in our study, with higher scores reported by primiparous mothers and caregivers who were highly educated. Infants with CFB were less likely to meet recommendations for ‘vegetables’ and ‘meat and protein-rich foods’ and were more likely to consume ‘CIF’. Further investigation is required to understand parental perceptions of feeding behaviours and the nutritional implications of CFB. Further research will determine the nutritional implications of not meeting the MoH food group guidelines during complementary feeding, investigate what support parents need in NZ to improve adherence to the MoH breastfeeding and food group recommendations, and the impact of CFB on nutrient intake.

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To Anne-Louise Heath and Rachel Taylor, thank-you for promoting the need for further infant research in New Zealand and providing the opportunity to be part of the First Foods New Zealand Team. Working with you both has been an honour. To my fellow Auckland First and Young Foods New Zealand PhD candidates, Maria Casale, Rio Monzales, and Emily Jones, working with you for the past three years has been a fantastic experience. Thank you all for your dedication to the study. You are inspiring individuals, and I look forward to seeing where your journey takes you next. To Rebecca Paul and Jenny McArthur, thank you for your indispensable project management during data collection. The day-to-day running of data collection would not have been possible without you both. To the Auckland research assistants, Andrea Wei, Emily Shoesmith, and Darrian Holten, data collection would not have been the same without you. Thank you for your contribution to our study. To Lizzie Jones, Ioanna Katiforis, Andrea Wei, Neve McLean, Rebecca Paul, and Liz Fleming, thank you for your time spent during FoodWorks data entry and quality checking. Working with you all was a great experience. To Ioanna Katiforis and Liz Fleming, thank you for your assistance in developing and implementing the First Foods New Zealand food coding system – a mammoth task that has allowed insight into crucial areas of infant nutrition in New Zealand. To Jillian Haszard, thank you for your statistical support and patience during data analysis. I have learnt a great deal from you. To the remaining University of Otago and Massey University teams, thank you for your invaluable input into the study. It was a pleasure working with you all.

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List of Abbreviations and Symbols

Abbreviation or Symbol	Definition
AAP	American Academy of Pediatrics
AYCE	About Your Child's Eating
BAMBI	Brief Autism Mealtime Behaviour Inventory
BLISS	Baby-Led Introduction to Solids Study
BLW	Baby-led weaning
BMI	Body mass index
BPFAS	Behavioral Pediatrics Feeding Assessment Scale
CDC	Centers for Disease Control and Prevention
CF	Complementary feeding
CFB	Concerning feeding behaviours
CEBI	Children's Eating Behaviour Inventory
CEBQ	Child Eating Behaviour Questionnaire
CEDQ	Children's Eating Difficulties Questionnaire
CIF	Commercial infant food
DONALD	DOrtmund Nutritional and Anthropometric Longitudinally Designed Study
DQIs	Diet quality indices
Dr	Doctor
EBF	Exclusive breastfeeding
e.g.,	For example
ESPGHAN	European Society for Paediatric Gastroenterology Hepatology and Nutrition
Et al.	and others
FITS	Feeding Infants and Toddlers Study
FSANZ	Food Standards Australia and New Zealand
GUiNZ	Growing up in New Zealand study
HRC	Health Research Council

Abbreviation or Symbol	Definition
ICFET	International Complementary Feeding Evaluation Tool
ICFI	Infant and Young Child Feeding Indexes
InFANT	INfant Feeding, Active play and NuTrition Program
MBQ	Mealtime Behaviour Questionnaire
MCHS	Montreal Children’s Hospital Feeding Scale
Meat and protein-rich foods	Legumes, nut butters, eggs, fish, seafood and chicken, or lean red meat
MoH	Ministry of Health
NZ	New Zealand
OzFITS	The Australian Feeding Infants and Toddler Study
PASSFP	Paediatric Assessment Scale for Severe Feeding Problems
PAHO	Pan American Health Organization
PubMed	Medline Public Publisher
RCT	Randomised control trial
SACN	Scientific Advisory Committee on Nutrition
SD	Standard deviation
STEP-CHILD	Screening Tool of Feeding Problems Applied to Children
TSF	Traditional spoon-feeding
UNICEF	United Nations Children's Fund
UK	United Kingdom
USA	United States of America
WHO	World Health Organization
YFNZ	Young foods New Zealand

List of Papers and Conference Presentations

Three papers, shown below, were written during the PhD candidature to meet the requirements of thesis by publication. Manuscripts are formatted for publication and will be submitted in the upcoming months. DRC 16 statements are presented in Appendix 2. Methods for the First Foods New Zealand Study have been published (Appendix 3), with the candidates input.

- Paper I:

  Contributions of Key Foods and Food Groups to the Dietary Intake of Infants in the First Foods New Zealand Study

  Paper II: Submitted to the Nutrients Journal 'Selected Papers from the 56th Annual Nutrition Society of New Zealand Conference'

  Adherence to Infant Feeding Guidelines in the First Foods New Zealand Study

- Paper III:

  Parent-reported Feeding Behaviours of New Zealand Infants and Associations with Demographic Characteristics and Feeding Practices in the First Foods New Zealand Study

- Methods (Appendix 3)

  Taylor RW, Conlon CA, Beck KL, von Hurst PR, Te Morenga LA, Daniels L, Haszard JJ, Meldrum AM, McLean NH, Cox AM, Tukuafu L, Casale M, Brown KJ, Jones EA, Katiforis I, Rowan M, McArthur J, Fleming EA, Wheeler BJ, Houghton LA, Diana A, Heath AM. Nutritional implications of baby-led weaning and baby food pouches as novel methods of infant feeding: Protocol for an observational study. JMIR Research Protocols, 10(4), e29048. https://doi.org/10.2196/29048

Conference presentations

1. Nutrition Society conference: 1st and 2nd December 2022

‘Adherence to Breastfeeding and Complementary Feeding Guidelines within the First Foods New Zealand Study’.

This research was extracted from paper II: Adherence to Infant Feeding Guidelines in the First Foods New Zealand Study. Awarded runner-up for best oral presentation.

Chapter 1

An introduction to this research

Starting with an introduction to infant feeding, this chapter provides a background and justification for the thesis. The introductory section is then followed by the thesis's aims, objectives, hypotheses, thesis structure, and author contributions.

1.1. INTRODUCTION AND JUSTIFICATION FOR THE STUDY

The provision of safe and nutritionally appropriate foods in early life sets a foundation for good health across an individual's lifespan (Jang & Serra, 2014). However, unlike other life stages, food choices rapidly change during infancy, as infants transition from breast or formula milk as a sole food source to a diet consisting of a range of foods and beverages from the family diet (Birch et al., 2007; Grummer-Strawn et al., 2008; Lioret et al., 2013). This can be a vulnerable phase of nutrition as an infant learns about new foods, tastes, and textures, developing food preferences that can last a lifetime (Berti & Agostoni, 2017; Birch & Doub, 2014; Nicklaus & Remy, 2013; Robinson & Fall, 2012). If poor food preferences and feeding behaviours are developed, individuals are more likely to make undesirable food choices in later life, increasing their risk of poor health. The diet during infancy, therefore, presents a window of opportunity to protect and promote good nutrition and healthy eating behaviours to support an individual's immediate and long-term health.

What is optimal infant nutrition?

Until 'around' six months of age, an infant should receive all nutrition from breast milk (Ministry of Health, 2021a). Exclusive breastfeeding, or the provision of only breast milk for the first six months of life, has beneficial outcomes for both mothers and their offspring (Ministry of Health, 2021a). Infants who are breastfed have increased immune development and tolerance (Field, 2005), cognitive function (Anderson et al., 1999), and maternal bond (Horta & Victora, 2013). They also have a reduced risk of allergies (Robinson & Fall, 2012), gastrointestinal and respiratory infections (Duijts et al., 2009; Sankar et al., 2015), type two diabetes mellitus (Horta et al., 2015; Horta & Victora, 2013; Koletzko et al., 2019), and becoming overweight or obese (Arenz et al., 2004; Bartok & Ventura, 2009). Infants may also have an increased acceptance of new foods because of exposure to maternal dietary flavours in breast milk (Spahn et al., 2019; Stoody et al., 2019). Around the age of six months, breast milk is unable to provide adequate energy and nutrients, and solid foods should be introduced in addition to breast milk (Fewtrell et al., 2017). Breast milk, however, continues to be the greatest source of energy and total nutrients until one year of age (Ministry of Health, 2021a).

The early introduction of solid foods, defined as before four months of age (Ministry of Health, 2021a), is associated with adverse health outcomes, including an increased risk of allergies (Fiocchi et al., 2006; Robinson & Fall, 2012), obesity (The Scientific Advisory Committee on Nutrition, 2018; Weng et al., 2012), and gastrointestinal damage (Butte et al., 2004; Fewtrell et al., 2017). An infant's renal system is also not physiologically mature enough to handle solid foods (Butte et al., 2004). Around six months of age, an infant is developmentally ready to start complementary feeding (CF) and it is recommended that spoon-fed puréed foods are introduced (Fewtrell et al., 2017). The Ministry of Health (MoH) does not recommend using baby-led weaning (BLW), where an infant self-feeds finger foods from the start of CF, as further research is required to determine if it is a nutritionally safe and developmentally appropriate feeding method (Ministry of Health, 2021a). Instead, infants should be encouraged to participate in mealtimes and self-feed when developmentally appropriate (Ministry of Health, 2021a). This allows infants to learn how to eat, enjoy mealtimes, follow their natural hunger and fullness cues, and learn how new foods taste and smell.

A variety of foods from each of the food groups should be introduced into the diet after CF has started, including vegetables; fruit; grain foods; milk and milk products; and legumes, nut butters, eggs, fish, seafood and chicken or lean red meat (referred to as meat and protein-rich foods in this thesis), progressing from a puréed texture to lumpy, mashed, and soft finger foods (Ministry of Health, 2021a). Each food group provides important nutrients for infant growth and development. However, not all foods are equal, and a variety of foods within each food group are required to meet daily nutrient requirements. Iron-rich foods are particularly important due to declining iron stores, and foods such as red meat, fish, poultry, and iron-fortified infant cereals, should be offered daily to meet infants' high iron requirements (EFSA Panel on Nutrition et al., 2019). Foods with different flavours, including naturally sweet, savoury, and bitter, should also be introduced to widen an infant's taste preferences (Ministry of Health, 2021a) and reduce fussy eating tendencies (de Barse et al., 2017). Commercial infant foods (CIF) can be included in an infant's diet if used in addition to home-cooked foods (Ministry of Health, 2021a). Pouches and mixed commercial products should be emptied into a bowl to allow infants to see, smell, and touch the food. CIFs are a convenient source of infant nutrition, however, if overused and not used in addition to home-cooked meals, they may reduce the variety of flavours and textures in an infant's diet (World Health Organization, 2021). For pouches, incorrect feeding through the nozzle instead of a spoon may also increase the risk of concerning feeding behaviours (CFB), overfeeding, and poor dental health (Theurich, 2018). Caregivers are also recommended to avoid feeding infants foods and beverages containing or with added salt and sugar. Adding salt or sugar changes the flavour of food and accustoms taste preferences for sweet and salty, which, when consumed in large amounts, are linked to heart disease and diabetes (Michaelsen, 2000; World Health Organization, 2015). Beverages such as juice, cordial, fruit drinks, flavoured milk, soft drinks, tea, and coffee should also be avoided as they do not enhance an infant's nutrition and may promote undesired taste preferences (Ministry of Health, 2021a). Cow's milk does not contain adequate nutrients compared to breast and formula milk and should also be avoided as a beverage until one year of age (Ministry of Health, 2021a; World Health Organization, 2009).

'Normal' feeding behaviours are not well defined and many infants experience difficulties when learning to eat (Pados et al., 2018). Responses such as gagging and refusal of new or unfamiliar foods are normal and typically resolve during the CF period. Behaviours are characterised as of concern when ongoing or when an infant will not eat enough despite the availability of appropriate foods (Kedesdy & Budd, 1998).

Infant feeding guidelines in New Zealand

The importance of infant feeding is recognised worldwide, as shown by the development of international and country-specific infant feeding recommendations. In New Zealand (NZ), dietary recommendations for infants and toddlers are guided by the recently updated 'Healthy Eating Guidelines for New Zealand Babies and Toddlers (0-2 years)' (Ministry of Health, 2021a). The 2021 released guidelines include six evidence-based eating statements to support optimal feeding practices for breastfeeding, CF, diet variety, appropriate foods, appropriate beverages, and eating environments.

What do we know about infant nutrition in New Zealand?

Many countries have reasonably up-to-date evidence on infant food or nutrient intake (Eldridge et al., 2019; Fox et al., 2004; Friel et al., 2010; Grummer-Strawn et al., 2008; Lennox et al., 2013; Lioret et al., 2013; United Nations International Children's Emergency Fund, 2021; White et al., 2017). New Zealand, however, has little comparable evidence (Taylor et al., 2021), with no national health or nutrition surveys undertaken in infants. Instead, most evidence regarding infant nutrition comes from the Growing Up in NZ (GUiNZ) study. GUiNZ is a longitudinal nationally generalizable study of 6470 mother and infant dyads born between 2007 and 2010 (Morton et al., 2012). A wealth of information was collected on infant feeding practices and dietary intake, including the incidence of breastfeeding, adherence to the 2008 MoH infant feeding guidelines, sociodemographic characteristics associated with guideline adherence, and food consumption at nine months of age (Castro et al., 2021; Ferreira et al., 2023; Gontijo de Castro et al., 2018; Morton et al., 2012; Morton et al., 2014). In recent years, other NZ studies have focused on specific areas of infant nutrition, including the nutritional outcomes when following BLW (Cameron et al., 2012; Cameron et al., 2013; Fu et al., 2018; Morison et al., 2016; Taylor et al., 2021) and adherence to specific dietary guidelines (Ministry of Health, 2021b). These studies provide some insight into the current nutrition and feeding practices of infants. However, many, excluding the national health survey, were unable to represent the ethnic diversity of the NZ population, reducing generalisability, with notable associations between infant feeding practices and sociodemographic characteristics noted in GUiNZ (Morton et al., 2012).

Various methods are available to assess feeding behaviours, including questionnaires and coding tools. Parent-reported questionnaires are minimally burdensome, affordable, highly repeatable, suitable for tracking feeding behaviours over time, and appropriate for research (Thoyre et al., 2014). The Paediatric Eating Assessment Tool (PediEAT) is a validated parent-reported questionnaire that measures CFB. Unlike most other questionnaires, PediEAT uses subscales to describe the type of CFB, including physiologic symptoms, problematic mealtime behaviours, selective/restrictive eating, and oral processing concerns (Thoyre et al., 2014). Parent concerns about infant feeding behaviours are commonly reported in high-income countries (Benjasuwantep et al., 2013; Goday et al., 2019). The prevalence of CFB in NZ infants is currently unknown, although other high-income countries have reported that at least 25% of typically developing children (Benjasuwantep et al., 2013; Goday et al., 2019) and 80% of children with developmental disabilities or diagnosed medical conditions (Gal et al., 2011; Goday et al., 2019) have CFB. Behaviours have also been associated with sociodemographic characteristics, with a higher prevalence of CFB in older and male children (Antoniou et al., 2016; Brown et al., 2018; Chilman et al., 2021; Tharner et al., 2014; Wardle et al., 2001), those living in high deprivation, and caregivers with low household income or education level (Emmett et al., 2018; Qiu & Hou, 2020; Tharner et al., 2015). Typically children with CFB are less likely to consume fruits and vegetables (Carruth et al., 1998; Perry et al., 2015; Switkowski et al., 2020). Previously breastfeeding has been associated with improved food acceptance in infants (Hausner et al., 2009; Mennella et al., 2017; Mennella et al., 2001; Sullivan & Birch, 1994) and reduced incidence of fussy eating tendencies behaviours in children (Cooke et al., 2004; Galloway et al., 2003). This is thought to be the result of exposure to a variety of flavours from the maternal diet.

During the last decade, there have been significant changes in how infants are fed, with increasing availability of CIF (Katiforis et al., 2021; Padarath et al., 2020) and trends surrounding BLW (Brown et al., 2017; Cameron et al., 2013). In 2020, 266 CIF foods from 19 brands were found in two major NZ supermarket chains (Foodstuffs and Woolworths) (Katiforis et al., 2021), and a recent report showed a 27% increase in products available in the baby food sector between 2010 and 2016 in NZ (GlobalData, 2016). The use of CIF has likely changed since GUiNZ. However, despite the increasing availability of

CIF, there is limited evidence available to determine the use of CIF, feeding methods used (e.g., spoon-feeding or direct consumption from products), and the influence products have on nutrient intake in NZ (Katiforis et al., 2021; Rowan et al., 2022). However, BLW seems to be growing in popularity (Brown et al., 2017; Cameron et al., 2013) despite not being recommended by the MoH (Ministry of Health, 2021a). Our knowledge surrounding infant feeding in NZ is therefore limited, and with the emergence of BLW (Brown et al., 2017; Cameron et al., 2013) and the increasing availability of CIF (Katiforis et al., 2021; Padarath et al., 2020), there are likely to be significant changes in what and how infants are fed.

Introducing the First Foods NZ study

First Foods New Zealand (FFNZ) is a Health Research Council (HRC) funded observational study of 625 Dunedin and Auckland infants aged 7.0 to 10.0 months. FFNZ aims to provide up-to-date insight into the changes that occur as an infant progresses from a diet consisting of 100% milk to one that resembles family meals. This information will allow a greater understanding of what NZ whānau (families) are feeding their infants and their feeding methods. Key outcomes of FFNZ include infant iron status, growth, food and nutrient intake, breastfeeding incidence, eating and feeding behaviours, dental health, oral motor skills, and choking risk of New Zealand infants in general and those using pouches or BLW. This thesis will provide information on infant food and food group consumption, adherence to key MoH infant feeding guidelines, and parent-reported feeding behaviours in NZ infants between 7.0 and 10.0 months of age. This information will provide the MoH, health professionals, and NZ health and wellbeing organisations such as Plunket with up-to-date evidence on infant nutrition in NZ.

1.2. Thesis Aims

The overall aims of this thesis were to investigate the following in NZ infants between 7.0 and 10.0 months of age:

1) Contributions that key foods and food groups make to the dietary intake of NZ infants,
2) Adherence of infants to key dietary indicators based on the Ministry of Health's Healthy Eating Guidelines for New Zealand Babies and Toddlers (0–2 years old),
3) Describe parent-reported feeding behaviours of NZ infants and associations with demographic characteristics and feeding practices.

1.3. Thesis Objectives

1. Explore the contributions that key foods and food groups make to the dietary intake of NZ infants between 7.0 and 10.0 months of age.

    1.1. Describe the food and food groups contributing to the dietary intake of NZ infants,

    1.2. Describe differences in food and food group intake in NZ infants between 7.0 to 10.0 months of age,

    1.3. Describe the contribution of commercial infant foods to the dietary intake of NZ infants.

2. Investigate adherence to key dietary indicators of NZ infants between 7.0 and 10.0 months of age, as guided by the Ministry of Health's Healthy Eating Guidelines for New Zealand Babies and Toddlers (0–2 years old).

    2.1. Describe adherence to exclusive and current breastfeeding guidelines,

    2.2. Describe adherence to complementary feeding guidelines, including the age of solid introduction, appropriate foods introduced, appropriate textures, and appropriate feeding styles,

    2.3. Describe adherence to food variety guidelines, including the consumption of vegetables, fruit, grain foods, milk and milk products, and meat and protein-rich foods (legumes, nut butters, eggs, fish, seafood, chicken, or lean red meat),

    2.4. Describe adherence to appropriate food and beverage guidelines, including the offering of appropriate drinks and avoiding the addition of salt and sugar,

    2.5. Describe adherence to self-feeding guidelines,

    2.6. Determine sociodemographic characteristics associated with guideline adherence.

3. Describe parent-reported feeding behaviours of NZ infants between 7.0 and 10.0 months of age and associations with demographic characteristics and feeding practices.

    3.1. Describe parent-reported feeding behaviours of NZ infants, according to the Paediatric Eating Assessment Tool (PediEAT) total and subscale scores,
    3.2. Describe associations between parent-reported feeding behaviours and infant and parent demographic characteristics,
    3.3. Describe associations between parent-reported feeding behaviours and infant feeding practices (current breastfeeding and food group consumption).

1.4. Study Hypotheses

1. Key food contributors within the five food groups will differ between infants of different ages. Older infants will be more likely to meet the MoH food group recommendations.
2. Adherence to key indicators will vary between infants with different demographic characteristics, including maternal age, education, parity and employment status, early child education centre attendance, the number of children in the household, and deprivation.
3. Differences in parent-reported feeding behaviours according to infant and parent demographics and feeding practices will be observed. Infants with concerning parent-reported feeding behaviours will be less likely than infants without to consume the MoH food groups (vegetables, fruit, grain foods, milk and milk products, and meat and protein-rich foods) and more likely to consume CIF.

1.5. Thesis Structure

This thesis is divided into six chapters. Chapter one is an introductory chapter, providing a background and justification of the study, aims, objectives, hypotheses, and author contributions. A narrative review in chapter two outlines the current NZ and international recommendations for feeding infants and critically reviews the current evidence on infant nutrition and dietary intake, adherence to key dietary indicators, and dietary behaviours. Chapters three, four, and five present research findings, answering the study's three aims. These chapters are presented as manuscripts for publication with the inclusion of abstracts, introductions, methods, results, discussion, references and links to appendices as relevant to the chapter. The final chapter, chapter six, provides a discussion of the key study findings, research outcomes, study limitations, and directions for future research. The appendices include relevant documents to support an understanding of the study, including recruitment resources, the published FFNZ protocol paper, participant information sheets, relevant standard operating procedures (SOPs), resources used during data collection, copies of the main and final questionnaires, and the candidates' abstract that was published in the Nutrition Society of NZ conference proceedings.

1.6. Researcher Contributions

This thesis uses data from the First Foods NZ study (FFNZ). The candidate played a significant role in all aspects of the study, including writing and reviewing study protocols, recruitment, data collection (both Auckland and Dunedin), data quality checking, data management and cleaning, development of the FFNZ food coding system, food and food group coding, and data analysis. The candidate was involved in all aspects of FFNZ data collection, including the collection of infant anthropometry, infant dental images, and saliva samples from breastfeeding mothers and infants. This thesis does not discuss these outcomes; they are part of the wider FFNZ study aims. The candidate also collected data for an associated study: Young Foods New Zealand (YFNZ), as cohorts overlapped when multiple children resided in a home. An overview of contributions made by the candidate are available in Table 1.1.

Several individuals were involved in FFNZ and contributed to this research, as discussed below:

Professor Anne-Louise Heath and Professor Rachael Taylor were the study's primary investigators and led the research. They oversaw the overall FFNZ study, designed and developed the study, applied for research funding and ethics approval, developed the study protocols, assisted in protocol training, and mentored and allocated student roles.

Professor Cathryn Conlon, Professor Pamela von Hurst, Associate Professor Kathryn Beck, Associate Professor Lisa Te Morenga, and Associate Professor Jill Haszard were FFNZ co-investigators. They were involved in the design and development of the study, research funding applications, and obtaining ethical approval. Additionally, they reviewed study protocols, questionnaires and data collection strategies. Professor Cathryn Conlon (main), Professor Pamela von Hurst (co), and Associate Professor Kathryn Beck (co) were the candidate's supervisors. They mentored the candidate, provided academic support for the development and design of this thesis, reviewed and revised each thesis chapter, assisted in the dissemination of the results, and approved the thesis for submission.

Lisa Daniels (postdoctoral fellow) was involved in the study conceptualisation, writing, and review of protocols. Associate Professor Lisa Te Morenga provided cultural advice and ensured that FFNZ researchers and publications were culturally safe and met the needs of the NZ population. Associate Professor Jillian Haszard provided statistical support for data analysis and the dissemination of the study results. She was involved in the development of student aims and objectives, statistical method design, data cleaning, statistical analysis, and dissemination of results.

Jenny McArthur and Rebecca Paul assisted in recruitment, participant bookings, and data collection in Dunedin and Auckland, respectively. They worked closely with FFNZ and YFNZ PhD students Maria Casale, Emily Jones, Rio Jupiterwala, Neve McLean, Alice Cox, Ioanna Katiforis, Lesieli Tukuafu, and Master's students Madeline Rowan, Madeline Gash, Bailey Bruckner, and Annabelle Malone, who assisted in the development and reviewing of study protocols, protocol training, recruitment, data collection, data entry, data cleaning, and dissemination of results in their specific areas of research. Additional support for data collection was received from research assistants Andrea Wei, Emily Shoesmith, Darrian Holten, Ella Brouwer, Marsha Piddington, and Shay Whickham.

Elizabeth Fleming, Elizabeth Jones, and Ioanna Katiforis led FoodWorks data entry, with the candidate conducting quality checking of recalls. The candidate and Ioanna Katiforis then developed the FFNZ food coding system under the supervision of Elizabeth Fleming and Professor Anne-Louise Heath. Ioanna Katiforis and the candidate were responsible for coding foods consumed during the diet recalls.

Table 1.1: Candidate research contribution

Stage	Task	Contribution
Study development	Study protocols	Assisted in the development of the recruitment, food recall, photo transfer, final questionnaire, and frequently asked question protocols. Reviewed all study protocols and advised revisions.
	Study questionnaires	Assisted in the development of the main questionnaire. Reviewed the main and final questionnaires.
	Participant forms	Assisted in the development of the participant information sheet, consent form, and diet recall forms.
	Training	Engaged in student training for all areas of FFNZ data collection, including peer observations of 24-hour diet recalls.
	Adherence indicator	Developed the indicators presented in chapter three (Adherence to infant feeding guidelines) based on the 2021 Ministry of Health infant feeding guidelines and available data from the study to assess adherence to the infant feeding guidelines.
	Food coding system	Developed FFNZ's food group and ingredient coding system and trained other team members to use the standard operating procedures and codebooks.
	Flow chart	Developed the flow charts for Auckland and Dunedin to support researchers. Charts included a study timeline, equipment required at each visit, and visit objectives. Charts were used by researchers to prepare for appointments and ensure appropriate equipment was available during appointments.
Recruitment		Assisted in the development and design of advertisements, posters, media content, and the FFNZ website and Facebook account. Assisted in the promotion of FFNZ and developed targeted recruitment strategies for Māori and Pacific participants. Assisted in screening new participants and scheduling appointments.
Data collection	Participant visits	Collected data in both Auckland and Dunedin. Conducted onsite, home, and online appointments in both locations.
	Tracking documents	Designed and monitored documents for tracking new and current participants for Auckland and Otago. This ensured that all researchers understood what the participant had completed and were yet to complete. Follow-up contacts and notes were added when required (e.g. requested diet recall images on 21 April).
	Ethnicity targets	Designed Red-Cap reports to track ethnicity numbers. This aided the wider team to monitor study targets during data collection.
	Student + research assistant support	Supported new students and research assistants during study visits and administration.

Stage	Task	Contribution
Data management	FoodWorks quality check	Assisted in FoodWorks data quality checking – checking 100% of formula entries and 45% of total recalls. Engaged in weekly team meetings to discuss data errors for FFNZ and YFNZ.
	Food groupings	Individually coded foods (n=12,628) into food groups and ingredients after discussions with the supervisory team. Supported the YFNZ team to complete ingredient and food group coding (n=19,577) Engaged in weekly meetings to discuss problematic foods and coding requirements.
	Data analysis	Worked alongside the study statistician to review data quality and results presented in this thesis. All data analysis strategies were initially developed by the candidate and confirmed after consultation with the study statistician. Analysed all food and food group data presented in manuscript one and the food group, salt, and sugar data presented in manuscript two.

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CHAPTER 2

A REVIEW OF THE CURRENT LITERATURE

THIS CHAPTER REVIEWS THE CURRENT LITERATURE ON INFANT DIETARY INTAKE, ADHERENCE TO INFANT FEEDING GUIDELINES, AND FEEDING BEHAVIOURS IN NEW ZEALAND AND HIGH-INCOME COUNTRIES. MULTIPLE SEARCH TERMS DERIVED FROM THE STUDY OBJECTIVES WERE USED BETWEEN JANUARY 2020 AND APRIL 2023.

APPENDIX 1 PROVIDES FURTHER INFORMATION ON THE SEARCH STRATEGY.

2.1. Infant Feeding Guidelines

Nutrition plays a crucial role in the first years of life, directly influencing infant growth (Dewey, 2001), development (Dewey, 2003; Ministry of Health, 2021a), and lifelong dietary habits (Matthews et al., 2019; Reidy et al., 2017; Schwartz et al., 2011; Young & Krebs, 2013). Inadequate nutrition during early life leads to stunting, poor cognitive development, and increased morbidity (Black et al., 2008), with the highest prevalence of undernutrition worldwide occurring during the complementary feeding (CF) period (Victora et al., 2010). Conversely, overfeeding has been associated with excessive weight gain and metabolic programming, influencing the development of non-communicable diseases (Hanson & Gluckman, 2011; Singhal, 2016; Wu & Chen, 2009). Due to the negative implications of under and overfeeding, the importance of optimal dietary choices during infancy is well known (World Health Organization, 2015b). To support optimal practices, infant feeding guidelines have been developed worldwide.

2.1.1. A Glimpse into the History of Infant Nutrition

Feeding practices have evolved significantly in the past 250 years as knowledge surrounding infant feeding has increased (Jones, 2016). From early times, the importance of breastfeeding was recognised for infant growth and development. However, not all women were able or wanted to breastfeed (Radbill, 1981; Stevens et al., 2009; Wickes, 1953a). This led to many women using a wet nurse, 'a woman who breastfeeds another's child' before the introduction of early infant formulas (Stevens et al., 2009). Wet nursing provided an alternative means of feeding and became popular in the early 18th century for women of higher social class (Wickes, 1953b). However, when evidence emerged for the maternal benefits of breastfeeding, a shift was observed, with working-class women becoming the leading employers of wet nurses. This was common until 1900 when milk alternatives (animal milks) became popular (Minchin, 2018; Osborn, 1979).

Early feeding practices were associated with high morbidity and mortality rates because of poor hygiene and sterilisation practices, the offering of low-nutrient or inappropriate foods, and sudden weaning from breast milk (Davies & O'Hare, 2004; Katzenberg et al., 1996; Weinberg, 1993). Recommendations for introducing solid foods were more ambiguous during early history. Like today, different recommendations were found in different parts of the world (Minchin, 2018). Until the Renaissance period, offering solid foods (such as meat, fruit, and vegetables) typically occurred at two or three years of age, after the final milk tooth had erupted (Forsyth, 1911; Levin, 1959). However, in parts of the world, thin gruels, such as pap (bread soaked in water, milk, wine or beer) and panada (cereals cooked in meat or vegetable broth), were cautiously added around six months of age (Forsyth, 1911; Levin, 1959; Obladen, 2014). By the 15th and 16th centuries, reports appear that gruels were frequently fed from birth, often in the replacement of breast milk (Forsyth, 1911; Levin, 1959; Obladen, 2014). When gruels were of a thicker consistency, pre-mastication, where a parent or caregiver chewed food into a suitable texture before feeding to an infant, was common practice (Pelto et al., 2010).

Until the end of the nineteenth century, animal milk was the most common source of artificial feeding (Radbill, 1981). Pap and panada were also commonly added to bottles/devices to support infants with faltering growth (Forsyth, 1911; Radbill, 1981; Wickes, 1953b). However, poor sanitisation practices resulted in a high mortality rate. Infant formulas started to appear in the 18th century, with the first powdered form produced and marketed in 1865 (Radbill, 1981). By 1883, 27 branded powdered infant food products were available in the United States of America (USA) (Fomon, 2001). Initially, these were poor sources of nutrition, however, over time, protein, vitamins, and minerals were added alongside recommendations for appropriate sanitation techniques (Fomon, 2001). Between 1940 and 1970, a steady decline in breastfeeding was observed, with many physicians and mothers promoting formula as a safe substitute for breastfeeding (Minchin, 2018). Because of this decline, regulations for the marketing of formula were put in place in the 1970s to support women who were not able to breastfeed (Fomon, 2001).

Following the development of early infant formula, recommendations for introducing solid foods changed again, with solid food considered unsuitable before a year of age. However, many parents continued to offer gruels by six months of age. Commercial infant foods (CIF), including jars of apple purée, also appeared during this century and were highly recommended by paediatricians for those over one year of age (Radbill, 1981). In the late 19th and early 20th centuries, it was rare to offer solid foods before one year of age, following fears that this would harm ‘the delicate child’ (Fomon, 2001). However, the discovery of vitamins in 1912 (Funk, 1912) promoted change. By 1920, it was recommended that meat and liver were introduced during the first two weeks of life, followed by cereals, vegetables, and fruit (including juice), forming a mixed diet by one year of age (Jundell, 1923). The latter was a significant factor in minimising scurvy (Apple, 1987; McCollum, 1957). Rickets were also problematic at this time, and supplementation with cod-liver oil after birth became common practice in the USA (Apple, 1987; Holt, 1963).

By the 1950s, knowledge surrounding the physiological process of chewing and swallowing was developing, and guidelines started referencing the importance of an infant being able to transfer food from the front of the tongue to the pharynx for safe eating (Bakwin & Bakwin, 1953). Infants were subsequently offered an array of foods, including fruit (commonly banana), chocolate, juice, ice cream, custard, and vegetables from a young age (American Academy of Pediatrics Committee, 1958; Levin, 1959). In 1958 the American Academy of Pediatrics (AAP) released its first report on infant feeding, acknowledging that the developmental maturity of the gut, growth, and activity level of an infant were better indicators than age to determine if the introduction of solid foods was appropriate (American Academy of Pediatrics Committee, 1958). However, the report suggested that these indicators were typically present between three and four months of age. Since then, recommendations for the appropriate age to start solid foods have varied between eight weeks (1960s) (Harris & Chan, 1969; Jones et al., 1964), four months (1970s) (Challacombe, 1983; Fomon, 1975; Fomon & Anderson, 1972), and six to nine months (1990s) (Grimshaw et al., 2009); significantly influenced by a greater understanding of the development of allergies and coeliac disease (Koplin & Allen, 2013).

Infant feeding in New Zealand

New Zealand (NZ) shares a similar history, following a slightly later timeline (Apple, 1994). A key difference in NZ's history was the inception of Plunket in 1907 by Sir Frederick Truby King (Bryder, 2008). Plunket, named after Lady Victoria Plunket, wife of the NZ governor at the time, aimed to promote maternal and infant health by providing care from trained nurses (Bryder, 2001). A decade after its initiation, NZ had the lowest infant mortality rate in the world (Bryder, 2017). A vital component of this success was the promotion of breastfeeding (Bryder, 2001), the opening of infant hospitals (Ryan, 1997), and recommendations of spoon-feeding solid foods rather than adding them to bottles (Jones, 2016; Ryan, 1997). Truby King recommended breastfeeding four-hourly between 6am-10pm, avoiding night feeding (Jones, 2016; Ryan, 1997). Additionally, infants were to receive fruit juice from two to three weeks of age and cod liver oil from one month. In the cases of failure to thrive, formula was supported. The introduction of solid foods was recommended to start no later than nine months of age, introducing food groups one at a time (Jones, 2016; Ryan, 1997).

Over time, the appropriate age for CF changed with differing opinions of medical professionals and women (Minchin, 2018). Post-war, the cessation of breastfeeding was reported to occur earlier, with 40% of infants being weaned by 12 weeks of age (Bryder, 2005). Women returning to work was considered a factor in this shift, with married women accounting for 42% of working women in 1966

(Nolan, 2000). The prevalence of breastfeeding, however, improved as knowledge developed for the benefits of breastfeeding (Bryder, 2005). CF practices also improved as scientific evidence grew for feeding infants (Deem & Fitzgibbon, 1964).

New feeding trends

In recent years, how infants are fed has changed with the emergence of a new feeding method known as baby-led weaning (BLW). Gill Rapley first described BLW in 2005 (Rapley & Murkett, 2008) and has increased in popularity globally (Brown et al., 2017; Cameron et al., 2013) following the 2002 World Health Organization (WHO) guideline change, advising that CF should start at six months instead of the previously advised four months (World Health Organization, 2002). Given the significant developmental changes that occur between four and six months, advocates for BLW have suggested that an infant does not need purées or to be spoon-fed (Rapley & Murkett, 2008). Instead, they are physiologically able to self-feed family food. BLW is not currently recommended in NZ (Ministry of Health, 2021a). However, given its increase in popularity, several studies have investigated the potential benefits of better energy self-regulation and improved motor skills, and risks including choking, inadequate nutrient and energy intake, suboptimal iron status, and diet quality, with inconclusive results (Brown et al., 2017; Cameron et al., 2012; D'Auria et al., 2018; Fewtrell et al., 2017; Rapley, 2011; Rapley & Murkett, 2008; Townsend & Pitchford, 2012). It is not currently known how pervasive BLW is in NZ, although a recent NZ study (n=876) suggested that more than half of families have tried it, with approximately 30% following BLW regularly (Fu et al., 2018). This is higher than those observed in 2013, with 8% of caregivers (n=199) meeting strict BLW criteria (Cameron et al., 2013), however, lower than observations in the United Kingdom (UK) (30 to 60%) (Brown, 2016; Rowan et al., 2019), Ireland (49%) (Mezynska et al., 2020), and Australia (46%) (Swanepoel et al., 2020). Due to the nutritional risks of BLW, increased popularity, and widespread online presence (about 13,700,000 results; Google 28 April 2023), further research is required to determine the incidence and health risks of BLW so that health professionals and policymakers can provide whānau (families) with evidence-based advice on how to feed their infants safely.

The availability of CIF has also changed in recent years, with a notable increase in products marketed towards infants in NZ (Katiforis et al., 2021; Padarath et al., 2020). In 2021, a study found 266 CIF available in two major NZ supermarket chains (Foodstuffs and Woolworths) (Katiforis et al., 2021). This was notably higher than those previously identified (Padarath et al., 2020). CIF are now available in various forms, including single-use food pouches (with and without plastic nozzles), jars, cans, microwavable bowls, cereals, crackers, bars, biscuits, rusks, and extruded snacks. This is different to the glass jars of puréed fruit and vegetables seen in the past. Concern has been expressed about the nutritional content of CIFs, including the total energy, sugar, and iron contained in many products (Pask, 2020; Sundborn et al., 2017). The use of plastic nozzles to feed directly from pouches is also concerning, with the recent Australian Feeding Infants and Toddlers Study (OzFITS) (n=598) reporting that half of those who consumed a pouch (n=299) sucked the contents directly through the nozzle (Netting, Moumin, Makrides et al., 2022). In NZ, the utilisation of CIF and use of nozzles is unknown (Taylor et al., 2021).

2.1.2. THE NEW ZEALAND MINISTRY OF HEALTH INFANT FEEDING GUIDELINES

The NZ 'Food and Nutrition Guidelines for Healthy Infants and Toddlers (Aged 0–2)' (Ministry of Health, 2008) were originally developed in 2008 and aimed to provide caregivers and health professionals with evidence-based recommendations specific to NZ. The series was recently transitioned and updated to include evidence-based recommendations for nutrition and physical activity, following an independent evaluation of the Ministry of Health's (MoH) Food and Nutrition Guidelines in 2011 (Ministry of Health, 2020a). The 2021 infant guidelines, 'Healthy Eating Guidelines for New Zealand Babies and Toddlers (0–2 years old)', were written by infant nutrition experts with the support of a maternal, infant, and toddler technical advisory group (Ministry of Health, 2021a). They include six revised feeding statements that align with WHO recommendations for breastfeeding, CF, food variety, the addition of sugar and salt, appropriate beverages, and feeding environments (Ministry of Health, 2021a). Recommendations are similar to those in the 2008 guidelines, however, the individual introduction of foods every two to four days is no longer recommended. Instead, a wide range of foods from each food group should be offered from the start of CF. Key guidelines used in this thesis have not changed and are instead provided in a simpler format with fewer statements, as compared in Table 2.1.

Table 2.1: Comparison of the 2021 and 2008 New Zealand Ministry of Health Infant Feeding Guidelines

Recommendation	Statement number	Eating statements for infants and toddlers within the 2021 Ministry of Health guidelines (Ministry of Health, 2021a)	Statement number	Eating statements for infants and toddlers within the 2008 Ministry of Health guidelines (Ministry of Health, 2008)
Breastfeeding	1	Aim to exclusively breastfeed your baby until they are around six months of age. Continue to breastfeed for up to two years or longer.	2	Exclusively breastfeed your baby until your baby is ready for and needs extra food – this will be at around six months of age.
			6	If your baby is not fed breast milk, then use an infant formula as the milk source until your baby is one year of age.
Complementary feeding	2	Around six months of age, when your baby is showing signs of readiness, introduce complementary foods. Offer iron-rich foods, vegetables, and fruit as first foods, and continue to offer these foods every day.	3	When your baby is ready, introduce him or her to appropriate complementary foods and continue to breastfeed until they are at least one year of age or beyond.
Diet variety	3	Once CF has started, offer your baby or toddler a variety of nutritious foods every day, including: • Vegetables and fruit • Grain foods (e.g., iron-fortified infant cereal, oats (porridge), bread, rice, noodles, and pasta) • Milk-based foods (e.g., yoghurt and cheese) • Legumes (e.g., lentils, tofu, and beans), nut butters, eggs, fish, seafood, chicken, or lean red meat.	4	Increase the texture, variety, flavour and amount of food offered so that your baby receives a complementary intake of nutrients, especially iron and vitamin C, and is eating more family foods by one year of age.
			7	Each day offer your toddler a variety of nutritious foods from each of the four major food groups, which are: vegetables and fruit; breads and cereals, including some wholemeal, milk and milk products or suitable alternatives; and lean meat, poultry, seafood, eggs, legumes, nuts, and seeds.
Sugar and salt	4	When preparing food for your baby or toddler, do not add salt or sugar. If using commercially prepared foods, choose those that are low in salt (sodium) and with no added sugars.	5	For your baby, prepare or choose pre-prepared complementary foods with no added fat, salt, sugar, honey or other sweeteners.
			8	For your toddler, prepare foods or choose pre-prepared foods, drinks, and snacks that: are low in salt, but if using salt, use iodised salt and have little added sugar (and limit your toddler's intake of high-sugar foods).
Beverages	5	Recommended drinks for your baby or toddler are breast milk [a] and water (once they are eating complementary foods). Cow's milk can be offered as a drink from 12 months of age [b] Do not give your baby or toddler juice, cordial, fruit drink, flavoured milk, soft drinks, tea, coffee or alcohol.	9	Provide your toddler with plenty of liquids each day, such as water, breast milk, or cows' milk (but limit cows' milk to about 500 mL per day).
			10	Do not give your infant or toddler alcohol, coffee, cordials, juice, soft drinks, tea (including herbal teas), and other drinks containing caffeine.
Eating environment	6	Let your baby and toddler guide you about how much they eat. Encourage your child to eat, but don't force them. Sit with your baby or toddler while they eat or drink and include them in family mealtimes. From a young age, encourage your child to feed themselves.	1	Maintain healthy growth and development of your baby and toddler by providing them with appropriate food and physical activity opportunities every day.
			11	Purchase, prepare, cook, and store food in ways to ensure food safety.

[a] or, if necessary, a commercial infant formula until 12 months of age. [b] consumption should be limited to 350mL per day

Statement 1: Aim to exclusively breastfeed your baby until they are around six months of age. Continue to breastfeed for up to two years or longer.

Exclusive breastfeeding (EBF) is the provision of only breast milk and prescribed medications to the infant from birth (Ministry of Health, 2021a). Breast milk is the optimal source of infant nutrition and has a high bioavailability of essential minerals suited for infants' immature digestive systems (Eidelman et al., 2012; James & Lessen, 2009). Breast milk is convenient, inexpensive, portable, promotes bonding between the mother and infant dyad, and is the most sustainable method of feeding (Martin et al., 2016; Ministry of Health, 2021a). It also provides protection against infection; promotes gastrointestinal, immune, and cognitive development; and establishes the infant's unique gut microbiome (Kau et al., 2011; Martin et al., 2016; Molinari et al., 2012; Walker, 2010; Zivkovic et al., 2011).

If breastfeeding is not possible, the MoH recommends that a commercially prepared infant formula should be fed for the first 12 months of life (Ministry of Health, 2021a). Infant formulas are designed to mimic the nutritional composition of breast milk and contain similar quantities of carbohydrates, fat, vitamins, and minerals. Protein, iron, calcium, and vitamin D are provided in higher amounts due to the reduced bioavailability in formula (Martin et al., 2016). Worldwide, infant formula production is strictly regulated to ensure infant safety and health (Kent, 2015). In NZ, infant formula production is guided by Food Standards Australia and New Zealand (FSANZ) (Food Standards Australia New Zealand, 2020; Ministry of Health, 2021a).

Systematic reviews have commonly reported associations between breastfeeding and improved health outcomes for mothers and infants (Chowdhury et al., 2015; Horta & Victora, 2013; Sankar et al., 2015). Health benefits exhibit a dose-response relationship, with those who breastfeed longer obtaining greater benefits (Kramer, 2009; Witsø et al., 2010). When breastfeeding, women have increased maternal emotional bonding and responsiveness, decreased postpartum bleeding, and increased weight loss with an earlier return to pre-pregnancy weight (Ekström & Nissen, 2006; Hannula et al., 2008; Murtagh & Moulton, 2011). Longer durations of breastfeeding have also been associated with a reduced risk of developing breast (26%) and ovarian (35%) cancer when breastfeeding for more than 12 months, and the risk of type two diabetes decreases by 9% for each twelve-month period that breastfeeding is undertaken (Aune et al., 2014; Chowdhury et al., 2015). Infants who are breastfed have fewer and less severe childhood illnesses, decreased risk of mortality in infancy and toddlerhood, improved performance in intelligence tests, and reduced risk of long-term diseases (Hauck et al., 2011; Horta et al., 2015; Koletzko et al., 2019; Sankar et al., 2015; The Scientific Advisory Committee on Nutrition, 2018).

Statement 2: Around six months of age, when your baby is showing signs of readiness, introduce complementary foods.

Around the age of six months, infants' nutritional requirements exceed those provided by milk (breast milk and/or formula), and the introduction of complementary foods (solid foods and liquids other than breast milk or formula) is recommended (EFSA Panel on Nutrition et al., 2019; Ministry of Health, 2021a; World Health Organization, 2009). At this age, infants are usually developmentally ready for food, as shown by the maturation of their gastrointestinal tract, display of motor skills, the ability to hold their head upright and sit with less help, open their mouth as food approaches, hold food in the mouth and effectively swallow, and display signs of biting and chewing (Ministry of Health, 2021a). Early introduction of complementary foods, before four months, is not recommended as the digestive system cannot digest, absorb, and process nutrients, and the kidneys are not mature enough to cope with foods and beverages other than breast milk and formula (Fewtrell et al., 2017; Naylor & Morrow, 2001). Additionally, recent systematic reviews and longitudinal studies have reported that an early introduction to solid foods increases an infant's risk of developing obesity (Scientific Advisory Committee on Nutrition, 2018).

When introducing complementary foods, caregivers are recommended to follow traditional spoon-feeding (TSF) methods, where an infant is initially spoon-fed puréed foods (Ministry of Health, 2021a; World Health Organization, 2009). They should then progress to mashed/lumpy, finger, chopped, and family foods, as developmentally appropriate. Puréed foods have a thicker texture than breast milk and infant formula, allowing infants to develop the necessary oral motor skills to manage solid foods safely (Cichero, 2016). Once CF has started, it is recommended that infants are offered a variety of foods of different flavours to establish a wide food acceptance (Ministry of Health, 2021a). A slow introduction of complementary foods is not required (Fewtrell et al., 2017; Ministry of Health, 2021a). Despite its high bioavailability, the comparatively low concentration of iron in breast milk cannot meet increased iron requirements beyond six months, and iron-rich foods are recommended as first foods (EFSA Panel on Nutrition et al., 2019; Ministry of Health, 2021a). Recommended iron-rich foods include cooked and puréed meats, chicken, fish, seafood, tofu, beans, lentils, and iron-fortified infant cereal (Ministry of Health, 2021a).

Statement 3: Once you have started complementary feeding, offer your baby or toddler a variety of nutritious foods every day, including vegetables and fruit, grain foods (such as iron-fortified infant cereal, oats (porridge), bread, rice, noodles and pasta), milk and milk products (such as yoghurt and cheese), and legumes (such as lentils, tofu and beans), nut butters, eggs, fish, seafood and chicken or lean red meat.

A variety of foods should be offered daily from the MoH food groups: vegetables and fruit, grain foods (e.g. porridge, rice, bread, pasta, noodles), milk and milk products (e.g. yoghurt, cheese), and meat and protein-rich foods (Ministry of Health, 2021a; World Health Organization, 2009). A varied diet increases the probability that an infant will meet nutritional requirements for growth and development (World Health Organization, 2009). Breast milk or infant formula should be offered before complementary foods until an infant reaches eight to nine months of age (Ministry of Health, 2021a). By eight to nine months, foods become a priority, and an infant will typically consume two to three meals and one or more snacks, depending on their appetite.

Statement 4: When preparing food for your baby or toddler, do not add salt or sugar. If using commercially prepared foods, choose those that are low in salt (sodium) and with no added sugars.

Caregivers are recommended to offer meals and snacks with low amounts of salt and added sugar (Ministry of Health, 2021a). Added salt (sodium) and sugar do not have nutritional benefits and can accustom infants to prefer salty (Stein et al., 2012) or sweet foods (Fidler Mis et al., 2017), developing less than optimal food preferences (Michaelsen, 2000; Ministry of Health, 2021a). Experimental studies during infancy have proposed that high sodium diets are associated with higher blood pressure in later life, with the early infancy period acting as a key window of opportunity for blood pressure changes (Gowrishankar et al., 2020; Leyvraz et al., 2018). A high sugar consumption is also detrimental to health (Ministry of Health, 2021a) and systemic reviews have identified an increased risk of excess body fat and dental caries in children when high amounts of sugar are consumed (Douglass et al., 2004; Te Morenga et al., 2013). It is recommended to avoid salt and added sugar in an infant's diet to reduce the risk of developing non-communicable diseases in later life (World Health Organization, 2013, 2015a).

Statement 5: Recommended drinks for your baby or toddler are breast milk[1] and water (once they are eating complementary foods). Cow's milk can be offered as a drink from 12 months of age.

Before one year of age, drinks other than breast milk, infant formula, and water are not required (Ministry of Health, 2021a). Compared to breast milk and formula, cow and milk alternatives do not provide adequate nutrition and should be avoided as drinks. Sugary drinks such as juice, cordials, fruit drinks, flavoured milk, and soft drinks should be avoided, as they are energy-dense, nutrient-poor, and if consumed regularly can damage an infant's developing teeth (Heyman et al., 2017). Currently, there is no known safe level of caffeine for children under the age of five years, and it is recommended to avoid all sources, such as tea and coffee (Lott et al., 2019). Alcohol is also unsafe and can damage an infant's developing brain (Ministry of Health, 2021a).

Statement 6: Let your baby or toddler guide you about how much they eat. Encourage your child to eat, but don't force them.

Responsive feeding or feeding in response to an infant's hunger and fullness cues, helps protect an individual's natural ability to self-regulate food intake (Ministry of Health, 2021a). Clear benefits, such as weight maintenance (DiSantis et al., 2011) and reduced fussy eating (Fu et al., 2018), have been observed, indicating that responsive eating is one of the most important practices for developing healthy eating behaviours (Cameron et al., 2012; Gerritsen & Wall, 2017). When spoon-feeding, caregivers should monitor signs of fullness, including when an infant turns away, closes their mouth, and shakes their head (Ministry of Health, 2021a). As infants accept new food textures and develops the ability to move food from the plate to their mouth, self-feeding should be encouraged. Self-feeding whole foods from the start of CF, as recommended by the BLW method, is not currently recommended by the MoH. Further research is required to determine if BLW is a developmentally and nutritionally safe practice (Ministry of Health, 2021a).

[1] If your baby is not breastfed, a commercial infant formula is the only suitable alternative to breast milk in the first year of life.

2.1.3. Comparing the New Zealand Infant Feeding Guidelines to Global Guidelines and those from High-income Countries

Various infant feeding guidelines that provide evidence-based food and nutrition recommendations exist throughout the world. A 2020 systematic review that aimed to identify public-facing nutrition guidelines in high-income countries found infant and toddler recommendations in 43 guidelines (Dewey & Harrison, 2020). The review identified 17 guidelines from the USA, one from Australia, seven from Canada, eight from Europe, three from NZ, four from the UK, and three from the WHO. The review included all available guidelines in countries, including those for specific feeding statements and supplementation, e.g., the recommended length of time for EBF and vitamin D supplementation for breastfed infants. From NZ, this included guidelines for dental health "Healthy smile, healthy child: Oral health guide for well child providers" and vitamin D "Companion statement on vitamin D and sun exposure in pregnancy and infancy in New Zealand", in addition to the 2008 MoH infant feeding guidelines 'Food and Nutrition Guidelines for Healthy Infants and Toddlers (Aged 0–2)' A background paper".

To explore differences between the 2021 MoH guidelines and those from other high-income countries, equivalent recommendations for exclusive and continual breastfeeding, CF, food group consumption, salt and sugar use, appropriate beverages, and feeding environments have been compared in Tables 2.2 to 2.7. Guidelines compared include global guidelines, position papers, and national guidelines that were available in English and are summarised in Table 2.2.

Table 2.2: Infant feeding guidelines identified and used to compare recommendations in high-income countries

Country of origin	Guideline name	Reference
Global guideline		
WHO	Infant and Young Child Feeding	(World Health Organization, 2021)
Position papers		
Europe	Complementary Feeding: A Position Paper by the ESPGHAN [a] Committee on Nutrition	(Fewtrell et al., 2017)
UK [b]	Feeding in the First Year of Life: SACN [c] Report	(The Scientific Advisory Committee on Nutrition, 2018)
Germany	Guidelines for Infant Nutrition in Germany	(Kersting et al., 2021)
Italy	Recommendations on Complementary Feeding for Healthy, Full-term Infants	(Alvisi et al., 2015)
National guideline		
USA [d]	Dietary Guidelines for Americans, 2020-2025	(U.S. Department of Agriculture and U.S. Department of Health and Human Services, 2020)
Austria	Eat Right From the Start! Baby's First Spoon	(Federal Ministry of Health, 2010)
Australia	Eat for Health, Infant Feeding Guidelines	(Lee et al., 2012)
Canada	Nutrition for Healthy Term Infants: Recommendations from Six to 24 Months	(Canada Health Society et al., 2012)
CDC [e]	Infant and Toddler Nutrition	(Centers for Disease Control and Prevention, 2020)
Denmark	Health Guidelines for Parents with Small Children	(Danish Health Authority, 2016)
Finland	Eating Together - Food Recommendations for Families with Children	(National Institute for Health and Welfare in Finland, 2019)
France	Review of Dietary Guidelines for Children Aged 0-36 Months and 3-17 Years	(High Council of Public Health, 2020)
Hong Kong	Healthy Eating for Infants and Young Children – Milk Feeding	(Family Health Service, 2021)
Iceland	Nutrition: The First Twelve Months	(The Office of the Medical Director of Health and the Development Division of the Health Care, 2016)

Country of origin	Guideline name	Reference
Ireland	Best Practice for Infant Feeding in Ireland	(Food Safety Authority of Ireland, 2011)
New Zealand (NZ)	Healthy Eating Guidelines for New Zealand Babies and Toddlers (0–2 years old)	(Ministry of Health, 2021a).
Norway	Food and Meals for Infants	(The Norwegian Directorate of Health, 2016)
Pan American Health Organization (PAHO)	Best Practices for Feeding Your Child from 0 to 5 Years of Age	(Pan American Health Organization, 2018)
Sweden	Good Food for Infants Under One Year	(Swedish National Food Agency, 2012)
Switzerland	Nutrition in the First Year of Life. Guidance for Transitioning from Pure Milk Feeds to Family Meals	(Swiss Society for Nutrition SGE & Angelika Hayer, 2018)
[a] the European Society for Paediatric Gastroenterology Hepatology and Nutrition, [b] United Kingdom, [c] Scientific Advisory Committee on Nutrition, [d] United States of America, [e] Centers for Disease Control and Prevention. Guidelines were sourced from were sourced from the 2020 systematic review (Dewey & Harrison, 2020), recent literature references, and Google searches		

Exclusive breastfeeding guidelines

In 2001, the WHO changed its EBF recommendation from between four to six months to until six months (World Health Organization, 2001, 2015b). Following this, most country-specific guidelines, including NZ, also modified their recommendations. Some, however, adopted the recommendation with minor exemptions, such as Sweden and the Netherlands, who suggested that 'trialling' or 'small tastes' of food between four to six months were appropriate (Lanting et al., 2013; Swedish National Food Agency, 2012). There continues to be differences in the length of time recommended for EBF in high-income countries (Table 2.3).

Table 2.3: Exclusive breastfeeding recommendations from guidelines in high-income countries, according to infant age

	Exclusive breastfeeding age recommendations		
	Until four months	Until four to six months	Until around six months of age
Country of origin and recommendation	**France** 0-4 months old: exclusive milk feed: breast milk and/or infant formula (known as 1st age milk) exclusively.	**Denmark** Only give your child breast milk for the first four to six months.	**WHO** [a] Exclusive breastfeeding for the first six months of life.
		Europe Exclusive or full breastfeeding should be promoted for at least four months and exclusive or predominant breast-feeding for around six months.	**PAHO** [b] Birth to six months, corresponding to the recommended period of exclusive breastfeeding.
		Finland Exclusive breastfeeding is recommended up till the age of four to six months.	**CDC** [c] Exclusive breastfeeding for about six months.
		Germany Exclusive milk diet in the first 4–6 months, with breastfeeding as standard.	**USA** [d] For about the first six months of life, exclusively feed infants human milk.
		Iceland For the first few months, a baby needs no other nourishment than breast milk or infant formula.	**Australia** Infants be exclusively breastfed until around six months of age when solid foods are introduced.
		Sweden For the first six months, breast milk or infant formula is the best food for your child. From the age of four months at the earliest, you can let your child taste small samples of solid foods.	**Austria** From about the 6th month of life, breast milk alone is no longer sufficient to meet the infant's energy and nutritional needs.
		Switzerland In the first four to six months: Breast milk or infant formula only.	**Canada** Breastfeeding - exclusively for the first six months.
			Hong Kong The first six months – exclusively breastfeeding.
			Ireland For the first six months, infants should be exclusively breastfed.
			NZ [e] Aim to exclusively breastfeed your baby until they are around six months of age.
			Spain Exclusive breastfeeding for the first six months of the child's life.
			UK [f] Breastfeed exclusively for around the first six months of an infant's life.

[a] World Health Organization, [b] Pan American Health Organization, [c] Centers for Disease Control and Prevention, [d] United States of America, [e] **New Zealand,** [f] United Kingdom

Continual breastfeeding guidelines

Recommendations for continual breastfeeding vary (Table 2.4). Some guidelines do not state a specific timeframe, however, encourage that breastfeeding is continued during the CF period. Few align with WHO and NZ guidelines for two years or beyond.

Table 2.4: Optimal breastfeeding recommendations from guidelines in high-income countries, according to infant age

Continual breastfeeding age recommendations			
	Not further specified [a]	One year or longer	Two years or more
Country of origin and recommendation	**CDC** [b] Continuing breastfeeding while introducing complementary foods.	**USA** [c] Continue to feed infants human milk through at least the first year of life, and longer if desired.	WHO [e] Continued breastfeeding up to 2 years of age or beyond.
	Austria Continue breastfeeding for as long as you and your child want.	**Australia** Breastfeeding be continued until 12 months of age and beyond, for as long as the mother and child desire.	**PAHO** [f] Six to 24 months, corresponding to the recommended period of continued breastfeeding and CF.
	Europe Continued breastfeeding is recommended alongside CF.	**Denmark** It is recommended that your child is only given breast milk or infant formula for the first year.	Canada Support breastfeeding for up to two years or beyond, as long as mother and child want to continue.
	Germany Continuation of breastfeeding, as long as mother and child so wish.	**Finland** It is recommended that breastfeeding is continued till one year's age, and even longer, if the family so wishes.	**Hong Kong** Mothers are recommended to continue breastfeeding up to two years and beyond to provide their children antibodies and nutrients.
	Iceland It's good to continue breastfeeding your baby until he has started eating a good variety of different foods, consuming foods from all food groups on a daily basis.	**Norway** If possible, babies should be breastfed for their first year of life, and ideally for longer if baby is thriving – and mum too.	**Ireland** From six months to two years and beyond, breastfeeding should continue whilst giving the infant suitable solid foods from a spoon.
	Italy When it is possible, an infant should be breastfed during the stage of introduction of solid foods.	**Sweden** The more regular food your child eats, the less breast milk or formula is needed, but you can continue breastfeeding as long as you and the child want to, even after the child is a year old. It's also good to continue with breast milk formula throughout the first year.	**NZ** [g] **Continue to breastfeed for up to two years or longer.**
	Switzerland Breastfeeding can continue for as long as mother and child want it to.	**UK** [d] Continue breastfeeding for at least the first year of life.	**Spain** Continue breastfeeding in combination with other foods to complement the child's nutrition until two years of age or older, for as long as the mother and child desire.

[a] no specific timeframe was provided, however, breastfeeding was supported, [b] Centers for Disease Control and Prevention, [c] United States of America, [d] United Kingdom, [e] World Health Organization, [f] Pan American Health Organization, [g] New Zealand

Complementary feeding guidelines

Internationally recommendations for CF vary, however, the majority agree with NZ guidelines that encourage spoon-feeding puréed iron-rich foods around six months of age (Table 2.5). Checking for signs that an infant is ready for solid food is less commonly advised, with various guidelines suggesting that at six months of age, an infant will be ready for solid foods (Dewey, 2003; Lee et al., 2012; Scientific Advisory Committee on Nutrition, 2018).

Table 2.5: Complementary feeding recommendations from guidelines in high-income countries

	Complementary feeding guidelines			
	Signs of readiness	Puréed foods	Iron-rich foods	Spoon-feeding
Country of origin and recommendation	**CDC** [a] How do you know if your child is ready for foods other than breast milk or infant formula? You can look for these signs that your child is developmentally ready. Your child: • Sits up alone or with support. • Is able to control head and neck. • Opens the mouth when food is offered. • Swallows food rather than pushes it back out onto the chin. • Brings objects to the mouth. • Tries to grasp small objects, such as toys or food. • Transfers food from the front to the back of the tongue to swallow.	**PAHO** [d] Your baby can eat puréed, mashed and semi-solid foods beginning at six months.	**PAHO** [d] Iron- and zinc-rich foods, such as meat, are particularly important as breast milk is low in these minerals.	**CDC** [a] Start small. Give 1 or 2 tablespoons of food, and watch for signs that he or she is still hungry or full.
	Finland For infants fed exclusively on formula, solid supplementing foods are started at about the age of four months, depending on how ready the individual baby is to eat solids.	**CDC** [a] At first, it's easier for your child to eat foods that are mashed, puréed, or strained and very smooth in texture.	**USA** [c] Include foods rich in iron and zinc, particularly for infants fed human milk.	**Austria** Start with a few spoons and continue breastfeeding for as long as you and your child want.

Complementary feeding guidelines				
	Signs of readiness	Puréed foods	Iron-rich foods	Spoon-feeding
	NZ [b] Around six months of age, when your baby is showing signs of readiness, introduce complementary foods. A baby is ready to start complementary foods if they: • are around six months old • can hold up their head and sit with less help • open their mouth as food approaches • can keep food in their mouth and then swallow it, instead of pushing the food out • show signs of biting and chewing.	**Australia** The texture of foods that are introduced should be suited to an infant's developmental stages, moving from puréed to lumpy to normal textures during the 6-12 month period.	**Australia** To prevent iron deficiency, iron-containing nutritious foods are recommended to be the first foods. Iron containing foods include iron-fortified cereals, puréed meat and poultry dishes. Cooked plain tofu and legumes/beans are also sources of iron. Care needs to be taken particularly with a plant-based diet to ensure that supplies of iron are adequate.	**Denmark** Then your child can start to eat solids with a spoon.
	Norway Signs that baby may be needing more to eat before the age of six months: • inadequate weight gain or growth • signs of hunger, even after frequent breastfeeds both day and night • baby shows an interest in other food. Signs that your baby is physically ready for solids: • good head control • can sit upright and lean forwards • can signal that he is full by turning his head away for example • grabs food and tries to bring it up to his mouth.	**Finland** At six months, children already participate in the mealtimes of the family, tasting foods that are suitable for small children. They gradually start to eat without help, using their fingers. Children are started on puréed food.	**Austria** Food suitable for complementary foods include; Iron-rich foods: meat (beef, veal, pork).	**Finland** With healthy babies who are growing well, solids are started in tasting portions (from just a pinch to a few teaspoons) at the earliest at four months and at the latest at six months.
	Switzerland The exact time at which you start will depend on your baby's development. Observe your child: can they sit upright and hold their head up with a little assistance? Are they showing interest in other people's food or putting things in their mouth? If so, you can start introducing your baby to the first type of purée.	**Iceland** Once your baby has reached the age of six months, the time has come to begin gradually introducing a varied range of mashed and puréed foods, along with drinks from sippy cups.	**Canada** Recommend iron-rich meat, meat alternatives, and iron-fortified cereal as the first complementary foods. Encourage parents and caregivers to progress to introduce a variety of nutritious foods from the family meals. Continue to recommend a variety of iron-rich foods. Ensure that foods such as meat and meat alternatives and iron-fortified cereal are offered a few times each day.	**Iceland** It's always best to start with only a small amount of a given food, no more than one teaspoon, and then gradually increase the amount over time to three to four tablespoonfuls.

Complementary feeding guidelines				
	Signs of readiness	Puréed foods	Iron-rich foods	Spoon-feeding
	USA [c] Signs that an infant is ready for complementary foods include: • Being able to control head and neck. • Sitting up alone or with support. • Bringing objects to the mouth. • Trying to grasp small objects, such as toys or food. Swallowing food rather than pushing it back out onto the chin.	**NZ** [b] Start with spoon-fed purées, then progress over the next few weeks to mashed/ lumpy foods and soft finger foods.	**Europe** All infants should receive iron-rich CF including meat products and/or iron-fortified foods.	**NZ** [b] Start with spoon-fed purées, then progress over the next few weeks to mashed/ lumpy foods and soft finger foods.
		Sweden Once your baby has reached the age of six months, the time has come to begin gradually introducing a varied range of mashed and puréed foods, along with drinks from sippy cups.	**Finland** Exclusive breastfeeding and the good iron stores of full-term babies at birth protect the child against anaemia, but after the age of six months other sources of iron are needed: meat, fish and whole grain cereals.	**Norway** The first meals might consist of just a little teaspoonful.
		Switzerland If so, you can start introducing your baby to the first type of purée. This first purée is best made from a single type of food (e. g. carrot).	**France** It is desirable to promote the food groups rich in iron (legumes, meats, concomitant consumption of foods source of vitamin C (such as citrus fruits) to improve iron absorption, etc).	**Sweden** During the first few weeks a couple teaspoons of gruel or porridge is enough; increase the amount little by little later on.
		UK [c] Food consistency should progress from puréed through minced/mashed to finely chopped.	**Hong Kong** It is essential to ensure iron intake by providing the baby meat, fish, egg yolk, liver, and dark green leafy vegetables.	**Switzerland** Initially, your baby will eat only a few spoonful's.
			Ireland Having enough dietary iron is important to help an infant to grow and develop, and to prevent iron deficiency anaemia. From about six months of age, an infant's store of iron accumulated from their mother during pregnancy is depleted, so rich dietary sources of iron become very important. Iron-rich food sources should be offered early in the weaning process to help ensure infants get the nutrition they need.	**UK** [c] Semi-solid foods should be given from a spoon and should not be mixed with milk or other drink in a bottle.

Complementary feeding guidelines				
	Signs of readiness	Puréed foods	Iron-rich foods	Spoon-feeding
			Italy *Recommendation not stated, however, discussed sources of iron and infant protein needs.*	
			NZ [b] Give iron-rich foods as first foods to prevent iron deficiency.	
			Sweden Iron is an important nutrient that can be difficult for small children to get enough of. If your child does not get iron-enriched instant porridge or gruel, it is very important that he or she gets other foods rich in iron like meat, blood pudding or other blood meals. Beans, chickpeas, lentils, and tofu are vegetarian sources of iron.	
			UK [c] From around six months of age, a diverse complementary diet is needed to meet the increasing iron requirements of older infants.	

[a] Centers for Disease Control and Prevention, [b] New Zealand, [c] United Kingdom, [d] Pan American Health Organization.

Food group guidelines for infants in high-income countries

Infant feeding guidelines tend to be less prescriptive for food servings and serving sizes than guidelines for children and adults. Guidelines from Italy, NZ, PAHO, and the UK recommend including vegetables, fruit, dairy products, carbohydrates, and protein foods in the diet (Alvisi et al., 2015; Dewey, 2003; Ministry of Health, 2021a; Pérez-Escamilla et al., 2017; Scientific Advisory Committee on Nutrition, 2018). There was no consensus on how many servings should be included daily, with dietary diversity often described as the overall inclusion of each food group daily (United Nations International Children's Emergency Fund, 2021; White et al., 2017). The United Nations Children's Fund (UNICEF) states that for optimal diet diversity, at least five of the eight food groups[2] should be included daily (United Nations International Children's Emergency Fund, 2021). In the USA, a 2021 study aimed to develop recommendations for optimal diet diversity (Dewey et al., 2021). However, they were unable to develop such guidelines, stating that further research is needed to distinguish age-appropriate foods that provide adequate nutrition without excessive energy.

Salt and sugar guidelines for infants in high-income countries

Most guidelines recommend avoiding adding salt and sugar to infant foods and foods and beverages that contain added salt and sugar (Table 2.6).

[2] Breast milk; dairy products (infant formula, milk, yoghurt, cheese); grains, roots, tubers, and plantains; pulses, nuts, and seeds, flesh foods (meat, fish, poultry, organ meats); eggs, vitamin A rich fruits and vegetables; and other vegetables.

Table 2.6: Salt and sugar recommendations from guidelines in high-income countries

	Salt and sugar recommendations
Country of origin and recommendation	**PAHO** [a] Ultra-processed products, such as sugar-sweetened beverages, industrialized foods and fast foods, have nothing nutritious, only sugar, salt and bad fats. Adding sugars to fruit juices and other home prepared beverages, meals and snacks should also be avoided.
	CDC [b] Foods high in salt (sodium), such as some canned foods, processed meats (e.g. lunch meats, sausages, hot dogs, ham), and frozen dinners should be avoided. Foods with added sugars, low-calorie sweeteners, or no-calorie sweeteners are not recommended.
	USA [c] Avoid foods and beverages with. added sugars. Limit foods and beverages higher in sodium.
	Australia Do not add salt to foods for infants. Limit intake of all foods with added sugars. Consumption of nutrient-poor discretionary foods with high levels of saturated fat, added sugars, and/or added salt (e.g. cakes, biscuits and potato chips) should be avoided.
	Austria If you add little salt and sugar to the food and do without these components in complementary foods, children later perceive these tastes much more sensitively than when they are used to them in infancy.
	Canada Recommend foods prepared with little or no added salt or sugar.
	Europe No sugar or salt should be added to CF.
	Finland Foods and beverages high in sugar or salt should not be given to infants before the age of one year.
	France In order to promote a healthy diet in adulthood, it is advisable to develop in children healthy eating habits, including a limited consumption of sweet products (such as candies, dessert creams, ice creams, sugary drinks, etc. etc.), fried foods, cold meats, salt and savoury products (such as biscuits).
	Germany General recommendation is not to add salt or sugar to baby food.
	Iceland Note that you should not add salt to your baby's food. Sweets and foods containing sugar damage your baby's sensitive teeth. Also keep in mind that eating habits are formed early in life. A baby who is fed very sweet cereals will hardly be very pleased with unsweetened oatmeal porridge as a toddler.

	Salt and sugar recommendations
	Ireland Do not add sauces, gravies, salt, or sugar to an infant's weaning foods. Encourage savoury and plainer tastes. High-salt foods and the addition of extra salt to an infant's diet during the first 12 months should be avoided. Foods high in sugar contribute significantly to the development of tooth decay, particularly if eaten frequently during the day/between meals. The capacity of an infant's stomach is small and offering an infant these types of foods will displace more nutritious food in the diet. Nutritious savoury and plain foods should be offered.
	Italy Do not add salt to foods. Reduce the intake of simple sugars (such as fruit juices, sugar and sweeteners in general).
	Norway Avoid sugary and fatty foods such as cakes, biscuits, ice cream, snacks and sugary drinks. Avoid salt and salty foods, because baby's kidneys are not fully developed.
	NZ [d] When preparing food for your baby or toddler, do not add salt or sugar. If using commercially prepared foods, choose those that are low in salt (sodium) and with no added sugars.
	Sweden Small children can't regulate their salt balances properly. It's also a good idea not to get children used to salty foods. When you serve the family dinner, set a little aside for your child before you salt it. Avoid salty snacks and don't give salted meats, like sausage and smoked pork, as often. Avoid sweetened foods as much as possible. Sugar only provides empty calories – no vitamins and minerals. There is a lot of sugar in foods like flavoured yogurt and sour milk, biscuits and cookies, rosehip soup, and creams, jellies, and marmalades, as well as candy and ice cream.
	UK [e] Sugar or salt should not be added to the solid foods in an infant's diet.

[a] Pan American Health Organization, [b] Centers for Disease Control and Prevention, [c] United States of America, [d] New Zealand, [e] United Kingdom.

Beverage guidelines for infants in high-income countries

Offering water was frequently recommended after starting CF. Most guidelines advised to avoid juice, tea, and coffee in an infant's diet (Table 2.7). No guidelines had recommendations for alcohol, as seen in the NZ MoH guidelines (Ministry of Health, 2021a).

Table 2.7: Beverage recommendations from guidelines in high-income countries

Beverage recommendations				
	Encouraged	Avoidance of as a drink		
	Water	Juice	Tea/coffee	Cow's milk
Country of origin and recommendation	**PAHO** [a] Give safe water to children older than six months.	**CDC** [b] Juice before 12 months old is not recommended. Sugar-sweetened drinks (such as soda, pop, soft drinks, flavoured milks, sports drinks, flavoured water with sugar, and juice drinks) contain added sugars. These drinks are different than 100% juice. Children younger than 24 months old should avoid added sugars.	**CDC** [b] Caffeinated drinks, such as soft drinks, tea, coffee, and sports drinks, should be avoided for children younger than age two. There is no established safe limit for caffeine for young children.	**CDC** [b] Drinking cow's milk or fortified soy beverages is not recommended until your child is older than 12 months, but other cow's milk products, such as yogurt, can be introduced before 12 months.
	CDC [b] When your child is between six and 12 months old, you can offer your child: water (four to six ounces per day).	**USA** [c] Before age 12 months, 100% fruit or vegetable juices should not be given to infants. Sugar-sweetened beverages (e.g. regular soda, juice drinks [not 100% fruit juice], sports drinks, and flavoured water with sugar) should not be given to children younger than age two.	**USA** [c] Beverages containing caffeine should be avoided for children younger than age two.	**USA** [c] Infants should not consume cow milk or fortified soy beverages before age 12 months to replace human milk or infant formula.
	USA [c] Small amounts (up to four to eight ounces per day) of plain, fluoridated drinking water can be given to infants with the introduction of complementary foods.	**Australia** Avoid juices and sugar sweetened drinks.	**Australia** Tea, herbal teas, coffee, and other beverages are of no known benefit to an infant and could possibly be harmful.	**Australia** Cow's milk should not be given as the main drink to infants under 12 months, however small amounts may be used in the preparation of solid foods.
	Australia For infants over the age of six months or for those who are not exclusively breastfed, tap water is preferred but this should be boiled and cooled for infants until 12 months of age.	**Austria** You should avoid juices, your baby does not need these.	**Austria** You should avoid sugary drinks, caffeinated and alcoholic beverages these are not suitable and therefore taboo.	**Denmark** Once your child is 12 months old, you can give it cow's milk.

Beverage recommendations				
	Encouraged	Avoidance of as a drink		
	Water	Juice	Tea/coffee	Cow's milk
	Canada Older infants can be offered water from an open cup along with CF.	**Canada** Fruit juice lacks the fibre of whole fruit. Fruits and vegetables should be emphasised instead of juice as recommended in Canada's Food Guide. Only 100% fruit or vegetable juice should be offered. Sweetened beverages, such as pop, fruit drinks, punches and sports drinks have a high sugar content and lack vitamins and minerals. Like fruit juice, they can also increase the risk of early childhood caries and should be limited.	**Canada** Beverages containing caffeine or artificial sweeteners should not be offered to young children. Coffee, tea, some carbonated beverages, and hot chocolate may also contain caffeine or caffeine-related substances. Caffeine is a drug that acts as a stimulant. Other beverages such as diet pop or fruit drinks contain artificial sweeteners. These may interfere with a young child's intake of nutritious, energy-dense foods needed for their rapid growth.	**Europe** Whole cows' milk should not be used as the main drink before 12 months of age.
	Denmark From the age of about six months, your child can start learning to drink milk and water from a cup.	**Europe** Fruit juices or sugar sweetened beverages should be avoided.	**France** Coffee, tea, caffeinated sodas and so-called energy drinks which should be avoided because of their caffeine content.	**Finland** Conventional fat free cow's milk or fortified, unsweetened plant-based beverages used in the same way as milk are suited as a drink from around the age of one year and fermented milk products from the age of 10 months.
	Iceland Give baby water or breast milk when thirsty.	**Finland** No fruit juices or juices made from concentrate are needed in the diet of an infant under one year of age.	**NZ [d]** Do not give your baby or toddler juice, cordial, fruit drink, flavoured milk, soft drinks, tea, coffee or alcohol.	**Hong Kong** Cow's milk is not suitable for the under one.
	Italy It is advisable to consume water and avoid other drinks, which often present a high content of sugars.	**Iceland** Avoid giving your baby sweet drinks such as orange, blackcurrant or apple juice as these are damaging to infants' teeth. Giving babies a bottle of juice at night is particularly harmful.		**Iceland** You should also give babies under 12 months of age follow-on milk to drink rather than regular cow's milk.
	NZ [d] Recommended drinks for your baby or toddler are breast milk* and water (once they are eating complementary foods).	**Ireland** Infants do not need fruit juices. However, if parents/carers choose to offer juices, only small amounts of well-diluted, unsweetened fruit juice (dilute one measure of pure juice to eight to 10 measures of cooled boiled water) should be given from a beaker at mealtimes or with snacks from six months onwards.		**Ireland** Cows' milk should not be offered as the main milk drink until: a term infant is one year of age and; a pre-term infant is at a corrected age of 12 months old.

Beverage recommendations				
	Encouraged	Avoidance of as a drink		
	Water	Juice	Tea/coffee	Cow's milk
	Norway Give baby water as a thirst quencher when he has started taking food and drink other than breast milk and infant formula.	**Norway** Fresh fruit and berries are preferable to juice. Avoiding giving your baby juice or squash in a bottle.		**NZ** [d] Cow's milk can be offered as a drink from 12 months of age.
	Sweden Don't give your child these drinks; get them used to drinking water instead.	**NZ** [d] Do not give your baby or toddler juice, cordial, fruit drink, flavoured milk, soft drinks, tea, coffee or alcohol.		**Norway** Children under the age of one should not be given cow's milk as a drink or in porridge, because cow's milk is low in iron. Small amounts of cow's milk can be used in food a little earlier, from 10 months.
	UK [e] Breast milk, infant formula and water should be the only drinks offered after six months of age.	**Sweden** Sweet drinks like juice mixes, fruit juices, and sodas also contain a lot of sugar. Don't give your child these drinks; get them used to drinking water instead.		**Sweden** Wait to give milk as a drink and larger amounts of sour milk or yoghurt until your child is a year old.
				UK [e] Unmodified cows' milk should not be given as a main drink to infants under 12 months of age.

[a] Pan American Health Organization, [b] Centers for Disease Control and Prevention, [c] United States of America, [d] New Zealand, [e] United Kingdom.

2.2. Assessing the Dietary Intake of Infants

There are many methods to collect dietary data, including food frequency questionnaires (FFQ), 24-hour diet recalls, food records, and diet histories. Each method has strengths and weaknesses, as shown in Table 2.8.

Table 2.8: Methods of dietary assessment

	FFQ	24-hour dietary recall	Estimated food record	Weighed diet record	Dietary history
Method	Measure using a questionnaire that contains a specific food list to estimate the usual diet.	Measure by a trained interviewer using open-ended questions.	Measure using a self-reported account of dietary intake.	Measure using the exact weights of foods and beverages consumed.	Measure by a trained interviewer using open and close-ended questions.
Outcomes	Data on the intake of various foods and beverages over a long period, e.g. six months or one year.	Dietary intake from the previous 24 hours.	Detailed dietary intake from a specific time period. (e.g. 3-7 days).	Detailed dietary intake from a specific time period. (e.g. 3-7 days).	Usual intake over a longer time period. (e.g. days, months).
Strengths	Simple method, cost-effective, suitable for large studies, can be modified to measure certain nutrients and foods.	Detailed data, small participant burden, high level of literacy is not required.	Dietary intake from a specific period of time provides detailed data on all foods and beverages consumed, less reliance on memory if recorded at the time of eating/drinking.	Detailed dietary intake from a specific period of time, exact amounts provided, less dependence on memory if recorded at the time of eating/drinking.	Can assess long or short-term usual dietary intake, high level of literacy is not required.
Weaknesses	Specific to study groups, closed questions, memory-based, self-administered tools require literacy and numeracy skills, limited by foods included, recall bias, and time-consuming to develop.	Possible recall bias, trained interviewer required, time-consuming, multiple days required to assess usual intake, significant dietary changes can occur between repeated measures.	High participant burden, possible under or over-reporting, high level of literacy and numeracy required, participant may change diet during record, time-consuming.	High participant burden, possible under or over-reporting, high level of literacy and numeracy required, scales required (more cost), participant may change diet during record, time-consuming.	Trained interviewer required, results depend on interviewer skill, time-consuming.

Sourced from: *(Ortiz-Andrellucchi et al., 2009; Shim et al., 2014; Welch & Mulligan, 2021)*

Measuring dietary intake in people of any age is challenging, with self-reporting bias identified to cause over or under-reporting (Althubaiti, 2016; Foster & Adamson, 2014). In infancy, numerous additional challenges have been identified, making dietary assessment at this age difficult. Researchers rely on caregivers to report all foods and beverages consumed (Foster & Adamson, 2014). This often involves multiple feeding events (food and breast milk and/or formula) across the day, which may be facilitated by different carers. Carers may use contrasting feeding styles and have differing opinions when estimating portion sizes (Foster & Adamson, 2014). Knowledge of what was consumed outside of the home, e.g. childcare, may also be limited, with early child education centre (ECE) staff often caring for multiple children at a time. Estimating food leftovers is also difficult in this population (Foster & Adamson, 2014), with leftovers often spread across the infant's body and feeding location.

Investigating nutrients vs foods, food groups, and dietary patterns

Traditionally dietary intakes have been described by individual nutrients and foods. However, this approach has limitations, including the inability to account for nutrient interactions and the fact that people do not eat foods in isolation but in combinations as meals and snacks (Fewtrell et al., 2017; Betoko et al., 2015). To mitigate limitations, the investigation of adherence to feeding guidelines, known as dietary indicators, has become a popular method of assessing diet quality (Kourlaba & Panagiotakos, 2009). Dietary indicators allow insight into the collective impact of feeding practices on the diet and have been shown to predict an individual's risk of chronic diseases (Golley et al., 2012). The investigation of food groups has also become popular and represents how foods are consumed in the diet (Hu, 2002; Jacques & Tucker, 2001; Betoko et al., 2015; Reidy et al., 2017; Spence et al., 2013).

2.2.1. Adherence to Infant Feeding Guidelines in High-income Countries

Historically research investigating the relationship between infant feeding practices and health outcomes has focused on single behaviours such as EBF (Chowdhury et al., 2015; Dieterich et al., 2013), the introduction of solid foods (Coulthard et al., 2009; Krebs, 2007; Schack-Nielsen et al., 2010), or single nutrients such as iron (Domellöf et al., 2014; Dube et al., 2010). Although this reductionist approach provides valuable information, it cannot describe the entire impact of infant feeding practices on health outcomes (Hoffmann, 2003; Ruel & Menon, 2002; Smithers et al., 2011; Tapsell et al., 2016).

Diet Quality Indices (DQIs) or Infant and Young Child Feeding Indexes (ICFI) or Infant Feeding Indexes (IFI) are tools (referred to as indexes moving forward) that provide an overall numeric rating of an individual's dietary intake with reference to dietary recommendations (Wirt & Collins, 2009). Indexes assess the diet's quality and variety, thus enabling an examination of associations between the diet and the individual's health status rather than just single nutrients or feeding behaviours (Wirt & Collins, 2009). Various indexes have been used in developing countries (Bork et al., 2012; Chaudhary et al., 2018; Lohia & Udipi, 2014; Qu et al., 2017; Sawadogo et al., 2006; Srivastava & Sandhu, 2007; Thaweekul et al., 2021). In contrast, few have been used in high-income countries.

Golley et al. (2012) were the first to develop and use an index for infants in a high-income country. Dietary data at eight months were obtained from the UK Avon longitudinal study (n=6065). A total adherence score of 48% was reported, with most infants meeting recommendations for exposure to iron-rich cereals (89%), no tea offered (94%), limited exposure to confectionary/cakes/biscuits (56%), and appropriate meal and snack frequencies (96%). Low adherence was found for breastfeeding to 12 months (11%), appropriate age of CF (<1%), frequent offering of fruit and vegetables (<1%), and exposure to sugary beverages (26%). These data were shown to be representative of the population at this time, however, it was noted that mothers were slightly older, higher educated, from a higher social class, and were more likely to be first-time mothers than the general population.

A subsequent American study (n=1261) adapted Golley's index to assess the dietary quality of seven to 12-month-old infants from low-income households (Au et al., 2018). Their adherence score was higher than the UK infants, with an average score of 56%. Similar variables with high adherence were found, and most infants had a high exposure to iron-rich cereal (87%) and low exposure to nutrient-poor foods (72%) and tea (68%). They also found low adherence to recommendations for vegetables (7%), fruits (14%), exposure to sugary beverages (14%), and 12-month breastfeeding duration (24%).

In 2018, GUiNZ assessed adherence to the MoH infant food and nutrition guidelines from data gathered between 2009 and 2010 (Gontijo de Castro et al., 2018). Their index was based on the 2008 MoH infant guidelines, including 13 indicators within four domains (breastfeeding, the introduction of solid foods, the variety of foods, and the intake of inappropriate foods and beverages). Each indicator was considered separately and then reported as a total adherence score. GUINZs average score (70%) was higher than those reported in the UK and USA. Of the 6,184 infants included at nine months of age, 90 participants (2%) received the top score of 100. The lowest adherence score reported was 13.5. They found that five of the 13 indicators were more often adhered to, with similar trends to the USA and UK. High adherence (defined as 80% or greater) was shown for eating three or more solid meals daily (94%), only breast milk and/or suitable formula supplied (94%), no sugar (86%) or salt (84%) added to infants meals or milk, and eating iron-rich food at least once since the start of CF (80%). Other recommendations such as inappropriate foods never tried (47%), eating fruit twice or more daily (37%), breastfeeding duration to 12 months or beyond (37%), EBF duration to around six months (35%), and eating vegetables twice or more daily (33%) were less commonly met.

To date, no other NZ studies have reported adherence using an index, however, a variety of studies have published adherence to specific recommendations (Abel et al., 2001; Fu et al., 2018; Heath et al., 2002; Morison et al., 2016; Morton et al., 2012), as discussed in the following sections. With new guidelines released in 2021, further assessment of adherence to infant feeding guidelines is required to determine what recommendations NZ whānau (families) are achieving and those that need further investigation.

Adherence to breastfeeding recommendations in high-income countries

A recent UNICEF report, using data from 123 countries, reported that 95% of infants are breastfed at one point in their lives (United Nations International Children's Emergency Fund, 2021). This is supported by literature with 71 to 98% of mothers initiating breastfeeding in high-income countries (Centers for Disease Control and Prevention, 2021; Gallegos et al., 2020; Kronborg et al., 2015; Lee et al., 2012; McAndrew et al., 2012; Netting et al., 2022). However, despite the high prevalence of initiation, most women do not meet recommendations for exclusive (one to 25%) and continual (27 to 44%) breastfeeding. What is defined as EBF and the timeframe for continual breastfeeding, however, has varied between studies making comparisons difficult (World Health Organization, 2002).

Similar trends have also been observed in NZ. In GUiNZ, 96% of women initiated breastfeeding (Castro et al., 2017). The prevalence of initiation, however, varied depending on maternal ethnicity; Asian and European mothers were more likely, while Māori and Pasifika mothers were less likely to initiate breastfeeding. This was higher than that observed by the NZ Breastfeeding Alliance, between 2017 and 2020, 82% of mothers initiated breastfeeding (The New Zealand Breastfeeding Alliance, 2020). At six months of age, EBF rates of 16% (Castro et al., 2017) and 22% (Plunket, 2020) have been reported. However, the most recent findings from the 2017 to 2020 NZ Health Survey identified a prevalence of 8% (Ministry of Health, 2021b), aligning with other high-income countries. There are limitations to measuring EBF at six months of age, as the MoH recommends exclusively breastfeeding until infants are 'around' six months of age. Infants who start solid foods at five months of age could also be characterised as meeting recommendations, depending on how 'around' six months of age is defined. In these studies, infants who started solid foods at five months of age were not included in breastfeeding statistics, reducing adherence. In GUiNZ, EBF prevalence increased (34%) when accounting for infants aged five months (Gontijo de Castro et al., 2018). Like other high-income countries, NZ also has a low prevalence of continual breastfeeding (37%) (Gontijo de Castro et al., 2018).

Adherence to infant complementary feeding recommendations in high-income countries

Low adherence to CF recommendations is commonly reported in high-income countries (Hamilton et al., 2011). Studies have found that solid foods are often introduced early, with 18 to 51% of infants being offered solid foods before four months of age (Bailey et al., 2021; Chiang et al., 2020; Klingberg et al., 2017; Wang et al., 2019). This was also observed in GUiNZ, with 39.3% of infants being offered solid foods before or at four months of age (Gontijo de Castro et al., 2018). However, the average age of solid food introduction seems to be gradually shifting to align with country-specific recommendations, as seen recently in Australia (five months) (Netting et al., 2022) and NZ (5.2 months) (Fu et al., 2018). Few infants (8%) were also offered solid foods before four months in the 2017 to 2020 NZ Health Survey (Ministry of Health, 2021b).

When introducing solid foods, infants are commonly offered fruits, vegetables, and CIF (especially infant cereals), aligning with recommendations (Abel et al., 2001; Garcia et al., 2019; Morton et al., 2012). In recently published data from GUiNZ, 65.5% of infants were reported to be introduced to fruits and vegetables and breads and cereals (57.2%) in the early CF period (between five and less than seven months of age) (Ferreira et al., 2023). This was less common for milk and milk products (46.2% were not introduced to this food group between five and less than seven months of age) and meat and meat alternatives (45.9%). At nine months of age some infants had not consumed fruits and vegetables (0.4%), grain foods (0.5%), milk and milk products (16.1%), and meat and meat alternatives (5.4%).

Meat and protein-rich foods are often reported as the least frequently consumed food group in infants (Fox et al., 2004; Grummer-Strawn et al., 2008; Lioret et al., 2013; Morton et al., 2012) and concerns have been expressed about the provision of adequate iron secondary to the low consumption of these foods, with iron-fortified infant cereals being the key source of iron for many infants when starting CF (Morton et al., 2012; Netting et al., 2022). The non-haem iron provided by iron-fortified infant cereals is less bioavailable than haem iron provided in animal products (Ministry of Health, 2021a).

Adherence to infant food group recommendations in high-income countries

Following the introduction of solid foods, it is expected that the range of foods included in an infant's diet will increase. However, global statistics show that many infants do not meet food group recommendations. Only 31% of infants in high-income countries met UNICEF’s minimum diet diversity targets in 2021 (United Nations International Children's Emergency Fund, 2021). Outside of NZ, three studies from high-income countries have reported the consumption of food groups that align with the

NZ MoH food group guidelines (Fox et al., 2004; Grummer-Strawn et al., 2008; Lioret et al., 2013). Due to the different infant ages included, comparison between studies is inappropriate. However, within studies, it seems that younger infants have a smaller diet diversity than older infants.

The first of the three studies was conducted as part of the American Infants and Toddlers Study (FITS) (n= 3,022) (Fox et al., 2004). FITS explored food groups consumed by American infants aged between four and 24 months through a 24-hour diet recall and reported an extensive list of foods consumed for each food group. Infants commonly consumed milk (formula, breast, cow, and/or soy) (100% between seven and eight months, 100% between nine and 11 months), grain foods (92%, 98%), vegetables (67%, 73%), and fruit (76%, 76%) at least once daily. Meat and protein-rich foods were less commonly consumed between seven and eight months (55%) than between nine and 11 months (79%).

The American Longitudinal Infant Feeding Practices Study II (n=2240) reported infant diets between six and eight months, eight and nine months, and nine and eleven months through a seven day food record (Grummer-Strawn et al., 2008). Similar to FITS, they found a high consumption of breast milk or formula (100% between six and eight months, 99% between eight and nine months, and 97% between nine and 11 months), cereals (92%, 96%, 96%), fruit (91%, 97%, 98%), and vegetables (93%, 97%, 98%). They reported similar trends for meat and protein-rich foods (49% between six and eight months, 78% between eight and nine months, 90% between nine and 11 months), with more frequent consumption in older infants. An analysis of the nutritional contribution of food groups was not accounted for in both studies, as the number of servings or portions consumed was not reported.

At a similar time, the Melbourne INfant Feeding, Active play and NuTrition Program (InFANT), an Australian longitudinal study (n=177) that investigated the dietary intake of infants at nine and 18 months by a 24-hour diet recall, reported food groups and the median intake of foods consumed (Lioret et al., 2013). Infants commonly consumed cereals (97%), fruit (95%), vegetables (95%), animal products (meat, poultry, fish, and eggs) (89%), and dairy foods (yoghurt and cheese) (88%) at nine months of age. This corresponded to a median daily intake of 32g of cereal-based products, 66g of fruit, 84g of vegetables, 24g of animal products, 47g of dairy products, and 461g of infant formula. At 18 months, the intake of each food group, except vegetables (decreased to 70g) and formula (decreased to 16g), increased.

In NZ, GUiNZ used an FFQ to identify food group consumption at nine months of age. Infants consumed a variety of foods daily, including vegetables (91%), fruit (87%), breads and cereals (90%), and meat and meat alternatives (61%) (Gontijo de Castro et al., 2018; Morton et al., 2012). These findings were similar to those found in a 2016 University of Otago study, which investigated infants aged six to eight months following BLW and TSF feeding methods (Morison et al., 2016). On at least one day of a three-day food diary, infants consumed vegetables (TSF: 96%, BLW: 89%), fruit (96%, 94%), and red meat (58%, 39%). Percentages, however, may be higher as consumption was reported across a three day period instead of a single day. Despite limitations, consumption in both studies tended to align with those in other high-income countries, with meat and meat alternatives being the least frequent food group consumed.

Milk and milk products are often not included in food group analyses, with many studies reporting formula and breast milk consumption instead (Fox et al., 2004; Grummer-Strawn et al., 2008). However, recent data from GUiNZ identified that 46.2% of infants are offered dairy foods (milk puddings, rice pudding, yoghurt, and custards) after seven months of age and 16.1% were not been offered dairy foods by nine months of age (Ferreira et al., 2023). This was lower than that reported in the Melbourne InFANT study who reported the intake of yoghurt and cheese as their "dairy foods" (88%).

Differences in dietary intake between infants of different ages have not yet been reported in NZ, creating a knowledge gap surrounding dietary development in the first year of life. Exploring this transitional period through observational data will provide valuable information about the changes that occur during CF.

Adherence to infant salt and sugar recommendations in high-income countries

Despite most guidelines worldwide recommending avoiding or limiting salt and sugar, various studies have found that infants consume foods that contain high amounts of salt and sugar (Hutchinson et al., 2021; Moumin et al., 2020), with consumption often increasing with age (Fox et al., 2004). Studies from France (33% of infants) (Bournez et al., 2019), the UK (70%) (Cribb et al., 2012), and the USA (61%) (Fox et al., 2004) have shown that notable amounts of salt and sugar are included in infant diets before ten months of age. Other studies from the USA and UK have shown high intakes of salt (Roess et al., 2018) or sugar (Grummer-Strawn et al., 2008), suggesting that adherence to recommendations is generally low.

Research on the addition of salt and sugar to infant foods has provided conflicting results in NZ. High adherence to recommendations was reported by GUiNZ, with most caregivers not adding salt (84%) or sugar (86%) to infant foods or beverages (Gontijo de Castro et al., 2018). Adherence was higher than findings in the Otago Baby-Led Introduction to Solids (BLISS) study (Morison et al., 2016). From three-day food records, 45% and 76% of infants were offered sweetened and salty foods on at least one occasion, respectively. There were no differences in sodium intakes of those following BLW and TSF.

Adherence to infant beverage recommendations in high-income countries

Low adherence to beverage recommendations has been reported in other high-income countries (Dratva et al., 2006; Grimes et al., 2015; Grummer-Strawn et al., 2008; Harton & Myszkowska-Ryciak, 2021; Martin-Kerry et al., 2020; Roess et al., 2018) and the intake of inappropriate beverages tends to increase with age (Kay et al., 2018). In NZ, GUINZ is the only study that has reported infant beverage consumption and found a moderate adherence (61%) to recommendations (Morton et al., 2012). Overseas, juice is the most frequently consumed inappropriate beverage (Grimes et al., 2015; Roess et al., 2018). In GUiNZ, 36% of infants had consumed fruit juice before nine months of age, and 25% consumed juice daily at nine months (Morton et al., 2012). Infants were, however, rarely offered soft drinks (5%), herbal beverages (2%), tea (3%), or coffee (1%).

2.2.2. Factors Associated with Infant Dietary Intake in High-income Countries

Dietary intake during infancy has been associated with various innate and environmental factors. The most significant is the reliance on caregivers to provide safe and appropriate forms of nutrition (Birch et al., 2007; Hetherington et al., 2011). The feeding practices, feeding environments, and parenting styles that caregivers adopt have been shown to significantly influence infant dietary intake, shaping an infant's future feeding behaviours and dietary choices ((Ferreira et al., 2023; Savage et al., 2007). Early life experiences, including the provision of breast milk, the age at which CF is initiated, how the diet is progressed, and food exposure have been shown to significantly influence food acceptance and dietary diversity, highlighting the importance of food and nutrition guidelines for caregivers (Coulthard et al., 2009, 2010; Grummer-Strawn et al., 2008; Maier et al., 2008; Mennella et al., 2001; Northstone et al., 2001).

Sociodemographic factors

Various sociodemographic variables, including maternal deprivation, education, ethnicity, and parity have been associated with adherence to infant feeding guidelines in high-income countries (Cohen et al., 2018; Ferreira et al., 2023; Gontijo de Castro et al., 2018). Many of these associations are interconnected with social inequalities, where those living in high deprivation and with lower education are less likely to receive dietary support and have lower access to nutritional food, nutrition information and resources (Zorbas et al., 2021; Zorbas et al., 2018). In NZ, inequalities in health exist between ethnicities, particularly among Māori (Harris et al., 2006) and Pasifika peoples (Marriott & Sim, 2015)). Assisting these populations is an important way to improve adherence to infant feeding guidelines.

Lower incidences of breastfeeding have been significantly associated with younger maternal age, lower education, low household income, and high deprivation (Cohen et al., 2018; Gontijo de Castro et al., 2018). These factors are often interconnected with women returning to work, with insufficient support and resources to sustain breastfeeding (Dutheil et al., 2021; Payne & James, 2008). They have also been associated with breastfeeding knowledge, with social inequalities in access to information and resources (Magnano San Lio et al., 2021). Positive and negative associations have been shown between maternal parity and the initiation of breastfeeding, however, women with multiple children are more likely to meet breastfeeding recommendations (Cohen et al., 2018). This is thought to result from previous experience (McAndrew et al., 2012). In GUiNZ, a higher prevalence of breastfeeding was found in women of Asian or Pasifika ethnicities and those with a partner (Gontijo de Castro et al., 2018), suggesting that culture and support are likely factors in sustaining breastfeeding. Firstborn infants, twins, and those with low birth weight were less likely to meet the EBF recommendation and breastfeed until 12 months of age (Gontijo de Castro et al., 2018). Intervention studies focusing on providing adequate breastfeeding support in the early stages of breastfeeding (Cohen et al., 2018; McFadden et al., 2017) and appropriate resources for those returning to work (Tsai, 2013) have shown promising results, indicating that additional support for women would likely improve the prevalence of breastfeeding.

The early introduction of solid foods has been associated with caregivers of younger age and lower levels of education (Ferreira et al., 2023; Gontijo de Castro et al., 2018; O'Donovan et al., 2015). Those of a Māori ethnicity or living in high deprivation in NZ were also less likely to meet recommendations for the introduction of solid foods in GUiNZ (Ferreira et al., 2023; Gontijo de Castro et al., 2018). As seen for breastfeeding, these associations are likely the result of social inequalities with lower education resulting in less knowledge of when solid foods should be introduced. Sociodemographic associations, therefore, highlight the complex interactions that an infant's environment has on dietary practice. It is important that these factors are considered when investigating adherence to infant feeding guidelines as they allow further insight into caregivers who may need additional support.

Infant age

Infant age makes the investigation of dietary intake difficult because rapid changes occur as an infant progresses from puréed foods to a family-based diet (Ministry of Health, 2008). Due to the rapid nature of dietary change, different dietary intakes have been observed among infants of different ages (Andersen et al., 2015; Kokkinopoulou et al., 2015; Cameron et al., 2015; Lioret et al., 2013; Morton et al., 2012; Skinner et al., 1997). The American FITS (Fox et al., 2004), American Longitudinal Infant Feeding Practices II (Grummer-Strawn et al., 2008), and Melbourne InFANT (Lioret et al., 2013) studies compared food group consumption between infants of different ages. Older infants included in the studies typically consumed breast milk and formula less frequently and cows or soy milk, dairy foods, fruit, meat and protein-rich foods, grains and cereals, desserts, sweets, and sweetened beverages more frequently. Differing results have been observed for vegetables. Within the American studies, vegetable consumption increased with age (Fox et al., 2004; Grummer-Strawn et al., 2008), while no differences were observed in Australia (Lioret et al., 2013).

Differences in foods consumed are likely the result of the dietary transitions during CF, with older infants having more time to accept new foods and consuming larger meals where a range of food groups can be incorporated (Nicklaus, 2009). However, the introduction of a wide variety of foods from each of the food groups from an early age supports optimal feeding behaviours, with research showing that food habits formed in early life track into childhood and give rise to the adult diet (Lioret et al., 2013; Nicklaus & Remy, 2013; Northstone & Emmett, 2008; Robinson et al., 2007). It should therefore be encouraged that a wide variety of foods are incorporated from the early stages of CF. Because of the importance of optimal nutrition during the CF period and the influence of early feeding behaviours on an individual's later health, further investigation is needed.

Lifestyle and other factors

Lower incidences of breastfeeding have also been significantly associated with maternal smoking (Golley et al., 2012; Magnano San Lio et al., 2021), and the early introduction of solid foods has been associated with infants who are unsettled or sleeping poorly, cultural traditions, and maternal perceptions of hunger (Abel et al., 2001; Tapera et al., 2017). Breastfed infants are often perceived as hungrier and 'need' solid foods to meet daily nutrient needs (Brown & Rowan, 2016). This is more frequently reported in male infants than female infants (Schrempft et al., 2013), with findings from the NZ health survey 2019/20 showing the male infants were twice as likely to be introduced solid foods before four months of age than female infants (Ministry of Health, 2020b). Opposingly previous experience and receiving dietary support have been supportive of starting solid foods around six months of age (Synnott et al., 2007), indicating that knowledge and support are key variables for guideline adherence.

Knowledge also seems to be a key influence for the provision of a range of food groups, with mothers who meet adult feeding guidelines being more likely to meet infant guidelines in the USA (Fox et al., 2004; Siega-Riz et al., 2010), Australia (Lioret et al., 2013), and the UK (Robinson et al., 2007). Unlike breastfeeding, previous experience has not been associated with adherence to food group guidelines. Firstborn infants were more likely to meet NZ MoH food group guidelines in GUiNZ than subsequent children (Gontijo de Castro et al., 2018). This has also been observed in older children, with first-time parents being more likely to follow health-conscious dietary patterns than those with additional children (Damen et al., 2019; Damen et al., 2020; Northstone & Emmett, 2013). Likely explanations for this include the novelty of the firstborn, time restrictions, and the availability of other types of foods in the home with older children (Damen et al., 2020).

Feeding methods

In recent years, studies have shown that those following BLW are more likely to meet appropriate age recommendations for introducing solid foods (Boswell, 2021; Brown & Lee, 2011; Costantini et al., 2019; Morison et al., 2016; Zielinska et al., 2019). There have also been differences in EBF duration, the provision of family-based meals, and the use of processed foods, with those following BLW being more likely to meet guidelines (Cameron et al., 2013). First foods offered vary, with those following TSF typically offering infant cereals, fruit, and vegetables as first foods (Brown & Lee, 2011; Carletti et al., 2017; Klingberg et al., 2017; Nicklas et al., 2020; O'Donovan et al., 2015; Roess et al., 2018). Those following BLW are more likely to offer fruits and vegetables, with infant cereals rarely offered (Brown & Lee, 2011; D'Andrea et al., 2016; Fu et al., 2018). Offering red meat has also been significantly associated with BLW in NZ (Cameron et al., 2013; Fu et al., 2018), However, not all studies have shown such trends with a 2016 NZ study of 51 infants finding no differences in the consumption of vegetables, fruit, and CIF or the age when red meat was introduced between those following BLW and TSF (Morison et al., 2016).

Most studies conducted have been observational, and there is a need for further randomised control trials (RCTs) to determine the 'cause and effect' relationship between feeding methods and foods offered. In NZ, the BLISS RCT (n=206) found no significant differences in food consumption between those following TSF and a modified BLW by 12 months of age (Williams Erickson et al., 2018). At seven months, small differences were observed for the consumption of grain food and meat and protein-rich foods (more frequently included in the BLW diet), however, it must be noted that those in the BLW group received eight education sessions that targeted nutritional practices at this time.

Commercial infant foods

The use of CIF appears to be increasing in high-income countries. In the recent OzFITS (n=598), 50% of infants under one year of age consumed CIF during a one-day food record (Netting et al., 2022). Similarly, a narrative review from the UK reported that almost half (45%) of infants aged between eight and 10 months used CIF at least once daily (McAndrew et al., 2012). These results were higher than that observed in the German DOrtmund Nutritional and Anthropometric Longitudinally Designed Study (DONALD) (n=366) in 2014 that found 31% of nine-month-old infants were predominately offered CIF during a three-day food diary (Foterek et al., 2014). However, a further 26% were also offered a mixture of CIF and homemade food. The use of CIF in each of these studies, was much lower than those reported by an American study (n=483), with findings that 95% of infants aged between seven and eight months consumed jarred infant foods daily (Briefel et al., 2004). Within the same American study, many infants continued to consume these foods daily between nine and 11 months (87%). Product availability and differences in national feeding guidelines are likely reasons why reports have differed between countries.

In NZ, evidence surrounding the use of CIF is limited (Katiforis et al., 2021). In GUiNZ, 48% of infants consumed CIF daily, with 25% consuming products weekly (Morton et al., 2012). Since GUiNZ data collection, the availability of CIF has significantly increased, and further investigation of the current use of products is required (Beauregard et al., 2019). Further investigation into how CIF influences dietary intake is also yet to take place. This is particularly important for the provision of total energy, sugars, and iron, which have been identified as key areas of concern in CIF available in NZ (Katiforis et al., 2021).

2.3. Feeding Behaviours

Feeding is a complex process that requires the interaction of various body systems, including the central and peripheral nervous, cardiopulmonary and musculoskeletal systems, gastrointestinal tract, and craniofacial structures (Goday et al., 2019). The autonomic nervous system plays a crucial role in ensuring the metabolic needs of an individual are met (Paul et al., 1996). For infants, the autonomic regulation of food intake interacts with somatic experiences in early life with differing feeding behaviours expressed by those with different learnings and cognitive experiences (Paul et al., 1996).

For what can be described as 'normal feeding behaviours', an infant must successfully integrate their autonomic nervous system and physical abilities (Goday et al., 2019; Paul et al., 1996). Disruption in one or more of these systems can result in feeding problems.

What normal feeding looks like, however, is less well described. Many infants will refuse foods when first offered, requiring multiple exposures before different flavours and textures are accepted (Fewtrell et al., 2017; Remy et al., 2013). This is particularly true for bitter and sour foods (Beauchamp & Mennella, 2009). When starting new textures, infants may also gag (Ministry of Health, 2021a). Gagging is a normal reflex that occurs when oral motor skills are developing for the movement of foods, preventing food from entering the airways. These behaviours are initially normal for a typically developing infant, however, if ongoing or if they affect dietary intake they may be described as concerning feeding behaviours (CFB) (Kerzner, 2009). It is generally agreed that feeding is concerning when an infant is unable to eat or will not eat enough despite the availability of appropriate foods (Kedesdy & Budd, 1998). Commonly reported CFB for infants and children include food fussiness or pickiness, refusal of new foods (neophobia), grumpiness during mealtimes, and inadequate self-feeding skills (Dovey et al., 2008; Oliveira et al., 2015). Internationally, CFBs are becoming more prevalent, with reports that from 25% of typically developing children display concerning behaviours (Benjasuwantep et al., 2013; Goday et al., 2019). This number increases to 80% for children with developmental disabilities or diagnosed medical conditions (Gal et al., 2011; Goday et al., 2019). Currently, the incidence of CFB is unknown in NZ infants.

2.3.1. Measuring Feeding Behaviours

Many families seek assistance when facing CFB (Thoyre et al., 2014). There is no gold standard for diagnosing CFB, and testing to determine the problem can be time-consuming, expensive, and at times unvalidated (Thoyre et al., 2014). Common methods of diagnosis include direct observation by a trained practitioner, questionnaires or coding tools, or caregiver reports (Piazza-Waggoner et al., 2008; Thoyre et al., 2014). Each method has strengths and limitations. Validated questionnaires provide a quick, comprehensive measure of behaviours and are minimally burdensome, affordable, and highly repeatable, making them suitable for tracking feeding behaviours over time (Thoyre et al., 2014). However, they are not without limitations, with differences observed in caregiver perception of feeding problems. Different tools exist for the assessment of feeding behaviours in children (Table 2.9). Some are designed for specific population groups, while others can be used for the general population. There are, however, few available for the assessment of CFB in infants (Table 2.9).

Table 2.9: Tools available for the assessment of feeding behaviours in infants and children

Tool name (reference)	Description of tool	Validated age ranges	Strengths	Limitations
Children				
Children's Eating Behaviour Inventory (CEBI) (Archer et al., 1991)	40 items. Measures child food preferences, motor skills, and behavioural compliance. It also measures the parent/family system and includes questions on controlling behaviours, feelings about feeding, and family mealtime interactions. Scored on a 5-point scale (1 = never, 5 = always) and responses are averaged. Parents are also asked if behaviours are a problem (yes or no).	2 to 12 years	First tool designed to assess feeding behaviours, has been modified for different languages, adequate reliability.	Selection bias noted in samples of the validation study, includes family mealtime interactions in total score, does not assess physiologic symptoms.
About Your Child's Eating—Revised (AYCE) (Davies et al., 2007)	25 items. Measures child mealtime behaviours and parent feeding responses. Scored on a 5-point scale (1 = never, 5 = nearly every time) and responses are totalled.	School aged children	Validated for both healthy and those with chronic illness, good internal consistency.	Further validation is needed for retest reliability, includes family mealtime interactions in the total score, does not assess physiologic symptoms and oral motor skills.
Brief Autism Mealtime Behaviour Inventory (BAMBI) (Lukens & Linscheid, 2008)	18 items. Measures mealtime behaviours. Scored on a 5-point scale (1 = never happens, 5 = always happens) and responses are totalled.	9 to 18 years	Assesses feeding behaviours for those with autism, good internal consistency, high test–retest reliability.	Specific to children with autism, does not assess physiologic symptoms and oral motor skills.
Mealtime Behaviour Questionnaire (MBQ) (Berlin et al., 2010)	33 items. Measures food refusal/avoidance; food manipulation; mealtime aggression/distress; and choking, gagging/vomiting). Scored on a 5-point scale (1 = never, 5 = always) and responses are totalled.	2 to 6 years	First tool to measure only child behaviours.	Needs future investigation for validity and reliability of data, does not assess physiologic symptoms.
Screening Tool of Feeding Problems Applied to Children (STEP-CHILD) (Seiverling et al., 2011)	15 items. Six subscales; chewing problems, rapid eating, food refusal, food selectivity, vomiting, and stealing food. Scored on a 3-point scale (0 = not at all, 2 = more than 10 times per month) and responses are totalled.	2 to 18 years	Validated for children with feeding problems, adequate internal validity.	Only for children with feeding problems, does not assess physiologic symptoms.
Children's Eating Behaviour Questionnaire (CEBQ) (Wardle et al., 2001)	35 items. Eight subscales: food responsiveness, food fussiness, emotional overeating, enjoyment of food, desire to drink, satiety responsiveness, slowness in eating and emotional undereating. Scored on a 4-point scale (1 = never, 5 = always) and responses are totalled.	4 to 12 years	Good internal consistency and reasonable reliability.	Needs further validation in a wider demographic sample and establishment of a predictive value, does not assess physiologic symptoms and oral motor skills.

Tool name (reference)	Description of tool	Validated age ranges	Strengths	Limitations
Children's Eating Difficulties Questionnaire (CEDQ) (Rigal et al., 2012)	15 items. Measures neophobia, pickiness, low appetite, and lack of food enjoyment. Scored on a 5-point scale (1 = very wrong, 5 = very true) and responses are totalled.	One to three years	Good internal consistency and reasonable reliability.	Validated in France only, does not assess physiologic symptoms and oral motor skills.
Infants				
International Complementary Feeding Evaluation Tool (ICFET) (Wright et al., 2021)	11 items. Two subscales: food enjoyment and refusal. Parents respond to each question on a 5-point scale (1 = very likely, 5 = very unlikely) and responses are totalled.	Six months to two years	Tested in low-income countries, short tool, validated for use in different languages, good internal variability, parent-reported measures have been compared to video footage in validation.	Further validation is needed, does not assess oral motor skills or problematic mealtime behaviours or physiologic symptoms.
Paediatric Assessment Scale for Severe Feeding Problems (PASSFP) (Crist et al., 2004)	15 items. Two sections: eating behaviours and oral sensory. The first section is completed by all and the second is only for those who are having oral foods. 12 questions are scored on a 4-point scale (1 = never, 4 = always) and responses are totalled. The remaining 3 questions are scored on different scales, according to the child's feeding.	Over four months	Assesses feeding behaviours in tube-fed children, able to describe feeding behaviours across different types of tube feeding.	For tube-fed children only, no validation yet, does not assess physiologic or problematic mealtime behaviours.
Behavioural Pediatrics Feeding Assessment Scale (BPFAS) (Crist & Napier-Phillips, 2001)	25 items. Measures mealtime and restrictive eating behaviours. An additional 10 items assess parent feelings about behaviours. Scored on a 5-point scale (1 = never, 5 = always) and responses are totalled. Parents are also asked if behaviours are a problem (yes or no).	Nine months to seven years	Infants and children with eating concerns were compared with those without	Validation groups had differences in demographics, does not assess physiologic symptoms and oral motor skills.
Montreal Children's Hospital Feeding Scale (MCHS) (Ramsay et al., 2011)	14 items. Measures mealtime behaviours. Scored on a 7-point scale (scales vary depending on the question). Complex scoring system available.	Six months to six years	Good internal consistency, high retest reliability, quick and easy to use.	Validation groups had differences in demographics, does not assess physiologic symptoms, oral motor skills, and selective/restrictive eating.
The Paediatric Eating Assessment Tool (PediEAT) (Thoyre et al., 2014).	78 items. Four subscales: physiologic symptoms, problematic mealtime behaviours, selective/restrictive eating, and oral processing. Scored on a five-point scale. Age-dependent total and subscale scoring system to define no concern, concern, and high concern.	Six months to Seven years (if consuming solid foods)	Good internal consistency, high retest reliability, easy to use, identifies specific behaviours within four subscales identifying areas to target. Can be used in both healthy children and those with CFBs	Uses parent-reported answers – may predispose bias results, longer questionnaire.

In 2012, clinical and research content experts designed the Paediatric Eating Assessment Tool (PediEAT) as a comprehensive parent-report measure of eating behaviours that caregivers may observe in children aged six months to seven years. The PediEAT was designed through a three-phase systematic and validation process including:

1. Item generation from parent descriptions of CFB (focus groups n=6 and individual interviews n=13), literature searches, and review of existing eating-related instruments,
2. Rating of item clarity (n=8) and relevance by interdisciplinary experts (n=9) on paediatric eating behaviours using content validity indices,
3. Cognitive interviews of two-parent groups (n=9 and n=13) who had children with and without feeding difficulties that allowed feedback on content, format, and item interpretation.

Both positive and concerning behaviours are included in PediEAT within 78 questions to accurately represent eating behaviours (Thoyre et al., 2014). A scoring system for infants and children of different ages was also developed to distinguish if feeding behaviours require intervention, with high scores indicating more symptoms of CFB. For further clarification, the scores can then be divided into four subscales, including physiologic symptoms, problematic mealtime behaviours, selective/restrictive eating, and oral processing to determine the infant's or child's problem areas. This is a key strength of PediEAT that other questionnaires lack (Table 2.9).

The PediEAT subscales focus on specific behaviours connected with problematic outcomes (Pados et al., 2018). Physiologic symptoms (27 items) describe signs of physical distress such as 'breathing faster or harder during mealtimes', 'coughs during or after eating', 'throws up during meals', and 'gets pale or blue colour around his/her lips during meals'. Physiologic symptoms are novel to the PediEAT and have been indicated as an early indicator of CFB. Within the PediEAT validation study, the physiologic symptom subscale was the most strongly correlated with the total score (Thoyre et al., 2018). Early detection of physiologic symptoms such as constipation and reflux are thought to reduce the risk of avoidant behavioural patterns, which are more complex to treat, avoiding nutritional concerns before they become a problem. The second subscale, problematic mealtime behaviours (23 items), investigates food refusal, stress responses to food, and infant mealtime preferences. It includes questions: 'refuses to eat', 'likes something one day but not the next', 'insists on being fed by the same person', and 'takes more than 30 minutes to eat'. Problematic mealtime behaviours are known to influence the acceptance of food and diet variety in toddlers (Carruth et al., 2004; Pados et al., 2018). However, they appeared to be less prevalent in infants included in the PediEAT norm-reference study (Pados et al., 2018). Selective/restrictive behaviours (15 items) assess infant food, texture, and temperature preferences and includes questions:

‘will eat mixed foods’, ‘will eat foods that need to be chewed’, ‘spits food out’, and ‘eats too fast’. Selective/restrictive behaviours are commonly assessed in feeding assessment tools, with caregivers commonly reporting picky and fussy eating (Pados et al., 2019). The final subscale, oral processing (13 items), assesses incoordination of the chewing and swallowing process. Questions include: ‘stores food in their cheek or roof of mouth’, ‘put fingers in mouth to move food’, ‘chews food but does not swallow it’, and ‘has to be reminded to chew food’. Oral processing is a complex task, and incoordination during the early stages of CF is normal (Pados et al., 2018). Ongoing issues, however, indicate that clinical intervention is required.

PediEAT is a cheap, effective, minimally burdensome, validated, and highly repeatable tool (Thoyre et al., 2014). It is, however, not without its limitations. As PediEAT relies on caregivers reporting their child’s feeding, inherent bias can arise. It is expected that caregivers may view eating behaviours differently, with some viewing CFB as normal, while others may be highly sensitive to particular feeding behaviours (Dirks et al., 2012).

PediEAT is widely used in the clinical domain and has been validated to describe CFB in those with and without diagnosed CFBs. In the PediEAT’s validation study, infants with CFB scored significantly higher than those without (Thoyre et al., 2014). A subsequent study to identify norm-reference values found that younger infants (six to 12 months) typically scored highest in the oral processing subscale, indicating the complexity of eating in early CF (Pados et al., 2018). Over time infant scores declined (e.g. improved) as oral motor skills developed. Problematic mealtime behaviours and selective/restrictive eating were the next highest subscales. Selective/restrictive eating tended to peak in toddlers who were more able to express independence, likes, and dislikes. Problematic mealtime behaviours, however, persisted into childhood. Physiologic symptoms were the lowest scored subscale, however, were the highest for any age. Scores were thought to indicate the physiological adaptations that occur as the body adjusts to solid foods.

Differences in PediEAT scores have been observed in infants with diagnosed medical conditions. Less than 50% of six to 12 month old full term infants (n=30) with congenital heart defects were reported to meet the PediEAT criteria for feeding problems at eight months (35%) and ten months (14%) (Pados & Harrison, 2022). Low mean scores were found for oral processing, physiologic symptoms, and problematic mealtime behaviours, despite infants being at higher risk for feeding difficulties. Infants scored highest (e.g. worse) for selective/restrictive eating, however, this declined between eight and ten months. Another study (n=58) of infants and children aged six months to seven years who were receiving feeding support reported that all scores (total and subscales) were in the concern category (Park et al., 2018). Constipation, diagnosed food allergies, genetic disorders, and diagnosed speech-language delay were significantly associated with CFB, particularly physiologic symptoms (Park et al., 2018). Studies are yet to compare PediEAT scores with feeding practices (breastfeeding and food group consumption). This study, therefore aims to explore feeding behaviours and their associations with infant feeding practices.

2.3.2. Influences on Feeding Behaviours

The development of CFB is multifactorial and can result from various factors, including underlying medical conditions, poor feeding environments, caregiver feeding practices, and infants asserting autonomy (Birch & Doub, 2014; Estrem et al., 2017; Gahagan, 2012; Kerzner, 2009; Scaglioni et al., 2011). For those experiencing side effects of an underlying medical condition (e.g. reflux), treatment will often see the resolution of feeding behaviours. However, for some, behaviours may persist (Kerzner, 2009). Those with specific medical diagnoses may also have a higher risk of certain CFB (Borowitz & Borowitz, 2018). For example, children with autism spectrum or attention-deficit/hyperactivity disorders are more likely to display food refusal and fussy eating tendencies, while those with Down Syndrome are more likely to experience oral motor delays (Field et al., 2003).

A key environmental influence is an infant's caregivers or those that provide food (Birch et al., 2007). Caregivers actively determine the type, texture and amount of foods provided to infants (Birch et al., 2007; Savage et al., 2007), shaping early food experiences. Differences in infant and child feeding behaviours have been identified based on parent demographic characteristics. Those living in high deprivation, with a low household income or education, and parents who smoke have been identified with higher incidences of fussy eating (Emmett et al., 2018; Qiu & Hou, 2020; Tharner et al., 2015). No study has investigated differences between first-time parents and those with multiple children. However, the influence of siblings has gained interest recently (Ayre et al., 2022; Ruggiero et al., 2021). Studies suggest that children with siblings are less likely to display CFB (Ayre et al., 2022; Ruggiero et al., 2021). Peer modelling, parent learnings from the first child, resource dilution, and availability of different foods may explain differences in feeding behaviours (Ayre et al., 2022; Ruggiero et al., 2021). The benefits of peer modelling have been shown elsewhere by improved food acceptance in toddlers who share mealtimes at ECE's (Birch, 1980). Age and sex have also been linked with CFB, with older and male children being more likely to be fussy eaters (Antoniou et al., 2016; Brown et al., 2018; Chilman et al., 2021; Tharner et al., 2014; Wardle et al., 2001). Factors, however, are yet to be investigated in infants.

Infants have an innate preference for sweet flavours and a natural aversion to bitter flavours (Beauchamp & Mennella, 2009). These preferences are considered as adaptations for survival, with sweet foods typically being a good source of energy, while bitter tastes are more likely to be toxic (Beauchamp & Mennella, 2009). Nevertheless, these innate tendencies can be modified by taste experiences. Some evidence suggests that food preferences may start forming during pregnancy, with strong maternal dietary flavours affecting the taste profile of amniotic fluid (Forestell, 2016). This continues into lactation, with a handful of studies identifying that breastfed infants have a higher initial acceptance of new foods than formula-fed infants if such food groups have been included in the maternal diet (Hausner et al., 2009; Mennella et al., 2017; Mennella et al., 2001; Sullivan & Birch, 1994). This is thought to be the result of breastfed infants being exposed to a variety of flavours from the maternal diet, increasing their familiarity to flavours compared to formula-fed infants who are provided with a consistent flavour (Harris & Coulthard, 2016; Hausner et al., 2009; Maier et al., 2008; Mennella, 2009; Mennella et al., 2001). The influence of breastfeeding has also been shown in older children, with breastfed infants showing less picky or neophobic patterns during childhood than formula-fed infants (Cooke et al., 2004; Galloway et al., 2003).

During CF, early exposure to a variety of foods has been associated with lower food fussiness (Coulthard et al., 2014; Maier et al., 2007). Typically, infants who are exposed to a wider variety of flavours are more likely to accept new foods from each food group, further promoting the importance of offering a variety of foods. Associations between feeding behaviours and CIF have not yet been investigated. With the increasing availability of products and concerns surrounding the sweet nutrition profile of products (Katiforis et al., 2021) and the use of pouch nozzles for self-feeding (Taylor et al., 2021; Theurich, 2018), investigation is important.

2.3.3. The Relationship Between Feeding Behaviours and Dietary Intake

Although restrictive and fussy eating tendencies can significantly affect food intake, there has been limited research into the associations between feeding behaviours and dietary intake in infancy (Carruth et al., 1998; Jacobi et al., 2003; Northstone & Emmett, 2013). Research in older children has shown a clear relationship between different eating behaviours and dietary intake (Burnett et al., 2021; Carruth et al., 1998; Carruth & Skinner, 2002; Howard et al., 2012; Perry et al., 2015; Russell & Worsley, 2008; Switkowski et al., 2020). Those with picky eating tendencies have been shown to refuse entire food groups, with common reports of limited fruit and vegetable acceptance (Carruth et al., 1998; Perry et al., 2015; Switkowski et al., 2020). Picky toddlers at two years of age are also more likely to consume a diet rich in discretionary foods (Perry et al., 2015). A recent online survey of Australian mothers with children aged two to five years (n=1349) that used the CEBQ found that CFB were associated with reduced dietary quality[3] (Burnett et al., 2021). These effects, however, were minimised when appropriate feeding practices such as structured mealtime settings and eating as a family (caregiver modelling) were implemented.

Currently, the incidence of CFB in NZ infants is unknown and further research surrounding the prevalence and associated sociodemographic variables and feeding practices is important. This information will support caregivers and health professionals to identify infants at higher risk and the influence of these behaviours on dietary intake. Increasing knowledge surrounding the detrimental effects of CFB may increase awareness of identifying these behaviours early, supporting improved dietary practices in later life.

2.4. Concluding Statement

Despite the well-known importance of the diet during infancy, there is a lack of up-to-date evidence on what and how infants are fed in NZ and high-income countries. Most evidence available for infant feeding practices focuses on those aged six months or above twelve months, leaving a significant gap for those during the early stages of CF (aged 7.0 to 10.0 months). In NZ, the majority of our evidence comes from the GUiNZ study which investigated dietary intake at nine months of age between 2009-2012. However, following GUiNZ data collection, there has been an increased availability of CIF and anecdotal evidence that BLW is becoming a popular method of introducing solid foods. There is currently limited evidence available for what foods infants consume and how frequently food group recommendations are met, although studies from other high-income countries have suggested that many infants do not meet recommendations for meat and protein-rich foods, increasing the risk of nutritional inadequacies such as iron. There is also limited evidence surrounding adherence to the 2021 MoH recommendations for

[3] Assessed using a diet quality index from a 13 item FFQ. Each item from the FFQ was scored from 0 (not meeting recommendations) to 5 (meeting recommendations). Items included water, fruit, vegetables, milk, and fruit juice. Higher scores indicated a better overall dietary quality.

breastfeeding, the introduction of solid foods, the provision of appropriate foods and beverages, and infant feeding environments, with further research needed to determine those at higher risk of not meeting guidelines. The investigation of feeding behaviours is a relatively new area of research, however, with reports that up to 25% of typically developing and 80% of those with developmental disabilities or diagnosed medical conditions display CFB, further research is needed to determine the incidence in NZ and associations with sociodemographic characteristics and feeding practices. Therefore, this thesis aims to provide observational data on infant dietary practices to understand what foods NZ infants are being provided, adherence to the 2021 MoH infant feeding guidelines, and the incidence of CFB and associations with sociodemographic characteristics and feeding practices. Clarification on infant feeding will provide much-needed support to the NZ MoH and health professionals, identifying if NZ feeding practices are appropriate and, if not, what can be addressed to support optimal nutritional outcomes.

2.5. References

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CHAPTER 3

CONTRIBUTIONS OF KEY FOODS AND FOOD GROUPS TO THE DIETARY INTAKE OF INFANTS IN THE FIRST FOODS NEW ZEALAND STUDY

This chapter provides insight into the foods and food groups consumed by infants during one and both diet recall days. To provide insight into the transitional complementary feeding period, food consumption has been stratified by infant age.

This report is presented in manuscript format but has not yet been published.

3.1. Abstract

Background: Around the age of six months infants require complementary foods, in addition to breast or formula milk, to meet increased energy and nutrient requirements. A variety of complementary foods should be offered daily, including; vegetables, fruit, grain foods, milk and milk products, and meat and protein-rich foods. Despite the importance of nutrition during this life stage, little is known about the food and food group intake of infants in New Zealand.

Aim: To explore the contributions that key foods and food groups (vegetables, fruit, grain foods, milk and milk products, meat and protein-rich foods, commercial infant foods, and discretionary foods) make to the dietary intake of New Zealand infants between 7.0 and 10.0 months of age.

Methods: Data were obtained from 625 infants living in Auckland and Dunedin who participated in the First Foods New Zealand (FFNZ) observational study. Food and food group data were collected by trained researchers using two 24-hour diet recalls with photograph prompts on different days of subsequent weeks. Consumed foods were allocated to food and food group codes developed by the FFNZ team. Data were analysed using Microsoft Excel (version 16.66) and in Stata software (StataCorp, Texas).

Results: Infants consumed a range of vegetables (96.2% of infants during at least one recall day and 63.2% of infants during both days), fruit (91.8%, 53.9%), grain foods (90.4%, 49.5%), milk and milk products (64.0% and 38.6%), and meat and protein-rich foods (84.3%, 31.8%). More than half of the infants consumed discretionary foods (56.3%) and commercial infant foods (78.1%) at least once. The ten most common foods consumed were carrot, banana, bread, brassicas, kumara, extruded commercial infant snacks, pumpkin, apple, potato, and commercial infant pouches.

Conclusion: FFNZ infants consumed a variety of foods from the Ministry of Health food groups. Vegetables and fruit were the most frequently consumed food groups. However, most infants did not meet MoH recommendations for the daily consumption of vegetables, fruit, grain foods, milk and milk products, and meat and protein-rich foods. Further research is required to determine the nutritional implications of not meeting the MoH food group recommendations during the complementary feeding period.

3.2. Introduction

Around the age of six months, an infant requires more energy and nutrients than breast or formula milk can provide (Fewtrell et al., 2017). Therefore, foods of age-appropriate textures should be gradually introduced into the diet (Ministry of Health, 2021). The New Zealand Ministry of Health (MoH) 'Healthy Eating Guidelines for New Zealand Babies and Toddlers (0–2 years old)' recommend that once complementary feeding (CF) has started, infants are offered a variety of nutritious foods to meet their increasing nutrient requirements and establish healthy eating behaviours (Ministry of Health, 2021). These include the daily consumption of vegetables; fruit; grain foods; milk and milk products; and legumes, nut butters, eggs, fish, seafood and chicken, or lean red meat (referred to as meat and protein-rich foods from here).

Guidelines discuss food groups instead of nutrients to simplify advice and provide nutrition recommendations in a way that the general population can understand. For example, it is easier to follow recommendations for consuming foods e.g. milk or cheese, rather than nutrients e.g. calcium. The MoH does not provide serving size recommendations for infants under one year of age (Ministry of Health, 2021). This is because breast and formula milk are the most important sources of energy and nutrients until one year of age. The addition of complementary foods allows an infant to transition from a diet consisting of only breast or formula milk to one resembling the family diet. Complementary foods expose infants to new tastes and textures and allow the development of appropriate eating behaviours and patterns for later life when food is essential to meet daily nutrient requirements.

Foods are grouped according to the key nutrients that they contain. However, not all foods are equal, and a variety of foods within each food group are required to meet all nutrient requirements (Ministry of Health, 2020). A varied diet also promotes the consumption of different flavours, including those that are naturally sweet, savoury, and bitter, to support a wide food acceptance (Ministry of Health, 2021). Not all foods meet the MoH food group criteria, such as processed foods (described as discretionary foods from here) which often contain high amounts of sodium and sugar or a reduced nutrient content than less refined alternatives (e.g. white vs wholemeal bread) (Ministry of Health, 2021). These foods should be limited as they can displace nutritious foods and accustom infants to nutrient-poor diets (Magarey et al., 2016; Ministry of Health, 2021). Although most MoH recommendations discuss food groups, in some cases, specific references have been made to nutrients such as iron due to the serious implications of deficiency (Ministry of Health, 2021). The MoH recommends that iron-rich foods, including meat, poultry, fish, seafood, and iron-fortified infant cereals, are offered daily.

A small number of studies have investigated the consumption of foods and food groups in infants from high-income countries. The majority have shown that infants generally do not consume foods from each of the food groups, increasing the risk of nutrition deficiencies (United Nations International Children's Emergency Fund, 2021; White et al., 2017). A large observational study, 'The American Feeding Infants and Toddlers Study' (FITS) (n=3,022), is the only study that has reported a comprehensive list of individual foods consumed by infants aged four to 24 months from a telephone 24-hour diet recall (Fox et al., 2004). The 2005 to 2007 Infant Feeding Practices Study II (seven day food record) in the United States of America (USA) (Grummer-Strawn et al., 2008) and the 2008 to 2010 Melbourne InFANT Program (24-hour diet recall via telephone) (Lioret et al., 2013) reported food groups consumed. Both studies found that meat and protein-rich foods were the least frequently consumed food group (Fox et al., 2004; Grummer-Strawn et al., 2008), reducing the dietary provision of protein, iron, zinc, and B vitamins (Ministry of Health, 2020). Fruit, vegetables, and grain foods are typically included daily, irrespective of infant age (Fox et al., 2004; Grummer-Strawn et al., 2008; Lioret et al., 2013). Discretionary foods are also commonly consumed, increasing in older infants (Fox et al., 2004; Grummer-Strawn et al., 2008; Lioret et al., 2013).

The Growing Up in New Zealand (GUiNZ) study (n=6470) reported food groups consumed by nine-month-old infants in an nationally generalizable infant population from data collected between 2009 to 2012 (Gontijo de Castro et al., 2018; Morton et al., 2012). Food frequency questionnaire (FFQ) and retrospective recall questions suggested that most infants consumed breast or formula milk, fruit, vegetables, and breads and cereals daily (Gontijo de Castro et al., 2018; Morton et al., 2012). Meat and protein-rich foods were the least commonly consumed food group, although 60.7% of infants consumed these foods daily. Some infants had not been introduced to all of the food groups, including fruits and vegetables (0.4%), grain foods (0.5%), milk and milk products (16.1%), and meat and meat alternatives (5.4%) by nine months of age (Ferreira et al., 2023). Other studies in New Zealand (NZ) have reported foods and food groups consumed using convenience sampling methods, including foods offered when starting CF (Fu et al., 2018) or foods consumed when using different feeding methods, such as baby-led weaning between six to eight months (Fu et al., 2018; Morison et al., 2016). Most infants in these studies consumed breast milk or formula, fruit, and vegetables daily, similar to GUiNZ. Other food groups were not reported, however, a low to moderate intake of individual foods such as red meat and iron-fortified infant cereals was found.

Less than a quarter of infants consumed discretionary foods (sweets, chocolate, hot chips, crisps, and fruit juices) in GUiNZ daily, however, most infants consumed each discretionary food at least once a week (Morton et al., 2012). Morison et al. (2016) observed a lower daily consumption of sweetened foods (39%) but higher consumption of sodium-rich foods (78%) in six to eight month old infants than GUiNZ, although specific foods were not reported. The use of commercial infant foods (CIF) in NZ is currently unknown (Taylor et al., 2021). However, there has been an increase in availability in recent years (Katiforis et al., 2021; Padarath et al., 2020), with CIF available in various food forms, including pouches, cans, jars, cereals, rusks, extruded crackers, biscuits, cereal bars, and yoghurt drops (Katiforis et al., 2021).

With limited recent evidence available about infant food and food group consumption in NZ, it is unknown if infants are meeting MoH food group recommendations or the contribution that discretionary foods and CIF make to the diet. Our study aims to explore the contributions that key foods and food groups make to the dietary intake of NZ infants aged between 7.0 and 10.0 months of age.

3.3. Methods

3.3.1. Study design

Data were obtained from the First Foods NZ (FFNZ) study, an observational study that recruited 625 infants from the Auckland and Dunedin regions of NZ. FFNZ aimed to describe the iron status, growth, food and nutrient intakes, breast milk intake, eating and feeding behaviours, dental health, oral motor skills, and choking risk of New Zealand infants. The FFNZ study protocol has been published (Taylor et al., 2021) (Appendix 3), therefore, only information relevant to this analysis is provided. Ethical approval was obtained from the Health and Disability Ethics Committees New Zealand (19/STH/151). The study was registered with the Australian New Zealand Clinical Trials Registry (www.anzctr.org.au, registration number: ACTRN12620000459921).

3.3.2. Participants

Infants aged 7.0 to 10.0 months were recruited if their adult caregiver was 16 years of age or older and could communicate in English, and they had not participated in a nutrition intervention study that may have influenced their diet. Participants were recruited through Facebook advertisement (Appendix 3) or word of mouth between July 2020 and February 2022 (Figure 3.1). After screening and initial contact, 860 verbal consents were obtained, with written consent from 630 caregivers. Of these, five were excluded for reasons shown in Figure 3.1, leaving a final sample of 625 infants.

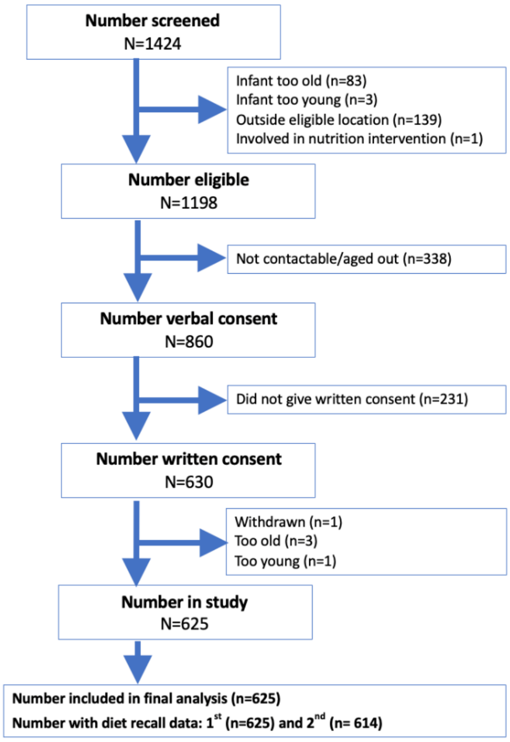

Figure 3.1: First Foods New Zealand study screening and consent pathway

3.3.3. Data collection

Participants were invited to attend two study visits on different days of the week, five to eight days apart in their home, appropriate research centre, or online (during Covid19 restrictions). At their first appointment, caregivers completed a demographic and feeding questionnaire (Appendix 13), which collected data on infant age, sex ethnicity, and if they were born at term, additional to caregiver age, relationship to infant, highest level of qualification, maternal parity, employment status, use of childcare, and breast and formula milk consumption. During each of the two appointments, a 24-hour diet recall (midnight to midnight of the day before their scheduled appointment) was performed using the multiple-pass method (Moshfegh et al., 2008) (Appendix 7). All breastfeeds, foods, and beverages consumed the day before their appointment were recorded (Appendix 8). Caregivers were also asked to take photographs of foods before meals to guide serving sizes. Prompts, including grid sheets (square and circle as shown in Appendix 11), measuring cups and spoons, exemplar baby food pouches and jars, baby bowls, and thickness sticks were available to aid in portion size estimation. If infants attended an early child education centre (ECE) or were cared for by someone else, a food diary with written instructions was provided (Appendix 9). If follow-up was required, contact was made via email or telephone with caregiver consent.

3.3.4. Food coding and data analysis

Diet recall data were entered into FoodWorks (Version 10, Xyris Software, Australia) using the New Zealand Food Composition database FOODfiles™ 2018 Version 01 by dietitians, nutritionists, and trained research assistants. Recipes and foods consumed were extracted from FoodWorks, with downloads categorised as ingredients from participant recipes (n=16,055), generic recipes from FoodWorks (n=947), individual ingredients (foods eaten individually) (n=853), commercial foods (n=500), infant and toddler commercial foods (marketed towards infants) (n=2,368), iodised breads (n=72), and infant formula (n=215). Each category was allocated a food code using the FFNZ coding system. Mixed recipes, or ingredients that could be separated, were coded as individual foods (e.g. a purée containing carrot, kumara, and parsnip was coded as carrot, kumara, and parsnip, respectively, as shown in Appendix 12). Ingredients included in baking recipes (cakes, muffins, slices, pancakes, and scones) were coded as the food offered (e.g. carrot cake instead of flour, carrot, canola oil, salt, spice, and sugar as shown in Appendix 12). Vegetables and fruit in baking (e.g. carrot in carrot cake) were not included in vegetable and fruit counts.

The coding system included two codebooks: general foods and infant and toddler foods. The general codebook included 34 major food group codes and was based on the 2008/09 Australia and New Zealand Adult Nutrition Survey (Ministry of Health, 2011). Major food group codes included grains and cereals; milk and milk products; eggs; meat; poultry; other meat (e.g. venison and offal); sausages and processed meats; fish/seafood; vegetarian meat alternatives; nuts and seeds; vegetables; fruit; discretionary foods; sugar/sweets; snack foods; fats and oils; savoury sauces and condiments; and non-alcoholic beverages. The infant and toddler food codebook included codes for formula, infant cereals, snack foods, pouches, and wet foods (cans, jars, microwaveable bowls, and pouches without nozzles).

Counts of individual foods were combined into food group categories, according to the MoH categorisation of foods (Table 3.1) (Ministry of Health, 2021). Foods were assigned to a food group if they made a healthy contribution to the diet, as described in the MoH guidelines. This meant that foods such as potato chips and fruit juice, for example, were not considered to contribute to the intake of the 'vegetable' or 'fruit' food groups, respectively. Food and food group counts were classified by month of age: seven months (7.0 to 8.0 months), eight months (8.1 to 9.0 months) and nine months (9.1 to 10 months) to describe critical periods during CF when food transitions into an essential role for daily nutrient requirements (Ministry of Health, 2021). Variables were reported as the number of infants and the percentage of each age group that consumed each food and food group during at least one diet recall and during both diet recalls. Iron-rich foods were defined using the MoH guidelines (Ministry of Health, 2021) and included meats, poultry, fish, seafood, offal (e.g. liver), and iron-fortified infant cereals. Stata software (StataCorp, Texas) was used to identify individual foods consumed after food coding. All analyses were performed using Microsoft Excel (version 16.66).

Table 3.1: Foods included and excluded in food group analyses

Food/group	Foods included in food groups	Foods not included in food groups
Fruit	All fruit (canned, frozen, fresh, commercial infant foods).	Fruit juice, fruit jam, fruit including in baked goods.
Vegetables	All vegetables (canned, frozen, fresh, commercial infant foods).	Potato chips, potato fries, herbs, spices, vegetables included in baked goods.
Grain foods	Pasta/noodles, rice, bread, cereals, infant cereals, crackers/crispbreads/rice and corn cakes (plain), oats, couscous, semolina, polenta, bulgur, quinoa, buckwheat, muesli, popcorn – plain.	Grain/corn chips, popcorn - butter/sweetened, crackers/crispbreads/rice and corn cakes (flavoured/yoghurt coated), all biscuits, pikelets/pancakes, bars (muesli bars and other), cakes, pastries, commercial infant foods, discretionary snack foods and extruded infant snacks.
Milk and milk products	Cow's milk [a], calcium fortified plant-based milks [b], cow's milk cheese and yoghurt, custard.	Breast milk, formula milk, sour cream, cream, non-calcium fortified plant-based milks [ab], ice cream, butter.
Meat and protein-rich foods	Beef, veal, lamb, mutton, fish, seafood, venison, egg, offal meats, pork, legumes, beans, lentils, nuts, seeds, tofu, tahini, hummus, Quorn, pea protein products.	Pies, sausages, ham, bacon.
Discretionary foods	Biscuits (all), cakes, slices, scones, muffins, milk puddings, ice cream, ice blocks, pancakes, waffles, potato chips, potato fries, wedges, crisps, corn snacks, popcorn, extruded snacks (all), pies and pastries, sausages, ham, bacon, lollies, chocolate, sweet spreads, fruit juice, cordial, soft drinks, marmite/vegemite.	
Commercial infant foods	Pouches, cans, jars, microwavable bowls, rusks, cereals, extruded snacks, dried/freeze dried fruit and vegetable snack foods, baby cereal bars, baby biscuits, discretionary snack foods.	

Foods were categorised by the FFNZ research team using the MoH categorisation of foods as a guide (Ministry of Health, 2021). [a] included in foods, [b] calcium-fortified milks were defined as milks with equal to or higher than 100mg of calcium per 100mL of milk (included in foods only) (Ministry of Health, 2021).

3.4. Results

3.4.1. Demographic characteristics

The mean (SD) age of the infants and caregivers was 8.4 (0.8) months and 32.7 (4.9) years, respectively. The majority (98%) of caregivers were the infant's mother. Other respondents included fathers (n=6), grandparent (n=1), and guardian (n=1). Most caregivers had received higher education, including university (64.9%) or polytechnic or similar (20.2%) and were not currently working (66.9%).

Most infants were the second born child (51.3%), male (53.6%), of term birth[4] (92.6%), and did not attend ECE (17.4%). Infant ethnicities included European (55.0%), Māori (21.0%), Pacific (7.0%), Asian (14.4%), and other (2.6%).

3.4.2. Breast milk and formula consumption

All infants consumed either breast milk and/or formula (Table 3.2). The use of mixed feeding (breast milk and formula) and formula was higher for older infants than young.

Table 3.2: Consumption of breast milk and formula at least once and during both diet recalls days according to infant age

Food/group	All infants		7 months		8 months		9 months	
	At least once	Both days	At least once	Both days	At least once	Both days	At least once	Both days
	% (n) n=625	% (n) n=614	% (n) n=247	% (n) n=243	% (n) n=234	% (n) n=231	% (n) n=144	% (n) n=140
Breast milk	67.0 (419)	65.8 (404)	66.4 (164)	65.4 (159)	69.2 (162)	68.0 (157)	64.6 (93)	62.9 (88)
Formula milk	53.0 (331)	48.5 (298)	51.0 (126)	47.3 (115)	51.7 (121)	47.2 (109)	58.3 (84)	52.9 (74)
Breast milk and formula	20.0 (125)	14.3 (88)	17.4 (43)	13.2 (31)	20.9 (49)	15.2 (35)	22.9 (33)	15.7 (22)

3.4.3. Food and food group consumption

Within the two diet recalls, 12,628 foods were consumed at least once, and 4,090 were consumed in both recalls. There was a general increase in food group consumption across infants of different ages (Figure 3.2). A smaller proportion of infants consumed food groups during both diet recall days than during at least one recall. A small proportion (6.5%) of infants consumed each food group on both diet recall days.

[4] Term birth was classified as those born after 37 weeks' gestation.

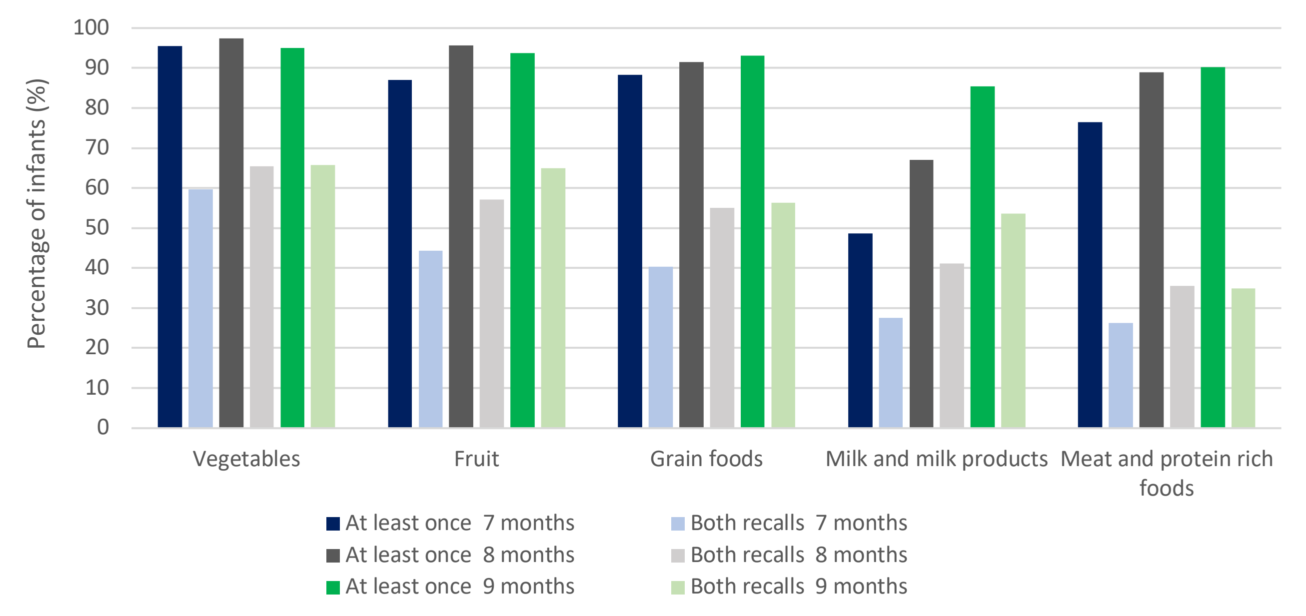

Figure 3.2: Food group consumption at least once and during both diet recall days according to infant age

3.4.4. Vegetables

Vegetables were the second most frequently consumed food group (96.2%) (Table 3.3). Consumption did not differ between infants of different ages (Figure 3.2). The proportion of infants consuming vegetables on both days (63.2%) was much lower than those that consumed vegetables at least once (96.2%) during the diet recalls. Carrots were the most commonly consumed vegetable across all age groups. Sweet vegetables were included more frequently than bitter and savoury vegetables. Less than 50% of seven month old infants consumed bitter vegetables such as brassica (49.4%) and leafy greens (33.6%), however, consumption increased in older infants (brassicas: 52.1% at eight and 53.5% at nine months and leafy greens (38.9% and 38.2%). Savoury vegetables such as onion/leek (25.5% at seven, 38.0% at eight, and 36.8% at nine) and mushroom (8.5%, 14.1%, and 16.7%) also were more frequently consumed in older infants.

Table 3.3: *Consumption of vegetables at least once and during both diet recalls days according to infant age*

Food/group	All infants		7 months		8 months		9 months	
	At least once	Both days	At least once	Both days	At least once	Both days	At least once	Both days
	% (n) n=625	% (n) n=614	% (n) n=247	% (n) n=243	% (n) n=234	% (n) n=231	% (n) n=144	% (n) n=140
Any vegetables	96.2 (601)	63.2 (388)	95.5 (236)	59.7 (145)	97.4 (228)	65.4 (151)	95.1 (137)	65.7 (92)
Carrot	63.2 (395)	26.5 (163)	60.7 (150)	21.4 (52)	66.7 (156)	30.7 (71)	61.8 (89)	28.6 (40)
Brassicas	51.4 (321)	17.9 (110)	49.4 (122)	17.7 (43)	52.1 (122)	15.6 (36)	53.5 (77)	22.1 (31)
Kumara	48.2 (310)	18.4 (113)	55.5 (137)	19.8 (48)	46.2 (108)	19.0 (44)	45.1 (65)	15.0 (21)
Pumpkin	45.8 (286)	15.5 (95)	50.2 (124)	20.2 (49)	41.5 (97)	12.1 (28)	45.1 (65)	12.9 (18)
Potato [a]	44.2 (276)	9.1 (56)	40.1 (99)	9.9 (24)	42.7 (100)	8.2 (19)	53.5 (77)	9.3 (13)
Tomatoes [b]	38.2 (239)	8.5 (52)	27.9 (69)	7.8 (19)	42.3 (99)	7.4 (17)	49.3 (71)	11.4 (16)
Beans/peas/corn	38.1 (238)	10.9 (67)	32.0 (79)	7.8 (19)	38.9 (91)	13.9 (32)	47.2 (68)	11.4 (16)
Leafy greens	36.6 (229)	11.1 (68)	33.6 (83)	12.3 (30)	38.9 (91)	11.3 (26)	38.2 (55)	8.6 (12)
Other vegetables [c]	33.0 (206)	7.5 (46)	23.9 (59)	4.5 (11)	35.5 (83)	8.2 (19)	44.4 (64)	11.4 (16)
Onion/leeks	32.8 (205)	7.0 (43)	25.5 (63)	4.5 (11)	38.0 (89)	8.2 (19)	36.8 (53)	9.3 (13)
Avocado	29.9 (187)	6.5 (40)	30.4 (75)	4.5 (11)	26.9 (63)	7.4 (17)	34.0 (49)	8.6 (12)
Other root vegetables	22.4 (140)	4.6 (28)	21.9 (54)	3.3 (8)	23.9 (56)	6.1 (14)	20.8 (30)	4.3 (6)
Courgette/egg plant	21.9 (137)	4.1 (25)	16.2 (40)	2.5 (6)	23.1 (54)	2.6 (6)	29.9 (43)	9.3 (13)
Mushroom/fungi	12.5 (78)	2.0 (12)	8.5 (21)	2.1 (5)	14.1 (33)	1.3 (3)	16.7 (24)	2.9 (4)
Baby food vegetables	2.6 (16)	0.8 (5)	4.0 (10)	1.2 (3)	0.9 (2)	0.4 (1)	2.8 (4)	0.7 (1)
[a] includes mashed, baked, and boiled, [b] includes fresh and canned, [c] includes mixed vegetables.								

3.4.5. Fruit

Most infants consumed fruit at least once (91.8%) (Table 3.4). Consumption nearly halved when assessing fruit intake from both recalls (53.9%), however, between seven and ten months, the proportion of daily consumption increased (Figure 3.2). Banana was the most common fruit consumed by all ages. Sweet fruits (banana 62.7% at least once and 28.0% during both diet recalls, apple 44.8% and 14.3%, and pear 28.6% and 6.4%) were included more frequently than citrus/sour fruits (citrus 21.1% at least once and 3.4% during both diet recalls and kiwifruit 20.6% and 5.0%)

Table 3.4: Consumption of fruit at least once and during both diet recalls days according to infant age

Food/group	All infants		7 months		8 months		9 months	
	At least once	Both days	At least once	Both days	At least once	Both days	At least once	Both days
	% (n) n=625	% (n) n=614	% (n) n=247	% (n) n=243	% (n) n=234	% (n) n=231	% (n) n=144	% (n) n=140
All fruit	91.8 (574)	53.9 (331)	87.0 (215)	44.4 (108)	95.7 (224)	57.1 (132)	93.8 (135)	65.0 (91)
Banana	62.7 (392)	28.0 (172)	53.0 (131)	21.4 (52)	67.5 (158)	29.4 (68)	71.5 (103)	37.1 (52)
Apple	44.8 (280)	14.3 (88)	48.2 (119)	14.4 (35)	43.2 (101)	14.3 (33)	41.7 (60)	14.3 (20)
Berry fruit	39.0 (244)	10.3 (63)	30.0 (74)	8.2 (20)	46.6 (109)	11.7 (27)	42.4 (61)	11.4 (16)
Pear	28.6 (179)	6.4 (39)	27.9 (69)	5.8 (14)	32.1 (75)	6.1 (14)	24.3 (35)	7.9 (11)
Other fruits [a]	25.6 (160)	5.4 (33)	17.8 (44)	2.5 (6)	30.3 (71)	7.4 (17)	31.3 (45)	7.1 (10)
Citrus fruit	21.1 (132)	3.4 (21)	13.0 (32)	1.2 (3)	25.2 (59)	3.5 (8)	28.5 (41)	7.1 (10)
Kiwifruit	20.6 (129)	5.0 (31)	15.4 (38)	3.3 (8)	24.4 (57)	7.4 (17)	23.6 (34)	4.3 (6)
Baby food fruit	17.8 (111)	3.4 (21)	20.2 (50)	3.7 (9)	16.2 (38)	3.0 (7)	16.0 (23)	3.6 (5)
Stone fruit	17.4 (109)	5.0 (31)	15.4 (38)	4.1 (10)	19.2 (45)	4.3 (10)	18.1 (26)	7.9 (11)
Dried fruit	10.2 (64)	2.1 (13)	7.7 (19)	2.5 (6)	9.8 (23)	0.4 (1)	15.3 (22)	4.3 (6)
Pineapple	5.0 (31)	0.7 (4)	4.9 (12)	0.8 (2)	4.7 (11)	0.4 (1)	5.6 (8)	0.7 (1)

[a] includes grapes, watermelon, and feijoa

3.4.6. Grain foods

Grain foods were consumed by 90.4% of infants at least once (Table 3.5). The consumption of grain foods increased between seven and ten months of age (Figure 3.2). Bread (51.5% at least once and 17.6% during both diet recalls), iron-fortified infant cereals (33.4% and 15.1%), and pasta (29.9% and 4.4%) were the most common sources of grain foods. White or sweet bread breads were consumed by 44.3% of infants.

Table 3.5: Consumption of grain foods at least once and during both diet recalls days according to infant age

Food/group	All infants		7 months		8 months		9 months	
	At least once	Both days	At least once	Both days	At least once	Both days	At least once	Both days
	% (n) n=625	% (n) n=614	% (n) n=247	% (n) n=243	% (n) n=234	% (n) n=231	% (n) n=144	% (n) n=140
All grain foods	90.4 (566)	49.5 (304)	88.3 (218)	40.3 (98)	91.5 (214)	55.0 (127)	93.1 (134)	56.4 (79)
Bread	51.5 (322)	17.6 (108)	43.7 (108)	13.6 (33)	56.0 (131)	19.0 (44)	57.6 (83)	22.1 (31)
Infant cereals [a]	33.4 (209)	15.1 (93)	37.2 (92)	14.0 (34)	29.9 (70)	15.2 (35)	32.6 (47)	17.1 (24)
Pasta	29.9 (187)	4.4 (27)	21.1 (52)	1.6 (4)	33.3 (78)	4.8 (11)	49.9 (57)	8.6 (12)
Oats and porridge	29.6 (185)	7.7 (47)	30.8 (76)	7.0 (17)	30.3 (71)	9.5 (22)	26.4 (38)	5.7 (8)
Rice	22.7 (142)	3.7 (23)	14.2 (35)	1.6 (4)	26.9 (63)	3.9 (9)	30.6 (44)	7.1 (10)
Wheat cereal [b]	20.0 (125)	7.8 (48)	15.8 (39)	4.1 (10)	23.1 (54)	11.3 (26)	22.2 (32)	8.6 (12)
Savoury biscuits	13.6 (85)	2.3 (14)	9.3 (23)	2.5 (6)	16.2 (38)	2.2 (5)	16.7 (24)	2.1 (3)
Other grains [c]	10.6 (66)	0.8 (5)	10.5 (26)	0.8 (2)	9.0 (21)	0.4 (1)	13.2 (19)	1.4 (2)
Other cereals [d]	5.6 (35)	0.7 (4)	4.5 (11)	0	4.7 (11)	0.9 (2)	9.0 (13)	1.4 (2)
Infant rusks	5.6 (35)	1.0 (6)	8.9 (22)	1.2 (3)	5.1 (12)	0.9 (2)	0.7 (1)	0.7 (1)
Rice products [e]	4.5 (28)	1.5 (9)	2.8 (7)	0.8 (2)	5.6 (13)	2.6 (6)	5.6 (8)	0.7 (1)

[a] iron-fortified, [b] includes wheat biscuits and shredded wheat, [c] includes quinoa, buckwheat, couscous, rye, millet, tapioca, and polenta, [d] includes puffed, flaked, extruded, bran, germ, and muesli, [e] includes rice cakes, wafers, and crackers

3.4.7. Milk and milk products

Milk and milk products were consumed by 64.0% of infants at least once (Table 3.6). Consumption nearly halved when assessing the consumption from both recalls (38.6%), however, between seven and ten months, the proportion of daily consumption increased. Cheese and yoghurt were the most commonly consumed milk products. Plant-based milk alternatives were consumed by 62 (9.9%) infants, and 15 (2.4%) consumed them on both diet recall days. Of the plant-based milk alternatives consumed, 37.1% did not meet calcium fortification recommendations of 100mg/100mL. Three infants (0.5%) consumed plant-based cheeses at least once.

Table 3.6: Consumption of milk and milk products at least once and during both diet recalls days according to infant age

Food/group	All infants		7 months		8 months		9 months	
	At least once	Both days	At least once	Both days	At least once	Both days	At least once	Both days
	% (n) n=625	% (n) n=614	% (n) n=247	% (n) n=243	% (n) n=234	% (n) n=231	% (n) n=144	% (n) n=140
Any milk and milk product	64.0 (400)	38.6 (237)	48.6 (120)	27.6 (67)	67.1 (157)	41.1 (95)	85.4 (123)	53.6 (75)
Yoghurt	38.9 (243)	10.1 (62)	34.0 (84)	9.5 (23)	42.3 (99)	10.8 (25)	41.7 (60)	10.0 (14)
Cheese	37.8 (236)	9.6 (59)	24.3 (60)	4.1 (10)	42.7 (100)	10.0 (23)	52.8 (76)	18.6 (26)
Cow's milk	22.2 (139)	6.8 (42)	17.0 (42)	3.7 (9)	23.9 (56)	8.7 (20)	28.5 (41)	9.3 (13)
Milk alternatives [a]	6.4 (40)	1.6 (10)	4.0 (10)	0.4 (1)	6.0 (14)	1.3 (3)	11.1 (16)	4.3 (6)
Baby food dairy	5.6 (35)	0.3 (2)	4.5 (11)	0.4 (1)	3.8 (9)	0	10.4 (15)	0.7 (1)
Soy, coconut, and other plant-based yoghurts	4.2 (26)	1.8 (11)	1.6 (4)	0.4 (1)	6.4 (15)	2.6 (6)	4.9 (7)	2.9 (4)

[a] included in foods, [b] calcium-fortified milks were defined as milks with equal to or higher than 100mg of calcium per 100mL of milk (included in foods only) (Ministry of Health, 2021)

3.4.8. Meat and protein-rich foods

Meat and protein-rich foods were the least commonly consumed food group (Table 3.7). More infants consumed animal proteins (76.6%) than plant proteins (49.8%). The proportion that consumed meat and protein-rich foods increased between seven and 10 months of age (Figure 3.2). Common sources, however, differed between infants of different ages. Iron-rich foods were consumed by 506 (81.0%) infants at least once and 108 (17.6%) infants on both recall days.

Table 3.7: Consumption of meat and protein-rich foods at least once and during both diet recalls days according to infant age

Food/group	All infants		7 months		8 months		9 months	
	At least once	Both days	At least once	Both days	At least once	Both days	At least once	Both days
	% (n) n=625	% (n) n=614	% (n) n=247	% (n) n=243	% (n) n=234	% (n) n=231	% (n) n=144	% (n) n=140
All meat and protein-rich foods	84.3 (527)	31.8 (195)	76.5 (189)	26.3 (64)	88.9 (208)	35.5 (82)	90.3 (130)	35.0 (49)
All animal protein foods	76.6 (479)	21.7 (133)	66.8 (165)	16.9 (41)	81.2 (190)	24.7 (57)	86.1 (124)	25.0 (35)
Chicken	39.2 (245)	7.2 (44)	34.0 (84)	4.9 (12)	37.2 (87)	7.8 (18)	51.4 (74)	10.0 (14)
Egg	32.8 (205)	7.2 (44)	25.9 (64)	4.1 (10)	35.5 (83)	9.1 (21)	40.3 (58)	9.3 (13)
Beef, veal, and venison	34.6 (216)	6.2 (38)	29.6 (73)	5.8 (14)	40.2 (94)	7.8 (18)	34.0 (49)	4.3 (6)
Lamb/mutton	11.5 (72)	1.8 (11)	10.1 (25)	1.2 (3)	12.8 (30)	2.2 (5)	11.8 (17)	2.1 (3)
Fish/seafood	18.9 (118)	1.0 (6)	10.9 (27)	0.4 (1)	22.2 (52)	1.7 (4)	27.1 (39)	0.7 (1)
Pork	6.4 (40)	0.7 (4)	4.0 (10)	0.4 (1)	6.4 (15)	0.9 (2)	10.4 (15)	0.7 (1)
Offal [a]	3.0 (19)	0.7 (4)	1.6 (4)	0.8 (2)	3.8 (9)	0.4 (1)	4.2 (6)	0.7 (1)
All plant protein foods	49.8 (311)	13.5 (83)	40.1 (99)	11.1 (27)	55.1 (129)	14.3 (33)	57.6 (83)	16.4 (23)
Nuts and Seeds	36.0 (225)	9.0 (55)	26.7 (66)	7.4 (18)	42.3 (99)	11.3 (26)	41.7 (60)	7.9 (11)
Legumes and pulses [b]	26.4 (165)	5.7 (35)	22.7 (56)	4.5 (11)	26.5 (62)	5.2 (12)	32.6 (47)	8.6 (12)

[a] includes liver and pate, [b] includes legumes and pulses products.

3.4.9. Discretionary foods

More than half of the infants consumed discretionary foods at least once (Table 3.8). Consumption increased between seven and 10 months of age (Figure 3.2). Consumption during both recalls was highest at nine months of age. Marmite/vegemite was the most common discretionary food for each age group.

Table 3.8: Consumption of discretionary food at least once and during both diet recalls days according to infant age

Food/group	All infants		7 months		8 months		9 months	
	At least once	Both days	At least once	Both days	At least once	Both days	At least once	Both days
	% (n) n=625	% (n) n=614	% (n) n=247	% (n) n=243	% (n) n=234	% (n) n=231	% (n) n=144	% (n) n=140
Any discretionary	56.3 (352)	16.1 (99)	44.9 (111)	10.7 (26)	58.1 (136)	18.2 (42)	73.9 (105)	22.9 (32)
Marmite/vegemite	23.5 (147)	7.7 (47)	15.8 (39)	4.9 (12)	27.8 (65)	6.9 (16)	29.9 (43)	13.6 (19)
Processed meats [a]	15.0 (94)	1.5 (9)	8.5 (21)	0.4 (1)	14.5 (34)	1.3 (3)	27.1 (39)	3.6 (5)
Snack foods [b]	13.1 (82)	3.1 (19)	10.5 (26)	2.5 (6)	9.0 (21)	3.0 (7)	14.6 (21)	4.3 (6)
Milk puddings, ice cream/blocks	10.9 (68)	2.1 (13)	9.7 (24)	1.6 (4)	11.5 (27)	2.6 (6)	11.8 (17)	2.1 (3)
Sweet biscuits	8.2 (51)	0.3 (2)	5.7 (14)	0	10.3 (24)	0.4 (1)	9.0 (13)	0.7 (1)
Pancakes and waffles	8.0 (50)	1.3 (8)	5.3 (13)	0.8 (2)	9.0 (21)	2.2 (5)	11.1 (16)	0.7 1)
Potato chips [c]	7.7 (48)	0.5 (3)	6.1 (15)	0	9.0 (21)	0.9 (2)	8.3 (12)	0.7 (1)
Muffins	7.2 (45)	0.7 (4)	2.0 (5)	0	10.3 (24)	1.3 (3)	11.1 (16)	0.7 (1)
Fruit juice, cordials, and soft drinks	6.6 (41)	1.0 (6)	4.9 (12)	0.4 (1)	6.8 (16)	1.7 (4)	9.0 (13)	0.7 (1)
Cakes, slices, and scones	6.6 (41)	0.2 (1)	5.7 (14)	0	5.1 (12)	0	11.1 (16)	0.7 (1)
Sweet spreads	5.6 (35)	0.8 (5)	2.4 (6)	0.4 (1)	6.0 (14)	1.3 (3)	10.4 (15)	0.7 (1)
Lollies and chocolate [d]	1.0 (6)	0	0.8 (2)	0	0.9 (2)	0	1.4 (2)	0

[a] includes sausages, pies, ham, bacon, [b] includes snack bars, crisps, corn snacks, popcorn, and extruded snacks (not commercial infant snacks), [c] includes wedges and hashbrowns, [d] includes chocolate-based confectionery

3.4.10. Commercial infant foods

CIFs were consumed by 78.1% of infants (Table 3.9). The number of infants who consumed CIF increased between seven and 10 months of age. Infant cereals were the most common food at seven months, and extruded snacks were the most common at eight and nine months.

Table 3.9: Consumption of commercial infant food at least once and during both diet recalls days according to infant age

Food/group	All infants		7 months		8 months		9 months	
	At least once	Both days	At least once	Both days	At least once	Both days	At least once	Both days
	% (n) n=625	% (n) n=614	% (n) n=247	% (n) n=243	% (n) n=234	% (n) n=231	% (n) n=144	% (n) n=140
Any commercial infant food	78.1 (488)	41.8 (257)	76.9 (190)	38.7 (94)	76.1 (178)	41.6 (96)	83.3 (120)	48.6 (68)
Extruded snacks [a]	46.2 (289)	23.3 (143)	40.9 (101)	18.9 (46)	45.7 (107)	22.9 (53)	56.3 (81)	31.4 (44)
Pouches [b]	39.7 (248)	8.3 (51)	42.5 (105)	9.1 (22)	35.0 (82)	7.4 (17)	42.4 (61)	8.6 (12)
Cereals	38.6 (241)	15.6 (96)	43.3 (107)	14.4 (35)	34.2 (80)	16.0 (37)	37.5 (54)	17.1 (24)
Other commercial infant foods [c]	10.2 (64)	3.1 (19)	4.5 (11)	1.2 (3)	12.4 (29)	3.9 (9)	16.7 (24)	5.0 (7)
Wet foods [d]	9.0 (56)	2.0 (12)	6.9 (17)	2.1 (5)	11.1 (26)	2.2 (5)	9.0 (13)	2.1 (2)
Rusks	5.6 (35)	1.0 (6)	8.9 (22)	1.2 (3)	5.1 (12)	0.9 (2)	0.7 (1)	0.7 (1)

[a] includes corn/rice/legume/potato-based, [b] with nozzle, [c] includes dried/freeze-dried fruit & vegetable snack foods, baby cereal bars, baby biscuits, and discretionary snack foods, [d] includes cans, jars, microwaveable bowls, pouches without nozzles

3.5. Discussion

Foods provide different types and amounts of nutrients, with no food or food group providing all essential nutrients (Ministry of Health, 2021). Therefore, eating a wide variety of foods, in addition to breast milk and/or formula, is essential to meet daily macronutrient and micronutrient requirements during CF (Nicklaus, 2009). All infants were breast or formula fed on both diet recall days. The majority of FFNZ infants consumed vegetables (96.2% of infants), fruit (91.8%), grain foods (90.4%), milk and milk products (64.0%), and meat and protein-rich foods (84.3%) at least once during the study. The intake of each food group was much lower when identifying food sources consumed during both 24-hour diet recalls, vegetables (96.2% of infants during at least one recall day and 63.2% of infants during both days), fruit (91.8%, 53.9%), grain foods (90.4%, 49.5%), milk and milk products (64.0% and 38.6%), and meat and protein-rich foods (84.3%, 31.8%), with only 6.5% of infants consuming all five food groups. This suggests that although most infants have been offered these foods, daily consumption, as recommended by the MoH (Ministry of Health, 2021), of each food group is low. This increases the risk of nutritional inadequacies and subsequent health consequences (World Health Organization, 2009). Additionally, many infants also consumed discretionary foods (56.3%) and commercial infant foods (78.1%) at least once.

There were differences between infants of different ages. Older infants consumed grain (93.1% at least once at nine months vs 88.3% at seven months), milk and milk products (85.4% vs 48.6%), meat and protein-rich foods (90.3% vs 76.5%), discretionary foods (73.9% vs 44.9%), and CIF (83.3% vs 76.9%) more frequently than their younger counterparts. The types of foods consumed by each age group also differed, with bitter and savoury foods becoming more common in older infants. This is likely due to the transition during CF as more food is offered and consumed by the infants as they age (Nicklaus, 2009).

3.5.1. Fruit and vegetables

Fruit and vegetables are rich sources of fibre, important vitamins and minerals, and phytonutrients (Ministry of Health, 2020). The MoH recommends that fruit and vegetables are offered daily to provide nutrients for growth and development, greater immunity, optimal digestion and a reduced risk of non-communicable diseases in later life (Ministry of Health, 2021). Most infants consumed fruit and vegetables at least once during the study. The proportion who consumed fruit (53.9%) and vegetables (63.2%) during both diet recall days was 20 to 30% lower than those observed in GUiNZ's FFQ, which found 86.8% and 90.8% of nine month old infants consumed fruit and vegetables daily (Morton et al., 2012). However, our infants were, on average, younger than GUiNZ, which may explain differences. These differences were slightly less when comparing only nine to ten month old infants from our study. Differences in this age group could also be due to methods used (FFQ in GUiNZ). Our fruit and vegetable consumption was higher than that observed in infants of the same ages in the USA (Fox et al., 2004) when comparing 'at least once' with FITS 24-hour diet recall data, identifying potential differences between countries.

Infants have an innate preference for sweet flavours (Mennella & Bobowski, 2015; Ventura & Mennella, 2011). This was reflected in our results, with the most common fruits (banana and apple) and vegetables (carrot) having a sweet nutrition profile, agreeing with previous American (Fox et al., 2004) and Australian (Lioret et al., 2013) studies. Typically, infants have an innate dislike of bitter foods e.g. broccoli, which is believed to be protective from consuming unsafe foods (Mennella & Bobowski, 2015). The MoH recommends repeatably offering bitter foods from a young age to increase food acceptance (Ministry of Health, 2021). Although less than 50% of seven month old infants consumed bitter foods, the proportion who consumed broccoli and leafy greens increased in older infants. FITS had similar observations (Fox et al., 2004), suggesting that infants are often provided sweet foods when starting solid foods, progressing to bitter flavours once CF is established.

3.5.2. Grain foods

Grain foods are described as a good first food because of their mild taste and semi-solid texture (Klerks et al., 2019). They are also good sources of energy, dietary fibre, vitamin B (excluding B12) and E, magnesium, iron, zinc, and selenium (Ministry of Health, 2020). In our study, we found that the proportion of infants who consumed grain foods increased between seven to ten months of age for one and both reported days' intake. Less than 50% of infants, however, consumed grain foods during both diet recall days, 30% lower than those reported in GUiNZ's nine month old infants (Gontijo de Castro et al., 2018) and 40 to 50% lower than FITS infants of corresponding ages (Fox et al., 2004). GUiNZ reported various forms of grains consumed (Morton et al., 2014), and like the current study, bread was reported as the most common grain food consumed. For infants, bread is likely a key source of iodine, which promotes optimal growth and development (Gibson, 2005). This aligns with previous observations in the NZ adult population, suggesting that iodine fortification schemes implemented in 2009 (Ministry of Primary Industries, 2021) are affecting a large proportion of those living in NZ.

Around the age of six months, an infant requires additional food sources of iron (Ministry of Health, 2021). Consumption of iron-fortified cereals (33.4% at least once and 15.1% during both diet recalls) was lower than those reported by GUiNZ (47.9% daily at nine months of age) (Morton et al., 2014) and Fu et al. (2018) (48% daily at six months of age) findings, however, was the most common iron-rich food consumed during both diet recalls (15.1% vs the most common meat and protein rich food: chicken 7.2%). The use of such products are, therefore, important sources of iron with previous NZ and international studies also identifying iron-fortified infant cereals as the main source of dietary iron during CF (Finn et al., 2017; Fox et al., 2006; Soh et al., 2002; Wall et al., 2009). This could be a result of iron-fortified infant cereals being highly palatable, convenient, suitable for vegetarians and vegans, and encouraged by health professionals as a good source of iron (Ministry of Health, 2021).

3.5.3. Milk and milk products

Milk products were the least commonly consumed food group (64.0%), markedly decreasing when considering those consumed during both recall days (38.6%). All infants, however, consumed either breast or formula milk which is a key difference when investigating food group consumption at this age. Further research into caregiver understanding of the difference between introducing milk and milk products and the continued provision of breast and formula milk would be appropriate, with GUiNZ reporting that milk and milk products are commonly introduced later in the CF period (46.2% had not consumed these by seven months and 16.1% by nine months) (Ferreira et al., 2023).

Previous NZ studies have not reported the intake of individual milk products. However, consumption of cheese (4.1% at seven months, 10.8% at eight months, and 18.6% at nine months) and yoghurt (9.5% at seven months, 10.8% at eight months, 10.0% at nine months) in this study was lower than that observed in an Australian longitudinal study (n=177), which found that 88.1% of nine month old infants consumed yoghurt and cheese daily (Lioret et al., 2013). Although FITS observed lower frequencies of milk product consumption (2.1% consumed cheese and 4.1% consumed yoghurt between seven to eight months and 18.5% and 15.7% between nine to 11 months), they also observed an increase in intake with increasing age (Fox et al., 2004).

The use of plant-based milks (also termed 'mylk') has increased in popularity in recent years (Cardello et al., 2022; Smith et al., 2022; Zhang et al., 2020). Often, they are used in replacement of cow's milk to meet dietary, health, and lifestyle requirements such as beliefs about animal welfare, environmental concerns, a lower fat option, and for the management of food intolerances and allergies (McCarthy et al., 2017). There are, however, nutritional differences between the products. Plant-based milks tend to contain lower concentrations and quality of protein, vitamin A, B2, B12, iodine, and zinc than cow's milk (Zhang et al., 2020). Calcium levels also vary depending on fortification levels, with plant-based milks available in NZ ranging from 0mg to 160mg calcium per 100mL of milk (Woolworths New Zealand Limited, 2022). The NZ MoH recommends avoiding plant-based milks for infants under one year of age because of their low nutrient content (Ministry of Health, 2021). Although a small percentage of infants (9.9%) consumed plant-based milks, several of the chosen plant-based milks were not adequately fortified with calcium, according to the MoH guidelines for toddlers (100mg per 100mL of milk (Ministry of Health, 2021)). This increases the risk of nutrient deficiencies, and with reports of more infants receiving cow's milk alternative products (Bridges, 2018; Mäkinen et al., 2016) concern should be noted.

3.5.4. Meat and protein-rich foods

Haem iron, provided from animal proteins such as red meat, poultry, and fish, is the most bioavailable source of iron. Despite this, only 21.7% of infants in the FFNZ study received an animal protein (chicken, meats, fish/seafood, pork, or offal) during both recall days. Although our results were nearly half those observed in GUiNZ (60.7%), they also found that meat and protein-rich foods were the least commonly consumed food group (Gontijo de Castro et al., 2018) and were commonly not introduced in the early stages of completementary feeding (six to seven months of age) (45.9%) (Ferreira et al., 2023). These trends suggest that further promotion around the importance of meat and protein-rich foods is required to increase the consumption of haem iron-rich foods in the early stages of CF.

In this study, the intake of meat and protein-rich foods increased in older infants (76.5% at least once at seven months vs 90.3% at nine months). However, the higher consumption of processed meat in older infants (8.5% at least once at seven months vs 27.1% at nine months) is concerning, given the low nutrient and high fat and sodium content of such foods (Ministry of Health, 2021). FITS also observed this trend, with a higher consumption of ham, bacon, sausages, hot dogs, and cold cuts in older infants (Fox et al., 2004). No study has reported infant consumption of total plant proteins. We, however, found a similar intake of nut and seed products at nine months (7.9% during both diet recalls) with GUiNZ (9.5% daily) (Morton et al., 2012) who reported nut and peanut butter consumption. GUiNZ, however, has not yet reported other foods from the plant protein group, making our study the first to release these results.

3.5.5. Discretionary foods

More than 50% of infants (56.3%) consumed discretionary foods at least once, which was slightly higher than observed in GUiNZ who reported that 53% of infants had consumed discretionary foods by nine months of age (Morton et al., 2012). However, diet recall methods differed between studies (FFQ in GUiNZ), and the foods and beverages included in the analyses were different. In our study, fewer infants consumed sweets, chocolate, and fruit juice than in GUiNZ (Gontijo de Castro et al., 2018), FITS (Fox et al., 2004), and Australia (Lioret et al., 2013). Marmite and vegemite, however, were the most consumed 'discretionary foods' which were not investigated in other studies. Although products like marmite contain five essential B vitamins and iron, they also contain high amounts of sodium (3310mg/100g) (Sanitarium, 2022), which should be avoided (Ministry of Health, 2021). They are often marketed based on their nutritional benefits (Mikkelsen et al., 2018; Sanitarium, 2023), which could be causing conflicting messages. Further education regarding their higher sodium content and appropriate spread alternatives such as nut or seed butters, hummus, pate, cheeses, and fruit or vegetable toppings e.g. avocado is required.

We also observed differences in infants of different ages, with a higher consumption of discretionary foods in older infants (44.9% at least once at seven months vs 73.9% at nine months), which agreed with findings in FITS who observed that 45.8% of seven to eight month olds consumed any type of dessert, sweet, sweetened beverage vs 61.1% of nine to eleven month old infants (Fox et al., 2004). As discussed previously, this is likely the result of more time passing for food exposure, with infants' diets aligning with parental food choices.

3.5.6. Commercial infant foods

We found that 78.1% of infants consumed CIF at least once during the study. Although more than three-quarters of our infants consumed CIF, results were lower than those who consumed baby food in jars in Australia (89.8%) (Lioret et al., 2013). Our study identified that a higher proportion of older infants consumed CIF (76.9% at least once at seven months vs 83.3% at nine months), particularly extruded snacks (40.9% vs 56.3%). Limited research has focused on extruded snacks, although a recent NZ study included them in an analysis of infant 'snack foods' available on the NZ market (Katiforis et al., 2021). They found that 27% of infant snack foods were fortified with iron, including extruded snacks, with an average of 3mg per serving (Countdown, 2022). Despite containing an important nutrient (iron), the nutritional profile of extruded snacks does not compare to the nutritional density of MoH-recommended snacks such as fruit, vegetables, or low-salt crackers with peanut butter (Ministry of Health, 2021). Pouches were also commonly used by infants in our study, particularly those aged seven months (42.5%) and nine months (42.4%). Katiforis et al. (2021) reported that pouches contained higher amounts of total sugar than other CIF. Concern was also raised about the low iron, meat, fish and poultry content of pouches. Given the nutritional concerns surrounding CIF and the high consumption observed in this study, more research is required on their contribution to nutrient intake and potential nutritional risks.

3.5.7. Attributes, limitations, and directions for future research

FFNZ is the first study to provide a comprehensive list of foods consumed by NZ infants. It is, however, not without limitations. To allow data collection from a large sample, dietary intake was assessed by two 24-hour diet recalls. This means that a comprehensive assessment of dietary intake cannot be determined due to the day-to-day variation of food intake, with some foods only eaten occasionally. However, as our guidelines promote the daily consumption of foods from the main food groups, we were able to determine that food group guidelines were not met. Foods consumed may have varied if further 24-hour diet recalls were undertaken. Serving sizes were not accounted for when determining food group intake, and all foods were entered regardless of the amount consumed (excluding fruit and vegetables in baking). This could have caused an overestimation of food and food group consumption. Due to the observational study design, infant diets were not tracked over time. However, the findings from this study identified trends across age groups that are worthy of further exploration. Further studies are now required to determine the nutritional implications when the MoH food group guidelines are not met during CF.

3.6. Conclusion

FFNZ provides much-needed evidence on infant food and food group consumption, with key findings that need to be addressed to improve infant nutrition in NZ. Infants were shown to consume a range of foods within the five food groups at least once during the study. However, only 6.5% of infants consumed all five food groups during both recalls. Although the majority consumed vegetables and fruit, less than 50% of infants consumed grain, milk and milk products, and meat and protein-rich foods during both recall days. Discretionary foods were also commonly consumed, with prevalence higher in older infants. Our results indicate that daily adherence to the MoH food group guidelines is low, increasing the risk for nutritional deficiencies. Further investigation is required to determine the nutritional implications of not meeting these MoH guidelines.

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CHAPTER 4

ADHERENCE TO INFANT FEEDING GUIDELINES IN THE FIRST FOODS NEW ZEALAND STUDY

This chapter discusses adherence to the 2021 Ministry of Health 'Healthy Eating Guidelines for New Zealand Babies and Toddlers (0–2 years old)'. Key guidelines are explored, including exclusive breastfeeding, age when solid foods are introduced, first foods offered, food group consumption, and the consumption of inappropriate drinks, and added salt and sugar. Associated sociodemographic characteristics are also reported to provide insight into caregivers and infants who are more and less likely to meet guidelines.

This report is presented in manuscript format and has been submitted to the Nutrients journal special issue 'Selected Papers from the 56th Annual Nutrition Society of New Zealand Conference'

4.1. ABSTRACT

Background: Infant feeding guidelines provide evidence-based recommendations to support optimal infant health, growth, and development and exploring adherence to guidelines is a useful way of assessing diet quality. In New Zealand (NZ), the Ministry of Health 'Healthy Eating Guidelines for New Zealand Babies and Toddlers (0–2 years old)' were recently updated. Adherence to these updated guidelines is currently unknown.

Aim: To investigate the adherence to key dietary indicators of NZ infants between 7.0 and 10.0 months of age, as guided by the Ministry of Health's 'Healthy Eating Guidelines for New Zealand Babies and Toddlers (0–2 years old)'. Sociodemographic characteristics associated with adherence will also be identified.

Methods: Data were obtained from First Foods New Zealand, a multicentre observational study of 625 infants aged 7.0 to 10.0 months. Caregivers completed two 24-hour diet recalls and a demographic and feeding questionnaire. Key indicators were developed from the 2021 Ministry of Health's 'Healthy Eating Guidelines for New Zealand Babies and Toddlers (0–2 years old)' and included recommendations for exclusive breastfeeding to 'around' six months of age, current breastfeeding, age of solid food introduction, offering iron-rich foods as first foods, spoon-feeding puréed foods when introducing solid foods, daily consumption of food groups, avoidance of inappropriate foods and beverages, and self-feeding when developmentally appropriate. Data were analysed using Microsoft Excel (version 16.66) and in Stata software (StataCorp, Texas).

Results: Nearly all caregivers (97.9%) initiated breastfeeding, 37.8% exclusively breastfed to around six months of age, and 66.2% were currently breastfeeding (mean age 8.4 months). Most met recommendations for solid food introduction, including appropriate age (75.4%), iron-rich foods (88.3%), puréed textures (80.3%) and spoon-feeding (74.1%). Infants consumed vegetables (63.2%) and fruit (53.9%) more frequently than grain foods (49.5%), milk and milk products (38.6%), and meat and protein-rich foods (31.8%) daily. Most avoided inappropriate beverages (93.9%) and adding salt (76.5%) and sugar (90.6%). Typically, infants of younger, higher educated, not currently working, primiparous caregivers, and living in low deprivation were more likely to meet the guidelines.

Conclusion: Our findings indicated that while most infants met the recommendations for introducing appropriate solid foods, the prevalence of exclusive breastfeeding could be improved, indicating New

Zealand whānau (families) may need more support with this. Further exploration into sociodemographic barriers is also required to improve adherence to NZ infant feeding guidelines.

4.2. Introduction

Rapid dietary changes are observed as an infant transitions from an exclusive milk diet to one that resembles that of the family (Birch et al., 2007; Grummer-Strawn et al., 2008; Lioret et al., 2013; Smithers et al., 2012). To support those involved in the care of infants, guidelines have been developed to provide evidence-based nutrition recommendations. Guidelines provide population health advice on meeting nutrition requirements for growth, development, and the establishment of healthy behaviours (Ministry of Health, 2021a). Most infant feeding guidelines include recommendations for breastfeeding, complementary feeding (CF), dietary variety (food groups), and appropriate foods and beverages.

In New Zealand (NZ), the Ministry of Health (MoH) infant feeding guidelines 'Healthy Eating Guidelines for New Zealand Babies and Toddlers (aged 0 to 2 years)' were recently revised and updated to include six statements on breastfeeding and formula feeding, CF, food groups, appropriate foods and beverages, and feeding environments (Ministry of Health, 2021a). Mothers are recommended to exclusively breastfeed (EBF) their infant until they are around six months of age, in accordance with the World Health Organization's (WHO) recommendations (World Health Organization, 2021). Exclusive breastfeeding has benefits for both mothers and their infants, including the provision of all of the energy and nutrients that an infant needs, supports infant gastrointestinal development and mother infant bonding, reduces the risk of infant mortality and maternal breast and ovarian cancer (World Health Organization, 2021). At six months of age, breast milk is not able to provide adequate energy and nutrients, and CF should be initiated (Ministry of Health, 2021a). Iron-rich foods (including meat, poultry, fish, seafood, and iron fortified infant cereals), vegetables, and fruits are suitable first foods and should each be offered daily once CF has started. Infants should be offered a wide variety of foods, especially during the first weeks and months, as this helps to establish healthy taste preferences. There is no need to introduce new foods one at a time unless the food is a common allergen. A variety of foods from the main food groups: vegetables and fruit; grain foods; milk and milk products; and legumes, nut butters, eggs, fish, seafood and chicken or lean red meat (referred to as meat and protein-rich foods from here), should be included in an infant's diet every day, increasing the amount consumed and food texture as developmentally appropriate (Ministry of Health, 2021a; United Nations

International Children's Emergency Fund, 2021). Inappropriate foods and beverages, such as foods with added sugar and salt (e.g., confectionary, biscuits, ice cream, processed meats, and fast foods) and beverages other than breast milk, infant formula, and water (such as juice, cordial, fruit drink, flavoured milk, soft drinks, tea, coffee, and alcohol) should be avoided (Ministry of Health, 2021a).

Investigating adherence to feeding guidelines is a common method of measuring diet quality. Golley et al. (2012) were the first to develop and utilise an index that measured adherence to infant feeding guidelines in a high-income country (England). Growing Up in New Zealand (GUiNZ), a longitudinal study of 6470 ethnically diverse infants, measured adherence to the 2008 MoH infant feeding guidelines (Gontijo de Castro et al., 2018). The GUiNZ study collected data on infant feeding at nine months of age between 2009 and 2011 and found low levels of adherence (defined as less than 50%) to breastfeeding recommendations (Gontijo de Castro et al., 2018; Morton et al., 2012). Exclusive breastfeeding to around six months of age was met by 35%, while 37% continued to breastfeed to 12 months or beyond. Similar relatively low adherence to EBF recommendations has been observed in other high-income countries (Castro et al., 2017; Centers for Disease Control and Prevention, 2021; Manhire et al., 2018; Netting et al., 2022; United Nations International Children's Emergency Fund, 2018), indicating a global issue. In some studies, low adherence to EBF recommendations can be explained by an early introduction of solid foods (Au et al., 2018; Golley et al., 2012; Gontijo de Castro et al., 2018), with recommendations for EBF and introducing solid foods often overlapping. In NZ and Australia, recent studies have suggested the age of introducing solid foods has increased to align with recommendations (Fu et al., 2018; Netting et al., 2022). The impact this has on EBF adherence is yet to be explored.

Studies have consistently shown high adherence for exposure to iron-rich foods, even though assessment methods have varied. In GUiNZ, high levels (80% of infants aged nine months of age) of adherence were found for offering iron-rich foods daily (Gontijo de Castro et al., 2018), while other studies have reported adherence to starting iron-rich foods of 89% and 87% at six (Golley et al., 2012) and seven (Au et al., 2018) months, respectively. By contrast, adherence to beverage recommendations appears to be more variable, depending on what beverages are reported (Au et al., 2018; Golley et al., 2012; Gontijo de Castro et al., 2018). In GUiNZ, a moderate (defined as 50–80%) adherence to avoiding inappropriate drinks (61%) was reported at nine months of age (Gontijo de Castro et al., 2018), with juice reported as the most commonly consumed inappropriate beverage (Grimes et al., 2015; Morton et al., 2012; Roess et al., 2018).

Adherence to food group recommendations is typically assessed by the consumption of vegetables, fruit, grain foods, milk and milk products, and meat and protein-rich foods, with varying levels of adherence between food groups (Au et al., 2018; Golley et al., 2012; Gontijo de Castro et al., 2018). The GUiNZ study found high levels of adherence for the daily consumption of vegetables (91%), fruit (87%), and grain foods (90%) in infants (Gontijo de Castro et al., 2018; Morton et al., 2012). They also found high adherence for the consumption of breast milk or infant formula (96%), although they did not report all milk and milk products (Gontijo de Castro et al., 2018; Morton et al., 2012). Meat and protein-rich foods were less frequently consumed daily (61%). In other high-income countries, similar trends have been observed (Fox et al., 2004; Golley et al., 2012). Although different dietary assessment methods have been used, meat and protein-rich foods are often reported as the least frequently consumed food group by infants (Fox et al., 2004; Golley et al., 2012). However, the consumption of vegetables and fruits appears to be lower than that reported in NZ (Au et al., 2018; Fox et al., 2004; Golley et al., 2012). Mixed results have been found for the offering of foods with added salt and sugar to infants, with high adherence for avoiding added sugar (86%) and salt (84%) in GUiNZ (Gontijo de Castro et al., 2018) but low adherence in the United States of America (USA) (Au et al., 2018).

Various sociodemographic characteristics have been associated with adherence to infant feeding guidelines. In GUiNZ, mothers of European ethnicity, of older age, with a higher education, who attended antenatal classes, who had a partner, and those living in the least deprived neighbourhoods were more likely to meet recommendations (Gontijo de Castro et al., 2018). Similar trends have been observed in the USA (Pak-Gorstein et al., 2009), the United Kingdom (UK) (Brown & Lee, 2013; Robinson et al., 2007), Ireland (O'Donovan et al., 2015), and other European countries (Gage et al., 2012). Maternal adherence to adult feeding guidelines (Fox et al., 2004; Lioret et al., 2013; Robinson et al., 2007) and having fewer children (Anderson et al., 2001; Robinson et al., 2007; Synnott et al., 2007) have also been associated with greater adherence to infant feeding guidelines.

In recent years, there have been notable changes in how infants are fed. Examples of these changes include the increasing availability of commercial infant foods (Katiforis et al., 2021; Padarath et al.,2020) and trends surrounding baby-led weaning (BLW) (Brown et al., 2017; Cameron et al.,2013), where an infant is provided whole foods from the start of CF (Fu et al., 2018; Morison et al., 2016). The MoH does not currently recommend BLW in New Zealand as more research is required to determine potential risks (Ministry of Health, 2021a). The practice also conflicts with recommendations for spoon-feeding puréed foods when starting CF. The advent of these approaches to infant feeding may have influenced adherence to other guidelines as well.

This study aimed to investigate adherence to the key indicators from the 2021 'Healthy Eating Guidelines for New Zealand Babies and Toddlers (0 to 2 years old)' in infants. Associations between sociodemographic characteristics and adherence to the guidelines were also explored.

4.3. Methods

4.3.1. Study design

Data for the current study were obtained as part of the First Foods New Zealand (FFNZ) observational study. A detailed description of FFNZ's methods can be found elsewhere (Taylor et al., 2021). FFNZ recruited 625 infants from the Auckland and Dunedin regions of NZ using word of mouth and Facebook advertisements. To ensure sufficient representation of Māori and Pacific infants, advertisements were promoted in Māori and Pasifika people's community groups. Data were collected between July 2020 and February 2022. Ethical approval was obtained from the Health and Disability Ethics Committee New Zealand (19/STH/151), and written consent was obtained from parent participants before data collection. The study was registered with the Australian New Zealand Clinical Trials Registry (www.anzctr.org.au, registration number: ACTRN12620000459921).

4.3.2. Participants

To meet eligibility criteria, infants were required to live in the Auckland or Dunedin regions of NZ, be 7.0 to 10.0 months of age at the time of participation, and not have taken part in a nutrition intervention study that might have influenced their diet. Caregivers were required to be 16 years or older and able to communicate in English. The screening questionnaire was available on the FFNZ website and generated 1,424 responses. Of those, 1,198 were eligible, and 630 provided written consent. Five participants did not meet the eligibility criteria, leaving a final sample of 625 infants. Questionnaire data were available from all infants and two days of diet recall data were available from 614 infants, with the remaining 11 infants providing one day of dietary data.

4.3.3. Data collection

Participants were invited to attend two study appointments at their home or closest research centre approximately one week apart. Due to COVID-19 restrictions, some second appointments were conducted online. At the first appointment, participants completed a questionnaire investigating demographics, infant health, breastfeeding, and CF practices. Participants who reported two or more ethnic groups were assigned to a single group using the MoH prioritisation system (order of ranking: Māori, Pacific, Asian, Others, European) (Ministry of Health, 2017). Socioeconomic deprivation levels were assigned according to the NZ index of deprivation using the participant's home address (Atkinson et al., 2014), which provides 10 deciles where low deprivation was classified as deciles 1–3, and high deprivation as deciles 8–10. At each of the two appointments, caregivers completed a 24-hour diet recall using a multiple-pass method. Caregivers recalled all breastfeeds, foods, and beverages offered and the amount consumed the day before their appointment. To aid in portion size estimation, caregivers were asked to take photographs of foods and drinks when they were offered. Measurement prompts (grid sheets (square and circle), measuring cups and spoons, exemplar infant food pouches and jars, infant bowls, and thickness sticks) were also available to guide portion size estimation. Open questions were administered to determine the addition of salt and sugar to infant foods. If infants attended an early child education centre (ECE) or were cared for by someone other than their main caregiver, a food diary with written prompts was provided. Telephone or email contact, with caregiver consent, was made if additional details were required. After their second appointment, caregivers were emailed a final questionnaire, which included the Paediatric Eating Assessment Tool (PediEAT) (Thoyre et al., 2014). Responses for 'eats a variety of foods (fruits, vegetables, proteins, etc.) (always, almost always, often, sometimes, almost never, and never)' were used to describe caregiver perceptions of diet variety.

4.3.4. Adherence to national infant feeding guidelines

Indicators presented in this paper were based on the 'Healthy Eating Guidelines for New Zealand Babies and Toddlers (0 to 2 years old)' (Ministry of Health, 2021a). Recommendations that were measurable from FFNZ data and applied to those aged 7.0 to 10.0 months were selected (Table 4.1). Mothers retrospectively reported breastfeeding initiation rates and when breastfeeding was stopped or if they continued to breastfeed. Exclusive breastfeeding to 'around six months' (Ministry of Health, 2021a) was defined as '5 months' or '6 months' (from a pull-down menu of months) being the age when something other than breast milk, i.e. either another drink, or solid foods, was first introduced. Due to the age of infants recruited, breastfeeding to two years of age was not assessed. Instead, current breastfeeding status at the time of participation (7.0 to 10.0 months of age) was reported. Food variety, or the consumption of diverse food groups, was determined by whether each food group was included at least once per day in both diet recalls, in accordance with the MoH recommendation for daily consumption of each food group (Ministry of Health, 2021a).

Table 4.1: Indicators developed from the Ministry of Health Infant Feeding Guidelines

Indicator	Guideline recommendation	FFNZ question	FFNZ indicator
Breastfeeding			
Exclusive breastfeeding duration	Aim to exclusively breastfeed your baby until they are around six months of age	Questionnaire: 'How old was your baby when they first had anything to drink that wasn't breast milk?' *Possible answers: They did not have any breast milk, breast milk is the only drink my baby has had so far, 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* & 'How old was your baby when they first had solid foods?' *Possible answers: They haven't had solids yet, 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* *& 'How old was your baby when they first had infant formula?'* *Possible answers: 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*	'5 months' or '6 months'

Indicator	Guideline recommendation	FFNZ question	FFNZ indicator
Breastfeeding			
Breastfeeding duration	Continue to breastfeed for up to two years or longer	Questionnaire: 'Is baby still being breastfed?' *Possible answers: yes, no*	'Yes'
Introduction of solids			
Age of solid introduction	Around six months of age, when your baby is showing signs of readiness, introduce complementary foods	Questionnaire: 'How old was your baby when they first had solid foods?' *Possible answers*: *They haven't had solids yet, 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*	'5 months' or '6 months'
Appropriate foods introduced	Offer iron-rich foods, vegetables and fruit as first foods, and continue to offer these foods every day	Diet recall data	An iron-rich food [a], vegetable, and fruit consumed on both recall days
Appropriate food textures	Start with spoon-fed purées, then progress over the next few weeks to mashed/lumpy foods and soft finger foods	Questionnaire: 'What texture was the first food you gave your baby?' *Possible answers: puréed, mashed, chopped, finger food, other*	'Puréed'
Appropriate feeding style	Start with spoon-fed purées, then progress over the next few weeks to mashed/lumpy foods and soft finger foods	Questionnaire: 'How was your baby fed when they first started eating solids?' *Possible answers: 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*	'Spoon fed by an adult'

Indicator	Guideline recommendation	FFNZ question	FFNZ indicator
Eating a variety of foods			
Food variety	Once you have started complementary feeding, offer your baby or toddler a variety of nutritious foods every day, including: • Vegetables and fruit • Grain foods (e.g., iron-fortified infant cereal, oats (porridge), bread, rice, noodles, and pasta) • Milk and milk products (e.g., yoghurt and cheese) • Meat and protein rich foods (e.g., lentils, tofu, beans, nut butters, eggs, fish, seafood, chicken, or lean red meat)	Diet recall data	Selected food group offered during both diet recall days
Appropriate foods			
Addition of salt	When preparing food for your baby or toddler, do not add salt	Diet recall question: 'Is salt added to any foods or drinks that baby eats (including on days not covered by the 24-hour recall)' *Possible answers: yes, no. If yes what foods/drinks*	'No'
Addition of sugar	When preparing food for your baby or toddler, do not add sugar	Diet recall question: 'Is sugar added to any foods or drinks that baby eats (including on days not covered by the 24-hour recall)' *Possible answers: yes, no. If yes what foods/drinks*	'No'
Appropriate drinks	Recommended drinks for your baby or toddler are breast milk [b] and water (once they are eating complementary foods). Cow's milk can be offered as a drink from 12 months of age	Diet recall question: 'Is baby offered any drinks other than breast milk, formula, or water (things like cow's milk, other milk, juice, soft drinks, tea, alcohol or any other drink)?' *Possible answers: yes, no. If yes what drinks*	'No'

Indicator	Guideline recommendation	FFNZ question	FFNZ indicator
Feeding environment			
Self-feeding	From a young age, encourage your child to feed themselves	Questionnaire: 'How is your baby being fed solids now?' *Possible answers: 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 does not eat solids*	'Mostly spoon fed by adult' or 'some baby feeding themselves' or 'about half spoon fed by an adult and half baby feeding themselves' or 'mostly baby feeding themselves' or 'some spoon feeding by an adult' or 'baby feeding themselves'
[a] including meat, poultry, fish, seafood, and iron fortified infant cereals, [b] or, if necessary, a commercial infant formula until 12 months of age.			

4.3.5. Food coding

All foods consumed in diet recalls (n=20,975) were individually coded into food groups, using the MoH infant and adult guidelines as a guide (Table 4.2). The food groups were: vegetables, fruit, grain foods, milk and milk products, and meat and protein-rich foods. Ingredients in recipes or mixed dishes (e.g., baby food pouches) containing multiple food groups were individually assigned to a food group, regardless of the amount consumed. Foods were only assigned to a food group if they complied with the MoH guidelines. This meant that foods such as sour cream and fruit juice, for example, were not considered to contribute to intake from the 'milk and milk products', or 'fruit', food groups, respectively. Iron-rich foods included meat, poultry, fish, seafood, and iron fortified infant cereals, as per the MoH guidelines (Ministry of Health, 2021a).

Table 4.2: Foods included and excluded in food group analyses

Food/group	Foods included	Foods not included
Vegetables	All vegetables (canned, frozen, fresh, commercial infant foods).	Potato chips, potato fries, herbs, spices, cakes/muffins/slices/biscuits/pancakes/scones including vegetables, dried/freeze dried vegetable snack foods.
Fruit	All fruit (canned, frozen, fresh, commercial infant foods).	Fruit juice, fruit jam, cakes/muffins/slices/biscuits/pancakes/scones including fruit, dried/freeze dried fruit snack foods.
Grain foods	Pasta/noodles, rice, bread, cereals, infant cereals, crackers/crispbreads/rice, and corn cakes (plain), oats, couscous, semolina, polenta, bulgur, quinoa, buckwheat, muesli, popcorn – plain.	Grain/corn chips, popcorn - butter/sweetened, crackers/crispbreads/rice and corn cakes (flavoured/yoghurt coated), all biscuits, slices, scones, waffles, pikelets/pancakes, bars (muesli bars and other), cakes, pastries, muffins, discretionary snack foods and commercial infant extruded snacks.
Milk and milk products	Cow's milk [a], calcium-fortified plant-based milks [ab], cow's milk cheese and yoghurt, homemade custard.	Breast milk, infant formula, sour cream, cream, non-calcium fortified plant-based milks [b], ice cream, butter, sweetened milk puddings.
Meat and protein-rich foods	Beef, veal, lamb, mutton, fish, seafood, venison, egg, offal meats, pork, legumes, beans, lentils, nuts, seeds, tofu, tahini, hummus, Quorn, pea protein products.	Pies, sausages, ham, bacon.
Commercial infant foods	Pouches, cans, jars, microwavable bowls, rusks, cereals, extruded snacks, dried/freeze dried fruit and vegetable snack foods, baby cereal bars, baby biscuits, discretionary snack foods.	

[a] included in foods, [b] calcium-fortified milks were defined as milks with equal to or higher than 100mg of calcium per 100mL of milk (included in foods only) (Ministry of Health, 2021a)

4.3.6. Statistical analysis

Variables were reported as percentages and means (standard deviation (SD)) from the study population. The proportions of the sample that met the indicator were also adjusted by weighting for ethnicity and socioeconomic deprivation to more closely represent the New Zealand population (Daniels, Haszard, Taylor, & Taylor, 2023) and estimate adherence with a 95% logit-transformed confidence interval. Logistic regression was used to estimate odds ratios, 95% confidence intervals, and p-values for associations between sociodemographic characteristics and adherence to different indicators. P-values <0.05 indicated statistical significance. Odds ratios were only calculated for variables with at least 10 participants in each cell and indicators with more than 10% of the sample in each category. Associations between sociodemographic variables (caregiver age, education, employment status; maternal parity; number of children living in household; use childcare/ECE; and socioeconomic deprivation) and MoH recommendations (exclusive breastfeeding, current breastfeeding, solid introduction between 5 and 7 months, puréed foods introduced first, iron-rich foods introduced first, food variety (iron-rich foods, vegetables, and fruit consumed on both recall days), no salt or sugar added, and infants not fully spoon-fed at current age) were investigated. Analyses were performed using Stata Statistical Software (version 17, StataCorp LP, College Station, TX) and Microsoft Excel (version 16.66).

4.4. Results

4.4.1. Maternal and infant characteristics

Maternal and infant demographic characteristics are summarised in Table 4.3. Infants and caregivers were on average (mean (SD)) 8.4 (0.8) months and 32.7 (4.9) years of age, respectively. The majority (98%) of caregivers were the infant’s mother. Six respondents were fathers, one was a grandparent, and one was a guardian.

Table 4.3: Demographic characteristics of infants and caregivers (n=625)

Demographic variable		Descriptive statistic
Infant		
Ethnicity, n (%)	Māori	131 (21.0)
	Pacific	44 (7.0)
	European	344 (55.0)
	Asian	90 (14.4)
	Others	16 (2.6)
Sex [a]	Male	335 (53.6)
Pre-term birth, n (%) [b]		46 (7.4)
Caregiver		
Highest level of education, n (%) [c]	School	93 (14.9)
	Polytechnic or similar	126 (20.2)
	University	405 (64.9)
Maternal parity, n (%)	Primiparous	304 (48.7)
Employment status, n (%)	Employed full time	70 (11.2)
	Employed part-time	137 (21.9)
	Other [d]	418 (66.9)
Environment		
Number of children living in household, n (%)	One	284 (45.5)
	Two	200 (32.1)
	Three	95 (15.2)
	Four or more	45 (7.2)
Number of adults living in household, n (%)	One	25 (4.0)
	Two	517 (82.7)
	Three	42 (6.7)
	Four or more	41 (6.6)
Childcare (ECE) outside the home, n (%)		109 (17.4)
Deprivation, n (%) [e]	1-3 (low)	181 (29.0)
	4-7	282 (45.1)
	8-10 (high)	162 (25.9)

[a] infant sex was not specified for one participant, [b] born before 37 weeks gestation, [c] highest qualification was not specified for one caregiver, [d] includes paid parental leave, unpaid parental leave, and unemployed, [e] defined according to deciles of the NZ index of deprivation using participant home address (Atkinson et al., 2014).

4.4.2. Adherence to infant feeding guidelines

Adherence to the MoH infant feeding guidelines (Table 4.1) is shown in Table 4.4, with further detail regarding each indicator and sociodemographic predictors provided below.

Table 4.4: Summary of adherence to indicators developed from the Ministry of Health Infant Feeding Guidelines

Recommendation	Indicator [a]	n (%) who met recommendation	Adjusted proportion (95% CI)[b] who met recommendation
Breastfeeding			
Aim to exclusively breastfeed your baby until they are around six months of age	Exclusive breastfeeding to at least 5 and less than 7 months	236 (37.8)	38.7 (34.7, 42.7)
Continue to breastfeed for up to two years or longer	Current breastfeeding at time of participation	414 (66.2)	67.6 (63.7, 71.3)
Introduction of solid foods			
Around six months of age, when your baby is showing signs of readiness, introduce complementary foods	Solid food introduced between 5 and fewer than 7 months of age	471 (75.4)	77.4 (73.9, 80.6)
	Puréed-texture food was used when solid foods were introduced	502 (80.3)	80.6 (77.2, 83.6)
	Spoon-fed by an adult when solid foods were introduced	463 (74.1)	74.1 (70.4, 77.5)
	Iron-rich foods introduced when solid foods were introduced	552 (88.3)	88.7 (85.9, 91.0)
	Iron-rich foods, vegetables and fruit consumed daily during recall days	82 (13.4)	-[d]
Food variety			
Once complementary feeding has started, offer your baby or toddler a variety of nutritious foods every day, including: • Vegetables and fruit • Grain foods • Milk and milk products • Meat and protein-rich foods	Vegetables consumed daily during recall days [c]	388 (63.2)	-[d]
	Fruit consumed daily during recall days [c]	331 (53.9)	-[d]
	Grain foods consumed daily during recall days [c]	304 (49.5)	-[d]
	Milk and milk products consumed daily during recall days [c]	237 (38.6)	-[d]
	Meat and protein rich foods consumed daily during recall days [c]	195 (31. 8)	-[d]
Appropriate foods			
When preparing food for your baby or toddler, do not add salt or sugar	Salt was not added to foods since solid foods were introduced [e]	455 (75.7)	75.1 (71.3, 78.6)
	Sugar was not added to foods since solid foods were introduced [e]	546 (90.9)	90.8 (88.1, 93.0)
Appropriate beverages			
Recommended drinks for your baby or toddler are breast milk [f] and water (once they are eating complementary foods). Cow's milk can be offered as a drink from 12 months of age. Do not give your baby or toddler juice, cordial, fruit drink, flavoured milk, soft drinks, tea, coffee or alcohol	Only offered breast milk, infant formula, and/or water at time of participation	587 (93.9)	94.5 (92.3, 96.1)

Recommendation	Indicator [a]	n (%) who met recommendation	Adjusted proportion (95% CI)[b] who met recommendation
Feeding environment			
From a young age, encourage your child to feed themselves	Infants were not 100% spoon-fed at time of participation	543 (86.9)	86.1 (82.8, 88.8)

[a] how guidelines were assessed in FFNZ, [b] proportion who met the indicator, weighted for ethnicity and NZ index of deprivation using participant home address (Atkinson et al., 2014), [c] assessed from 614 participants, [d] weighted estimates not provided for adherence of diet recalls, [e] assessed from 601 participants, [f] or, if necessary, a commercial infant formula until 12 months of age.

4.4.2.1. Breastfeeding

Breastfeeding was initiated by 97.9% of women. At around six months of age, 37.8% met EBF recommendations (Table 4.4). Of those who did not meet recommendations, 51% stopped breastfeeding before one month of age (376 stopped BF between birth and 4.9 months and 191 of these were in the first month) (Figure 4.1a). At the time of participation, 66.2% were still breastfeeding. A progressive decline in continued breastfeeding was observed between birth and seven months, however, it seemed to be stabilising around 9-10 months of age (Figure 4.1b).

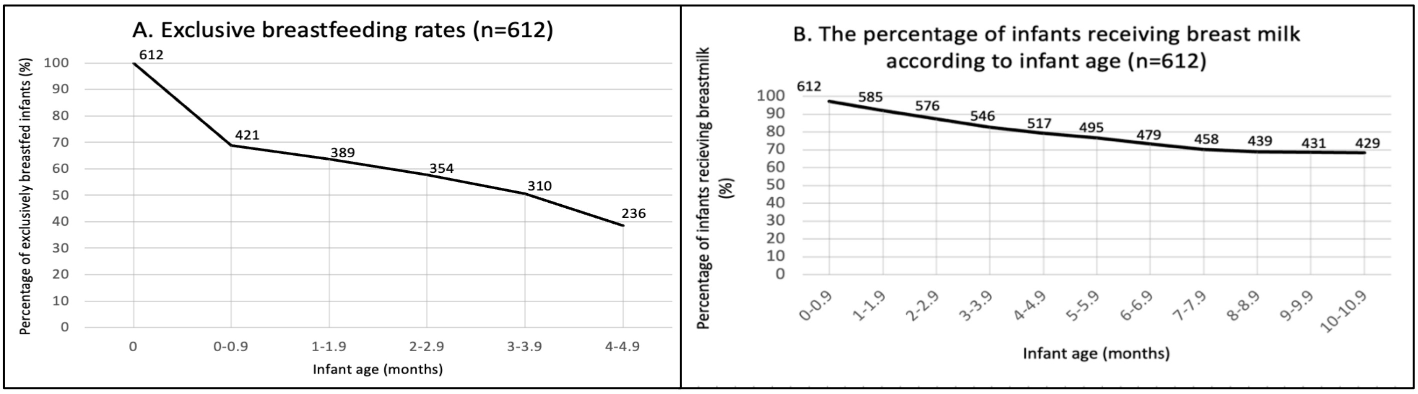

Figure 4.1: (A) Exclusive breastfeeding prevalence (between birth and 4.9 months). (B) The percentage of infants receiving breast milk according to infant age. n=612.

Infants had a higher odds of meeting EBF recommendations if their caregivers were older (1.05 (1.01, 1.08), p=0.008) vs young, highest qualification was university vs school (0.37 (0.22, 0.64), p<0.001), were not currently working vs employed full-time (0.54 (0.31, 0.96), p=0.035), multiparous mothers vs primiparous (0.67 (0.48, 0.93), p=0.016), had two children in the household (1.56 (1.08, 2.27), p=0.019) vs one, and did not attend an ECE vs those who did (0.60 (0.38, 0.95), p=0.028) (Table 4.5).

Caregivers were more likely to be breastfeeding at the time of the study (mean infant age 8.4 months) if their highest qualification was university vs school (0.41 (0.25, 0.64), p<0.001) or polytechnic (0.47

(0.31, 0.72), p<0.001) only, they were not currently working vs employed full time (0.41 (0.25, 0.64), p=0.014), they had two children (1.52 (1.03, 2.26), p=0.037) vs one child, their infant did not attend vs did attend an ECE (0.54 (0.35, 0.81), p=0.004), or they lived in low vs high socioeconomic deprivation areas (0.61 (0.39, 0.96), p=0.032).

Table 4.5: Sociodemographic characteristics associated with adherence to breastfeeding recommendations

	Exclusively breastfed to around 6 months		Current breastfeeding	
	Met guideline n=236	Odds ratio (95% CI)	Met guideline n=414	Odds ratio (95% CI)
Parent/caregiver age, mean (SD) years				
	33.3 (4.5)	**1.05 (1.01, 1.08)**	32.9 (4.6)	1.03 (1.00, 1.07)
Highest parent/caregiver qualification				
School	20 (21.3)	**0.37 (0.22, 0.64)**	49 (52.1)	**0.41 (0.25, 0.64)**
Polytechnic or similar	46 (36.8)	0.80 (0.53, 1.22)	70 (56.0)	**0.47 (0.31, 0.72)**
University	170 (42.0)	Reference	295 (72.8)	Reference
Employment status of parent/caregiver				
Employed full time	18 (25.7)	**0.54 (0.31, 0.96)**	49 (52.1)	**0.41 (0.25, 0.64)**
Employed part-time	55 (40.2)	1.05 (0.71, 1.56)	70 (56.0)	0.47 (0.31, 0.72)
Other [a]	163 (39.0)	Reference	295 (72.8)	Reference
Maternal parity, n (%)				
Primiparous	100 (33.0)	**0.67 (0.48, 0.93)**	223 (69.5)	0.74 (0.53, 1.03)
Multiparous	136 (42.4)	Reference	190 (62.7)	Reference
Number of children living in household, n (%)				
One	96 (33.9)	Reference	181 (64.0)	Reference
Two	89 (44.5)	**1.56 (1.08, 2.27)**	146 (73.0)	**1.52 (1.03, 2.26)**
Three	38 (40.0)	1.30 (0.80, 2.10)	63 (66.3)	1.11 (0.68, 1.81)
Four or more	13 (28.3)	0.77 (0.39, 1.53)	24 (52.2)	0.61 (1.39, 2.26)
Childcare (ECE) outside the home, n (%)				
No	205 (39.7)	Reference	355 (68.8)	Reference
Yes	31 (28.4)	**0.60 (0.38, 0.95)**	59 (54.1)	**0.54 (0.35, 0.81)**
Socioeconomic deprivation, n (%) [b]				
Low	73 (40.6)	Reference	125 (69.4)	Reference
Medium	106 (37.6)	0.88 (0.60, 1.29)	194 (68.8)	0.97 (0.65, 1.45)
High	57 (35.0)	0.79 (0.51, 1.22)	95 (58.3)	**0.61 (0.39, 0.96)**

Did not meet recommendations: exclusive breastfeeding (n=389) and continued breastfeeding (n=211). Odds ratio (95% CI) values with p values <0.05 are bolded. [a] includes paid parental leave, unpaid parental leave, and unemployed, [b] defined according to the NZ index of deprivation using participant home address (Atkinson et al., 2014).

4.4.2.2. Introduction of solid foods

The recommendation for introducing solid foods 'around' six months of age was met by 75.4% of participants (Table 4.4). Solid foods were introduced at a mean age (SD) of 5.18 (0.89) months, with the majority starting by six months (Figure 4.2). Most infants met recommendations for puréed food textures (80.3%), spoon-feeding (74.1%), and the introduction of iron-rich foods (88.3%) (Table 4.4). Few infants consumed an iron-rich food, vegetable, and fruit during both diet recall days (13.4%). During the time when solid foods were introduced, 61.4% and 65.6% of infants consumed infant rice cereal and red meat, respectively.

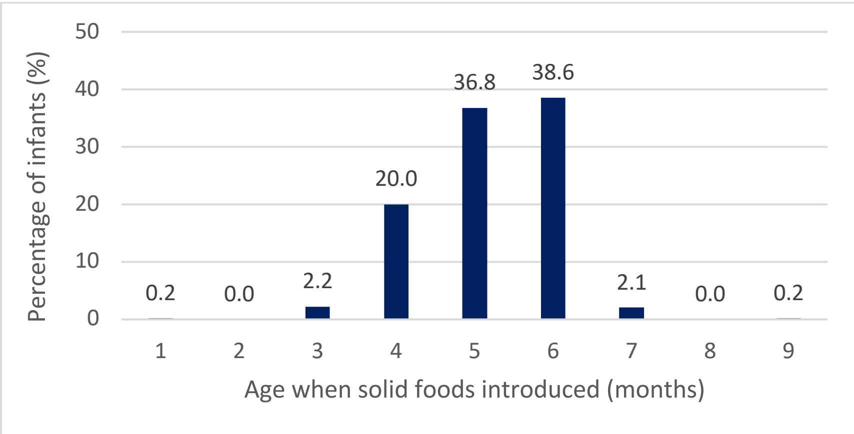

Figure 4.2: Infant age when solid foods were introduced (n=625)

Infants were more likely to be introduced to solid foods 'around' six months of age if they had younger (1.12 (1.08, 0.02), p<0.001) vs older caregivers, caregiver's highest qualification was university level vs school (0.21 (0.13, 0.34), p<0.001) or polytechnic (0.53 (0.33, 0.84), p=0.007), caregivers with one child vs four or more in the household (0.44 (0.23, 0.84), p=0.013), or if the infant did not attend an ECE vs those who did (0.54 (0.35, 0.81), p=0.004), and if they were living in a low vs high socioeconomic deprivation area (0.47 (0.28, 0.77), p=0.003) (Table 4.6). Infants were more likely to be spoon-fed when starting solid foods if their caregiver's highest qualification was school (2.08 (1.16, 3.70), p=0.013) or polytechnic (1.70 (1.05, 2.77), p=0.032) vs those with a university qualification, and if the infant attended an ECE (2.29 (1.30, 4.03), p=0.004) vs those who did not.

Table 4.6: *Sociodemographic characteristics associated with adherence to solid food introduction recommendations*

	Introduction of solid foods between 5- <7 months		Puréed food texture introduced first		Spoon-fed by adult when solid foods first introduced		Iron-rich foods introduced first	
	Met guideline n=471	Odds ratio (95% CI)	Met guideline n=502	Odds ratio (95% CI)	Met guideline n=463	Odds ratio (95% CI)	Met guideline n=552	Odds ratio (95% CI)
Parent/caregiver age, mean (SD) years								
	33.4 (4.6)	**1.12 (1.08, 1.16)**	32.7 (4.8)	1.0 (0.96, 1.04)	32.6 (5.0)	0.99 (0.95, 1.02)	32.6 (4.9)	0.99 (0.94, 1.04)
Highest parent/caregiver qualification								
School	47 (50.0)	**0.21 (0.13, 0.34)**	75 (79.8)	0.99 (0.56, 1.73)	78 (83.0)	**2.08 (1.16, 3.70)**	84 (89.4)	1.08 (0.52, 2.22)
Polytechnic or similar	89 (71.2)	**0.53 (0.33, 0.84)**	103 (82.4)	1.18 (0.70, 1.98)	100 (80.0)	**1.70 (1.05, 2.77)**	108 (86.4)	0.81 (0.45, 1.48)
University	334 (82.5)	Reference	324 (80.0)	Reference	284 (70.1)	Reference	359 (88.6)	Reference
Employment status of parent/caregiver								
Employed full time	49 (70.0)	0.68 (0.39, 1.19)	56 (80.0)	1.03 (0.55, 1.95)	56 (80.0)	1.54 (0.82, 2.87)	58 (82.9)	0.61 (0.31, 1.22)
Employed part-time	98 (71.5)	0.73 (0.47, 1.13)	114 (83.2)	1.28 (0.77, 2.13)	105 (76.6)	1.26 (0.80, 1.98)	123 (89.8)	1.11 (0.59, 2.09)
Other [a]	324 (77.5)	Reference	332 (79.4)	Reference	302 (72.3)	Reference	371 (88.8)	Reference
Maternal parity, n (%)								
Primiparous	244 (76.0)	0.93 (0.64, 1.33)	253 (78.8)	1.21 (0.82, 1.80)	242 (75.4)	0.88 (0.61, 1.26)	282 (87.9)	1.09 (0.67, 1.78)
Multiparous	226 (74.6)	Reference	248 (81.9)	Reference	221 (72.9)	Reference	269 (88.8)	Reference
Number of children living in household, n (%)								
One	211 (74.6)	Reference	236 (83.4)	Reference	- [c]	- [c]	- [c]	- [c]
Two	162 (81.0)	1.45 (0.93, 2.27)	157 (78.5)	0.73 (0.46, 1.15)	- [c]	- [c]	- [c]	- [c]
Three	71 (74.7)	1.01 (0.59, 1.72)	72 (75.8)	0.62 (0.35, 1.10)	- [c]	- [c]	- [c]	- [c]
Four or more	26 (56.5)	**0.44 (0.23, 0.84)**	36 (78.3)	0.72 (0.33, 1.54)	- [c]	- [c]	- [c]	- [c]
Childcare (ECE) outside the home, n (%)								
No	394 (76.3)	Reference	409 (79.3)	Reference	370 (71.7)	Reference	- [c]	- [c]
Yes	77 (70.6)	**0.54 (0.35, 0.81)**	93 (85.3)	1.52 (0.86, 2.63)	93 (85.3)	**2.29 (1.30, 4.03)**	- [c]	- [c]

	Introduction of solid foods between 5- <7 months		Puréed food texture introduced first		Spoon-fed by adult when solid foods first introduced		Iron-rich foods introduced first	
Socioeconomic deprivation, n (%) [b]								
1-3 (low)	147 (81.7)	Reference	139 (77.2)	Reference	126 (70.0)	Reference	155 (86.1)	Reference
4-7	214 (75.9)	0.71 (0.44, 1.13)	231 (81.9)	1.34 (0.84, 2.12)	209 (74.1)	1.23 (0.81, 1.86)	251 (89.0)	1.31 (0.74
8-10 (high)	110 (67.5)	**0.47 (0.28, 0.77)**	132 (81.0)	1.26 (0.74, 2.12)	128 (78.5)	1.57 (0.96, 2.56)	146 (89.6)	1.39 (0.72, 2.67)

Did not meet recommendation: introduction of solids between 5 - <7 months (n=154), puréed food texture introduced first (n=123), spoon-fed by adult when solids first introduced (n=162), iron-rich foods introduced first (n-=73). Odds ratio (95% CI) values with p values <0.05 are bolded. [a] includes paid parental leave, unpaid parental leave, and unemployed, [b] defined according to the NZ index of deprivation using participant home address (Atkinson et al., 2014), [c] less than 10% of the sample was in one of the adherence groups for 'number of children in the household' and 'childcare (ECE) outside of the home' for spoon-feeding and iron-rich foods, which was deemed too small for reliable logistic regression analyses.

4.4.2.3. Food group intake of infants

Vegetables (63.1%) and fruit (53.9%) were the most commonly consumed food groups. Fewer than half of infants consumed 'grain' (49.5%), milk and milk products (38.6%), and 'meat and protein-rich' foods (31.8%) on both diet recall days. A small proportion (6.5%) of infants consumed each food group on both diet recall days. When asked if caregivers felt that their infant consumed a variety of foods, 144 of 146 (98.6%) participants reported 'sometimes' or more.

Infants were more likely to consume 'iron-rich foods' and 'vegetables' on both diet recall days if caregivers were older (iron-rich: 1.06 (1.02, 1.10) p=0.003; vegetables: 1.07 (1.04, 1.12) p=<0.001) vs younger, primiparous (iron-rich: 1.44 (1.01, 2.04) p=0.042; vegetables: 1.81 (1.29, 2.52) p=0.001) vs multiparous, and had a university qualification as their highest level of education vs polytechnic qualification (iron-rich: 0.58 (0.36, 0.94) p=0.020 and vegetables: 0.52 (0.35, 0.79) p<0.001). Infants were also more likely to consume vegetables on both diet recall days if the caregiver's highest qualification was university vs school (0.42 (0.27, 0.68), p<0.001), there was one child in the household vs three (0.53 (0.33, 0.86), p=0.010) and four or more (0.23 (0.12, 0.45), p<0.001), and those living in low vs high socioeconomic deprivation (0.45 (0.29, 0.70), p<0.001) (Table 4.7). Infants were more likely to consume fruit if their caregiver's highest qualification was university vs school (0.47 (0.29, 0.75), p=0.002).

Table 4.7: Sociodemographic characteristics associated with adherence to food variety recommendations on both 24-hour recall days

	Iron-rich food consumed on both days		Vegetables consumed on both days		Fruit consumed on both days	
	Met guideline n=179	Odds ratio (95% CI)	Met guideline n=388	Odds ratio (95% CI)	Met guideline n=331	Odds ratio (95% CI)
Parent/caregiver age, mean (SD) years						
	33.6 (4.6)	**1.06 (1.02, 1.10)**	33.3 (4.3)	**1.07 (1.04, 1.12)**	33.0 (4.3)	1.03 (1.00, 1.06)
Highest parent/caregiver qualification						
School	20 (22.7)	0.60 (0.35, 1.03)	43 (48.9)	**0.42 (0.27, 0.68)**	35 (39.8)	**0.47 (0.29, 0.75)**
Polytechnic or similar	27 (22.1)	**0.58 (0.36, 0.94)**	66 (54.1)	**0.52 (0.35, 0.79)**	60 (49.2)	0.68 (0.46, 1.03)
University	132 (32.8)	Reference	279 (69.2)	Reference	236 (58.6)	Reference
Employment status of parent/caregiver						
Employed full time	20 (29.4)	1.07 (0.61, 1.88)	46 (67.6)	1.31 (0.76, 2.26)	33 (48.5)	0.78 (0.47, 1.30)
Employed part-time	44 (32.4)	1.22 (0.81, 1.87)	90 (66.2)	1.22 (0.82, 1.84)	74 (54.4)	0.99 (0.47, 1.31)
Other [a]	115 (28.1)	Reference	252 (61.5)	Reference	224 (54.6)	Reference
Maternal parity, n (%)						
Primiparous	80 (25.4)	**1.44 (1.01, 2.04)**	178 (56.5)	**1.81 (1.29, 2.52)**	165 (52.4)	1.14 (0.83, 1.57)
Multiparous	98 (32.9)	Reference	209 (70.1)	Reference	166 (55.7)	Reference
Number of children living in household, n (%)						
One	93 (33.6)	Reference	194 (70.0)	Reference	151 (54.5)	Reference
Two	51 (25.6)	0.68 (0.46, 1.02)	126 (63.3)	0.74 (0.50, 1.09)	112 (56.2)	1.07 (0.74, 1.55)
Three	23 (24.5)	0.64 (0.38, 1.10)	52 (55.3)	**0.53 (0.33, 0.86)**	49 (52.1)	0.91 (0.57, 1.45)
Four or more	12 (27.9)	0.77 (0.37, 1.56)	15 (34.9)	**0.23 (0.12, 0.45)**	18 (41.9)	0.60 (0.31, 1.15)
Childcare (ECE) outside the home, n (%)						
No	144 (28.4)	Reference	319 (62.8)	Reference	277 (54.5)	Reference
Yes	35 (33.0)	1.24 (0.80, 1.95)	69 (65.1)	1.10 (0.71, 1.71)	54 (50.9)	0.87 (0.57, 1.32)

	Iron-rich food consumed on both days		Vegetables consumed on both days		Fruit consumed on both days	
Socioeconomic deprivation, n (%) [b]						
1-3 (low)	56 (31.6)	Reference	125 (70.6)	Reference	103 (58.2)	Reference
4-7	82 (29.6)	0.91 (0.60, 1.37)	180 (65.0)	0.77 (0.51, 1.16)	156 (56.3)	0.93 (0.63, 1.36)
8-10 (high)	41 (25.6)	0.74 (0.46, 1.20)	83 (51.9)	**0.45 (0.29, 0.70)**	72 (45.0)	0.59 (0.38, 0.91)

Did not meet recommendations: iron-rich food consumed on both recall days (n=179), vegetables consumed on both recall days (n=388), fruit consumed on both recall days (n=388). Odds ratio (95% CI) values with p values <0.05 are bolded. [a] includes paid parental leave, unpaid parental leave, and unemployed, [b] defined according to the NZ index of deprivation using participant home address (Atkinson et al., 2014).

4.4.2.4. Appropriate foods and beverages

Most participants met recommendations for avoiding inappropriate foods, including salt (23.5%) and sugar (9.3%) (Table 4.4). For those using salt, this was typically added to roasted meat/vegetables, vegetable mash, family meals, and potato fries. Sugar was added to weetbix, baking, fruit purées, and family meals. Inappropriate beverages were rarely consumed, and 93.9% of infants met the recommendation (Table 4.4). Juice was the predominant inappropriate beverage reported in diet recalls (6.6%). Tea and coffee were not reported in any diet recall.

Different sociodemographic characteristics were observed for adding salt and sugar to food (Table 4.8). Primiparous mothers (p=0.001) were less likely to add salt to infant foods than multiparous. Those with two (p=0.026) or three (p=0.022) children in the household were more likely to add salt to infant foods than those with one child. Younger caregivers (p=0.019) were less likely to add sugar than older caregivers, and those with a school education (p=0.001) were more likely to add sugar than university-educated caregivers.

Table 4.8: Sociodemographic characteristics associated with adherence to the recommendation of not adding salt and sugar

	No added salt		No added sugar	
	Met guideline n=455	Odds ratio (95% CI)	Met guideline n=546	Odds ratio (95% CI)
Parent/caregiver age, mean (SD) years				
	32.7 (5.0)	0.99 (0.95, 1.03)	32.8 (4.9)	**0.94 (0.88, 0.99)**
Highest parent/caregiver qualification				
School	63 (69.2)	1.47 (0.88, 2.44)	74 (81.3)	**3.20 (1.65, 6.19)**
Polytechnic or similar	93 (76.9)	1.00 (0.61, 1.62)	109 (90.1)	1.53 (0.75, 3.14)
University	298 (76.8)	Reference	362 (93.3)	Reference
Employment status of parent/caregiver				
Employed full time	53 (79.0)	0.85 (0.45, 1.60)	- [c]	- [c]
Employed part-time	92 (71.9)	1.26 (0.81, 1.98)	- [c]	- [c]
Other [a]	310 (76)	Reference	- [c]	- [c]
Maternal parity, n (%)				
Primiparous	213 (70.1)	**0.53 (0.36, 0.78)**	274 (90.1)	0.84 (0.48, 1.47)
Multiparous	241 (81.4)	Reference	271 (91.6)	Reference
Number of children living in household, n (%)				
One	223 (80.8)	Reference	- [c]	- [c]
Two	136 (72.0)	**1.64 (1.06, 2.54)**	- [c]	- [c]
Three	63 (69.2)	**1.87 (1.09, 3.18)**	- [c]	- [c]
Four or more	32 (72.7)	1.58 (0.76, 3.28)	- [c]	- [c]
Childcare (ECE) outside the home, n (%)				
No	376 (75.5)	Reference	453 (91.0)	Reference
Yes	79 (76.7)	0.94 (0.57, 1.54)	93 (90.3)	1.08 (0.53, 2.23)
Socioeconomic deprivation, n (%) [b]				
1-3 (low)	133 (76.9)	Reference	158 (91.3)	Reference
4-7	203 (75.2)	1.10 (0.70, 1.72)	257 (95.2)	0.53 (0.23, 1.15)
8-10 (high)	119 (75.3)	1.09 (0.66, 1.81)	131 (82.9)	2.17 (1.11, 4.25)

Did not meet recommendations: no added salt (n=146), no added sugar (n=55). Odds ratio (95% CI) values with p values <0.05 are bolded. [a] includes paid parental leave, unpaid parental leave, and unemployed, [b] defined according to the NZ index of deprivation using participant home address (Atkinson et al., 2014), [c] less than 10% of the sample was in one of the adherence groups for 'employment' and 'number of children in the household' for added sugar, which was deemed too small for reliable logistic regression analyses.

4.4.2.5. Feeding environment

At the age of participation, 86% of infants were no longer fully spoon-fed, aligning with the MoH recommendation that encourages self-feeding from a young age (Table 4.4). Infants were more likely to meet the recommendation for self-feeding if there was one child in the household vs those with four or more children (0.41 (0.20, 0.87), p=0.020) (Table 4.9). Infants of caregivers with part-time employment had a higher odds of self-feeding than those who were not currently working (2.21 (1.10, 4.44), p=0.026).

Table 4.9: Sociodemographic characteristics associated with adherence to spoon-feeding recommendations

	Not fully spoon-fed at current age	
	Met guideline n=82	Odds ratio (95% CI)
Parent/caregiver age, mean (SD) years		
	32.6 (4.8)	0.99 (0.94, 1.03)
Highest parent/caregiver qualification		
School	79 (84.0)	0.64 (0.34, 1.21)
Polytechnic or similar	103 (82.4)	0.57 (0.33, 1.00)
University	361 (89.1)	Reference
Employment status of parent/caregiver		
Employed full time	60 (85.7)	1.04 (0.51, 2.15)
Employed part-time	127 (92.7)	**2.21 (1.10, 4.44)**
Other [a]	356 (85.2)	Reference
Maternal parity, n (%)		
Primiparous	282 (87.9)	0.84 (0.53, 1.33)
Multiparous	260 (85.8)	Reference
Number of children living in household, n (%)		
One	247 (87.3)	Reference
Two	179 (89.5)	1.24 (0.70, 2.20)
Three	82 (86.3)	0.92 (0.47, 1.82)
Four or more	34 (73.9)	**0.41 (0.20, 0.87)**
Socioeconomic deprivation, n (%) [b]		
1-3 (low)	162 (90.0)	Reference
4-7	242 (85.8)	0.67 (0.37, 1.21)
8-10 (high)	139 (85.3)	0.64 (0.34, 1.23)

Did not meet recommendation (n=82). Odds ratio (95% CI) values with p values <0.05 are bolded. [a] includes paid parental leave, unpaid parental leave, and unemployed, [b] defined according to the NZ index of deprivation using participant home address (Atkinson et al., 2014).

4.5. Discussion

The current study has provided insight into adherence to the 2021 NZ MoH infant feeding guidelines in an ethnically diverse infant population. High levels of adherence to recommendations for the introduction of solid foods, appropriate foods and beverages, and eating environments were observed, whereas breastfeeding and food group recommendations were less commonly met. Socioeconomic deprivation, caregiver education, parity, and the number of children in the household were key sociodemographic characteristics associated with adherence to NZ guidelines.

4.5.1. Adherence to breastfeeding recommendations

Breastfeeding initiation rates in NZ are high (Plunket, 2020), however, as seen in this study and previous NZ research, many women do not meet EBF and continued breastfeeding recommendations (Castro et al., 2017; Gontijo de Castro et al., 2018; Manhire et al., 2018; Ministry of Health, 2021b; Plunket, 2020). Although most women did not meet the EBF recommendation, our cohort's response was higher (37.8%) than that observed in GUiNZ (34.3%) in 2009–2011, suggesting that adherence might be improving. Despite higher adherence, further promotion is required if NZ is to meet the 2030 global nutrition target of at least 70% of women EBF to six months of age (United Nations Children's Fund, 2023). A possible area to target is EBF during the first month—the vast majority of those who did not meet EBF recommendations in our study stopped during this time. These results indicate a crucial time window that needs further investigation. Although we did not investigate the reasons why women stopped EBF in our study, we found that primiparous women were less likely to meet the EBF recommendation. Similar patterns have been observed in NZ (Gontijo de Castro et al., 2018) and other high-income countries (McAndrew et al., 2012), with strong associations between EBF and previous breastfeeding experience (McAndrew et al., 2012). Early intervention through breastfeeding support programmes has shown beneficial outcomes (Wong et al., 2021) and could be targeted toward those, such as primiparous mothers, who are at higher risk of not meeting EBF recommendations. We also observed that caregivers who were older, higher educated, not currently working, and infants who did not attend an ECE were more likely to meet EBF recommendations. This agrees with global findings (Mangrio et al., 2018), with factors such as education, employment status, and use of an ECE often being interconnected with socio-economic status, with those who are more highly educated having greater opportunity to take paid maternity leave than those who are less highly educated and require ECE support when returning to work (Gallegos et al., 2020; McAndrew et al., 2012). Sustaining breastfeeding is typically harder for women who return to work in the first twelve months postpartum, with common reports of inadequate support and facilities for breastfeeding (McIntyre et al., 1999; Mitra et al., 2004). Finding ways to support women who are required to return to work, such as encouraging peer support and regulations for the provision of appropriate facilities has improved the incidence of EBF in other countries (Scott et al., 2019) and would be beneficial in NZ. Further, qualitative, input from mothers would also be helpful to determine what support is required to achieve EBF recommendations.

After six months of age, breastfeeding continued to decline. Rates of decline, however, seem to have reduced since those reported in GUiNZ (48%) (Morton et al., 2012) and plateaued around 9–10 months of age, with 70.4% of women (n=431) continuing to breastfeed at nine months of age in our study. As in GUiNZ (Gontijo de Castro et al., 2018), women in the current study with higher levels of education were more likely to meet continued breastfeeding recommendations. As shown for EBF, education, returning to work, use of ECE, and socio-economic status are often interconnected, making these complex markers to investigate (Gallegos et al., 2020; McAndrew et al., 2012). The positive influence of previous experience was also evident for continued breastfeeding as seen for EBF, with caregivers of two children having higher adherence, suggesting that experience and education are key factors in sustaining breastfeeding. Further support to sustain breastfeeding for first-time mothers and those who are required to return to work may improve rates of adherence in NZ.

4.5.2. Adherence to complementary feeding recommendations

The recommendation to introduce solid foods 'around six months of age' was met by most FFNZ participants (75.4%, average age of 5.18 months); notably higher than those within the GUiNZ cohort (56.9%), who reported that 39.4% of infants had started solid foods before or at four months of age (Gontijo de Castro et al., 2018; Morton et al., 2012). Other recent NZ studies have also suggested that the average age of solid food introduction has increased since GUiNZ, with an average age of 5.2 months reported in 2018 (Fu et al., 2018) and few infants being offered solid foods before four months (5.4%) in the 2020–2021 NZ Health Survey (Ministry of Health, 2022). However, sample bias within studies focusing on nutrition may explain differences, with a common limitation being that those who are interested in nutrition take part, compared to GUiNZ, which included a wider range of health and environmental variables beyond nutrition. A higher number of Pacific mothers, who were less likely to meet solid introduction recommendations than European mothers, also took part in GUiNZ compared to the current study. Similar trends exist in Australia, with survey results suggesting the average age of solid food introduction is moving towards 'around six months' (5.3 months (Lioret et al., 2013), 5.1 months (Arora et al., 2020), 5.0 months (Netting et al., 2022)), with few caregivers providing solid foods before four months (Arora et al., 2020). As in GUiNZ, caregivers with lower education levels and those living in areas of high socioeconomic deprivation were less likely to meet this recommendation (Gontijo de Castro et al., 2018), identifying key population groups who require additional support. The relationship between low adherence and attending an ECE was a new finding and may suggest an area of influence that needs additional investigation.

Previously reported trends for the increasing number of caregivers following BLW (Rapley, 2015) did not appear to influence food textures or feeding methods in the current study. Most infants consumed puréed foods when solids were introduced and were spoon-fed by an adult. However, university-educated women were less likely to spoon feed their infant when starting solid foods, agreeing with findings that maternal education may influence BLW trends (Brown, 2016). Attendance at an ECE appears to be a positive influence for spoon-feeding, a finding which has not been reported before. The rate of introducing iron-rich foods when starting solids (88.3%) was similar to that observed in recent studies (Fu et al., 2018), suggesting that many infants are offered iron-rich foods in the early CF period. We also observed a higher likelihood that iron-fortified infant cereals were consumed (64.1%) than that reported in a recent online survey (12%) (Fu et al., 2018) and GUiNZ (47.9%) (Morton et al., 2012). This may be secondary to the increased availability of these products in NZ (Katiforis et al., 2021). However, the continuation of offering iron-fortified cereals in addition to other food groups was low, with only 13.4% of infants consuming an iron-rich food, vegetable, and fruit on both recall days. Further promotion of the importance of offering these foods daily during CF is required in NZ to increase diet diversity and the provision of a wide range of nutritious foods.

4.5.3. Adherence to food group recommendations

Few infants consumed a food from each food group on both diet recall days (6.5%), increasing the risk of nutritional inadequacies. Our results were lower than those reported by GUiNZ (Morton et al., 2012). In GUiNZ, most infants consumed vegetables (91% vs 63.2% in the current study), fruit (87% vs 53.9%), grain foods (90% vs 49.5%), and meat and protein-rich foods (61% vs 31.8%) daily at nine months of age (Gontijo de Castro et al., 2018; Morton et al., 2012). They did not report milk and milk products. The different (and mainly younger) infant ages recruited here could be a factor in why fewer infants met recommendations in our study, with foods often gradually added to infants' diets during the CF transition (Nicklaus, 2009). The difference of approximately one month between average ages (8.4 months in the current study vs 9.0 months in GUiNZ) in the studies, therefore, must be considered. This however, was not the case when comparing results to those reported by Morison et al. (Morison et al., 2016), where the majority of 6–8 month old infants consumed vegetables (96%) and fruit (96%) at least once during a three-day food diary. However, again, differences in methodological approaches (intake was calculated across a three day period) is likely to have contributed to higher results than when assessing daily intakes by 24-hr recall. Therefore, this is the first study to suggest that most infants aged 7.0 to 10.0 months are not meeting MoH food group recommendations, and further investigation into adherence of infants at different ages is required. Investigation into the nutritional implications of not meeting MoH recommendations is also required to determine the impact that current dietary practices have on nutrient intake. Given that 98.6% of parents reported that their infants consumed a varied diet 'sometimes or more', further promotion about the optimal provision of food groups is likely required to support understanding of recommendations promoting daily consumption of each food group from the start of CF.

4.5.4. Adherence to appropriate food and beverage recommendations

Research on the use of added salt and sugar in the infant's diet has provided conflicting results in NZ. The absence of sugar added to food in the current study (90.6%) is the highest adherence observed in NZ to date, higher than GUiNZ (86%) (Gontijo de Castro et al., 2018) and Morison et al. (2016) (55%). Adherence to the salt recommendation, however, was lower (76.5%) than in GUiNZ (84%) (Gontijo de Castro et al., 2018) but higher than reported by Morison et al. (2016) (22%). In the current study, the addition of salt appeared to come from family meals, becoming more frequent with higher parity. This is consistent with results observed in other high-income countries (Bournez et al., 2019; Grummer-Strawn et al., 2008; Kay et al., 2018; Lioret et al., 2013; Wang et al., 2018), indicating a need for education about sources of salt to improve recommendation adherence. Sugar was added to a range of foods, indicating that promotion strategies should focus on key messages (e.g., added sugar is not required in an infant's diet).

Before the current study, GUiNZ was the only study that had reported inappropriate drinks consumed by NZ infants (Gontijo de Castro et al., 2018). They found a moderate adherence (61%) to recommendations, whereas adherence in the current study was considerably higher (93.9%). In alignment with GUiNZ (Gontijo de Castro et al., 2018) and studies from the UK (McAndrew et al., 2012), juice continues to be the most commonly consumed inappropriate drink. Further research into why these beverages continue to be offered would allow targeted approaches to improve recommendation adherence.

4.5.5. Strengths, limitations, and future research

The present findings should be interpreted within the context of the study's strengths and limitations. The FFNZ study recruited a large cohort of ethnically diverse infants. Our results provide important updated information about adherence to the MoH infant feeding guidelines. A potential limitation is that the key indicators used in this study are those from the 2021 guideline release, and our data were collected between June 2020 and February 2022; therefore, a portion of the reported data were collected before the guidelines were available to the public. The decision to compare to the 2021 guidelines was made after comparisons between guidelines showed minimal changes to the key indicators discussed. Although a full analysis of breastfeeding to two years could not be completed, FFNZ provided a snapshot of 'continued breastfeeding' from 7.0 to 10.0 months of age. A small number of infants were born preterm (n=46), and it is not known whether caregivers reported corrected age for starting solid foods or not. A three-pass assessment approach and photographic memory prompts were used to ensure accuracy of diet recalls but the 24-hour diet recalls relied on caregiver-reported data and have the potential for misreporting. Although a full representation of the diet, including the usual intake of foods, cannot be achieved from two diet recalls, low daily consumption of MoH food groups was evident.

Further research is now required to investigate why early breastfeeding cessation is occurring and what interventions can be implemented to support breastfeeding. Investigation into the nutritional implications of not meeting food group recommendations during CF will be important to determine the seriousness of these dietary shortcomings.

4.6. Conclusion

The current study results provide an important update on adherence to the newest MoH infant feeding guidelines in NZ. The initiation of breastfeeding continues to be high, however, EBF to 'around' six months of age is low. Most infants met recommendations for starting solid foods, but many did not consume foods from the MoH food groups daily. The consumption of foods with added salt and/or sugar and inappropriate beverages has improved since previous assessments, however, a small number of caregivers continue to offer these. As seen previously, there are associations between sociodemographic characteristics and adherence, identifying key groups (primiparous mothers, caregivers with lower levels of education, those living with multiple children, and those living in areas of high socioeconomic deprivation) that require additional support with infant feeding. Further research is now required to identify reasons for these findings and the most appropriate support for NZ whānau (families) so that they can adhere to current recommendations.

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Chapter 5

Parent-reported Feeding Behaviours of New Zealand Infants and Associations With Demographic Characteristics And Feeding Practices in the First Foods New Zealand Study

This chapter provides insight into the prevalence of concerning infant feeding behaviours from parent-reported data. The Paediatric Eating Assessment Tool (PediEAT) was used to determine infants with and without concerning feeding behaviours. To provide insight into those who were more likely to report concern, infant and caregiver characteristics were compared. Feeding practices, as discussed in chapters three and four, were also compared to investigate the potential associations between concerning feeding behaviours and current breastfeeding and food group consumption.

This report is presented in manuscript format but has not yet been published.

5.1. ABSTRACT

Background: During complementary feeding, infants are exposed to food for the first time and must learn to accept new flavours and textures. While infant feeding guidelines in New Zealand (NZ) encourage breastfeeding, and the daily consumption of foods from each of the food groups (vegetables and fruit, grain foods, milk and milk products, and meat and protein-rich foods), parents commonly report concerns about feeding behaviours. Within NZ, the prevalence of concerning feeding behaviours (CFB), such as when an infant is unable to eat or will not eat enough despite the availability of appropriate food, is unknown.

Aim: Describe parent-reported feeding behaviours of NZ infants between 7.0 and 10.0 months of age and associations with sociodemographic characteristics and feeding practices.

Methods: Data for 7.0 to 10.0 month old infants (n=544) were obtained from the First Foods New Zealand (FFNZ) observational study. Parents completed the Paediatric Eating Assessment Tool (PediEAT), a sociodemographic questionnaire, and two 24-hour recalls. PediEAT scores (total, physiologic symptoms, problematic mealtime behaviours, selective/restrictive eating, and oral processing) were classified as 'concern' or 'no concern' using the PediEAT scoring system and compared with norm-reference values. Unpaired t-tests (continuous variables) and the chi-squared test (categorical variables) were used to determine associations between PediEAT scores and infant (age, sex, ethnicity, early child education centre (ECE) used outside the home, diagnosed medical condition) and caregiver (age, education, employment, parity, deprivation) sociodemographic characteristics. Logistic regression, adjusted by infant age and deprivation, determined associations between PediEAT scores, current breastfeeding, and food groups consumed during both diet recalls.

Results: 'Concern' feeding behaviours were reported by 17.3% of infant caregivers. Our mean participant score was higher than PediEAT norm-reference values (78.3 vs 66.3 in infants aged 7.0 to 9.0 months and 76.4 vs 64.0 in infants aged 9.1 to 10.0 months). 'Concern' scores were highest for selective/restrictive eating (29.2% of infants), problematic mealtime behaviours (21.5%), and

physiologic symptom (13.7%) subscales, whereas just five infants had oral processing concerns (0.9%). Mothers who were primiparous or highly educated were significantly more likely to report 'total PediEAT scores of 'concern'. Problematic mealtime behaviours were more common in primiparous mothers and caregivers who did not use ECE, those of higher education, and not currently working, and infants of NZ Asian ethnicity. Infants with feeding behaviours that met levels of 'concern' had a lower odds of consuming 'vegetables' and 'meat and protein-rich foods' for the total PediEAT and the selective/restrictive eating subscale. Those with selective/restrictive eating had a lower odds of consuming foods from 'all four food groups' on recall days. Infants in the 'concern' group for total PediEAT and the selective/restrictive eating subscale had a higher odds of consuming 'commercial infant foods' (CIF).

Conclusion: Concerning infant feeding behaviours were prevalent in our study, with 17.3% of parents reporting 'concern' PediEAT scores. First-time mothers and caregivers who were highly educated were more likely to report 'concern' feeding behaviours. Infants with 'concern' feeding behaviours were less likely to meet recommendations for consuming 'vegetables' and 'meat and protein-rich foods' and were more likely to consume 'CIF'. Further investigation is required to understand parental perceptions of feeding behaviours and the nutritional implications of CFB.

5.2. Introduction

Complementary feeding (CF) is a period of rapid dietary change, when an infant transitions from an entirely milk based diet to one that resembles family meals (Ministry of Health, 2021). During CF, infants acquire basic eating skills and develop food preferences that may last a lifetime, with evidence emerging that feeding behaviours formed in early life track into adulthood (Lioret et al., 2013; Nicklaus & Remy, 2013; Northstone & Emmett, 2008; Robinson et al., 2007). These feeding behaviours, characterised by food preferences, acceptance, and consumption, can be advantageous or problematic for long-term health (Thoyre et al., 2014; Williams et al., 2009).

'Normal' feeding is not well defined and many infants experience difficulties when learning to eat (Pados et al., 2018). Gagging (Ministry of Health, 2021) and refusal of new or unfamiliar foods are commonly reported (Beauchamp & Mennella, 2009). These are normal responses, and typically improve as oral motor skills develop and foods become familiar (Ministry of Health, 2021). However, some infants may continue to display concerning feeding behaviours (CFB), affecting food consumption and dietary adequacy (Kerwin, 1999). Concerning feeding behaviours have been defined as when an infant is unable to eat or will not eat enough despite the availability of appropriate foods (Kedesdy & Budd, 1998). Concern about infant feeding behaviours are common among parents in high-income countries. Although there is limited evidence on the prevalence in NZ, other countries have reported that at least 25% of typically developing children display CFB (Benjasuwantep et al., 2013; Goday et al., 2019). This increases to 80% for children with developmental disabilities or diagnosed medical conditions (Gal et al., 2011; Goday et al., 2019). The risk of a child developing CFB has been associated with sex and age (Antoniou et al., 2016; Brown et al., 2018), caregiver sociodemographic characteristics (Tharner et al., 2014), and early feeding experiences (Antoniou et al., 2016; Chilman et al., 2021). Older and male children (Antoniou et al., 2016; Brown et al., 2018; Chilman et al., 2021; Tharner et al., 2014; Wardle et al., 2001), those living in high deprivation, and caregivers with low household income or education have been associated with a higher incidence of fussy eating (Emmett et al., 2018; Qiu & Hou, 2020; Tharner et al., 2015). Early exposure to a variety of foods appears to be protective against CFB (Coulthard et al., 2014; Maier et al., 2007).

The NZ national feeding guidelines 'Healthy Eating Guidelines for New Zealand Babies and Toddlers (0–2 years old)' recommends early and frequent taste exposures after starting CF to promote acceptance and enjoyment of a variety of nutritious foods (Ministry of Health, 2021). Infants should be offered a range of foods daily from each of the food groups: vegetables and fruit; grain foods; milk and milk products; and legumes, nut butters, eggs, fish, seafood and chicken or lean red meat (referred to as meat and protein-rich foods from here), increasing diet diversity from the start of CF. Commercial infant foods (CIF) are a convenient alternative to home-made infant foods; however, if used overused they may reduce textures and flavours in an infant's diet, reducing early exposure to a variety of flavours (World Health Organization, 2019). Repetitive use of CIF is believed to increase CFB (Foterek et al., 2016), however, more studies are required to confirm this relationship, especially with the recent increase in CIF available in NZ recently (Katiforis et al., 2021; Padarath et al., 2020). More infant studies are also required to understand the relationship between CFB and breastfeeding and food group consumption. In children, breastfeeding has been associated with improved initial food acceptance (Hausner et al., 2009; Mennella et al., 2017; Mennella et al., 2001; Sullivan & Birch, 1994) and reduced fussy eating behaviours (Cooke et al., 2004; Galloway et al., 2003). This is thought to be the result of exposure to a variety of flavours from the maternal diet. Children with picky eating tendencies have also been shown to refuse foods from entire food groups, with common reports of limited fruit and vegetable acceptance (Carruth et al., 1998; Perry et al., 2015; Switkowski et al., 2020). Acceptance of discretionary foods may also be higher in toddlers with picky eating tendencies (Perry et al., 2015).

The assessment of CFB is complex, and there are different methods available, including direct observation by a trained practitioner, questionnaires and coding tools, or caregiver reports. Parent-reported questionnaires are minimally burdensome, affordable, highly repeatable, suitable for tracking feeding behaviours over time, and appropriate for using in research (Thoyre et al., 2014). Few validated questionnaires are available to assess infant feeding behaviours; however, the Paediatric Eating Assessment Tool (PediEAT) provides a comprehensive measurement of CFB. The PediEAT provides a total score and categorises concerning behaviours into four subscales (physiologic symptoms, problematic mealtime behaviours, selective/restrictive eating, and oral processing) (Thoyre et al., 2014). PediEAT (78 items) was designed to assess observable symptoms of concerning feeding in infants and children between six months and seven years of age and is validated for those with and without feeding difficulties. A validated scoring system developed by Pados et al. (2018) describes norm-reference values and identifies behaviours that are 'no concern', 'concern', and 'high concern'. Despite increasing knowledge about the importance of early feeding behaviours, the prevalence of CFB in NZ infants is unknown. This study therefore aims to describe parent-reported feeding behaviours of NZ infants between 7.0 and 10.0 months of age and associations with sociodemographic characteristics and feeding practices.

5.3. Methods

5.3.1. Study design

Data were obtained from the First Foods New Zealand (FFNZ) observational study. Data were collected in Auckland and Dunedin regions of NZ between July 2020 and February 2022. FFNZ methods have been published (Taylor et al., 2021) (Appendix 3), therefore, only those relevant to this manuscript are provided. Ethical approval was obtained from the Health and Disability Ethics Committees New Zealand

(19/STH/151), and written informed consent was obtained from participants before data collection. The study was registered with the Australian New Zealand Clinical Trials Registry (www.anzctr.org.au, registration number: ACTRN12620000459921).

5.3.2. Participants

Infants aged 7.0 to 10.0 months who resided in Auckland or Dunedin and had not participated in a recent nutrition intervention study that may have influenced their diet were eligible to participate in FFNZ. Caregivers were required to be 16 years or older and able to communicate in English. Infants and caregivers were recruited through word of mouth, the FFNZ website, and Facebook advertisements. To achieve a sample with ethnic diversity, targeted Facebook posts were used in Māori and Pasifika people's community groups.

5.3.3. Data collection

Participants were invited to attend two study visits at their home, available research centre, or online (during Covid19 restrictions for second the appointment only). Appointments were conducted five to eight days apart on different days of the week to allow for day-to-day dietary variation. At the first appointment, caregivers completed a demographic questionnaire that assessed infant (age, sex, ethnicity, early childhood education centre (ECE) use, diagnosed medical conditions) and caregiver (age, education, employment, parity, deprivation) sociodemographic characteristics (Appendix 13). Participants who reported two or more ethnic groups were assigned to a single group using the Ministry of Health prioritisation system (order of ranking: Māori, Pacific, NZ Asian, Others, European) (Ministry of Health, 2017). Deprivation levels were assigned according to the NZ index of deprivation using the participant's home address (Atkinson et al., 2014). Low deprivation was classified as deciles one to three and high deprivation was classified as deciles eight to 10. The age when complementary foods were introduced and current breastfeeding were also assessed in the questionnaire, with a drop-down menu of ages (e.g. 'five months').

At both appointments, a 24-hour diet recall was administered using the multiple-pass method (Moshfegh et al., 2008). Caregivers were encouraged to take photographs of foods during the reported day and were given measurement prompts to aid in portion size estimation (Appendix 11). In the cases when infants attended an ECE or were cared for by someone else, a food diary with written prompts was provided (Appendix 9). All foods consumed on both diet recall days were coded into food groups that aligned with MoH recommendations, using the FFNZ food coding system (see Chapter 3: Contributions of Key Foods and Food Groups to the Dietary Intake of Infants in the First Foods New Zealand Study: section 3.4. Food coding (page 100) and Appendix 12). Food groups included vegetables, fruit, grain foods, milk and milk products, meat and protein-rich foods, CIF, and discretionary foods. Foods were assigned to a food group if they made a healthy contribution to the diet, as described in the MoH guidelines. This meant that foods such as potato chips, for example, were not considered to contribute to the intake of the 'vegetable' food groups respectively. Food group counts included foods included on both diet recall days, irrespective of the amount consumed. Discretionary foods were defined as foods that did not make a healthy contribution to the diet (Ministry of Health, 2020).

Following their second appointment, participants were emailed a final questionnaire that included PediEAT (Appendix 14). Feeding behaviours were characterised according to PediEAT's (Thoyre et al., 2018) total score (78 items) and physiologic symptoms (27 items), problematic mealtime behaviours (23 items), selective/restrictive eating (15 items), and oral processing (13 items) subscales. The physiologic symptom subscale is novel to PediEAT and assesses symptoms of difficulty coordinating eating and breathing and gastrointestinal irritability. Physiologic symptoms are identified as early indicators of CFB and if effectively managed, reduce the risk of more severe behaviours developing. The second subscale, problematic mealtime behaviours, assesses common fussy eating behaviours, including food acceptance and refusal, stress responses, and food preferences. This scale differentiates between behaviours that are consistent with typical child development and those that require intervention. The third subscale, selective/restrictive eating, assesses the types of food that are refused including texture and temperature preferences, identifying hypersensitivities that may be influencing behaviours. And finally, oral processing assesses discrepancies in oral motor skills including difficulties chewing, moving and swallowing food, identifying those that are likely experiencing physical delays. The PediEAT scoring systems for six to nine and nine to 12 month old infants were used to categorise infants with and without CFB (Thoyre et al., 2014). 'No concern values' were those below values listed in Table 5.1. PediEAT scores for 'concern' and 'high concern' were combined.

Table 5.1: Feeding behaviour criteria for PediEAT total and subscale scores

Feeding behaviour and possible scores	Criteria for 'concern' feeding behaviour	
	7.0-9.0 months	9.1-10.0 months
Total score (0-390)	Score ≥101	Score ≥102
Physiologic Symptoms (0-135)	Score ≥27	Score ≥27
Problematic Mealtime Behaviours (0-115)	Score >30	Score >32
Selective/restrictive eating (0-75)	Score >26	Score >27
Oral processing (0-65)	Score >37	Score >32

5.3.4. Statistical analysis

Variables were reported as percentages and counts; means (SD) for continuous data. Missing data from PediEAT were imputed as the mean of all other items in the scale (Allison, 2001). No score was calculated if the participant was missing more than 20% of the items. To determine differences in sociodemographic characteristics between infants with normal versus CFB unpaired t-tests were used for continuous variables and chi-squared tests were used for categorical variables, with a Fisher's exact test used for categorical variables with less than 10 participants in at least one cell. Logistic regression was used to estimate odds ratios, 95% confidence intervals, and p-values for food group consumption associated with CFB, adjusted for age and deprivation. P-values <0.05 were used to define statistical significance. Odds ratios were only calculated for variables with at least 10 participants in each cell and feeding behaviours with more than 10% of the sample in each category. Analyses were performed using Stata Statistical Software (version 17, StataCorp LP, College Station, TX) and Microsoft Excel (version 16.66).

5.4. Results

Screening questionnaire results were available from 1,424 caregivers; of those, 1,198 were eligible to take part in FFNZ (Figure 5.1). Written consent was obtained from 630 caregivers and 625 were included in the final FFNZ sample. Preterm infants (n=46) were excluded from this analysis as corrected age was not available. Those with two diet recalls and PediEAT responses were included in this study (n=554).

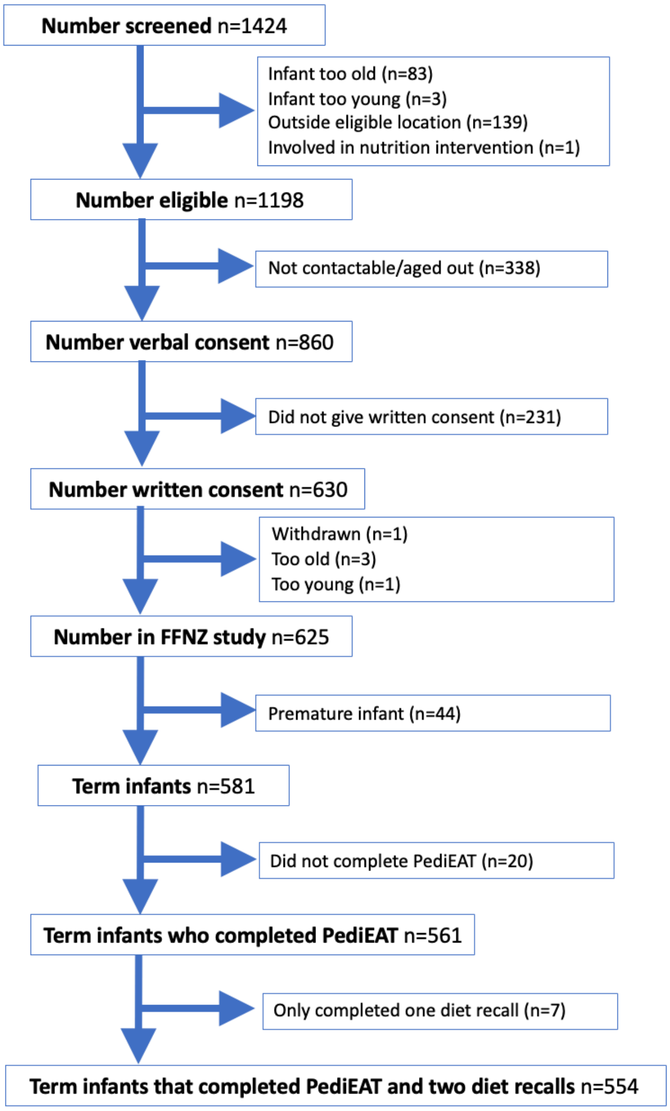

Figure 5.1: First Foods New Zealand study flow diagram of recruitment, consent, and those included in the final analysis

5.4.1. Paediatric Feeding Assessment Tool scores

'Concern' feeding behaviours were reported by 17.3% of infant caregivers and mean PediEAT scores (total, physiologic symptoms, problematic mealtime behaviours, and selective/restrictive eating) were higher than norm-reference values (Table 5.2). The proportion of participants with 'concern' scores was highest in the selective/restrictive eating, problematic mealtime behaviours, and physiologic symptoms subscales. Due to only five infants meeting the criteria for oral processing concern, further analysis was not conducted on this subscale.

Table 5.2: PediEAT norm reference scores for total PediEAT and subscales and participant mean score, with score ranges

	Norm reference values mean (SD)		Mean score (SD)		Infants who met 'concern' criteria (%) [a]	Participant score range
	6-9 months	9-12 months	7.0 to 9.0 months	9.1-10 months		
Total PediEAT scale (0-390)	66.3 (27.2)	64.0 (27.3)	78.3 (24.7)	76.4 (27.9)	17.3	14-169
Physiologic symptoms (0-59)	12.6 (8.7)	11.4 (8.8)	17.6 (8.7)	15.3 (9.4)	13.7	0-59
Problematic mealtime behaviours (0-67)	15.1 (11.1)	16.9 (10.6)	20.8 (12.1)	21.1 (13.2)	21.5	0-67
Selective/restrictive eating (0-75)	14.6 (7.4)	17.3 (7.2)	21.9 (7.8)	20.0 (7.8)	29.2	3-42
Oral processing (0-65)	24.0 (9.7)	18.5 (9.3)	18.7 (6.1)	20.1 (6.6)	0.9	3-40

[a] includes participants who completed at least 80% of the scale. One participant did not complete 80% of the problematic mealtime behaviour subscale, and their responses were excluded from the problematic mealtime behaviour analysis. Due to only five infants meeting the criteria for oral processing concern, further analysis was not conducted.

5.4.2. Feeding behaviours associated with sociodemographic characteristics

Differences between PediEAT scores and sociodemographic characteristics are reported in Table 5.3. Significant differences were found for infants classified as 'concern' versus 'no concern' for maternal education (p=0.041) and parity (p=0.014) (Table 5.3). Primiparous mothers (61.5% in the 'concern' group vs 47.7% in the 'no concern' group) and university educated caregivers (74.7% vs 65.5%) were more likely to report 'concern' behaviours. There were no significant differences between 'concern' total PediEAT scores and infant sociodemographic characteristics.

Significant differences were found for 'concern' problematic mealtime behaviours and use of an ECE, infant ethnicity, maternal education, employment, and parity. First-time mothers (46.5% of infants in the 'no concern' group vs 62.7% in the 'concern' group), those with university education (64.5% vs 76.3%), those who were not currently working (62.7% vs 78.2%), and those who had an infant of NZ Asian ethnicity (13.4% vs 21.0%) were more likely, and those using an ECE (20.3% in the 'no concern' group vs 11.8% in the 'concern' group) were less likely, to report 'concern' scores. There were no significant differences between infant or maternal sociodemographic characteristics and the physiologic symptoms or selective/restrictive eating PediEAT subscales. Although not significant, more infants with diagnosed medical conditions met 'concern' scores for physiologic symptoms (9.0% of infants in the 'no concern' group vs 15.8% of infants in the 'concern' group).

Table 5.3: Sociodemographic characteristics associated with infants in the 'no concern' and 'concern' categories for total PediEAT, physiologic symptoms, problematic mealtime behaviours, and selective/restrictive feeding behaviours (n=554)

	Total sample demographics	Total score			Physiologic symptoms			Problematic mealtime behaviours			Selective/restrictive eating		
	n (%)	No concern	Concern [a]	p-value [b]	No concern	Concern [c]	p-value [b]	No concern	Concern [d]	p-value [b]	No concern	Concern [e]	p-value [b]
n (%)	554 (100)	458 (82.7)	96 (17.3)		478 (86.3)	76 (13.7)		434 (78.5)	119 (21.5)		392 (70.8)	162 (29.2)	
Infant characteristics													
Age, mean (SD) months	8.4 (0.8)	8.3 (0.8)	8.5 (0.8)	0.229	8.4 (0.8)	8.3 (0.8)	0.814	8.4 (0.8)	8.4 (0.8)	0.661	8.4 (0.8)	8.3 (0.8)	0.279
Male sex, n (%) [f]	293 (53.6)	243 (53.2)	50 (52.1)	0.846	251 (52.6)	42 (55.3)	0.668	231 (53.4)	61 (51.3)	0.686	204 (52.2)	89 (54.9)	0.553
Childcare (ECE) used outside of home, n (%)	102 (18.4)	90 (19.7)	12 (12.5)	0.100	93 (19.5)	9 (11.8)	0.150	88 (20.3)	14 (11.8)	**0.034**	69 (17.6)	33 (20.4)	0.444
Ethnicity, n (%)		8.3 (0.8)	8.5 (0.8)	0.229			0.636			**0.033**			0.077
European	314 (56.7)	260 (56.8)	54 (56.3)		271 (56.7)	43 (56.6)		244 (56.2)	69 (58.0)		226 (57.7)	88 (54.3)	
Māori	111 (20.0)	90 (19.7)	21 (21.9)		96 (20.1)	15 (19.7)		89 (20.5)	22 (18.5)		76 (19.4)	35 (21.6)	
Pacific	35 (6.3)	33 (7.2)	2 (2.1)		28 (5.9)	7 (9.2)		32 (7.4)	3 (2.5)		29 (7.4)	6 (3.7)	
NZ Asian	83 (15.0)	64 (14.0)	19 (19.8)		72 (15.1)	11 (14.5)		58 (13.4)	25 (21.0)		51 (13.0)	32 (19.8)	
Others	11 (2.0)	11 (2.4)	0		11 (2.3)	0		11 (2.5)	0		10 (2.6)	1 (0.6)	
Diagnosed medical condition, n (%) [g]	55 (9.9)	43 (9.4)	12 (12.5)	0.354	43 (9.0)	12 (15.8)	0.066	43 (9.9)	12 (10.1)	0.955	37 (9.4)	18 (11.1)	0.549
Caregiver characteristics [h]													
Age, mean (SD) years	32.7 (4.8)	32.8 (4.7)	32.2 (4.8)	0.237	32.7 (4.7)	32.3 (4.9)	0.484	32.6 (4.8)	33.1 (4.7)	0.332	32.7 (4.8)	32.6 (4.7)	0.683
Education, n (%)				**0.041**			0.335			**0.044**			0.062
School	77 (13.9)	66 (14.4)	11 (11.6)		66 (14.4)	10 (13.2)		67 (15.4)	10 (8.5)		46 (11.7)	31 (19.3)	
Polytech	105 (19.0)	92 (20.1)	13 (13.7)		92 (20.1)	10 (13.2)		87 (20.1)	18 (15.3)		78 (19.9)	27 (16.8)	
University	371 (67.1)	300 (65.5)	71 (74.7)		300 (65.5)	56 (73.7)		280 (64.5)	90 (76.3)		268 (68.4)	103 (64.0)	
Employment, n (%)				0.207			0.177			**0.006**			0.415
Fulltime	61 (11.0)	53 (11.6)	8 (8.3)		57 (11.9)	4 (5.3)		52 (12.0)	9 (7.6)		39 (10.0)	22 (13.6)	
Part-time	127 (22.9)	113 (24.7)	14 (14.6)		111 (23.2)	16 (21.1)		110 (25.4)	17 (14.3)		93 (23.7)	34 (21.0)	
Other [i]	366 (66.1)	292 (63.8)	74 (77.1)		310 (64.9)	56 (73.7)		272 (62.7)	93 (78.2)		260 (66.3)	103 (65.4)	
Primiparous, n (%)	277 (50.1)			**0.014**	236 (49.5)	41 (54.0)	0.469			**0.002**	194 (49.6)	83 (51.2)	0.729

	Total sample demographics	Total score			Physiologic symptoms			Problematic mealtime behaviours			Selective/restrictive eating		
	n (%)	No concern	Concern [a]	p-value [b]	No concern	Concern [c]	p-value [b]	No concern	Concern [d]	p-value [b]	No concern	Concern [e]	p-value [b]
Household deprivation, n (%) [J]							0.137			0.133			0.673
1-3 (Low)	165 (29.8)	135 (29.5)	30 (31.3)	0.854	135 (28.2)	30 (39.5)		133 (30.7)	32 (26.9)		121 (30.9)	44 (27.2)	
4-7 (medium)	250 (45.1)	206 (45.0)	44 (45.8)		220 (46.0)	30 (39.5)		186 (42.9)	63 (52.9)		175 (44.6)	75 (46.3)	
8-10 (High)	139 (25.1)	117 (25.6)	22 (22.9)		123 (25.7)	16 (21.1)		115 (26.5)	24 (20.2)		96 (24.5)	43 (26.5)	

Scores are reported as the number and percentage of infants within the ‘no concern’ or ‘concern’ groups. Due to only five infants meeting criteria for oral processing concern, further analysis was not conducted. One participant did not complete 80% of the problematic mealtime behaviour subscale, and their responses were excluded from the problematic mealtime behaviour analysis. [a] scores >101 for infants aged 7.0-9.0 months and >102 for infants aged 9.0-10.0 months, [b] p-values <0.05 were used to define statistical significance. Significant values are bolded, [c] scores >27, [d] scores >30 for infants aged 7.0-9.0 months and >32 for infants aged 9.0-10.0 months, [e] scores >37 for infants aged 7.0-9.0 months and >32 for infants aged 9.0-10.0 months, [f] infant sex was not specified for one participant. [g] included, eczema (n=14), allergies/food intolerances (n=14), reflux or colic (n=9), congenital heart defect (n=5), vesicoureteral reflux (n=4), tongue tie (n=2), and hypospadias (n=2). Individual infants had also been diagnosed with, benign familial neonatal seizures, club foot, epilepsy, failure to thrive, haemangioma of lip, haemolytic disease of the new-born, iron deficiency, laryngomalacia, osteomyelitis, pneumothorax, sleep apnoea, and torticollis. [h] caregiver sociodemographic characteristics (n=554) were collected from 547 mothers, five fathers, one grandparent, and one guardian, [I] includes paid parental leave, unpaid parental leave, and unemployed, [J] defined according to deciles of the NZ index of deprivation using participant home address (Atkinson et al., 2014). No score was calculated if the participant was missing more than 20% of the items. Unpaired t-test were used for continuous variables and the chi-squared test was used for categorical variables (with a Fisher’s exact test used for categorical variables with less than 10 participants in at least one cell).

5.4.3. Feeding behaviours associated with current breastfeeding and the consumption of Ministry of Health food groups

The mean age (SD) of CF was 5.18 months (0.89) and 7.0% of infants consumed foods from all food groups on both diet recall days. Differences between PediEAT scores and current breastfeeding and MoH food group consumption are reported in Table 5.4. Infants with 'concern' total feeding behaviours had a reduced odds of consuming vegetables (p=0.012), meat and protein-rich foods (p=0.009), and a higher odds of consuming CIF (p=0.046). When adjusting for infant age and deprivation, associations strengthened. Infants who were breastfed had a higher odds of 'concern' feeding behaviours (p=0.087), although not significant. Too few infants consumed 'all food groups' for further analysis.

For individual subscales, 'concern' selective/restrictive behaviours were significantly associated with a lower odds of consuming vegetables (p=0.045), and meat and protein-rich foods (p=0.004) and a higher odds of consuming CIF (p=0.035). Infants with 'concern' problematic mealtime behaviours had a lower odds of consuming discretionary foods (p=0.029). 'Concern' problematic mealtime behaviours were also significantly associated with current breastfeeding; those currently breastfed had a higher odds of displaying problematic mealtime behaviours (p=0.003). Associations were maintained when adjusting for infant age and deprivation for all significant variables. There were no significant associations between physiologic symptoms and food group consumption, although strong trends were identified for lower vegetable (p=0.053 after adjustment) and meat and protein-rich food (P=0.058 after adjustment) consumption.

Table 5.4: Food group consumption on both diet recall days associated with infants in the 'no concern' and 'concern' categories for total PediEAT, physiologic symptoms, problematic mealtime behaviours, and selective/restrictive eating (n=554)

			Total score		Physiologic symptoms		Problematic mealtime behaviours		Selective/restrictive eating	
Food group		n (%)	No concern	Concern [a]	No concern	Concern [b]	No concern	Concern [c]	No concern	Concern [d]
n= 554			458 (82.7)	96 (17.3)	478 (86.3)	76 (13.7)	434 (78.5)	119 (21.5)	392 (70.8)	162 (29.2)
Vegetables, n (%)		361 (65.3)	310 (67.7)	52 (54.2)	319 (66.7)	43 (56.6)	286 (65.9)	75 (63.0)	271 (69.1)	91 (56.2)
	Odds ratio (95% CI)		Reference	**0.56 (0.36, 0.88)**	Reference	-	Reference	0.88 (0.58, 1.34)	Reference	**0.57 (0.39, 0.83)**
	Adjusted [e] odds ratio (95% CI)		Reference	**0.53 (0.34, 0.83)**	Reference	-	Reference	0.84 (0.55, 1.29)	Reference	**0.58 (0.40, 0.85)**
Fruit, n (%)		300 (54.3)	250 (54.6)	51 (53.1)	262 (54.8)	39 (51.3)	232 (53.5)	68 (57.1)	213 (54.3)	88 (54.3)
	Odds ratio (95% CI)		Reference	0.94 (0.61, 1.47)	Reference	0.87 (0.54, 1.41)	Reference	1.16 (0.77, 1.75)	Reference	1.00 (0.69, 1.44)
	Adjusted [e] odds ratio (95% CI)		Reference	0.88 (0.56, 1.38)	Reference	0.86 (0.53, 1.42)	Reference	1.11 (0.73, 1.69)	Reference	1.04 (0.72, 1.53)
Grain foods, n (%)		275 (49.7)	233 (50.9)	42 (43.8)	239 (50.0)	36 (47.4)	222 (51.2)	53 (44.5)	198 (50.5)	77 (47.5)
	Odds ratio (95% CI)		Reference	0.75 (0.48, 1.17)	Reference	0.90 (0.55, 1.46)	Reference	0.77 (0.51, 1.15)	Reference	0.89 (0.62, 1.28)
	Adjusted [e] odds ratio (95% CI)		Reference	0.71 (0.45, 1.12)	Reference	0.90 (0.55, 1.48)	Reference	0.75 (0.50, 1.14)	Reference	0.92 (0.63, 1.33)
Milk and milk products, n (%)		223 (40.3)	186 (40.6)	37 (38.5)	193 (40.4)	30 (40.3)	173 (39.9)	49 (41.2)	166 (42.4)	57 (35.2)
	Odds ratio (95% CI)		Reference	0.92 (0.58, 1.44)	Reference	0.96 (0.59, 1.58)	Reference	1.06 (0.70, 1.59)	Reference	0.74 (0.51, 1.08)
	Adjusted [e] odds ratio (95% CI)		Reference	0.87 (0.55, 1.38)	Reference	0.96 (0.58, 1.60)	Reference	1.07 (0.70, 1.62)	Reference	0.76 (0.51, 1.12)
Meat and protein-rich foods, n (%)		184 (33.3)	164 (35.8)	21 (21.9)	166 (34.7)	19 (25.0)	147 (33.9)	37 (31.1)	150 (38.3)	35 (21.6)
	Odds ratio (95% CI)		Reference	**0.50 (0.30, 0.84)**	Reference	0.63 (0.36, 1.09)	Reference	0.88 (0.57, 1.36)	Reference	**0.45 (0.29, 0.68)**
	Adjusted [e] odds ratio (95% CI)		Reference	**0.47 (0.27, 0.79)**	Reference	0.58 (0.33, 1.02)	Reference	0.84 (0.54, 1.32)	Reference	**0.45 (0.29, 0.70)**
Discretionary foods, n (%)		93 (16.8)	80 (17.5)	13 (13.5)	82 (17.2)	11 (14.5)	81 (18.7)	12 (10.1)	68 (17.4)	25 (15.4)
	Odds ratio (95% CI)		Reference	0.74 (0.39, 1.39)	Reference	0.82 (0.42, 1.66)	Reference	**0.49 (0.26, 0.93)**	Reference	0.87 (0.53, 1.43)
	Adjusted [e] odds ratio (95% CI)		Reference	0.71 (0.38, 1.35)	Reference	0.83 (0.42, 1.66)	Reference	**0.49 (0.26, 0.94)**	Reference	0.91 (0.55, 1.51)
Commercial infant foods, n (%)		232 (42.0)	183 (40.0)	49 (51.0)	198 (41.4)	34 (44.7)	177 (40.8)	55 (46.2)	153 (39.0)	79 (48.8)
	Odds ratio (95% CI)		Reference	**1.56 (1.01, 2.44)**	Reference	1.14 (0.70, 1.87)	Reference	1.25 (0.83, 1.88)	Reference	**1.49 (1.03, 2.15)**
	Adjusted [e] odds ratio (95% CI)		Reference	**1.58 (1.01, 2.48)**	Reference	1.23 (0.75, 2.03)	Reference	1.25 (0.82, 1.89)	Reference	**1.49 (1.03, 2.17)**
Current breastfeeding, n (%)		379 (68.4)	306 (66.8)	73 (76.0)	328 (68.6)	51 (67.1)	283 (35.2)	95 (79.8)	273 (69.6)	106 (65.4)
	Odds ratio (95% CI)		Reference	1.58 (0.95, 2.62)	Reference	0.93 (0.56, 1.56)	Reference	**2.11 (1.29, 3.45)**	Reference	0.83 (0.56, 1.22)
	Adjusted [e] odds ratio (95% CI)		Reference	1.56 (0.94, 2.60)	Reference	0.92 (0.54, 1.54)	Reference	**2.06 (1.26, 3.38)**	Reference	0.83 (0.56, 1.23)

Food group counts included infants that consumed foods from each respective food group during both diet recalls. Scores are reported as number and percentage of infants within the 'no concern' or 'concern' group. Due to only five infants meeting criteria for oral processing concern, further analysis was not conducted. One participant did not complete 80% of the problematic mealtime behaviour subscale, and their responses were excluded from the problematic mealtime behaviour analysis. Comparison groups were not large enough for an odds ratio analysis of 'all food groups' [a] scores >101 for infants aged 7.0-9.0 months and >102 for infants aged 9.0-10.0 months, [b] p-values <0.05 were used to define statistical significance. Significant values are bolded, [c] scores >27, [d] scores >30 for infants aged 7.0-9.0 months and >32 for infants aged 9.0-10.0 months, [e] scores >37 for infants aged 7.0-9.0 months and >32 for infants aged 9.0-10.0 months, [e] adjusted for baby age and NZ deprivation. Odds ratio scores with p-values <0.05 have been bolded to highlight significant results. Logistic regression was used to estimate odds ratios, 95% confidence intervals, and p-values for food group consumption associated with concern feeding behaviours, adjusted for age and deprivation. P-values <0.05 were used to define statistical significance. Odds ratios were only calculated for variables with at least 10 participants in each cell and feeding behaviours with more than 10% of the sample in each category.

5.5. Discussion

Complementary feeding is a crucial time for the establishment of healthy feeding behaviours, although little research has focused on the prevalence of infant CFB. FFNZ is the first study to use the PediEAT to describe parent-reported feeding behaviours in healthy term infants living in NZ, identifying that 17.3% of infants were categorised with CFB. Primiparous mothers and caregivers with a university level education were more likely to report CFB than multiparous mothers and caregivers with a school or polytechnic education. Infants with CFB were significantly less likely to consume vegetables and meat and protein-rich foods and more likely to consume CIF.

5.5.1. Comparison of FFNZ PediEAT scores with norm-reference values and other studies

Our mean total score was higher than the PediEAT norm-reference value, identified by Pados et al. (2018). This was likely a result of our study having higher scores for physiologic symptoms, problematic mealtime behaviours, and selective/restrictive eating. By contrast, oral processing scores were lower in our study. Caregiver and infant sociodemographic characteristics may explain differences between results. We found significant associations between feeding behaviour scores for maternal education, employment and parity, the use of ECE, and infant ethnicity. Although parity, ECE use, and maternal employment were not reported in the norm-reference study (Pados et al., 2018), there were differences in maternal education and infant ethnicities between studies. Our caregivers were more highly educated and infant ethnicities aligned with the NZ population, compared to the norm-reference study that recruited infants from the United States of America, Columbia, Australia, Canada, Malaysia, the United Kingdom, NZ, and Ireland (Pados et al., 2018). Opposingly, our study results were lower than those reported in previous studies that have used PediEAT in infants (Pados & Harrison, 2022; Park et al., 2018). These studies, however, focused on infants with diagnosed medical conditions, making comparisons between studies inappropriate.

5.5.2. Sociodemographic associations with total PediEAT scores

Primiparous mothers were more likely to report concerning PediEAT scores. Our results align with previous studies showing differences in knowledge, expectations, attitudes, and experience in first-time mothers than those with other children (Holowko et al., 2016; Kieffer et al., 1997; Leahy Warren, 2005;

McVeigh, 1997). For primiparous mothers, the care and feeding of infants is new and often met with high levels of anxiety and fear (Gameiro et al., 2009). With no clear definition of what is 'normal' during CF, they may be more likely to report concern than mothers with previous experience who have seen the behaviours resolve with time. Problematic mealtime behaviours seemed to be the main form of concern, suggesting that further insight into caregiver perception of these behaviours is required.

We also observed a significant association between concerning PediEAT scores and university educated caregivers, who represented the majority of our caregivers. Previously higher maternal education has been associated with a higher adherence to infant feeding guidelines (Gontijo de Castro et al., 2018; Hendricks et al., 2006; Robinson et al., 2007). Knowledge may impact adherence (Robinson et al., 2007), with university educated caregivers having greater access to support and financial resources (Cameron et al., 2014). Studies suggest that greater knowledge increases the chance of understanding and achieving guidelines (Chezem et al., 2003; Kostecka et al., 2020; Wojcicki et al., 2009). However, this knowledge may also increase anxiety for CFB, as seen in children (Saxton et al., 2009). Infants of NZ Asian ethnicity and mothers who were not working were also more likely to report concerning mealtime behaviours, while attendance at an ECE seemed to be protective. Differences in adherence to infant feeding guidelines have been reported for different ethnic groups in NZ, with NZ Asian populations commonly having the highest adherence (Gontijo de Castro et al., 2018). As discussed for education, this may lead to greater anxiety around behaviours. Maternal working status and the use of an ECE are likely interconnected variables, with higher scores reported for infants who are predominately cared for by their caregiver. The influence of shared eating environments in ECE is another possible factor that may support food acceptance, as shown in children (Birch, 1980).

5.5.3. PediEAT subscale findings

Selective/restrictive eating was the highest scored subscale. This is fitting for our cohort, with previous studies identifying that selective/restrictive eating increases during the CF period when infants are exposed to new foods, textures, and flavours (Coulthard et al., 2014; Maier et al., 2007; Pados et al., 2018). The mean age of introduction of solid foods in our study was 5.18 months, suggesting that most infants were past the initial stages of CF and likely being offered new foods of different textures and flavours. An infant's refusal of new or unfamiliar foods, therefore, may have explained a high prevalence of selective/restrictive eating. No sociodemographic characteristics were associated with this subscale, suggesting that some degree of selective/restrictive eating may be normal for infants when using the

PediEAT. Previously, breastfeeding has been indicated as a protective factor for food acceptance (Harris & Coulthard, 2016; Hausner et al., 2009; Maier et al., 2008; Mennella, 2009; Mennella et al., 2001). Although there were trends, no significant differences were observed between those who were currently breastfed in our study.

Problematic mealtime behaviours were the second most common CFB. Although these behaviours are thought to increase as an infant becomes able to express their food preferences and exert independence (Cano et al., 2015) and tend to peak in childhood (Pados et al., 2018), we observed that 22% of infants already met concerning levels; indicating concern for long-term feeding behaviours in this group. Associations between problematic mealtime behaviours and infants of NZ Asian ethnicity, primiparity, and caregivers who were not currently working have not been reported before and suggest groups that may need further investigation. We found conflicting results for caregiver education. Previously, 'fussy eating' behaviours in children have been associated with mothers with lower education (Emmett et al., 2018; Qiu & Hou, 2020; Tharner et al., 2015); however, our results were highest for university educated caregivers. These studies were carried out in different population groups and used different definitions of 'fussy eating behaviours', and assessment methods, which may explain differences. The influence of maternal knowledge, as discussed, could also be a factor to consider when using parent-reported behaviours.

The assessment of physiologic symptoms is novel to PediEAT (Pados et al., 2018; Thoyre et al., 2018). Physiologic symptoms, however, are often a normal part of early CF when the digestive system is adapting to solid foods and infants are learning the process of biting, chewing, and swallowing. For caregivers, these symptoms may cause alarm, however, they will often resolve as time passes and eating skills develop. In previous studies, physiologic symptoms have been significantly associated with medical conditions (Pados & Harrison, 2022; Park et al., 2018). We also observed this trend, however, few infants had diagnosed medical conditions and results were not significant.

5.5.4. Feeding behaviours and food group consumption

Previously, breastfeeding has been associated with greater food acceptance, with exposure to maternal dietary flavours in breast milk promoting acceptance (Harris & Coulthard, 2016; Hausner et al., 2009;

Maier et al., 2008; Mennella, 2009; Mennella et al., 2001). However, we found a higher prevalence of concerning scores in those currently breastfeeding. There are multiple reasons why we may have observed this, including mothers continuing to breastfeed concerning infants to ensure nutritional adequacy or infants filling up on milk feeds before solid meals, displacing their appetite for food. Further research is required to understand this relationship.

Infants with CFB had a lower odds of consuming meat and protein-rich foods and vegetables. The reason why these food groups were less frequently consumed in infants with CFB cannot be distinguished from our observational results and could be a multifactorial outcome of innate food preferences, limited food exposure, family feeding practices, and infant feeding characteristics (Fisher & Dwyer, 2016). However, selective/restrictive eating appeared to be a significant behaviour associated with consumption. This was not surprising and aligns with previous studies that have identified fussy/picky eating as a predictor for low vegetable, fruit, and meat and protein-rich food consumption in toddlers (Van Der Horst et al., 2016) and children (Cooke et al., 2006; Cooke et al., 2004; Dubois et al., 2007). Fruit and grain foods (baby rice) are common first foods introduced in NZ (Morton et al., 2012) and are typically well accepted. These foods commonly have a sweet nutrition profile that is favourable for infants' innate preference for sweet flavours (Nicklaus, 2016; Schwartz et al., 2009). We did not observe any differences between the consumption of fruit and grain foods between infants with and without CFB. Possible reasons for this include an early introduction of flavours, continued exposure, and their sweet taste profile.

The associations between feeding behaviours and CIF was also a significant finding; 'concern' infants having a 1.5 times higher odds of consuming CIF. In NZ, recent studies have highlighted that most CIF, including pouches, mixed dishes (jars, cans, etc), and infant snacks contain sweet fruits and vegetables (Katiforis et al., 2021; Padarath et al., 2020), while other such as fortified infant cereals have a naturally sweet profile. This makes products highly palatable for infants who have a natural preference for sweet flavours. The taste profile of CIF may, therefore, encourage food acceptance in infants with CFB, including selective/restrictive eating tendencies. Although this initially supports food consumption, it can exacerbate CFB, as early exposure to a variety of flavours promotes greater food acceptance in later life (Coulthard et al., 2010; Coulthard et al., 2014; Gerrish & Mennella, 2001; Maier et al., 2008). The naming of products could be a barrier for parents in achieving food variety recommendations, with many front of pack labels not accurately reflecting the contribution of ingredients (Katiforis et al., 2021; Padarath et al., 2020). For example, a product labelled 'chicken, sweet corn, and brown rice' available in NZ contains more sweet potato and carrot than sweet corn (25%), chicken (3.5%), and rice (3%) (Countdown, 2023). Caregivers may think they are providing a variety of foods and flavours to support optimal feeding behaviours; however, in reality 'sweet' flavours are likely to be masking the flavour of other foods. The mode of feeding CIF may also influence food acceptance. Recently the Australian Feeding Infants and Toddlers (OzFITS) Study reported that 50% of children under the age of two years that were provided pouches consumed them directly from the nozzle (Netting et al., 2022). This bypasses the sensory processes of feeding, reducing an infant's visual exposure; ability to touch, taste, and smell; need to chew, manipulate, and move food around in the mouth (Koletzko et al., 2019). Consuming food directly from the pouch nozzle may also mean that mealtimes are faster than if the food was spoon-fed (Theurich, 2018). For infants with selective/restrictive eating tendencies, faster and easier mealtimes may mitigate concerning behaviours; however, without exposure to the physical form and smell of food, different textures and development of feeding skills, behaviours are likely to worsen (Koletzko et al., 2019). We did not see the same relationship with discretionary foods. However, few infants consumed discretionary foods on both recall days in our study, making comparison groups small.

5.5.5. Strengths and limitations

A key strength was FFNZ's large ethnically diverse sample. Our sample allowed insight into the prevalence of infant feeding behaviours, being the first NZ study to explore associated sociodemographic characteristics and associations between feeding behaviours and food group consumption. With our current observational data, we cannot determine the cause of the reported behaviours, however, have provided insight into areas that require further investigation. There is no gold standard for identifying problematic mealtime behaviours (Thoyre et al., 2014). The PediEAT has several advantages, such as parents being able to classify reoccurring behaviours within the home, without the need for unfamiliar mealtime environments or observers during formal assessments. This makes the tool highly repeatable and cost effective for research studies. Parental perceptions, however, have an inherent bias and parents may have under or over reported symptoms. Other strengths and limitations were associated with our food group data. A three pass approach with photographic and measurement prompts was utilised to promote accuracy in recall collections, allowing insight into the current food groups consumed by infants in NZ. Diet recalls, however, have inherent limitations, including the reliance on caregiver memory to recall all foods consumed and the inability to represent day-to-day variations within the diet, with our data providing a snapshot of food consumption. Foods were allocated to their corresponding food group irrespective of the amount consumed and we cannot determine portion sizes consumed. We also cannot determine the influence of feeding environments and previous food exposure in our results.

We have previously identified that the majority of FFNZ infants did not meet MoH food group guidelines and associations between feeding behaviours have now been found. Future research will address how feeding behaviours affect daily nutrient provision. This will be important for public health advisors, with 17.3% of caregivers reporting CFB. Highlighting the detrimental influence of CFB will emphasise the importance of early assessment and intervention, promoting a public health response for those affected.

5.6. CONCLUSION

The CF period has been identified as a window of opportunity for later food acceptance and feeding behaviours. Our results highlight the importance of early assessment and intervention of CFB, particularly selective/restrictive eating, problematic mealtime behaviours, and physiologic symptoms, with significant associations with the consumption of food groups. Mothers who are primiparous, highly educated, have NZ Asian infants, and who are not currently working were more likely to report concern, with further research required to investigate these relationships. Infants with CFB were also less likely to meet recommendations for vegetables and meat and protein-rich foods and were more likely to consume CIF. Further investigation is required to understand the nutritional implications of CFB.

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CHAPTER 6

CONCLUSIONS AND FUTURE RECOMMENDATIONS

This chapter provides an overview of this research and explores the implications of the findings. Strengths and limitations are discussed, in addition to suggestions for future research.

6.1. Study Summary and Achievement of Aims and Objectives

This thesis aimed to investigate the following:

1. Contributions that key foods and food groups make to the dietary intake of New Zealand infants,
2. Adherence of infants to key dietary indicators based on the Ministry of Health's Healthy Eating Guidelines for New Zealand Babies and Toddlers (0–2 years old),
3. Describe parent-reported feeding behaviours of New Zealand infants and associations with demographic characteristics and feeding practices.

To achieve study aims, data were obtained from the First Foods New Zealand (FFNZ), a New Zealand (NZ) Health Research Council funded observational study. Between July 2020 and January 2022, 625 infants living in Auckland and Dunedin aged 7.0 to 10.0 months participated in FFNZ. Infants and their caregivers were invited to attend two study visits. During appointments, caregivers completed a demographic and feeding questionnaire and two 24-hour recalls. Appointments were conducted five to eight days apart to allow for day-to-day diet variations. After their second appointment, caregivers were emailed a final questionnaire, which included the Paediatric Eating Assessment Tool (PediEAT).

Key results and their significance are discussed in the following sections.

Contributions that key foods and food groups make to the dietary intake of New Zealand infants

Across two diet recalls, infants consumed a wide range of foods. Most consumed vegetables, fruit, grain foods, milk and milk products, and meat and protein-rich foods at least once during the study. However, the intake of each food group was much lower when identifying foods consumed during both 24-hour diet recall days, with only 6.5% of infants consuming all five food groups on both days. This suggests that daily consumption, as recommended by the Ministry of Health (MoH) (Ministry of Health, 2021a), of each food group is low, increasing the risk of nutritional inadequacies and subsequent health consequences (World Health Organization, 2009). The different infant ages recruited could explain why many infants did not meet guidelines and why our results were lower than those previously observed in NZ (Gontijo de Castro et al., 2018), with foods often gradually added to infants' diets during the complementary feeding (CF) transition (Nicklaus, 2009). Older infants were more likely to consume all food groups, with more time passing for caregivers to introduce and infants to accept foods. This agrees with the study hypotheses that an infant's diet rapidly changes during CF, with food variety increasing with age. The impact this transition period has on nutritional adequacy is currently unknown, and further analysis of FFNZ data is required to determine the nutritional implications of not meeting all food group recommendations from the start of CF.

Meat and protein-rich foods were the least frequently consumed food group (31.8% on both diet recall days), agreeing with previous studies in America (Fox et al., 2004; Grummer-Strawn et al., 2008) and New Zealand (NZ) (Gontijo de Castro et al., 2018). Secondary to a low consumption of meat and protein-rich foods, few infants consumed sources of haem iron. This is concerning as infants' iron requirements increase when iron stores become depleted around six months of age (Ministry of Health, 2021a). Breast milk is a relatively low source of iron, therefore, rich sources, particularly haem iron, are required in the diet. Iron-fortified infant cereals were the most common iron-rich food consumed (33.4% of infants at least once) and consumption appeared to align with other NZ studies (Fu et al., 2018; Morton et al., 2014), identifying that many NZ infants obtain iron from commercial infant foods (CIF) available in NZ.

Grain foods were the second least commonly consumed food group, consumed by 49.5% of infants on both diet recall days. As seen in the Growing Up in New Zealand study (GUiNZ) (Gontijo de Castro et al., 2018) and NZ Adult Nutrition Survey results (Parnell et al., 2011), bread was the most common grain food consumed, showing that for this age group the choice of bread as the vehicle to increase iodine intake was an appropriate choice for iodine fortification schemes implemented in 2009 (Ministry of Primary Industries, 2021). Another observation that aligned with results in the NZ adult population (Ministry of Primary Industries, 2021) was the use of plant-based milks, despite the MoH not recommending their use in infants under one year of age (Ministry of Health, 2021a). Plant-based milks were consumed by 9.9% of infants. Of those, 37% of milks chosen did not meet the MoH's adult calcium guidelines of at least 100mg of calcium per 100mL (Ministry of Health 2020). This is concerning with trends surrounding the use of plant-based milks increasing (Bridges, 2018; Mäkinen et al., 2016) and notable nutritional differences between plant-based milks and cow's milk.

The 10 most commonly consumed foods were carrot, banana, bread, brassicas, kumara, extruded commercial infant snacks, pumpkin, apple, potato, and commercial infant pouches. Most of the frequently consumed foods had a sweet nutrition profile. In older infants, there was a trend for increased food and flavour diversity. Most infants (78%) consumed CIF at least once and 42% consumed products on both diet recall days, suggesting that CIFs contribute to the diet of many infants. This was higher than previously observed in NZ (Morton et al., 2014), showing the potential impact of increased product availability. With an increased use of CIF and recent studies expressing concern about the sweet nutrition profile and energy, sugar, iron, meat, fish and poultry content (Katiforis et al., 2021; Padarath et al., 2020), further exploration of the nutritional impact of CIFs is required. Discretionary foods, such as sweets, chocolate, and juice, were offered less frequently than previously identified (Gontijo de Castro et al., 2018). However, many infants consumed marmite/vegemite products, likely due to nutritional promotions for iron and B vitamins (Sanitarium, 2022). Because these products contain high amounts of sodium, further education about their salt/sodium content is required.

Adherence of infants to key dietary indicators based on the Ministry of Health's Healthy Eating Guidelines for New Zealand Babies and Toddlers (0–2 years old),

FFNZ was the first NZ study to investigate adherence to the 2021 MoH infant feeding guidelines and found varying levels of adherence to the current six feeding statements. Adherence levels were mostly higher than those reported in the GUiNZ study (Gontijo de Castro et al., 2018). However, few infants met guidelines for the daily consumption of MoH food groups which was of concern. Different sociodemographic characteristics were associated with adherence, as hypothesised. Deprivation, caregiver education, parity, and the number of children in the household were the most common characteristics associated with guideline adherence.

As found previously in NZ (Gontijo de Castro et al., 2018), the initiation of breastfeeding was high in FFNZ. However, many did not meet MoH recommendations for exclusive breastfeeding (EBF) to 'around' six months of age. Half of those who did not meet the EBF guideline stopped in the first month. These results may indicate a crucial time window to support EBF that needs further investigation. The reason why women stopped EBF was not determined in our study, however, we found that primiparous mothers were less likely to meet recommendations. This has been observed previously, with associations identified between EBF and previous breastfeeding experience (McAndrew et al., 2012). Increased breastfeeding support may be beneficial for primiparous mothers, as seen previously (Wong et al., 2021), however, further investigation of why mothers stop EBF is required to determine what resources would be appropriate. We also observed that caregivers who were older, higher educated, not currently working, and infants who did not attend early child education centres (ECE) were more likely to meet EBF recommendations. This agrees with global findings, with these sociodemographic characteristics often being interconnected with socio-economic status, with those who are more highly educated having greater opportunity to take paid maternity leave than those who are less highly educated and require ECE support when returning to work (Gallegos et al., 2020; McAndrew et al., 2012).

Experience also seemed to be a factor for current breastfeeding, with mothers of two children being more likely to be breastfeeding at the time of participation. Returning to work, using childcare, and living in high deprivation, were also associated with early cessation of breastfeeding. These results identified women who potentially need additional support to sustain breastfeeding. However, more research is required to determine why women stop breastfeeding and what resources are required to support guideline adherence.

Most infants met guidelines for the introduction of solid foods, with trends between our study and recent literature (Fu et al., 2018; Ministry of Health, 2021b) that the age of CF is occurring later, aligning with MoH guidelines (Ministry of Health, 2021a). However, some individuals had a higher risk of not meeting recommendations, including those with lower education levels and living in high deprivation. Higher adherence to guidelines for infants attending an ECE was a new finding and requires additional investigation, however, may suggest an area of positive dietary influence. Most infants were spoon-fed puréed foods when starting solid foods, however, caregivers with a higher education were less likely to meet guidelines, which aligns with those who are more likely to follow trends for baby-led weaning (BLW) (Brown, 2016). With increasing trends surrounding BLW, further research is required to determine the impact on nutritional adequacy and the safety of feeding whole foods. BLW weaning practices oppose guidelines for spoon-feeding and the use of puréed foods, therefore, if trends continue, we may see a decline in guideline adherence, highlighting the importance of understanding the impact of these practices.

As shown in 'chapter 3', the daily adherence to MoH food group recommendations was low, particularly when two days were assessed. This was concerning, and further research is required to determine the nutritional implications of low adherence during the CF period. Most infants were offered iron-rich foods when starting solid foods, although the daily intake of iron-rich foods was low, increasing the risk of iron deficiency during a crucial time of growth and development. How feeding practices used by FFNZ whānau (families) influence the intake of iron is yet to be released. These results will be important to determine the nutritional implications of few infants meeting the MoH guidelines for the daily consumption of iron-rich foods.

The offering of appropriate foods and beverages was met by most caregivers, although there is still room for improvement, with higher parity significantly associated with reduced adherence in our study. This may be a result of the availability of different foods in the household when older siblings are present (Ayre et al., 2022; Ruggiero et al., 2021). We observed a higher adherence to beverage guidelines than observed in GUiNZ (Gontijo de Castro et al., 2018). Juice was the most frequently consumed inappropriate beverage and was consumed 6.6% of infants. Juice can damage infants' teeth and contains high quantities of sugar, and further investigation into why parents continue to offer such beverages is required to further improve adherence. The avoidance of added sugar has also improved since GUiNZ, however, more infants consumed foods with added salt. The main sources of added salt and sugar were family foods, with a higher consumption in infants with siblings. Low adherence in older infants has also been observed previously (Bournez et al., 2019; Grummer-Strawn et al., 2008; Kay et al., 2018; Lioret et al., 2013; Wang et al., 2018), suggesting that education around the addition of salt and sugar to family foods would be beneficial in NZ.

Describe parent-reported feeding behaviours of New Zealand infants and associations with demographic characteristics and feeding practices.

Until now, the prevalence of concerning infant feeding behaviours (CFB) in NZ was unknown. We identified that 17.3% of parents reported CFB according to the PediEAT total scoring system, higher than the PediEAT norm-reference value (Pados et al., 2018). Higher mean values for total scores and the selective/restrictive eating, problematic mealtime behaviours, and physiologic symptoms subscales were observed. However, results for oral processing were lower (e.g. of less concern). Demographic characteristics likely explain differences between our results and norm-reference values. Our population had more highly educated caregivers and infants of different ethnicities than those included in the PediEAT validation study (Thoyre et al., 2014). Other demographic characteristics, including parity, the use of ECE, and maternal employment could not be compared as they were not reported in the norm-reference study (Pados et al., 2018).

As hypothesised, we saw associations between concerning behaviours and sociodemographic characteristics. Mothers who were primiparous, higher educated, not currently working, not using an ECE, and had an infant of NZ Asian ethnicity were more likely to report CFB. Although we cannot determine why these sociodemographic characteristics were associated with CFB with an observational study design, they align with previous research in children that found associations between CFB and those living in high deprivation and caregivers with low household income or education (Emmett et al., 2018; Qiu & Hou, 2020; Tharner et al., 2015). A key limitation of using a parent-reported feeding behaviour questionnaire is the influence of participant bias (Thoyre et al., 2014). Previously in NZ, higher adherence to infant feeding guidelines has been shown for mothers who were primiparous, higher educated, and of NZ Asian ethnicity (Gontijo de Castro et al., 2018), which may suggest that these individuals have a higher awareness of guidelines and potential CFBs, increasing their sensitivity to questions (Saxton et al., 2009). Further research is now required to investigate the impact of caregiver perception on PediEAT responses to determine if 'concern' feeding scores were secondary to perceptions or clinical symptoms.

As hypothesised, we also saw differences in feeding behaviours and current breastfeeding, although not the results we thought we might observe. Previously breastfeeding has been associated with reduced CFBs in children (Cooke et al., 2004; Galloway et al., 2003; Hausner et al., 2009; Mennella et al., 2017; Mennella et al., 2001; Sullivan & Birch, 1994), however, we saw higher problematic mealtime behaviours in those currently breastfeeding. We cannot determine the reason why we observed this result, and further investigation is required.

Finally, our hypothesis that 'infants with concerning parent-reported feeding behaviours will be less likely to consume MoH food groups and more likely to consume CIF than those without' was supported by our data. Infants with CFB, likely due to the selective/restrictive eating subscale, were less likely to consume vegetables and meat and protein-rich foods. This agrees with previous research in children, with vegetables often being the most commonly refused food group acceptance (Carruth et al., 1998; Perry et al., 2015; Switkowski et al., 2020). There were no differences in acceptance of fruit or grain foods which may align with these foods often being offered as first foods (Ministry of Health, 2021a) or an infant's innate preference for sweet flavours (Nicklaus, 2016; Schwartz et al., 2009). Flavour profiles may also explain why we observed a positive relationship between CFB and CIF consumption, with many products available in NZ having a sweet nutrition profile (Katiforis et al., 2021; Padarath et al., 2020). Further exploration surrounding the nutritional implications of CFB is now justified.

6.2. Strengths and Limitations

FFNZ is one of few observational studies investigating infant nutrition in an ethnically diverse sample in NZ. Our research has various strengths, including our study design, methodology, demographic characteristics, and outcomes.

The use of a observational study design allowed FFNZ to collect a wide array of data from a large cohort, answering a broad range of study objectives in different research disciplines. Through our study design, we were unable to determine the cause and effect relationship between study variables, however, we have provided insight into infant nutrition and areas that require further investigation. Our research methods, including offering home visits, ensured the recruitment of a diverse sample. This allows our results to be translated to the general population, highlighting individuals who have an increased risk of nutritional inadequacies. Our methods allowed FFNZ researchers to collect data during Covid19 restrictions, when many studies were unable to proceed. Using validated questionnaires increased the reliability and the quality of our data. The use of two 24-hour diet recalls on different days of subsequent weeks allowed insight into a wide range of foods consumed without the limitations of a food frequency questionnaire (FFQ) that has a set number of foods investigated. Limitations exist for the 24-hour diet recalls; however, strategies were implemented to mitigate limitations, including using a three-pass dietary assessment, photographic prompts, grid sheets, and measurement aids.

Our study outcomes are also a strength, filling gaps in our current knowledge. We were the first study to provide a comprehensive list of foods consumed by infants in NZ, showing trends of increased diversity in older infants. We have also described adherence to the recently updated key infant feeding guidelines, identifying areas that NZ whānau (families) are doing well and what can be improved. Finally, we were the first study to identify the prevalence of parent-reported feeding behaviours in NZ infants and associated sociodemographic characteristics and feeding practices.

Additional limitations should also be considered when reviewing our findings. Participation in the study was optional, however, participants received $150 in vouchers as reimbursement for their time, which should be considered as a reason for participation. A small number of infants were born preterm (n=46), and it is unknown if caregivers reported corrected age for starting solid foods or not. Finally, our data were collected between July 2020 and January 2022; therefore, a proportion of data were collected before the 2021 MoH guidelines were released. The decision to compare to the 2021 guidelines was made after comparisons of recommendations showed minimal changes to the key indicators discussed.

6.3. Concluding Remarks

Foods available and feeding method trends have changed in recent years, and until now, there has been a lack of evidence for what and how infants are fed in NZ during the CF period, adherence to the 2021 MoH infant feeding guidelines, and the prevalence of CFB. Our observational data have filled this gap, identifying key areas that NZ whānau (families) are doing well and areas that need further investigation.

6.4. Recommendations For Future Studies

The importance of infant nutrition is highlighted worldwide, however, there continues to be gaps in our knowledge that require further research. In order to understand what is the 'optimal diet', further research is justified. Within this study, our aims have been achieved, however, our results also give rise to additional questions, including;

1. Identifying the frequency and portions of Ministry of Health food groups consumed during a longer time frame (e.g. one week to show daily consumption). This will provide further insight into the adherence to MoH guidelines, identifying the inadequacies in food group consumption.
2. Further qualitative investigation of women that were identified to have a higher odds of not meeting breastfeeding guidelines (mothers who were primiparous and caregivers who were younger, lower educated, working full time, and using an ECE) to determine what mothers require to meet the MoH breastfeeding guidelines. This information could then be utilised to form national strategies and support systems to support breastfeeding.
3. As our study could not identify the number of women who met MoH continual breastfeeding (breastfeeding to two years of age) guidelines, further investigation into the incidence of adherence is warranted. This research could also provide further insight into associations between breastfeeding and infant feeding behaviours.
4. Further examination into demographic characteristics associated with concerning feeding behaviours (CFB). For example, is caregiver knowledge influencing the perception of what 'concerning' feeding behaviours are?
5. Why was current breastfeeding associated with higher CFB scores? Are mothers continuing to breastfeed when dealing with CFB, or is breast milk reducing an infant's appetite for solid foods? Qualitative investigation would allow caregivers of future research to discuss their PediEAT responses and feeding behaviour concerns.
6. Further examination surrounding the influence of offering sweet fruit and vegetables vs bitter or savoury options on dietary intake and feeding behaviours in later life.
7. The long-term influence of CIF use on infant feeding behaviours. Do sweet flavours affect later food acceptance? Does the continued provision of puréed foods affect later texture acceptance? Does the use of CIF affect an infant's ability to explore and play with food? How does CIF affect food familiarity (e.g. how do infants react to whole foods e.g. banana when previously only offered banana from a pouch).

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Appendices

Appendix 1: Search Strategy

Literature was searched for between January 2020 and April 2023. Databases utilised include Massey Discover, Google Scholar, Web of Science (2020-2022), Science Direct, Scopus, Statistics New Zealand, and MEDLINE/ PubMed. Search strategies were dependent on the piece of writing, as shown in Table 1. Additional publications were identified from publications cited in selected references or specific google searches. Dietary guidelines were downloaded from The New Zealand Ministry of Health website. Only literature published in English was included.

Table 1. Study search strategy

Search criteria	Key words
Child	Infant*, toddler*, baby, babies, child*, newborn
Health	Health, growth, development, digestion, digestive, obesity, weight, chronic disease*, illness*, diabetes, cardiovascular, "heart disease", mortality, cardiometabolic, immune, immunity, infection, cancer, allergy, allergies, non-communicable diseases (NCD)
Food and food groups	Nutrients, nutrition, feeding, food, diet*, dietary intake, food group*, complementary feeding, solid introduction, diet* requirements, diet variety, salt, sodium, sugar, beverage*, drink* Breast*, formula, bottle feeding, exclusive breastfeeding, continual breastfeeding Vitamin*, mineral*, Fruit, vegetable*, grain foods, infant cereal, milk and milk products, dairy*, plant-based, plant milk, dairy alternatives, mylk, legumes, nut butters, eggs, fish, seafood and chicken, lean red meat, protein food*, iron-rich, iron, commercial, discretionary, lollies, candy, crackers, biscuits, cake*, scone*, muffin*, Complementary infant food (CIF), pouch*, canned food*, jar*, ready to eat, infant food Sweet, savoury, bitter, umami, sour, salty, cool, hot
Feeding method	Traditional spoon-feeding (TSF), spoon*, baby-led weaning (BLW), baby-led, mixed feeding, self-feeding, pouch feeding, pouch*,
Guideline documents	Nutrient recommendations, nutritional requirement*, required nutrients, recommended nutrients, infant feeding guideline*, nutrition guideline*, diet* guideline*, breastfeeding guideline*, complementary feeding guideline*, early life nutrition *Note. International and national infant feeding guidelines and background papers were accessed from government websites (e.g. Ministry of Health, WHO)*
Demographics	Demographic*, sociodemographic, meshblock, deprivation, socioeconomic status Ethnicity, Māori, Pacific*, New Zealand European, Asian

Search criteria	Key words
	Education, age, income, employment, job, work, antenatal class*, smoking, smoker, parity, multiparous, firstborn, primiparous, married, partner, childcare, day-care, kindergarten
Location	New Zealand, NZ, Aotearoa Developed country, developed countries, high-income country, high-income countries, Australia, America, Italy, United Kingdom, Spain, Netherlands, Austria, Finland Norway, Switzerland, Iceland, Canada, Denmark, Sweden, France, Hong Kong, Germany, Ireland, OECD, World Health Organization, WHO
Feeding behaviours	Feeding behaviour, problematic feeding, difficult feeding, food acceptance, fussiness, fussy, food preference, mealtime, behaviours, Influence* OR association* OR factor* Gagging, choking, texture*, aversion, avoid* PediEAT OR feeding assessment Infant OR baby OR toddler OR child*
Methods of dietary analysis	Food recall, food diary, food diaries, food record, recall, food frequency questionnaire* (FFQ), 24-hour diet recall
Specific studies	Growing up in New Zealand (GUiNZ), Feeding infants and toddlers (FITS)

Appendix 2: Statement of Contribution for Manuscripts

DRC 16

MASSEY UNIVERSITY
GRADUATE RESEARCH SCHOOL

STATEMENT OF CONTRIBUTION
DOCTORATE WITH PUBLICATIONS/MANUSCRIPTS

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

Name of candidate:	Kimberley Brown
Name/title of Primary Supervisor:	Professor Cathryn Conlon
Name of Research Output and full reference:	
CONTRIBUTIONS OF KEY FOODS AND FOOD GROUPS TO THE DIETARY INTAKE OF INFANTS IN THE FIRST FOODS NEW ZEALAND STUDY (yet to be published)	
In which Chapter is the Manuscript /Published work:	3
Please indicate:	
• The percentage of the manuscript/Published Work that was contributed by the candidate:	70%
and	
• Describe the contribution that the candidate has made to the Manuscript/Published Work:	
Responsible for all aspects of the manuscript including: conceptualisation and design of manuscript, searching the literature, data collection, data analysis, and drafting manuscript.	
For manuscripts intended for publication please indicate target journal:	
To be determined	
Candidate's Signature:	Kimberley Brown Digitally signed by Kimberley Brown Date: 2023.06.01 15:00:13 +12'00'
Date:	1 June 2023
Primary Supervisor's Signature:	Cathryn Conlon Digitally signed by Cathryn Conlon DN: cn=Cathryn Conlon, c=NZ, o=Massey University, ou=School of Sport, Exercise and Nutrition, email=c.conlon@massey.ac.nz Date: 2023.06.02 14:58:14 +12'00'
Date:	2 June 2023

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STATEMENT OF CONTRIBUTION
DOCTORATE WITH PUBLICATIONS/MANUSCRIPTS

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

Name of candidate:	Kimberley Brown
Name/title of Primary Supervisor:	Professor Cathryn Conlon
Name of Research Output and full reference:	
ADHERENCE TO INFANT FEEDING GUIDELINES IN THE FIRST FOODS NEW ZEALAND STUDY (yet to be published)	
In which Chapter is the Manuscript /Published work:	4
Please indicate:	
• The percentage of the manuscript/Published Work that was contributed by the candidate:	70%
and	
• Describe the contribution that the candidate has made to the Manuscript/Published Work:	
Responsible for all aspects of the manuscript including: conceptualisation and design of manuscript, searching the literature, data collection, data analysis, and drafting manuscript.	
For manuscripts intended for publication please indicate target journal:	
Nutrients	
Candidate's Signature:	Kimberley Brown Digitally signed by Kimberley Brown Date: 2023.06.01 15:00:13 +12'00'
Date:	1 June 2023
Primary Supervisor's Signature:	Cathryn Conlon Digitally signed by Cathryn Conlon DN: cn=Cathryn Conlon, c=NZ, o=Massey University, ou=School of Sport, Exercise and Nutrition, email=c.conlon@massey.ac.nz Date: 2023.06.02 14:57:39 +12'00'
Date:	2 June 2023

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MASSEY UNIVERSITY
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STATEMENT OF CONTRIBUTION
DOCTORATE WITH PUBLICATIONS/MANUSCRIPTS

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

Name of candidate:	Kimberley Brown
Name/title of Primary Supervisor:	Professor Cathryn Conlon
Name of Research Output and full reference:	
PARENT-REPORTED FEEDING BEHAVIOURS OF NEW ZEALAND INFANTS AND ASSOCIATIONS WITH DEMOGRAPHIC CHARACTERISTICS AND FEEDING PRACTICES IN THE FIRST FOODS NEW ZEALAND STUDY (yet to be published)	
In which Chapter is the Manuscript /Published work:	5
Please indicate:	
• The percentage of the manuscript/Published Work that was contributed by the candidate:	70%
and	
• Describe the contribution that the candidate has made to the Manuscript/Published Work:	
Responsible for all aspects of the manuscript including: conceptualisation and design of manuscript, searching the literature, data collection, data analysis, and drafting manuscript.	
For manuscripts intended for publication please indicate target journal:	
To be determined	
Candidate's Signature:	Kimberley Brown Digitally signed by Kimberley Brown Date: 2023.06.01 15:00:13 +12'00'
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Date:	2 June 2023

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APPENDIX 3: PUBLISHED FIRST FOODS NEW ZEALAND STUDY PROTOCOL PAPER

Note: only the main text has been included. Please see reference for further details.

Protocol

Nutritional Implications of Baby-Led Weaning and Baby Food Pouches as Novel Methods of Infant Feeding: Protocol for an Observational Study

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Abstract

Background: The complementary feeding period is a time of unparalleled dietary change for every human, during which the diet changes from one that is 100% milk to one that resembles the usual diet of the wider family in less than a year. Despite this major dietary shift, we know relatively little about food and nutrient intake in infants worldwide and virtually nothing about the impact of baby food "pouches" and "baby-led weaning" (BLW), which are infant feeding approaches that are becoming increasingly popular. Pouches are squeezable containers with a plastic spout that have great appeal for parents, as evidenced by their extraordinary market share worldwide. BLW is an alternative approach to introducing solids that promotes infant self-feeding of whole foods rather than being fed purées, and is popular and widely advocated on social media. The nutritional and health impacts of these novel methods of infant feeding have not yet been determined.

Objective: The aim of the First Foods New Zealand study is to determine the iron status, growth, food and nutrient intakes, breast milk intake, eating and feeding behaviors, dental health, oral motor skills, and choking risk of New Zealand infants in general and those who are using pouches or BLW compared with those who are not.

Methods: Dietary intake (two 24-hour recalls supplemented with food photographs), iron status (hemoglobin, plasma ferritin, and soluble transferrin receptor), weight status (BMI), food pouch use and extent of BLW (questionnaire), breast milk intake (deuterium oxide "dose-to-mother" technique), eating and feeding behaviors (questionnaires and video recording of an evening meal), dental health (photographs of upper and lower teeth for counting of caries and developmental defects of enamel), oral motor skills (questionnaires), and choking risk (questionnaire) will be assessed in 625 infants aged 7.0 to 9.9 months. Propensity score matching will be used to address bias caused by differences in demographics between groups so that the results more closely represent a potential causal effect.

Results: This observational study has full ethical approval from the Health and Disability Ethics Committees New Zealand (19/STH/151) and was funded in May 2019 by the Health Research Council (HRC) of New Zealand (grant 19/172). Data collection commenced in July 2020, and the first results are expected to be submitted for publication in 2022.

Conclusions: This large study will provide much needed data on the implications for nutritional intake and health with the use of baby food pouches and BLW in infancy.

Trial Registration: Australian New Zealand Clinical Trials Registry ACTRN12620000459921; http://www.anzctr.org.au/Trial/Registration/TrialReview.aspx?id=379436.

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KEYWORDS

infant; diet; complementary feeding; food pouch; baby-led weaning; iron; growth; eating behavior; feeding behavior; dental health; choking; breast milk

Introduction

Background

The biggest dietary change in every human's life is the change from consuming a 100% milk diet in the first months of life to consuming a diet that is broadly the same as that of the rest of the family by the first birthday. This change is large. In fact, an infant following the current infant feeding guidelines globally [1-4] would have breast milk (or infant formula) as the sole source of nutrition until around 4 to 6 months of age. The first "complementary" foods would then be introduced one at a time in 1 to 2 teaspoon serves of "thin smooth purée," followed by a progression in food texture from puréed to mashed to chopped, and by around 1 year of age, family foods are consumed. While many countries have reasonably up-to-date information on the nutrient intake of infants [5-7], there is no such comparable data in New Zealand infants. Additionally, no country has specific information yet on the impact of the revolution in infant feeding offered by the new phenomena of baby food "pouches" and "baby-led weaning" (BLW).

Baby food pouches are squeezable containers with a plastic spout described as a "mess-free and easy alternative for baby food on the go" [8]. They have immense appeal to parents for their convenience [9] and perceived superior safety and freshness over more traditional glass jars [9], and parental perceptions that they are healthy and enjoyed by the baby. This appeal is demonstrated by an extraordinary market share. A recent analysis of 24 major brands of infant and toddler foods in the United States (that represent more than 95% of market share) showed that 56% of the food products were packaged as squeeze pouches [10]. The market share continues to grow. Sales of baby food pouches in Europe have grown annually by 125% in Spain and 916% in the Ukraine [11]. Surprisingly, there appears to have been almost no direct research on the possible impact of this new technology on infant diet or health, despite several groups cautioning against the use, highlighting the urgent need for research on the safety, nutrition, and health impacts of pouches [12-14].

Although the foods offered in baby food pouches are broadly similar in content to those offered as baby foods in jars and cans, there has been some concern, albeit not universal [15], that the content of added sugar might be higher [10,13,14,16]. Certainly, cereal products in pouches are a poor source of iron and should not be used to replace iron-fortified infant cereals [15]. Regardless of nutrient content, the delivery method itself has the potential to markedly change infant nutrition for several reasons. Anecdotal reports suggest food products are being consumed straight from the pouch, unsupervised, and "on the go," so they are outside usual eating contexts. This could have a number of important impacts on infant health and development.

First, these smooth highly processed products with multiple blended ingredients bear little resemblance to intact fruits and vegetables, and they are marketed well beyond the early weeks of complementary feeding when it might be argued a "super smooth" product is appropriate (eg, many are marketed for infants 8 months plus). This raises a number of questions. Do these products increase energy intake because they are so easy to eat (smooth consistency and do not require chewing; an entire 120-g serve can be accessed merely by squeezing the soft pouch and sucking)? Conversely, does the ease of consumption lead to displacement of other more nutrient-rich foods, such as breast milk (or infant formula), from the diet (eating "on the go" is unlikely to be consistent with New Zealand Ministry of Health recommendations that until 8 months of age infants are offered solid foods after milk to avoid displacing nutrient-rich milk [2])? Certainly, the structure of baby food pouches is described as "facilitating rapid passage of solid foods" [12], which suggests overeating is possible.

Second, if these pouches are indeed being consumed "on the go" by infants, what implications does this have for learning about food and eating? For example, do infants who feed themselves by sucking a purée out of a pouch while "on the go" have the same relationship with food as that for infants who sit and eat with their family? The description of pouches "promoting self-feeding and independence" [11] may suggest not. Positive reciprocal interaction during feeding or "responsive feeding" (ie, the caregiver and child respond appropriately to one another's cues) may support the infant's innate ability to respond to hunger and satiety cues [17]. If pouch use promotes "self-feeding and independence," does frequent pouch use result in a lack of interaction during feeding? Moreover, is there any association between regular pouch use and the infant's satiety responsiveness (ie, ability to cease eating once full)? Furthermore, parents are able to model healthy eating behaviors when the infant takes part in shared eating occasions, and this is associated with infants being less "food responsive" (ie, less likely to eat just because food is available) [18]. Beyond this, family routines and rituals around shared meals provide "a predictable structure that guides behavior and an emotional climate that supports early development" [19]. If feeding interactions and modeling influence the development of eating behaviors, then regularly eating from a pouch while "on the go" rather than in a shared eating setting may have important impacts on the development of infant eating behaviors.

Third, what is the impact of prolonged exposure to these often sweet and acidic (and therefore presumably cariogenic) foods on erupting teeth? There is a strong relationship between the frequency of cariogenic food intake and childhood caries [20]. Children who experience caries as infants or toddlers (ie, early childhood caries) have a much greater risk of developing caries in their permanent teeth [21], with children who have high exposure to sugars during infancy having a much greater risk of dental caries at 3 years than children who have less exposure to sugars in infancy [22]. Frequent consumption of sweet and acidic foods in early infancy may be of particular concern because newly erupted teeth have immature enamel and are more likely to develop caries [21]. Dental caries can have immediate and ongoing impacts on child health and quality of life, including reduced weight gain if food consumption is impacted, pain and discomfort, altered sleeping habits, and in the worst cases, hospitalization. Concerns have been raised about the possible impact of baby food pouches on pediatric dental health [12,23]. Certainly, advice to limit cariogenic foods to meal times [24] is not being followed if fruit- or cereal-containing pouches are used for snacks while "on the go" and therefore between meals.

While the use of food pouches is starting to be investigated internationally [25], there is no published research examining their relationship with infant nutrient intake, eating and feeding behaviors, growth, or dental health. The US Feeding Infants and Toddlers Study (FITS 2016) has collected but not yet reported data on the use of baby food pouches [25], but FITS 2016 did not collect data on nutritional status or health outcomes. Despite the lack of research on the possible impacts of pouch use, health professionals have expressed concerns [23,26-29]. A recent New York Times article [26] reports a spokeswoman for the American Academy of Pediatrics expressing concerns that pouch use may lead to children "overriding their body's own cues for hunger and fullness" and recommending families should have established times for meals rather than "pouching the calories throughout the day." In response to the article, a pediatric occupational therapist describes behaviors she has observed as follows: "Pouches appear to solve so many problems: kids who make a mess, kids who refuse fruits and veggies, kids who refuse to touch food or use a utensil, kids who won't sit still through a meal… I see toddlers waltzing through homes every day, sucking on pouches to start, end, or replace a meal" [26].

These are just anecdotal reports, but they underline the urgent need to determine the effect of pouches on infant nutrition and health. Interestingly, given the lack of research in this area, some health professionals in Germany [27] and the United Kingdom [23] have already gone so far as to recommend against the use of baby food pouches.

The second recent phenomenon in infant feeding is the popular adoption of BLW, an alternative approach to introducing solids to infants. In BLW, infants feed themselves all their foods from the start of the "complementary feeding" period. This means no spoon feeding by a parent, and only "finger foods" are offered [30]. BLW differs considerably from the more traditional approach espoused by infant feeding guidelines in many countries [1-4], in which the infant *gradually* learns how to eat solid foods safely by eating foods with progressively increasing textures from puréed to mashed to chopped to whole. We currently do not know how pervasive BLW is, although a recent New Zealand study [31] suggests more than half of families have tried it, with approximately 30% following it regularly. However, considerable concern has been expressed by health professionals about the potential increased risks of iron deficiency, growth faltering, and choking with BLW [32,33]. The limited international research base would suggest these concerns may be justified. We have shown previously in a small sample of infants aged 6 to 8 months that those following BLW had a much lower iron intake than traditionally fed infants [34], which is an issue given that iron is already a nutrient of concern in infants and toddlers, both in New Zealand [35] and internationally [36]. In order to truly know whether concern about low iron intake in infants following BLW is justified, the biochemical iron status of infants must be determined as iron intake is a notoriously poor indicator of iron status [37]. Only two small studies appear to have examined intake of other nutrients in infants following BLW, suggesting that intakes of zinc and vitamin B12 may be lower [34], and intakes of total fat, saturated fat [34], and sodium [38] may be higher than those for traditional spoon feeders. These important differences require clarification in a much larger sample. Proponents of BLW argue that infants are able to feed themselves sufficient food from 6 months of age and that allowing children to have control over their own eating promotes a greater ability to regulate their own appetite appropriately. Whether this is indeed true or translates into differences in growth rates is uncertain given that the few existing studies [39,40] have used parental reports, which can be inaccurate [41], particularly in infants who are growing so rapidly. Lastly, foods, such as raw apple, raw carrot, and grapes are some of the most commonly seen foods in videos promoting BLW, despite the substantial choking risk they pose to young children [42]. Whether choking rates differ in BLW versus more traditional solid feeding is not clear. Only one large study internationally has specifically investigated choking rates in infants following BLW rather than traditional spoon feeding (TSF) [43]. This study suggested that choking rates may in fact be lower for infants who consume finger foods regularly, but it recruited the BLW participants from BLW websites rather than the general population. This may have biased the results as choking and gagging are common topics discussed on BLW websites (particularly the importance of not mistaking gagging for choking), and this may have influenced the reporting of choking rates in the BLW infants. Given the substantial number of parents following this approach with their infants and BLW's widespread online presence (7,690,000 results on Google; December 24, 2020), it is critically important to determine the health risks of BLW so that health professionals and policy makers can provide families with evidence-based advice on how to feed their infants safely.

Infant milk (breastmilk or infant formula) is a substantial component of the diet for infants during the complementary feeding period, providing more than half of their energy intake at 7 months of age [44]. While it is straightforward to estimate intake of infant formula for those who consume it, researchers currently have to use a "one size fits all" approach to estimate breast milk intake, either using a single volume for all breastfed infants of a particular age [45] or excluding breastfed infants from dietary analyses [46]. Neither approach is ideal because breast milk intake varies considerably between mother-infant pairs [47] and because breastfed infants do not necessarily have the same food intake or socioeconomic background as formula fed infants. The conventional method used to measure breast milk intake is to weigh the infant before and after every feed. However, this "test-weighing" technique is time consuming and may disturb usual feeding patterns. In contrast, the stable isotope deuterium oxide technique requires the mother to consume a small amount of the stable isotope (deuterium oxide) in water, and the amount of this marker transferred to the infant (ie, via the breast milk the infant consumes) is then measured by collecting saliva samples from the mother and infant over the following fortnight [48-50]. The normal feeding pattern is not disturbed, and the total volume of breast milk consumed by the infant over the fortnight can be accurately assessed. The use of this technique will allow the First Foods New Zealand (FFNZ) study to collect data that will enable more accurate estimates of nutrient intake in this age group and allow us to generate predictive models that use infant and diet characteristics that are routinely measured to estimate breast milk volumes. Such models would be invaluable for estimating total nutrient intake for breastfeeding infants (69% of infants at 4-8 months in New Zealand [51]) in future studies.

The FFNZ study will determine the iron status, growth, food and nutrient intakes, breast milk intake, eating and feeding behaviors, dental health, oral motor skills, and choking risk of New Zealand infants, with a particular focus on the use of baby food pouches and BLW.

Primary Objective

In infants aged 7.0 to 9.9 months, we will determine whether iron status and BMI z-score differ according to the extent of food pouch use and complementary feeding approach (BLW compared with TSF).

Secondary Objectives

In infants aged 7.0 to 9.9 months, we will estimate the following: (1) Nutrient intake, nutrient adequacy, and foods of cultural importance in New Zealand infants and in infants fed using baby food pouches regularly or those following BLW; (2) Breast milk intake in New Zealand infants and in infants fed using baby food pouches regularly or those following BLW; (3) Prevalence and nature of food pouch use; (4) Prevalence of BLW; (5) How eating behaviors (ability to eat with appetite, speed of eating, and picky eating) and feeding behaviors (parental responsiveness to infant hunger and satiety cues) differ according to the extent of food pouch use and complementary feeding approach (BLW compared with TSF); (6) How dental health differs according to the extent of food pouch use and complementary feeding approach (BLW compared with TSF); (7) How oral motor skills differ according to the extent of food pouch use and complementary feeding approach (BLW compared with TSF); and (8) How the risk of choking differs according to the extent of food pouch use and complementary feeding approach (BLW compared with TSF).

Methods

Design

The FFNZ study is an observational cross-sectional study of food and health in infants aged 7.0 to 9.9 months. The study will compare infants using baby food pouches with those not using these pouches, and those following BLW with those following TSF, while collecting data on nutrient intake and nutritional status in this age group in general. The age range has been chosen because it is close enough to when complementary feeding starts (usually 4-6 months of age) that we can expect to see large variations in both baby food pouch use and BLW rates, while also giving enough time from the start of complementary feeding for eating patterns to have had an impact on iron status and growth. A narrow age range has specifically been chosen because diet changes rapidly in infancy. Observational study designs are appropriate for identifying associations between behaviors as they are carried out in the "real world." While a randomized controlled trial is required to determine causality, it is not ethical to randomize infants to follow BLW or pouch use because that would require randomization of participants to eating patterns that health professionals have concerns about [23,26-28,32,33]. Instead, we will use propensity score matching [52], which is able to remove some of the bias caused by differences in demographics between groups so that the estimates of the impact of pouch use or BLW on infant diet and health will more closely represent a potential causal effect [53].

Participants and Recruitment

In total, 625 parents/guardians who have an infant less than 9.9 months of age will be recruited from two regions of New Zealand (Dunedin and Auckland) to participate in the study when their infant is aged 7.0 to 9.9 months. Recruitment will occur by advertisement and word of mouth and will target all infants rather than those adopting BLW, TSF, or food pouch use. We aim to recruit a sample that is broadly representative of the ethnicity and socioeconomic status of New Zealand children. It is not feasible to recruit a truly representative sample using typical methods, such as electoral roll and door knocking, because they would identify very few infants in the narrow age band that is necessary for this study (because diet changes so

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rapidly in infancy). We will, however, collect data from a diverse range of ethnic and socioeconomic groups by (1) engaging with Māori and Pasifika community health organizations to assist with recruitment, (2) targeting recruitment in suburbs with a high proportion of Māori, Pasifika, and Asian populations, and (3) having research team members who have experience working with or who culturally identify with Māori, Pasifika, and Asian communities. We will also statistically weight the estimates to account for demographic disparities if appropriate. The study has ethical approval from the Health and Disability Ethics Committees New Zealand (19/STH/151), and written informed consent will be obtained at the first appointment. The study is registered with the Australian New Zealand Clinical Trials Registry (registration number: ACTRN12620000459921).

Sample Size

Our sample size calculation is based on comparing the BMI z-score and plasma ferritin concentration in infants following BLW and TSF, as there are currently no data internationally on these measures in pouch users. Our recent studies suggest that 29% of infants will meet the definition of BLW [31] and 70% of enrolled infants will provide a blood sample [54]. A recruitment size of 625 would therefore enable us to collect complete data from 125 BLW and 312 TSF infants, which would be sufficient to detect a difference of 0.3 for the BMI z-score and a 5-μg/L lower plasma ferritin concentration in the BLW group assuming a mean of 29 μg/L in the TSF group [54], both with 80% power and α of .05. As outlined above, we expect pouch use to be very common, based on the 70% market share they have, but we do not have the data needed to calculate the sample size required to detect differences in health outcomes with pouch use. With a sample size of 625, however, we will be able to estimate the prevalence of frequent pouch use to a 95% precision level of at least ±4%.

Data Collection

Overview

Participation in the study will involve three (participants in the main study) or five (participants in a consecutive subsample of breastfed infants) contacts over 2 weeks following recruitment. For the main study (n=625), the first main appointment will generally be held in the participant's home and involve a 24-hour diet recall, completion of two questionnaires, and anthropometric measurements of the child. The second main appointment will generally take place at university research rooms, and involve a second 24-hour diet recall and photography of the infant's teeth to assess dental health. A third main appointment will take place at our university rooms (Dunedin) or a local blood testing facility (Auckland) to collect a blood sample to measure the iron status. Finally, a self-administered questionnaire will be completed by the participants in their homes. For the subsample (n=150) involved in the measurement of breast milk intake, a stable isotope will be given at the first main appointment, with three additional saliva samples collected over the ensuing fortnight (the third sample being collected at the second main appointment).

Demographic Data

At the initial appointment, ethnicity, maternal education, maternal work status, household deprivation (New Zealand deprivation index 18 [55]), household food security [56], and childcare use will be collected by questionnaires, using the New Zealand census questions where relevant. These data will be used to describe the sample and minimize bias.

Measuring Baby Food Pouch Use

This is related to primary objective 1 and secondary objectives 1, 2, 3, 5, 6, 7, and 8. We will measure the frequency of pouch use in the past month by a questionnaire. We intend to define infants as being frequent baby food pouch users if their parents state that they are currently being given food from a food pouch "5 to 6 times a week," "once a day," or "more than once a day," although this may need to be modified when the distribution of intakes is determined (there are currently no published data on the frequency of baby food pouch use to base this cutoff on). We will collect data on the frequency of pouch use, use of "ready-to-eat" pouches versus "home-filled" pouches, extent to which the infant feeds directly from the pouch rather than being fed by spoon, types of foods given in "pouches," contribution of pouch foods to total intake of solid foods, proportion of the "pouch" consumed on a typical eating occasion, duration of a typical eating occasion, physical situations in which pouches are used, proximity of an adult when the pouch is being used, reasons for using pouches rather than other methods of food delivery, and anything not liked about using baby food pouches. Key pouch questions will be asked referring to when the infant first started eating solids, when the infant was around 6 months of age, and "now."

Measuring BLW

This is related to primary objective 1 and secondary objectives 1, 2, 4, 5, 6, 7, and 8. Parents will be asked to describe the way their infants were fed when they first started eating solids, when they were around 6 months of age, and "now," using five answer options. Parents who choose "spoon fed by an adult" or "mostly spoon fed by an adult, some baby feeding themselves" will be classified as TSF. Parents who select "about half spoon feeding by an adult and half baby feeding themselves" will be classified as partial BLW [31]. Those who report "mostly baby feeding themselves, some adult spoon feeding" or "baby feeding themselves" will be assigned to full BLW [57,58]. As there is no validated definition of BLW, these definitions have been designed to capture the major point of difference between BLW and TSF, while allowing occasional adult spoon feeding.

Iron Status

This is related to primary objective 1. A nonfasting venipuncture blood sample will be collected at the third main appointment (3-mL EDTA anticoagulated vacutainer blood collection tube; Becton Dickinson and Company) to determine the plasma ferritin concentration and iron status defined using the body iron concentration (calculated using plasma ferritin and soluble transferrin receptor concentrations [36]) and hemoglobin concentration (from a complete blood count). The iron status categories are defined in Table 1 [54].

Table 1. Iron status categories.

Category	Body iron value	Hemoglobin value	Plasma ferritin value
Iron sufficient	≥0 mg/kg	≥105 g/L	≥15 µg/L
Iron depleted	≥0 mg/kg	≥105 g/L	<15 µg/L
Early functional iron deficiency	<0 mg/kg	≥105 g/L	N/A[a]
Iron deficiency anemia	<0 mg/kg	<105 g/L	N/A

[a]N/A: not applicable.

As ferritin is an acute phase reactant and can be artificially elevated by inflammation, we will also analyze two inflammatory markers (C-reactive protein and α-1-acid glycoprotein) as recommended by the World Health Organization (WHO) [59]. This will enable us to use the BRINDA (Biomarkers Reflecting Inflammation and Nutritional Determinants of Anemia) statistical method to adjust for inflammation on a continuous scale, consistent with the assumption that higher concentrations of inflammatory markers will be associated with a greater effect on plasma ferritin concentration [60].

Participants will be given verbal instructions on how to apply a local anesthetic (Ametop gel; Perstorp Pharma) and will be given access to an instruction video. The gel is to be applied to the insides of both of the infant's elbows (this enables phlebotomy to be attempted on the second arm if necessary) and covered with an occlusive dressing at least 1 hour (no more than 4-6 hours) before the blood test appointment. It is removed after 30 to 45 minutes. The blood sample will be taken by a pediatric phlebotomist. The research team has extensive experience overseeing research projects involving the collection of venipuncture blood samples from infants and toddlers [54,60,61], with 70% [54] to 92% [61] of participants providing samples.

Commercial laboratories (Southern Community Laboratories, Dunedin, New Zealand and Labtests NZ, Auckland, New Zealand) will determine complete blood count (requires fresh blood) and plasma ferritin, so that the iron status can be immediately communicated to the infant's general practitioner if the infant is identified as having anemia. The remaining plasma will be frozen at –80°C for batch analysis of soluble transferrin receptor, C-reactive protein, and α-1-acid glycoprotein concentrations at the University of Otago Department of Human Nutrition Laboratory at the end of the study [54].

Anthropometry

This is related to primary objective 1. Infant weight will be measured at the initial appointment on an electronic scale (model 354; Seca) and length will be measured on a 99-cm measuring mat (model SE210; Seca) in duplicate following WHO protocols [62]. BMI (weight in kg divided by height in meters squared) will be calculated, and BMI-for-age z-scores will be determined using WHO reference data [63]. We will also request consent from parents to collect information on BMI from the B4 School Check [64] when the children are 4 years of age. This will enable us to look at the effects of pouches and BLW on growth longitudinally.

Infant Diet

This is related to secondary objective 1. Information on infant nutrient intake and adequacy, food group intake, dietary patterns, and culturally important foods will be obtained using interviewer-administered multiple pass 24-hour recalls collected at the first and second appointments. The two 24-hour recalls take place on different days of the week to capture variation in intake between days. Collecting two 24-hour recalls will enable us to calculate "usual intake" using the multiple source method (MSM) for estimating usual dietary intake of individuals [65]. Photograph prompts will be used to assist recall of foods eaten. Participants will be asked to photograph (using their own smartphone or a camera provided) the eating surface (eg, plate, high chair surface, and table) at the start of all meals and snacks from midnight to midnight on the day before the appointment. The quality of the photographs will not be important as long as they are clear enough to remind the parent what the child ate. Diet recalls will be analyzed with FoodWorks (version 10, Xyris Software) using the New Zealand Food Composition database FOODfiles 2018 Version 01 [66]. Nutrient information for commercial infant foods and milk will be determined by generating recipes using the ingredients lists on food products modified to match the nutrient information panel on the packet so that the contribution of nutrients that do not appear on the nutrient information panel can be included [15]. Information on supplement use will be collected by a questionnaire.

Particular focus will be on free sugars and added sugars given a recent small study [45] suggested that even by 7 months of age, 12% of New Zealand infants may already be consuming free sugars at levels that are above the WHO recommendation [67]. Parents are discouraged from adding sugar to infants' diets because it is unnecessary and may increase liking of sweet foods [2]. In addition, the WHO recommends that free sugars should be <5% of energy intake due to the dose-response relationship between free sugar intake and dental caries (even in populations with water fluoridation) [67]. Data on free sugars and added sugars are available in the New Zealand food composition database [66,68].

Questionnaire and 24-hour recall data will also be used to determine the extent to which key indicators of diet quality are being met, as guided by the New Zealand Ministry of Health Eating and Activity Guidelines for New Zealand Infants and Toddlers [2].

Breast Milk Intake

This is related to secondary objectives 1 and 2. We will obtain accurate data on the amount of breast milk infants consume using the stable isotope (deuterium oxide) "dose-to-mother" technique [48-50] in a consecutive sample of 150 breastfeeding mother-infant dyads. This will enable us to measure intake to ±34 mL/day (ie, 5% of expected total intake [47]) at a 95% precision level. The isotope will be administered to the mother orally at the initial appointment (after collection of the baseline saliva sample), and saliva samples will be collected from the mother and infant at three further appointments to measure the disappearance of the deuterium from the mother and appearance in the infant. Baseline and three postdose sampling points (days 2-3, 7-9, and 13-14) are required to achieve adequate accuracy and precision of human milk intake. Height/length and weight will be measured at baseline, with weight measured again at the final appointment for both mother and infant, so that breast milk intake can be calculated. Breast milk intake data will be used along with questionnaire and recall data to generate predictive equations of breast milk intake so that intake can be estimated for participants who did not have breast milk intake measured.

Eating Behaviors

This is related to secondary objective 5. Eating behaviors will be assessed using the following four subscales from the Children's Eating Behavior Questionnaire (CEBQ) [69]: "satiety responsiveness" (eating appropriately in response to appetite), "food responsiveness," "food enjoyment" (eating in response to environmental food cues rather than hunger), and "slowness in eating." Although a Baby Eating Behavior Questionnaire has been developed [70], it is designed for infants who are exclusively milk fed, so it would not capture complementary feeding. Food fussiness will be measured using five items in the "picky eating" subscale of the Toddler-Parent Mealtime Behavior Questionnaire [71]. We have demonstrated the internal consistency and reliability of these scales in New Zealand infants at 12 months of age, with Cronbach α ranging from .83 to .90 [58]. Participants will also be asked whether they feed their infants any foods of particular cultural relevance. Feeding behaviors will be determined by observing how infants eat and how parents react in response to hunger and satiety cues by videotaping one evening meal (at which solid foods are offered) in each infant recruited in the Dunedin cohort (n is approximately 300). Participants will be issued a GoPro wide-angle video camera (Hero 2018; GoPro Inc) and tripod at their first appointment and asked to video record the main meal on the day for which the second 24-hour recall will be obtained. The camera will take a continuous video from approximately 10 minutes before the infant first joins the meal to when they leave it. Videos will be coded using the Responsiveness to Child Feeding Cues Scale [72].

Dental Health

This is related to secondary objective 6. Photographs of the infant's upper and lower teeth will be taken by trained interviewers using a dedicated study Oppo Reno2 Z (Oppo) mobile phone with a small portable Smile Light MDP lighting source specifically designed for taking dental pictures [73]. These images will be examined by a single registered dental practitioner, with blinded evaluation of a subset by another examiner, using validated indices for caries and developmental defects of enamel, which have a positive correlation with dental caries [74].

Oral Motor Skill Development

This is related to secondary objective 7. The questionnaires administered at the final appointment include the validated Child Oral Motor Proficiency Scale (ChOMPS) to identify oral motor and eating skill delay [75,76] and the Pediatric Eating Assessment Tool (PediEAT) to measure behaviors that characterize symptoms of feeding difficulties [77,78]. Both questionnaires have age-based reference values for infants and rely on parent reporting [79,80].

Choking

This is related to secondary objective 8. The questionnaire administered at the initial appointment will include questions on choking since birth. We developed these retrospective questions for previous work in this age group and have demonstrated that they provide data that are comparable to choking data collected prospectively using a daily choking calendar [81].

Statistical Analysis

We expect that there will be crossover between BLW/TSF status and pouch use. We will be able to explore whether mean differences in energy and nutrient intake, as well as other measures, between pouch users and nonusers are different for those who use BLW and those who do not. These results will be stratified by BLW/TSF status, and estimated differences will be compared.

Regression models will be used to determine differences between groups. Propensity score matching will be undertaken to reduce the bias caused by differences in demographics between the groups (eg, maternal education and ethnicity), infant age (to the nearest week), and sex. Propensity score matching is not like traditional paired matching, where each individual is matched to another individual in the other group according to covariates. Instead, propensity score matching uses a participant's propensity score (found using covariates) and estimates what their outcome (eg, energy intake) would have been if they were in the other of two dichotomous groups. By using this method, we expect the estimates will more closely represent a potential causal effect [53]. Another advantage is that it allows data from the whole sample to be used, unlike a traditional matched analysis in which only matched pairs are analyzed.

Estimates of BLW, frequent pouch use, nutrient intake, status, and adequacy will be calculated for the whole sample along with 95% CIs. If the sample is not demographically representative of the wider population, statistical weighting of these estimates will be undertaken using the survey command in Stata (StataCorp).

Nutrient intake will be determined using 24-hour recall data adjusted to provide estimates of usual intake (using the MSM method [65]). Adequacy of intake will be determined as follows: for zinc (for which an estimated average requirement [EAR] is available for New Zealand and Australia [82]), the EAR cut point method will be used; for iron (for which an EAR and tables of probabilities of inadequate intakes are available for the United States of America and Canada [83]), the full probability approach will be used [83]; for other nutrients (only an adequate intake [AI] is available for this age group in New Zealand and Australia [82]), mean group intake above the AI will be considered to indicate adequacy, but a conclusion as to inadequacy will not be possible if mean group intake is below the AI [84]. The BRINDA method [60] will be used to adjust plasma ferritin, and therefore, body iron and iron status, for the impact of inflammation.

The best-fitting polynomials to predict breast milk intake will be estimated by regression models using fractional polynomial functions of variables, such as age, sex, body weight, and food and beverage intake (eg, kJ/day). This will result in equations that can be used to predict breast milk intake based on a variety of input variables. Ideally one based on data that can be collected in a single clinical appointment, and another that uses data requiring more extensive collection in a research or surveillance setting.

Results

This observational study has full ethical approval from the Health and Disability Ethics Committees New Zealand (19/STH/151) and was funded in May 2019 by the Health Research Council (HRC) of New Zealand (grant 19/172). Data collection commenced in July 2020, and the first results are expected to be submitted for publication in 2022. Data collection will only take place while New Zealand is in Alert Levels 1 or 2 during the COVID-19 pandemic. The Otago and Auckland regions of New Zealand, where the data collection will take place, have been in Level 1 for all but 7 weeks in Otago (all at Level 2) and 11 weeks in Auckland (7 weeks at Level 2 and 4 weeks at Level 3) since July 2020, as overall case numbers in New Zealand remain extremely low (<2000 in a population of more than 5 million). As daily life is essentially normal in Level 1 with the exception of closed international borders and Level 2 just requires some physical distancing and appropriate hygiene recommendations, we feel confident that the pandemic will have relatively little effect on our data.

Discussion

This large observational study will provide much needed data on nutrient intake (including breast milk intake) and nutritional status (specifically iron status, growth, and dental health) in a large diverse sample of New Zealand infants. However, our data will also have considerable international appeal given the lack of research assessing the implications for nutritional intake and health for those infants who obtain a large proportion of their food via baby food pouches. Similarly, determining how iron status, growth, nutrient intake, and choking risk may differ in infants following BLW compared with TSF is urgently warranted given the widespread interest in this alternative approach to complementary feeding worldwide.

Acknowledgments

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Authors' Contributions

RWT and ALMH are the co-principal investigators of the First Foods New Zealand study. RWT, CAC, KLB, PRvH, LAT, LD, JJH, AMM, LAH, and ALMH designed the project and applied for funding. RWT and ALMH produced the first and subsequent drafts of the manuscript. JJH advised on study design, sample size calculation, and statistical analysis. JA is the project coordinator. LD, NHM, AC, LT, MC, KB, EJ, IK, EF, and DA developed the study data collection protocols, and NHM, AC, LT, MC, KB, EJ, IK, MR, and JM undertook data collection. All authors made important intellectual contributions to the manuscript, and all have read and approved the final version.

Conflicts of Interest

None declared.

Multimedia Appendix 1

Peer-reviewer reports and grant approval from Health Research Council of New Zealand.
[PDF File (Adobe PDF File), 1958 KB-Multimedia Appendix 1]

Multimedia Appendix 2

Ethics approval.
[PDF File (Adobe PDF File), 396 KB-Multimedia Appendix 2]

References

Appendix 4: Study Posters

MASSEY UNIVERSITY
TE KUNENGA KI PŪREHUROA
UNIVERSITY OF NEW ZEALAND

FIRST FOODS
— New Zealand —

Attention Parents and Guardians

The First Foods New Zealand study is looking for parents and guardians from Auckland to take part in an exciting new study when their pēpi is 7, 8, or 9 months old. The study will look at what and how New Zealand babies are being fed and how that might affect their health.

We would like to meet with you 2-4 times over two weeks. We will ask about what your pēpi eats, take baby's weight and length, and look at your baby's teeth and iron levels. Each visit normally takes 1-2 hours.

- Help improve the health of NZ infants
- Help health workers give parents and whānau advice they can trust
- Find out if your baby is not getting enough iron
- You will be given a $150 voucher as a thank you for taking part

Contact us
auckland@firstfoods.co.nz
021 279 2190
www.firstfoods.co.nz

This study has ethical approval from the Health and Disability Ethics Commitee 19/STH/151 version 3: 7July2020

CALLING ALL PASIFIKA FĀMILI / 'AIGA

Do you have a pepe aged between 5 and 9 months?

FIRST FOODS
— New Zealand —

Take part in an exciting new study to help us learn more about what they eat and receive

$150 in vouchers

(Supermarket or petrol or The Warehouse)

2 visits over a week, either at our clinic or your home

Join here:
www.firstfoods.co.nz/join

Or call or text on 021 279 1290

For more information, visit www.firstfoods.co.nz

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UNIVERSITY OF NEW ZEALAND

Appendix 5: Study Information Sheet

What if I have any questions?

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

www.firstfoods.co.nz

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

Co-Principal Investigator (Dunedin)
Anne-Louise Heath
03 479 8379
anne-louise.heath@otago.ac.nz

Investigator (Auckland)
Cathryn Conlon
09 414 0800 ext. 43658
C.Conlon@massey.ac.nz

Investigator (Wellington)
Lisa Te Morenga
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:
Arai Te Uru Whare Hauora
Phone: 03 471 9960
Email: reception@araiteuru.co.nz

You can also contact the Health and Disability Ethics Committee (HDEC) that approved this study on:
Phone: 0800 4 ETHICS
Email: hdecs@moh.govt.nz

Feeding our babies – are we getting it right?

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

July, 2020

Investigators
Assoc Prof Anne-Louise Heath, University of Otago (Dunedin)
Prof Rachael Taylor, University of Otago (Dunedin)
Dr Cathryn Conlon, Massey University (Albany)
Dr Kathryn Beck, Massey University (Albany)
Dr Lisa Te Morenga, Victoria University (Wellington)

Why?

How babies are introduced to solid foods might be important for baby's health, including how they grow, how healthy their teeth are, and whether they are getting enough nutrients like iron. We want to look at how and what babies 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 how to introduce solids safely to their babies. This study has ethical approval from the Health and Disability Ethics Committee: 19/STH/151.

What does this study involve?

We are looking for parents or guardians from Dunedin, Auckland or Wellington with infants who are 7, 8, or 9 months of age to take part in this study. First Foods NZ is an 'observational' study, looking at what and how babies are fed. You will **not** have to change the way you feed your baby in any way or do anything different. We need to recruit a large number of families – a total of 625 – so expect that the study will finish in 2022.

What would I be asked to do?

Attend three visits when your baby is between 7 and 10 months old. If you are breastfeeding, you may have two extra visits. These visits will take place over two weeks and will take 4-7 hours in total.

2

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 baby 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 (e.g., when carrying out analyses or coding videos).

Saliva and breast milk samples will be stored until lab analysis is complete. We are planning to keep any leftover blood sample for up to three years before destroying it, so that more nutrients can be measured if funding becomes available. All left over sample will be destroyed, with an appropriate karakia (Māori prayer) if you wish.

7

What if something goes wrong?

If we find that your baby has low iron status or problems with their teeth, then we will let you and your GP, or 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 yours or your baby'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 may choose not to give a sample at any time, even if you have previously given consent to providing a sample. You have the right to access information about yourself and your baby collected as part of this study.

You may hold beliefs about a sacred or shared value of tissue samples removed. Feel free to discuss with your family/whānau the cultural issues associated with sending your samples overseas and/or storing your tissue. Māori people hold a range of views around these issues; some iwi disagree with storage of samples referring to whakapapa, and advise their people seek information before participating in research where this occurs. However, it is acknowledged that individuals have the right to choose.

First visit

We will come to your home for this visit and will measure baby's weight and length and ask you to fill out a couple of questionnaires about baby's feeding and health. We will ask you to tell us what, and how much, baby ate the day before. Because this can be difficult to remember, we will ask you to take photos of baby'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.

Between visits

We will lend you a camera and tripod to film your baby eating a meal at home before you come to your second visit. We will also ask you to complete a short questionnaire about the meal.

Second visit

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

There will be one last online questionnaire after this visit.

Third visit

At this visit we would like to do a blood test, so we can measure baby's iron levels. The blood test will be done by someone who is very experienced at collecting blood samples from babies, and we use a numbing gel to make sure it doesn't hurt. We have done lots of these types of blood tests before with infants and toddlers. This visit will take no more than 30 minutes and is held in our clinic.

We will ask your permission to let us access information from your baby'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 baby's National Health Index (NHI) number to do this.

If you are breastfeeding

If you are breastfeeding, we may invite you to be in another part of the study. We would ask you to drink a small amount of "special" water that lets us track how much breast milk your baby drinks. This method is very safe and is used all over the world. If you did this part of the study, then you would do the same study as everyone else but complete some extra tasks at the first and second visits and have two extra visits. This part of the study would take about 20-30 minutes at each of the four visits. At the first visit you would drink the water. At all four visits we would collect some saliva (spit) from you and your baby, so that we can measure how much of the "special" water your baby has got from your breast milk. At a couple of the visits, we would collect your height and weight. We'd also like to ask you to collect a small amount of breast milk so that we can analyse the nutrients it contains.

This is an important part of the study because, for the first time, parents and health professionals will know how much breast milk New Zealand babies are getting.

Who pays for the study?

This study is funded by the Health Research Council of New Zealand. There is no cost for you to take part. However, as a recognition for taking part in the study we will give you a $150 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 First Foods NZ study. For example, you will:

- Know that you are helping improve the health of NZ infants
- And helping health workers give parents and whānau advice they can trust
- Find out if your baby isn't getting enough iron

What are the potential risks?

We don't think there are any large risks to taking part in this study. Giving blood may cause minor discomfort and bruising but we will use a numbing gel to prevent pain, and in the unlikely event that bruising does occur, it should fade in about a day. No adverse side effects have been reported in mothers or babies given the "special water" in a wide range of other studies across multiple countries.

APPENDIX 6: STUDY CONSENT FORM

MASSEY UNIVERSITY
TE KUNENGA KI PŪREHUROA
UNIVERSITY OF NEW ZEALAND

Consent form for the First Foods NZ study

Please tick to show you consent to the following		
I have read and understand the information pamphlet for volunteers in the First Foods NZ study.		
I have had enough time to decide if I want to take part in the study.		
I have had the opportunity to get friend, family, or whānau support to help me ask questions and understand the study.		
I am happy with the answers I have been given about this study and I have a copy of this consent form and the information pamphlet.		
I understand that taking part in this study is my choice and that I may withdraw from the study at any time without it affecting my health care or that of my baby.		
I consent to a blood sample being from my baby from an appropriate Labtest facility.	Yes ☐	No ☐
If I consent to a blood sample being taken from my baby: I understand that any blood that is left over after analysis will be disposed of with: a) Standard biohazard laboratory disposal ☐ OR b) An appropriate karakia ☐		
I consent to me and my baby providing saliva (spit) samples.	Yes ☐	No ☐
If I consent to me and my baby providing saliva samples: I understand that any saliva that is left over after analysis will be disposed of with: a) Standard biohazard laboratory disposal ☐ OR b) An appropriate karakia ☐		

[PTO]

I consent to allowing the researchers to access information about my child's growth and dental health from their "B4 School Check" when they are about four years old. I understand that this means they will need to access my baby's National Health Index (NHI) number.	Yes ☐	No ☐
If I decide to withdraw from the study, I agree that the information collected about me up to the point when I withdraw may continue to be processed.	Yes ☐	No ☐
I consent to my baby's GP being informed about any significant abnormal results from their iron blood test. Name of GP …………………………………………………………………………………… Address or Name of GP's practice ……………………………………………………………………………………		
I consent to a dentist or dental therapist being informed about any significant abnormal results from my baby's teeth check. Name of my preferred dentist or dental therapist …………………………………………………………………………………… Address or Name of practice ……………………………………………………………………………………		
I don't have a preferred dentist or dental therapist so if there are any significant abnormal results from my baby's teeth check please refer my baby to my local Community Oral Health Service (a free service).	Yes ☐	No ☐
I understand that taking part in this study is confidential and that no material which could identify me, or my baby, will be used in any reports on this study.		

[PTO]

I understand the ACC provisions in case of injury during the study.	
I know who to contact if I have questions about the study.	
I understand my responsibilities as a volunteer taking part in the study.	
I wish to receive a summary of the results from the study when the study is finished and will keep the researchers informed if my address changes.	Yes ☐ No ☐
I am happy for the data collected in this study to be used in future research on topics related to this study.	Yes ☐ No ☐
I am happy to be contacted in the future to see if I might be interested in taking part in other related studies.	Yes ☐ No ☐

Declaration by participant:

I hereby consent to take part in this study.

Participant's name:

Signature: Date:

Declaration by member of research team:

I have given a verbal explanation of the research project to the participant and have answered the participant's questions about it.

I believe that the participant understands the study and has given informed consent to participate.

Researcher's name:

Signature: Date:

APPENDIX 7: 24-HOUR DIET RECALL STANDARD OPERATING PROCEDURE

P-6b1: 24-h recall protocol

Copy no. ______

Study:	FFNZ	*Version number:*	Version 6
Prepared by:	NM, LF, ALH, HD	*Date prepared:*	08/06/2020

Objective

- Capture a detailed assessment of the infant's diet from the previous day, while also capturing data relevant to baby food pouch use, Baby-Led Weaning, dental health, and speed of eating.

Equipment required

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

Process – Before

In office:

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

At appointment:

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

1

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 [*baby'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 [*baby'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 [*baby'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 [*baby'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 [*baby'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 [*baby's name*] drink yesterday?" (*record*)

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

"Did [*baby'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 [*baby's name*] ate yesterday that someone else gave [*him/her*]?" (*note this on Quick List; ask question below*)

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

"Do you have any information about what [*baby'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 [*baby'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 [*baby'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 baby 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 [*baby's name*] eating/drinking was [*XXX*]." (*record*)

"What time did [*baby'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 (where was the child sitting e.g., highchair, car seat, buggy, floor, bed, couch) and broad place fed (what setting where they in e.g., home, friend's house, park, supermarket, car, childcare).
- **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. *NB*: If breastfed – add duration of each breastfeed instead of amount (unless expressed breast milk given in which case record amount).
- **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 both the amount <u>offered</u> (i.e. the amount baby was given the opportunity to eat), and 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).

- **Fed by**. Tick the option that best describes who put the food in baby's mouth. You can tick both options if it was a combined effort (e.g., a breastfeed, both holding the spoon).
- **Used pouch**. Tick to indicate whether food was from (stored in or served from) a baby food pouch (including commercial and home-filled pouches). If so, tick the option that best describes how the pouch was used:
  - Baby fed self directly (i.e. baby holds pouch and sucks through nozzle)
  - Adult fed baby directly (i.e. adult holds pouch and baby sucks through nozzle)
  - Adult fed baby 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?"

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

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

→ *If <u>participant provided food to eat while in their care</u> (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.*

<u>If you identify any significant missing information</u> *(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. *Time spent eating at each occasion (first to last mouthful of <u>solid</u> food).*
2. *If applicable: Duration of each formula feed. NB: Breastfeeding duration (from the breast or expressed) is to be recorded separately (see O-5: First Foods NZ FAQs, 24-h recall section, for examples).*
3. *Forgotten foods/liquids*
4. *Home-filled pouch use*

"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 [*baby's name*] ate or drank so we can record it. As we go through, we also need to work out how long each eating (and formula-feeding) occasion lasted."

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

Review the list of foods and beverages with the participant and determine how long baby spent eating or drinking, for:

1. *Solid foods: From their first to last mouthful of food for each meal/snack* ***(E.g.*** "At 8 am, [baby's name] ate a rice cracker and some peanut butter toast while in the car going to day care. How long did they spend eating these, from first to last mouthful?").
   Note: if they continued to consume liquids such as water or juice after their last mouthful of solid food, don't include this drinking in the time estimate.

2. *Formula (if applicable): From their first to last mouthful of formula at each formula-feeding occasion.* (E.g. "At 6pm [baby's name] had a drink of formula while sitting on the couch at home. How long did they spend drinking the formula, from first to last mouthful?")

Record the length of each eating/formula-feeding occasion in the 'Time' column (or in the left-hand column if multiple foods consumed at one occasion – see examples in 24-h recall section of **O-5_FAQ***) and use a horizontal line to separate different eating occasions.*

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

4. *Ask about home-filled pouch use:*
   1. Has the parent/guardian reported any pouch use
      YES **(GO TO 'b')**
      NO **(END)**

   2. "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 baby 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)*

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., FF1001AB_DR1

   Label each file with Participant ID, diet recall number, document name, and date:
   [*Participant ID*]_DR[*1/2*]_[*document name*]_[*date*]
   E.g., FF1001AB_DR1_RecordingSheet_10Jun2020

4. All 24-h recalls will be entered in Dunedin 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., FF1001AB_DR1

   Label each file with Participant ID, diet recall number, document name, and date:
   [*Participant ID*]_DR[*1/2*]_[*date*]
   E.g., FF1001AB_DR1_10Jun2020

6. Complete the **Diet Recall form** (under Main Visit 1 + BF1) in REDCap – when all fields have been answered mark the form status as 'Complete'.

APPENDIX 8: 24-HOUR DIET RECALL TEMPLATE

Note: pages shown are those with different headings.

First recall ☐
Second recall ☐

FIRST FOODS
— New Zealand —

Participant ID: ____________ Interviewer: ________________

Date: ____________ Day of the Week: ________________

O-15: 24-hr recall recording sheet

1. Was baby unwell yesterday?	☐ NO	☐ YES
1a. If unwell, did this influence baby's appetite?	☐ NO	☐ YES

QUICK LIST

☐ ______________________________________
☐ ______________________________________
☐ ______________________________________
☐ ______________________________________
☐ ______________________________________
☐ ______________________________________
☐ ______________________________________
☐ ______________________________________
☐ ______________________________________
☐ ______________________________________
☐ ______________________________________
☐ ______________________________________
☐ ______________________________________
☐ ______________________________________
☐ ______________________________________
☐ ______________________________________

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

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

Yes No **Is baby offered any drinks other than breast milk, formula, or water (things like cow's milk, other milk, juice, soft drinks, tea, alcohol or any other drink)?**

Version 2: 8Jun 2020 - 1

Participant ID: ____________ Interviewer: ________________

Date: ____________ Day of the Week: ________________

DETAILED 24-H RECALL

Time	Place	Description of Food/Drink	Brand	Amount		Fed by		Pouch used?			
			State the brand or 'brand unknown' (commercial food) or 'homemade'	Amount offered	Amount eaten	Adult	Baby	No	Yes		
									Baby fed self directly	Adult fed baby directly	Adult fed baby from spoon

Version 4: 29 Oct 2020 - 3

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 9: Foods Fed By Other Adults (FFOA) Form

FIRST 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 First Foods NZ study, our website is www. http://www.firstfoods.co.nz/.
If you have any comments or questions, then feel free to contact the study on 021 279 1290 or auckland@firstfoods.co.nz.

O-12 – Version 5: 20 July 2020

First Foods NZ

Foods Fed by Other Adults Diary

FIRST 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 babies 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 how to introduce solids safely to their babies.

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 baby food pouch. If yes, tick the option that best described how baby was fed food from the pouch. *Note*: *baby fed directly from pouch* means baby held pouch and sucked through pouch nozzle, *adult fed baby directly from pouch* means adult held pouch and baby 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		Step 5			
					Food was put in baby's mouth by:		Was food from a baby food pouch?			
							No	Yes, how was food from pouch fed?		
Time & Place	Food name	Food brand	Cooking method	Amount eaten	Adult	Baby		Baby fed self directly from pouch	Adult fed baby directly from pouch	Adult fed baby from 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	¼ cup		✓	✓			
	Peas		boiled	10 peas		✓	✓			

Food diary:

Step 1	Step 2			Step 3	Step 4		Step 5			
Time & Place	Food name	Food brand	Cooking method	Amount eaten	Food was put in baby's mouth by:		Was food from a baby food pouch?			
							No	Yes, how was food from pouch fed?		
					Adult	Baby		Baby fed self directly from pouch	Adult fed baby directly from pouch	Adult fed baby from spoon

APPENDIX 10: 24-HOUR DIET RECALL PROMPTS

FIRST FOODS
— New Zealand —

O-16: Food description prompts sheet

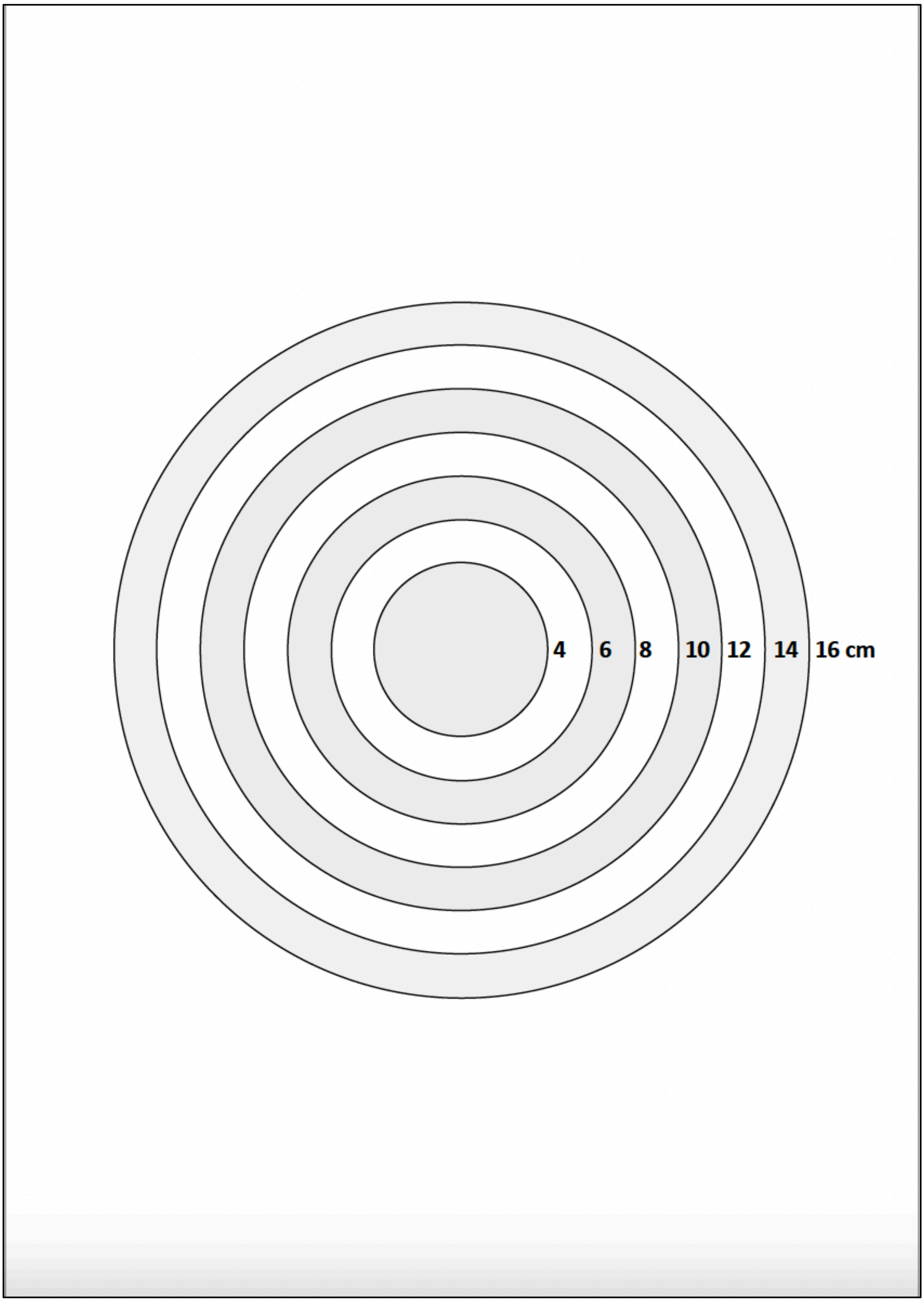
Food group	Description
Bakery items (e.g., biscuits, cakes, muffins) (see Bread separately)	• Biscuits: Flavour? Chocolate covered/Iced/Sandwich? • Cakes: Flavour? Type (e.g., sponge, fruit)? Icings or fillings? • Muffins: Flavour? Icings or fillings? • Homemade: Salt added? If so, was it iodised?
Bread	• White, wholemeal, wholegrain, light or dark rye • Brand name (important for information on fortification) • Thick, medium, or thin slice? • Toasted? • Buns: Toppings? Sweet or plain bun?
Breast milk	• Not expressed: Duration of breastfeed (e.g., Breastfeed (15 mins)). *NB*: We are interested in time latched (as opposed to time suckling). • Expressed: Quantity (if breast milk was expressed and fed via bottle, cup, etc) • Did baby spill/vomit after their feed (if yes, was it a sml, med or lge amount?)
Breakfast cereal	• Type (e.g., wheat, corn, oats, bran, rice, mixed) • Muesli: Added sugar/fruit? • Porridge: Made with milk or water or both? • Additions (e.g., milk, yoghurt, fruit, sugar, water)
Butter, margarine, spreads	• Butter: Salted or unsalted? Spreadable butter? • Fat spreads: Low fat or standard • Fat spreads: Cholesterol lowering (e.g., Flora Pro-Activ)? • Fat spreads: With olive oil? E.g., Olivani
Cheese	• Type (e.g., Edam, Colby) • Grated, sliced, or cubed • Block cheese or cheese sticks/slices
Chips, crackers and other snacks	• Standard, low fat, low salt • Flavour • Potato, corn, wheat, rice, etc • Sticks, rings, crackers, puffs, etc
Confectionary (e.g., chocolate, sweets)	• Sweets: Name? Type (e.g., jelly, boiled)? Sugar free? • Chocolate: Name? Type (e.g., white, milk, dark)? Any additions or fillings (e.g., raisins, nuts, caramel)?
Cordial (incl. Raro)	• Name and flavour • Standard or low sugar version • Powder or liquid concentrate? • Mixed with water or something else? • How much water (or other substance) was added?

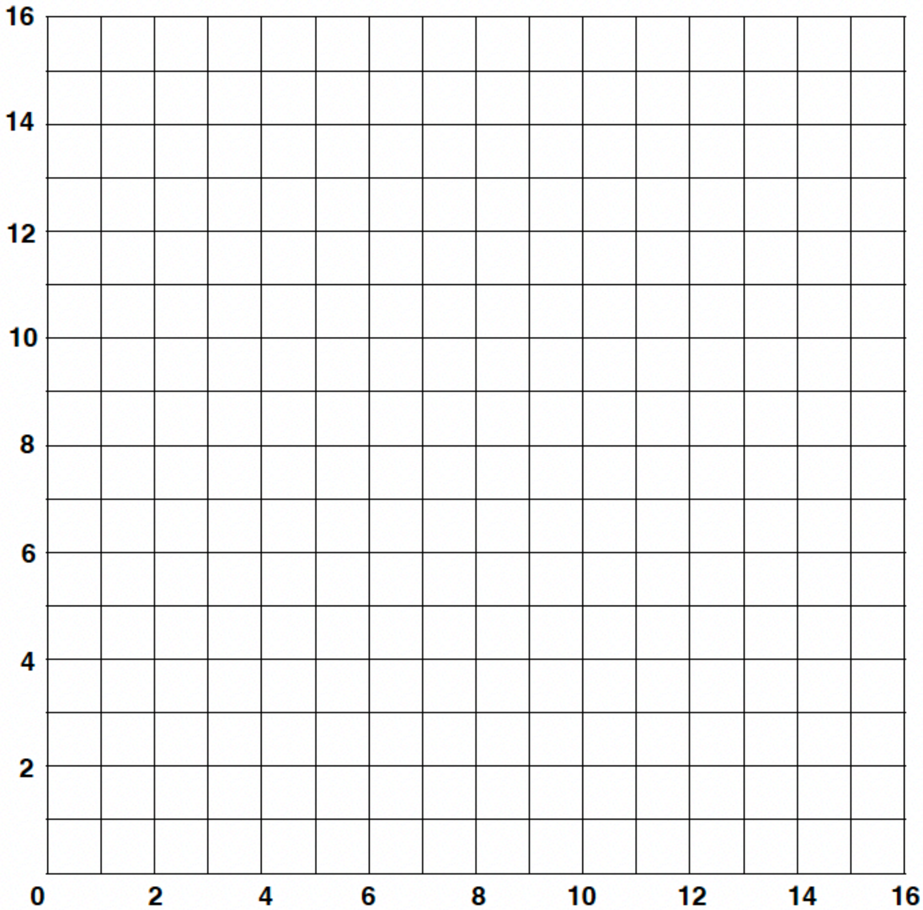
Meat, Fish, Poultry	• Type of meat (name of animal, cut of meat, preparation e.g., minced) • Cooking method (e.g., stewed, casseroled, baked, roasted, stir-fried, barbequed, steamed, microwaved) • Fat removed. If not, was it eaten? • Skin removed. If not, was it eaten? • Crumbed? • Cooked in fat or oil? If so, what type and how much?
Milk	• Type (e.g., cows, goats, soy) • Fat content (whole, reduced fat, trim) • Flavoured? Sweetened (if plant-based milk)? • Was the milk heated? For how long? • Was milk diluted with water? (if yes, how much?)
Mixed dishes	• Homemade or commercial? • If recipe unavailable, try to get as much detail as possible • Any protein ingredients, starchy ingredients, vegetables, sauces • Salt added? If so, was it iodised?
Nuts and seeds	• Type(s) (e.g., peanuts, almonds, sunflower seeds) • Raw, roasted • Salted, other flavour • Whole, chopped, slivered, "butter"
Oil	• Type of oil (e.g., canola, olive, sunflower, flaxseed, soybean)
Pasta	• White, wholemeal, legume • Fresh, dried, canned in sauce • Type of filling (e.g., ravioli, cannelloni) • *NB: was the amount given as raw or cooked?*
Potatoes & Starchy roots (e.g., taro, kumara, yam) (see Fries/Hot chips separately)	• Cooked, canned, frozen • Cooking method (boiled, baked, stir-fried, roasted, microwaved, steamed) • With or without skin • Additions (e.g., butter, milk, margarine, cream) • Cooked in fat or oil? If so, what type and how much? • If instant mash, what was it made up with?
Rice	• White or brown • Basmati, short grain, long grain, etc • *NB: was the amount given as raw or cooked?*
Soup	• Flavour • Base: cream/clear? • Instant mix, canned, homemade?

Culturally important foods for Māori & Pacific whānau	• Fruits and vegetables (e.g. pikopiko (fern shoots), puha (milk/sow thistle), taewa (Māori potato), watercress): Grown? Foraged? Gifted? Purchased – from where? • Seafood (e.g. kina, paua, shellfish, tuna (eel)): Gifted? Foraged? Fished? Purchased – from where? • Other traditional foods: Obtained from where?
Dairy desserts (e.g., custard, rice pudding)	• Instant (i.e. powder)/ready-made (i.e. from pottle)/homemade • What type of milk added?
Fizzy drinks	• Name and flavour • Standard, diet, zero sugar, type of sweetener? • Caffeinated? • Fortified with vitamins and minerals?
Fries/Hot chips	• Made at home: Frozen, oven, microwave, fresh-cut • Take-away: Where from (e.g., fish and chip store, McDonalds) • Cut (e.g., thick, thin, crinkle, French fries) • Cooked in oil or fat? (if so, what type if known and how much)
Fruit	• Fresh, canned, cooked, from baby food jar/pouch • Peeled or unpeeled • Colour (e.g., red/green apple) • In juice or syrup? (if so, how much)
Homemade food	• Ask for the recipe – record in 'Recipe' section • Salt added? If so, was it iodised?
Ice cream	• Flavour • Any additions? (e.g., sauce, toppings, fruit)
Infant cereal	• Infant cereal or family cereal • What form was it bought in? ("prepared" or "unprepared") • What fluid was used in preparation (e.g., breast milk, formula, water) • Plain or mixed with other components
Infant formula	• Form (powder, concentrate, ready-to-feed) • Amount of water and powdered formula used (i.e. concentration) • Total volume offered and remaining after each serve • Type of milk-base? (e.g., cows, goats, soy) • Stage (i.e. stage 1, 2, 3) • Gold or standard
Juices/Fruit drinks	• 100% juice or "fruit drink"? • Sweetened or no added sugar? • Commercial or freshly squeezed? • Added vitamins? • Was juice diluted with water? (if yes, how much?)

Vegetables (see Potatoes & Starchy roots separately)	• Fresh, canned, cooked, frozen, baby food from jar/pouch • Cooking method (boiled, baked, stir-fried, roasted, microwaved, steamed) • Peeled or unpeeled • Colour (e.g., red/green capsicum) • In sauce/juice (if so, how much)
Yoghurt	• Fat content (e.g., reduced fat, low fat) • Sweetened or low sugar • Natural or flavoured (e.g., fruit, vanilla)? • Fruit pieces/puree or just flavoured? • Greek yoghurt?

APPENDIX 11: 24-HOUR DIET RECALL GRID SHEETS




16
14
12
10
8
6
4
2
0
2
4
6
8
10
12
14
16

Appendix 12: Examples of Food and Food Group Coding

Food and food group coding was utilised in each manuscript presented in this thesis. This appendix aims to provide examples of how foods were coded using the FFNZ codebooks.

Background: When infants were provided meals or snacks that contained multiple ingredients a new 'recipe' was created in FoodWorks. This produced a large number of 'recipes' when our data were exported, in addition to singular foods (e.g. if an banana was offered on its own this was entered as a single food). As ingredients varied within each participants 'recipes' these were individually coded using the FFNZ food and food group codebooks.

The codebooks are available upon request from the FFNZ study team if required.

After food coding was completed, students were able to group coded foods into their relevant food groups. In this thesis, foods were allocated according to the MoH food groups. Baking such as carrot cake (example two below) was included in discretionary foods and not a source of carrot or vegetables.

Example of Excel export from FoodWorks

Four columns of information were provided on the FoodWorks export:

A. DocID: used to identify participant recipes. All ingredients have the same number.
B. FoodID: used to identify individual foods consumed within recipes e.g. carrots in recipes had a unique number.
C. Recipe name: name entered during FoodWorks entry. Recipe name started with participant ID
D. Ingredients: Ingredients entered into FoodWorks.
E. FFNZ food code: Identified from FFNZ codebook. This column was used during the coding process.
F. FFNZ food code number: Identified from FFNZ codebook. This column was used during the coding process.

A	B	C	D	E	F
DocID	FoodID	Recipe name	Ingredient	FFNZ food code	FFNZ food code number
734559295	2:7601101	FF1007AD_DR1_baby_mash	Carrot, flesh, fresh, boiled, drained, no salt added		
734559295	1917021706	FF1007AD_DR1_baby_mash	Kumara, flesh, boiled, drained, no salt added		
734559295	1917021706	FF1007AD_DR1_baby_mash	Parsnip, boiled, drained, no salt added		

Example 1. Simple mixed recipe

Using the example above two columns of information was added (column E and F).

Step 1. Check what recipe produced – was it a mixed dish or were ingredients combined to make a 'new food'?

In this case the recipe is a mixed dish.

Step 2. Identify ingredient in column D e.g. the first ingredient in this recipe was carrot (image below)

D
Ingredients
Carrot, flesh, fresh, boiled, drained, no salt added

Step 3: Identify corresponding ingredient in FFNZ codebook (image below)

Carrot was located in the vegetable food group, under orange vegetables. Code 24.04.01

FFNZ/YFNZ Major Group name	FFNZ/YFNZ Major Group code	FFNZ/YFNZ Sub Group name	FFNZ/YFNZ Sub Group code	FFNZ/YFNZ Minor Group name	FFNZ/YFNZ Minor Group code
Vegetables	24.00.00				
		Leafy greens	24.01.00		
				Leafy greens includes lettuce, spinach, silver beet, bok choy etc (Vegetables)	24.01.01
		Beans/peas/corn	24.02.00		
				Beans/peas/corn (Vegetables)	24.02.01
		Tomatoes and tomato products	24.03.00		
				Cooked or canned tomatoes (Vegetables)	24.03.01
				Purees and pastes (Vegetables)	24.03.02
				Fresh tomato (vegetables)	24.03.03
		Orange vegetables	24.04.00		
				Carrots (Vegetables)	24.04.01
				Pumpkin/squash/butternut (Vegetables)	24.04.02
				Yams (Vegetables)	24.04.03

Step 4: The code name and corresponding code were then entered into column E and F (image below)

A	B	C	D	E	F
DocID	FoodID	Recipe name	Ingredient	FFNZ food code	FFNZ food code number
734559295	2:7601101	FF1007AD_DR1_baby_mash	Carrot, flesh, fresh, boiled, drained, no salt added	Carrots (Vegetables)	24.04.01

Final coded food

A	B	C	D	E	F
DocID	FoodID	Recipe name	Ingredient	FFNZ food code	FFNZ food code number
734559295	2:7601101	FF1007AD_DR1_baby_mash	Carrot, flesh, fresh, boiled, drained, no salt added	Carrots (Vegetables)	24.04.01
734559295	1917021706	FF1007AD_DR1_baby_mash	Kumara, flesh, boiled, drained, no salt added	Kumara (Potatoes, kumara and taro)	25.04.01
734559295	1917021706	FF1007AD_DR1_baby_mash	Parsnip, boiled, drained, no salt added	Other root vegetables e.g. parsnip, beetroot, swede, turnip, radish	24.07.01

Example 2. Recipes that made a 'new food'

Baking and recipes that made a 'new food' were consumed by several infants. It was important that these were coded as the new food instead of ingredients to provide context of what the infant consumed.

The below recipe was a carrot cake.

A	B	C	D	E	F
DocID	FoodID	Recipe name	Ingredient	FFNZ food code	FFNZ food code number
1102362263	2:101803	FF1014JG_DR1_carrot_cake	Flour, plain, raw		
1102362263	2:7601101	FF1014JG_DR1_carrot_cake	Carrot, flesh, fresh, raw		
1102362263	931780617	FF1014JG_DR1_carrot_cake	Oil, canola		
1102362263	2:100174	FF1014JG_DR1_carrot_cake	Salt, table, iodised		
1102362263	2:108062	FF1014JG_DR1_carrot_cake	Spice, cinnamon, ground		
1102362263	2:7101008	FF1014JG_DR1_carrot_cake	Sugar, white		

Step 1. Check what recipe produced – was it a mixed dish or were ingredients combined to make a 'new food'?

In this case the recipe made a 'new food'

Step 2. Identify corresponding code for the 'new food' in FFNZ codebook (image below)

FFNZ/YFNZ Major Group name	FFNZ/YFNZ Major Group code	FFNZ/YFNZ Sub Group name	FFNZ/YFNZ Sub Group code	FFNZ/YFNZ Minor Group name	FFNZ/YFNZ Minor Group code
Cakes and muffins	05.00.00				
		Standard	05.01.00		
				Plain e.g. chocolate (Cakes and muffins)	05.01.01
				Fruit cake: dried fruit (Cakes and muffins)	05.01.02
				Fruit cake: banana (Cakes and muffins)	05.01.03
				Cake with vegetable: pumpkin (Cakes and muffins)	05.01.04
				Cake with fruit and vegetable: banana, pumpkin, and spinach (Cakes and muffins)	05.01.05
				Cake with berries (Cakes and muffins)	05.01.06
				Cake with dried fruit and stone fruit (Cakes and muffins)	05.01.07
				Carrot cake (Cakes and muffins)	05.01.09

Step 3: The code name and corresponding code were then entered into column E and F (image below)

A	B	C	D	E	F
DocID	FoodID	Recipe name	Ingredient	FFNZ food code	FFNZ food code number
1102362263	2:101803	FF1014JG_DR1_carrot_cake	Flour, plain, raw	Carrot cake (Cakes and muffins)	05.01.09
1102362263	2:7601101	FF1014JG_DR1_carrot_cake	Carrot, flesh, fresh, raw	Carrot cake (Cakes and muffins)	05.01.09
1102362263	931780617	FF1014JG_DR1_carrot_cake	Oil, canola	Carrot cake (Cakes and muffins)	05.01.09
1102362263	2:100174	FF1014JG_DR1_carrot_cake	Salt, table, iodised	Carrot cake (Cakes and muffins)	05.01.09
1102362263	2:108062	FF1014JG_DR1_carrot_cake	Spice, cinnamon, ground	Carrot cake (Cakes and muffins)	05.01.09
1102362263	2:7101008	FF1014JG_DR1_carrot_cake	Sugar, white	Carrot cake (Cakes and muffins)	05.01.09

Step 4: After all foods were coded, Excel documents were uploaded onto Stata. The DocID was then used to remove all 'recipes' that included multiple entries of the same ingredient. This ensured that the 'carrot cake' was counted once.

APPENDIX 13: MAIN QUESTIONNAIRE

Office use only

Date:

Participant ID:

Researchers name:

Main Questionnaire (first visit)

Welcome and thank you for being part of the FFNZ Study.
This questionnaire is split into 9 sections and should take about 20 minutes to complete.
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 baby?

- O Mother
- O Father
- O Grandparent
- O Guardian
- O 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 and baby

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

- O Yes Please describe: ________________
- O No
- O Don't know

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

- O Yes
- O No
- O Don't know

*If answer is 'No' or 'Don't know' – skip [Q4a-c]; 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 all that apply.*

- O First trimester
- O Second trimester
- O Third trimester

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

- O Yes
- O No

If answer is 'No' – skip [Q4b & 4c]

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

____

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

- O First trimester
- O Second trimester
- O Third trimester

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

- O Yes
- O No

If answer is 'No' – skip [Q4c]

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

____

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

- O First trimester
- O Second trimester
- O Third trimester

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

- O Yes
- O No

If answer is 'No' – skip [Q4d]

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

____

4d-ii. When was this prescribed medication taken? *Please select all that apply.*

- O First trimester
- O Second trimester
- O Third trimester

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

- O Yes
- O No

If answer is 'No' – skip [Q4e]

4e-i. **Medication 5:** What was the name of the prescribed medication?

____

4e-ii. When was this prescribed medication taken? *Please select all that apply.*

- O First trimester
- O Second trimester
- O Third trimester

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

- O Forceps were used
- O Caesarean birth

- O Other Please describe: ___________
- O There were no interventions

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

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

7. Is your baby a girl or a boy?

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

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

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

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

- O NZ European
- O Māori
- O Samoan
- O Cook Island Māori
- O Tongan
- O Niuean
- O Chinese
- O Indian
- O other, e.g., 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)?

- O Yes
- O Don't know
- O No

*If answer is 'No' – go to **Q11***

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

FIRST FOODS — New Zealand —

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 baby have any diagnosed health conditions or disabilities?

- ○ Yes Please state: ______
- ○ No

Section 3: Some questions about your baby and food

12. How old was your baby when they first had anything to drink that was not breast milk? (e.g., infant formula, water, other liquids)

- O They did not have any breast milk
- O Breast milk is the only drink my baby has had so far
- O Less than 1 month old
- O 1 month old
- O 2 months old
- O 3 months old
- O 4 months old
- O 5 months old
- O 6 months old
- O 7 months old
- O 8 months old
- O 9 months old
- O 10 months old
- O 11 months old

If answer is 'They didn't have any breast milk' – skip [Q13a-d]

13. Is baby still being breastfed?

- O Yes
- O No

*If answer is 'No' – go to **Q13d***
*If answer is 'Yes' – **answer Q13a, Q13b, Q13c**; skip [Q13d]*

13a. How many breastfeeds does your baby have a day? *Please include night feeds and think about the average over the past week.*

_______ per day (including night feeds)

13b. What quantity of breast milk does your baby spill/vomit for each feed? *Please think about the average over the past week.*

- O None
- O A little
- O Some
- O Most
- O All

13c. Is your baby breastfed on demand or by schedule? *On demand is when baby decides when feeding happens, by schedule is where you have set times when feeding happens.*

- O On demand only
- O By schedule only
- O On demand during the day, by schedule overnight
- O By schedule during the day, on demand overnight

13d. How old was your baby when they stopped being breastfed?

- O Less than 1 month old
- O 1 month old
- O 2 months old
- O 3 months old
- O 4 months old
- O 5 months old
- O 6 months old
- O 7 months old
- O 8 months old
- O 9 months old
- O 10 months old
- O 11 months old

14. Has your baby ***ever*** had infant formula?

- O Yes
- O No

If answer is 'No' – skip [Q14a-c]

14a. How old was your baby when they first had infant formula?

- O Less than 1 month old
- O 1 month old
- O 2 months old
- O 3 months old
- O 4 months old
- O 5 months old
- O 6 months old
- O 7 months old
- O 8 months old
- O 9 months old
- O 10 months old
- O 11 months old

14b. Does your baby still drink infant formula?

- O Yes
- O No

If answer is 'Yes' – skip [Q14c]

14c. How old was your baby when they stopped drinking infant formula?

- O Less than 1 month old
- O 1 month old
- O 2 months old
- O 3 months old
- O 4 months old
- O 5 months old
- O 6 months old
- O 7 months old
- O 8 months old
- O 9 months old
- O 10 months old
- O 11 months old

15. Are you *currently* offering your baby any drinks other than water, breast milk or infant formula?

- O Yes
- O No

If answer is 'No' – skip [Q15a]

15a. What other drinks are you *currently* offering your baby? *Please select all that apply.*

- O Cow's milk – undiluted
- O Cow's milk – diluted
- O Soy milk or other milk alternative
- O Tea
- O Juice or fruit drink
- O Other Please state: _____

16. Do you *usually* offer your baby milk feeds (breast milk or formula) before or after solid food is offered (meals or snacks)?

- O Before
- O After
- O Both before and after
- O Baby isn't having milk feeds
- O Baby isn't having solid food

17. How old was your baby when they first had solid foods? *(solid foods are anything that isn't breast milk, infant formula or other drinks. They don't have to be thick – some solids are runny, and some have drinks like breast milk or infant formula mixed into them)*

- O They haven't had solids yet
- O Less than 1 month old
- O 1 month old
- O 2 months old
- O 3 months old
- O 4 months old
- O 5 months old
- O 6 months old
- O 7 months old
- O 8 months old
- O 9 months old
- O 10 months old
- O 11 months old

If answer is 'They haven't had solids yet' – skip [rest of solids Q's, incl. rest of section 3, section 4 & 5, and choking on food Q's]
If answer is '6 months' – skip [double up 6-7 mo/started solids Q's ***[Q18 & Q42-42b & 43-43a]***

17a. What was the first food you gave your baby?

____

17b. What texture was the first food you gave your baby?

- O Puréed
- O Mashed
- O Chopped
- O Finger food
- O Other

18. How was your baby fed when they *first started* eating solids?

- O Spoon fed by an adult
- O Mostly spoon fed by adult, some baby feeding themselves
- O About half spoon fed by an adult and half baby feeding themselves
- O Mostly baby feeding themselves, some spoon feeding by an adult
- O Baby feeding themselves

19. How was your baby fed at *around 6 months of age*?

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

20. How is your baby being fed solids *now*?

- O Spoon fed by an adult
- O Mostly spoon fed by adult, some baby feeding themselves
- O About half spoon fed by an adult and half baby feeding themselves
- O Mostly baby feeding themselves, some spoon feeding by an adult
- O Baby feeding themselves
- O Baby does not eat solids

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

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

If answer is 'No' or 'Don't know what BLW is' – skip [Q21a]

21a. How old was your baby when you first tried baby-led weaning?

- O Less than 1 month old
- O 1 month old
- O 2 months old
- O 3 months old
- O 4 months old
- O 5 months old
- O 6 months old
- O 7 months old
- O 8 months old
- O 9 months old
- O 10 months old
- O 11 months old

22. Have you used any traditional foods or practices when starting baby on solids? You might have chosen them because they are traditional to your culture, or your family or whānau.

- O Yes Please describe: __________
- O No

22a. Are there any traditional or cultural (family or whānau) foods you like your baby to have now?

- O Yes Please describe: __________
- O No

23. When your baby was ***around 6 months*** of age, did they eat bought baby rice cereal? (foods like Farex rice cereal, Only Organic baby rice)

- O Yes
- O No - I offered it but they wouldn't eat it
- O No - I didn't offer it because I don't agree with my baby eating it
- O No - I didn't offer it because I didn't think it would be safe for my baby
- O No - I didn't offer it because my baby hadn't started eating solids yet
- O No - I didn't offer it for another reason Please state: ______

If answer is 'No...' – skip [Q23a]

23a. How often did they eat baby rice cereal?

- ○ 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

24. When your baby was ***around 6 months*** of age, did they eat red meat (like beef or lamb)?

- ○ Yes
- ○ No - I offered it but they wouldn't eat it
- ○ No - I didn't offer it because I don't agree with my baby eating it
- ○ No - I didn't offer it because I didn't think it would be safe for my baby
- ○ No - I didn't offer it because my baby hadn't started eating solids yet
- ○ No - I didn't offer it for another reason Please state: _____

If answer is 'No...' – skip [Q24a]

24a. How often did they eat red meat (like beef or lamb)?

- ○ 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

25. Have you offered these foods to your baby? *Please select all options that apply.*

- ○ Egg (cooked)
- ○ Dairy (e.g., milk, yoghurt, cheese)
- ○ Peanut (including peanut butter)
- ○ Tree nuts (e.g., almond, cashew, walnuts)
- ○ Sesame (e.g., as seeds on top of some breads, in hummus, tahini)
- ○ Wheat (e.g., breakfast cereal, pasta, flour, bread (excluding gluten-free))
- ○ Soy (e.g., tofu, soy milk, soy sauce)
- ○ Seafood (fish and shellfish)
- ○ Bread (common commercial varieties, excluding soy-free bread)
- ○ None of the above

26. Have you, or do you plan to, ***avoid*** offering any foods to your baby in their first year of life?

- O Yes
- O No

26a. Please comment:

____

27. Does your baby have any known food allergies?

- O Yes Please state which food(s): ____
- O No

If answer is 'No' – skip [Q27a]

27a. Comments (especially how these allergies were diagnosed)

____

Section 4: Your baby and baby food pouches

28. Has your baby ever eaten food from a baby food pouch?

- O Yes
- O No

*If the answer is 'No' – go to [pouch dislikes; **Q41**]*

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

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

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

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

31. When baby has food from a baby food pouch, how does baby get the food?

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

*If answer is 'Always on a spoon' – skip [pouch nozzle Q's: **Q31a, Q33, Q34, 35, 36**]*

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

- O An adult
- O Mostly an adult, sometimes baby
- O About half of the time an adult and half of the time baby
- O Mostly baby, sometimes an adult
- O Baby

32. What are the three most common baby food pouches your baby eats?

32a-i

Flavour and brand of baby food pouch baby eats most commonly:

____

32a-ii How often has your baby eaten this food *in the past month*?

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

32b-i

Flavour and brand of baby food pouch baby eats second most commonly:

____

32b-ii How often has your baby eaten this food *in the past month*?

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

32c-i

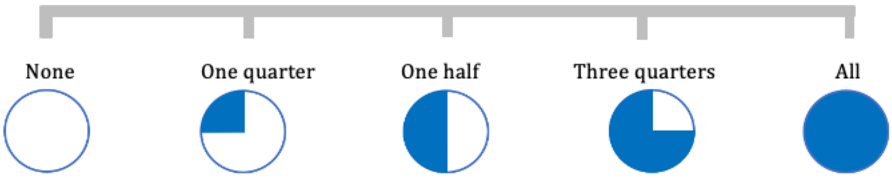
Flavour and brand of baby food pouch baby eats third most commonly

____

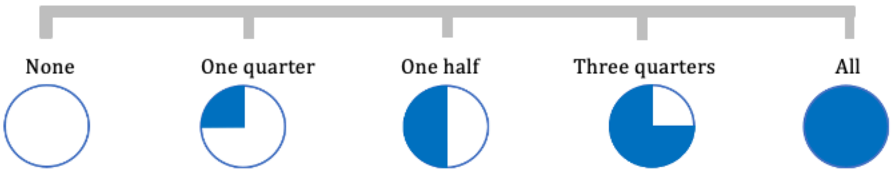
32c-ii How often has your baby eaten this food *in the past month*?

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

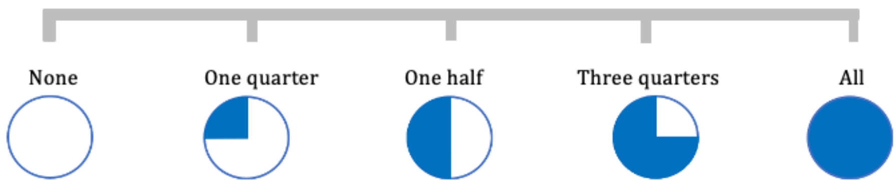
33. Out *of all the food your baby eats*, what proportion do they eat by feeding themselves directly from a pouch (holding a pouch themselves and sucking through the nozzle)? Show this on the sliding scale:



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



35. When your baby feeds themselves directly from a baby 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 [Q36]; go to **Q37***

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

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

37. Where is your baby usually when they are given a baby food pouch? *Please select the option that is the __most common__.*

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

38. Does baby eat from baby food pouches anywhere else? *Please select all options that apply.*

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

39. How often do you, or another adult, sit with your baby when they are eating from a baby food pouch? *Please only include sitting with them when you can see them – for instance please don't include driving when they're in the back seat.*

- ○ Never
- ○ Sometimes
- ○ About half the time
- ○ Almost always
- ○ Always

40. Why do you use baby food pouches? *Please select all options that apply.*

- ○ Easy to use
- ○ Less mess
- ○ Cost less
- ○ Takes less time
- ○ Practical
- ○ I have my hands free to do other things
- ○ My baby 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 baby eats
- ○ Healthier than foods the family eats
- ○ The food in them is good for baby
- ○ Organic
- ○ Doesn't waste as much food
- ○ The packaging keeps the food fresh
- ○ Safety
- ○ Other Please state: ____

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

- O Yes Please state: ___
- O No

42. When your baby first ***started eating solids***, were they having food from a baby food pouch?

- O Yes
- O No

*If answer is 'No' – go to **[Q44]***

42a. When your baby first ***started eating solids***, how often would they have food from a 'ready-to-eat' baby food pouch? (i.e. a pouch that was filled when you bought it)

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

42b When your baby first ***started eating solids***, how often did your baby eat from a 'home-filled' baby food pouch? (i.e., pouches that you have to put the food in at home)

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

43 When baby had food from a baby food pouch when they ***first started solids***, how did baby get the food?

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

*If answer is 'Always on a spoon' – go to **[Q44]***

43a When baby had food straight from a baby food pouch nozzle when they ***first started solids***, who put the nozzle in baby's mouth?

- O An adult
- O Mostly an adult, sometimes baby
- O About half of the time an adult and half of the time baby
- O Mostly baby, sometimes an adult
- O Baby

44. Was your baby eating food from a baby food pouch when they were ***around 6 months*** of age?

- O Yes
- O No

*If answer is 'No' – go to **[Section 5]***

44a. How often did baby eat food from a 'ready-to-eat' baby food pouch when they were ***around 6 months*** of age? (i.e. a pouch that was filled when you bought it)

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

44b. How often did your baby eat from a 'home-filled' baby food pouch when they were *around 6 months* of age? (i.e. pouches that you have to put the food in at home)

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

45 When baby had food from a baby food pouch at *around 6 months* of age, how did baby get the food?

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

*If answer is 'Always on a spoon' – go to **[Section 5]***

45a When baby had food straight from a baby food pouch nozzle at *around 6 months* of age, who put the nozzle in baby's mouth?

- O An adult
- O Mostly an adult, sometimes baby
- O About half of the time an adult and half of the time baby
- O Mostly baby, sometimes an adult
- O Baby

Section 5: Some questions about your baby's eating behaviour

Children's Eating Behaviour Questionnaire – satiety responsiveness, food responsiveness, enjoyment of food and slowness in eating subscale (Wardle); Toddler-Parent Mealtime Behavior Questionnaire – Picky eater subscale (Horodynski)

Please read the following statements and select the answer most appropriate to your baby's eating behaviour now.

46. My baby loves food

○ Never ○ Rarely ○ Sometimes ○ Often ○ Always

47. My baby has a big appetite

○ Never ○ Rarely ○ Sometimes ○ Often ○ Always

48. My baby finishes his/her meal quickly

○ Never ○ Rarely ○ Sometimes ○ Often ○ Always

49. My baby is interested in food

○ Never ○ Rarely ○ Sometimes ○ Often ○ Always

50. My baby eats slowly

○ Never ○ Rarely ○ Sometimes ○ Often ○ Always

51. My baby's always asking for food

○ Never ○ Rarely ○ Sometimes ○ Often ○ Always

52. If allowed to, my baby would eat too much

○ Never ○ Rarely ○ Sometimes ○ Often ○ Always

53. My baby leaves food on his/her plate at the end of a meal

○ Never ○ Rarely ○ Sometimes ○ Often ○ Always

54. My baby takes more than 30 minutes to finish a meal

○ Never ○ Rarely ○ Sometimes ○ Often ○ Always

55. Given the choice, my baby would eat most of the time

○ Never ○ Rarely ○ Sometimes ○ Often ○ Always

56. My baby looks forward to mealtimes

○ Never ○ Rarely ○ Sometimes ○ Often ○ Always

57. My baby gets full before his/her meal is finished

○ Never ○ Rarely ○ Sometimes ○ Often ○ Always

58. My baby enjoys eating

○ Never ○ Rarely ○ Sometimes ○ Often ○ Always

59. My baby gets full up easily

○ Never ○ Rarely ○ Sometimes ○ Often ○ Always

60. Even if my baby is full up, s/he finds room to eat his/her favourite food

○ Never ○ Rarely ○ Sometimes ○ Often ○ Always

61. My baby cannot eat a meal if s/he had a snack just before

○ Never ○ Rarely ○ Sometimes ○ Often ○ Always

62. If given the chance, my baby would always have food in his/her mouth

O	O	O	O	O
Never	Rarely	Sometimes	Often	Always

63. My baby eats more and more slowly during the course of a meal

O	O	O	O	O
Never	Rarely	Sometimes	Often	Always

64. My baby tries new foods (for example, will take a bite or taste of a new food)

O	O	O	O	O
Never	Rarely	Sometimes	Often	Always

65. My baby refuses vegetables

O	O	O	O	O
Never	Rarely	Sometimes	Often	Always

66. My baby is a picky eater

O	O	O	O	O
Never	Rarely	Sometimes	Often	Always

67. My baby refuses fruits

O	O	O	O	O
Never	Rarely	Sometimes	Often	Always

68. My baby accepts new foods

O	O	O	O	O
Never	Rarely	Sometimes	Often	Always

69. Please add any comments here if you wish:

____

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Section 6: Some questions about your baby's health

70. Does your baby currently have reflux?

- O Yes
- O No

If answer is 'No' – skip [Q70a]

70a. Does this change how or what you feed them?

- O Yes Please describe: __________
- O No

71. Has your baby ever choked on any liquid (e.g., breast milk, infant formula, or water)? *Please only count times when baby's airway was blocked (partially or totally) – they may have coughed or spluttered. Please don't count gagging, or spitting or vomiting to get food out of the mouth.*

- O Yes How many times? __________
- O No

72. Has your baby ever choked on any other food? *Please only count times when baby's airway was blocked (partially or totally) – they may have coughed or spluttered. Please don't count gagging, or spitting or vomiting to get food out of the mouth.*

- O Yes How many times? __________
- O No

If answer is 'No' – skip [Q72a-72f]; go to ***Q73***

72a. Thinking of the most serious choking episode (on food) which of the following did your baby do? *Choose as many as apply.*

- O Eyes watered
- O Pushed tongue out
- O Coughed
- O Gasped
- O Retched
- O Vomited
- O Cried
- O Went silent
- O Other Please state: ______

72b. Thinking again of the most serious choking episode (on food), which of the following happened? *Choose as many as apply.*

- O Baby resolved it themselves
- O Parent resolved it
- O A health professional resolved it
- O Another person resolved it
- O A health professional was involved
- O Baby was admitted to hospital
- O Other Please state: ______

72c. Thinking again of the most serious choking episode (on food), what was the food responsible?

____

72d. Thinking again of the most serious choking episode (on food), what form was the food in?

- O *Thin* liquid
- O *Thick* liquid
- O Puréed
- O Mashed
- O Diced
- O Sliced
- O Whole

72e. Thinking again of the most serious choking episode (on food), who fed the baby the food that was responsible?

- O Baby him/herself
- O Parent
- O Another adult
- O Brother or sister
- O Another child

72f. How old was your baby when this incident happened?

- O Less than 1 month old
- O 1 month old
- O 2 months old
- O 3 months old
- O 4 months old
- O 5 months old
- O 6 months old
- O 7 months old
- O 8 months old
- O 9 months old
- O 10 months old
- O 11 months old

73. Has baby ever choked on food from a baby food pouch? *Please only count times when baby's airway was blocked (partially or totally) – they may have coughed or spluttered. Please don't count gagging, or spitting or vomiting to get food out of the mouth.*

- O Yes How many times? __________
- O No

*If answer is 'No' – skip [Q73a-73e]; go to **Section 7***

73a. Was the most serious choking episode (on food from a baby food pouch) the same as an incident you described above?

- O Yes
- O No

*If answer is 'Yes' – skip [73b-73e]; go to **Section 7***

73b. Thinking of the most serious choking episode (on food from a baby food pouch) which of the following did your baby do? *Choose as many as apply.*

- O Eyes watered
- O Pushed tongue out
- O Coughed
- O Gasped
- O Retched
- O Vomited
- O Cried
- O Went silent
- O Other Please state: ______

73c. Thinking again of the most serious choking episode (on food from a baby food pouch), which of the following happened? *Choose as many as apply.*

- O Baby resolved it themselves
- O Parent resolved it
- O A health professional resolved it
- O Another person resolved it
- O A health professional was involved
- O Baby was admitted to hospital
- O Other Please state: ______

73d. Thinking again of the most serious choking episode (on food from a baby pouch), who fed the baby the food that was responsible?

- O Baby him/herself
- O Parent
- O Another adult
- O Brother or sister
- O Another child

73e. How old was your baby when this incident happened?

- O Less than 1 month old
- O 1 month old
- O 2 months old
- O 3 months old
- O 4 months old
- O 5 months old
- O 6 months old
- O 7 months old
- O 8 months old
- O 9 months old
- O 10 months old
- O 11 months old

Section 7: Some questions about your baby's teeth

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

- O My baby does not have any teeth
- O Birth
- O 1 month old
- O 2 months old
- O 3 months old
- O 4 months old
- O 5 months old
- O 6 months old
- O 7 months old
- O 8 months old
- O 9 months old
- O 10 months old
- O 11 months old

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

- O Yes
- O No
- O Sometimes

If answer is 'No' – skip [Q75a]

75a. How do you clean baby's teeth (or mouth if they don't have any teeth)? (e.g., brush with a soft brush, wipe with a damp cloth)

____

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

- O Yes
- O No

If answer is 'No' – skip [Q76a]

76a. What else do you do to look after your baby's teeth (or mouth if they don't have any teeth)?

____

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

- O Yes
- O No

If answer is 'No' – skip [Q77a]

77a. What concerns do you have about your baby's teeth (or mouth if they don't have any teeth)?

____

Section 8: Some questions about supplements

78. Has your baby taken any supplements in the past month?

- O Yes
- O No

*If answer is 'No' – skip [Q79-81]; go to **Section 9***

79. What type of supplement was it? *Please select all that apply.*

- O Multivitamin and/or multimineral
- O Single vitamin or mineral
- O Other Please specify ____

[Complete Q79-81 as appropriate]

79a-i. Multivitamin and/or multimineral: How often did your baby take the supplement in the past month?

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

79a-ii. Multivitamin and/or multimineral: Is your baby currently taking this supplement?

- O Yes
- O No

79a-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.

____

79a-iv. Multivitamin and/or multimineral: If you have the supplement please could the researcher take a photo of it.

[*upload photo*]

[repeat option]

80a-i. Single vitamin or mineral: Please tell us what vitamin or mineral it was:

____

80a-ii. Single vitamin or mineral: How often did your baby take the supplement in the past month?

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

80a-iii. Single vitamin or mineral: Is your baby currently taking this supplement?

- O Yes
- O No

80a-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.

____

80a-v. Single vitamin or mineral: If you have the supplement please could the researcher take a photo of it.

[*upload photo*]

[repeat option]

81a-i. Other: How often did your baby take the supplement in the past month?

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

81a-ii. Other: Is your baby currently taking this supplement?

- O Yes
- O No

81a-iii. Other: If you know the brand name and/or the product name please write them here. Please provide as much information as possible.

____

81a-iv. Other: If you have the supplement please could the researcher take a photo of it.

[*upload photo*]

[repeat option]

Section 9: Some final questions

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

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

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

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

- O Yes
- O Don't know
- O No

If answer is 'No' – go to Q84

83a Do you know the name(s) of your iwi (tribe or tribes)?
See the Guide Notes for a list of iwi.

- O Yes
- O No

If answer is 'No' – go to Q84

83b 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: ________________________________

84. Do you currently have paid employment?

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

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

- O School
- O Polytechnic or similar
- O University
- O Other Please state: ___

86. How tall are you without shoes?

______ cm *or* ______ feet and ______ inches

87. How much do you weigh?

______ kg *or* ______ pounds *or* ______ stone and ______ pounds

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

- O One
- O Two
- O Three
- O Four or more

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

- O One
- O Two
- O Three
- O Four or more

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

- O One
- O Two

- O Three
- O Four or more

91. Is your baby regularly looked after by someone other than yourself? *Please select __all__ answers that apply.*

- O No
- O Yes, by another family member
- O Yes, by a nanny
- O Yes, they go to an early childhood centre
- O Yes, they go to homebased care
- O Yes, other Please state: ___

Thank you very much for completing this questionnaire

APPENDIX 14: FINAL QUESTIONNAIRE (PEDIEAT)

Note: section one and two were not used in this thesis and have been removed.

Office use only

Date:

Participant ID:

Final questionnaire

Thank you for continuing to be part of the First Foods New Zealand Study.
This questionnaire is split into 3 sections and takes about 20 minutes to complete.
Take your time and talk to others who also care for your baby, if needed.
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 3: Eating behaviours

Pediatric Eating Assessment Tool (PediEAT)

The items below may not apply to every child. When filling this out, think about what is typical for your child at the moment.

Part 1: Physical

My child...	Never	Almost Never	Sometimes	Often	Almost Always	Always
73. gets watery eyes when eating	☐	☐	☐	☐	☐	☐
74. gets red colour around eyes or face when eating	☐	☐	☐	☐	☐	☐
75. coughs during or after eating	☐	☐	☐	☐	☐	☐
76. sounds gurgly or like they need to cough or clear their throat during or after eating	☐	☐	☐	☐	☐	☐
77. sounds different during or after a meal (for example, voice becomes hoarse, high-pitched, or quiet)	☐	☐	☐	☐	☐	☐
78. chokes or coughs on water or other thin liquids	☐	☐	☐	☐	☐	☐
79. moves head down toward chest when swallowing	☐	☐	☐	☐	☐	☐
80. has food or liquid come out of nose when eating	☐	☐	☐	☐	☐	☐
81. gets pale or blue colour around his/her lips during meals	☐	☐	☐	☐	☐	☐
82. breathes faster or harder when eating	☐	☐	☐	☐	☐	☐
83. needs to take a break during the meal to rest or catch their breath	☐	☐	☐	☐	☐	☐
84. gets tired from eating and is not able to finish	☐	☐	☐	☐	☐	☐
85. sweats/gets clammy during meals	☐	☐	☐	☐	☐	☐
86. tilts head back while eating	☐	☐	☐	☐	☐	☐
87. burps more than usual while eating	☐	☐	☐	☐	☐	☐
88. throws up during mealtime	☐	☐	☐	☐	☐	☐
89. throws up between meals (from 30 minutes after the last meal until the next meal)	☐	☐	☐	☐	☐	☐

My child...		Never	Almost Never	Sometimes	Often	Almost Always	Always
90.	arches back during or after meals	☐	☐	☐	☐	☐	☐
91.	gags when it is time to eat (for example, when they see food or when placed in high chair)	☐	☐	☐	☐	☐	☐
92.	gags with smooth foods like pudding	☐	☐	☐	☐	☐	☐

My child...		My child isn't offered textured food	Never	Almost Never	Sometimes	Often	Almost Always	Always
93.	gags with textured food like coarse oatmeal	☐	☐	☐	☐	☐	☐	☐

My child...		Never	Almost Never	Sometimes	Often	Almost Always	Always
94.	gags, coughs, or vomits when brushing teeth (if your child does not have teeth, select Never. If your child will not allow you to brush his/her teeth, select Always)	☐	☐	☐	☐	☐	☐
95.	gets a bloated tummy after eating	☐	☐	☐	☐	☐	☐
96.	turns red in face, may cry with pooing	☐	☐	☐	☐	☐	☐
97.	has gas	☐	☐	☐	☐	☐	☐
98.	drools when eating	☐	☐	☐	☐	☐	☐
99.	has a hard time eating due to stuffy nose	☐	☐	☐	☐	☐	☐

100. If you would like to explain any of your responses, please do so here:

Part 2: Mealtime behaviours

My child...	Never	Almost Never	Sometimes	Often	Almost Always	Always
101. avoids eating by playing or talking	☐	☐	☐	☐	☐	☐
102. has to be told to start eating	☐	☐	☐	☐	☐	☐
103. has to be reminded to keep eating	☐	☐	☐	☐	☐	☐
104. won't eat at meals, but wants food later	☐	☐	☐	☐	☐	☐
105. stops eating after a few bites	☐	☐	☐	☐	☐	☐
106. refuses to eat	☐	☐	☐	☐	☐	☐
107. shows more stress during meals than during non-mealtimes (whines, cries, gets angry, tantrums)	☐	☐	☐	☐	☐	☐
108. likes something one day and not the next	☐	☐	☐	☐	☐	☐
109. insists on food being offered in a certain way (such as, how food is on the plate or what dish or spoon is used, or where they sit)	☐	☐	☐	☐	☐	☐
110. insists on being fed by the same person(s)	☐	☐	☐	☐	☐	☐
111. becomes upset by the smell of food	☐	☐	☐	☐	☐	☐
112. throws food or pushes food away	☐	☐	☐	☐	☐	☐
113. prefers to drink instead of eat	☐	☐	☐	☐	☐	☐

My child...	My child isn't offered crunchy foods	Never	Almost Never	Sometimes	Often	Almost Always	Always
114. prefers crunchy foods	☐	☐	☐	☐	☐	☐	☐

My child...	Never	Almost Never	Sometimes	Often	Almost Always	Always
115. eats better when entertained	☐	☐	☐	☐	☐	☐
116. takes more than 30 minutes to eat	☐	☐	☐	☐	☐	☐
117. needs mealtime to be calm	☐	☐	☐	☐	☐	☐
118. wants the same food for more than two weeks in a row	☐	☐	☐	☐	☐	☐

My child...	Never	Almost Never	Sometimes	Often	Almost Always	Always
119. likes to eat	☐	☐	☐	☐	☐	☐
120. eats a variety of foods (fruits, vegetables, proteins, etc.)	☐	☐	☐	☐	☐	☐
121. is willing to stay seated during mealtime	☐	☐	☐	☐	☐	☐
122. opens their mouth when food is offered	☐	☐	☐	☐	☐	☐
123. is willing to touch food with their hands	☐	☐	☐	☐	☐	☐

124. If you would like to explain any of your answers, please do so here:

Part 3: Eating

My child...	My child isn't offered mixed texture foods	Never	Almost Never	Sometimes	Often	Almost Always	Always
125. will eat mixed texture foods	☐	☐	☐	☐	☐	☐	☐

My child...	Never	Almost Never	Sometimes	Often	Almost Always	Always
126. will eat food warmer than room temperature	☐	☐	☐	☐	☐	☐
127. is willing to feed self (if younger in age, holds cup, feeds self crackers)	☐	☐	☐	☐	☐	☐
128. keeps food in mouth when eating (food means non-liquids)	☐	☐	☐	☐	☐	☐
129. keeps liquids in mouth when drinking	☐	☐	☐	☐	☐	☐
130. keeps their tongue inside mouth during eating	☐	☐	☐	☐	☐	☐
131. acts hungry before meals	☐	☐	☐	☐	☐	☐

My child...	My child isn't offered this	Never	Almost Never	Sometimes	Often	Almost Always	Always
132. will eat foods that need to be chewed	☐	☐	☐	☐	☐	☐	☐
133. will eat textured food like coarse oatmeal	☐	☐	☐	☐	☐	☐	☐
134. will eat frozen food, like ice cream	☐	☐	☐	☐	☐	☐	☐

My child...	My child isn't offered chewable food	Never	Almost Never	Sometimes	Often	Almost Always	Always
135. chews their food enough	☐	☐	☐	☐	☐	☐	☐

My child...	Never	Almost Never	Sometimes	Often	Almost Always	Always
136. moves food in their mouth when chewing without help	☐	☐	☐	☐	☐	☐
137. sniffs food or objects	☐	☐	☐	☐	☐	☐
138. spits food out	☐	☐	☐	☐	☐	☐
139. eats too fast	☐	☐	☐	☐	☐	☐

140. If you would like to explain any of your responses, please do so here:

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— New Zealand —

Part 4: Oral processing

My child...	Never	Almost Never	Sometimes	Often	Almost Always	Always
141. stores food in their cheek or roof of mouth	☐	☐	☐	☐	☐	☐
142. gets food stuck in their cheek or roof of mouth	☐	☐	☐	☐	☐	☐

My child...	My child has only ever been offered smooth foods	Never	Almost Never	Sometimes	Often	Almost Always	Always
143. prefers smooth foods like yogurt	☐	☐	☐	☐	☐	☐	☐

My child...	Never	Almost Never	Sometimes	Often	Almost Always	Always
144. puts too much food in mouth at one time	☐	☐	☐	☐	☐	☐
145. puts fingers in mouth to move food	☐	☐	☐	☐	☐	☐
146. prefers strong flavours	☐	☐	☐	☐	☐	☐
147. bites down on the spoon or fork and does not release it easily	☐	☐	☐	☐	☐	☐
148. grinds teeth when awake (if your child does not have teeth, please select Never)	☐	☐	☐	☐	☐	☐
149. chews on toys, clothes, or other objects	☐	☐	☐	☐	☐	☐

My child...	My child isn't offered chewable foods	Never	Almost Never	Sometimes	Often	Almost Always	Always
150. has to be reminded to chew food	☐	☐	☐	☐	☐	☐	☐
151. sucks on food to soften or moisten it, rather than chewing it	☐	☐	☐	☐	☐	☐	☐
152. chews food but doesn't swallow it	☐	☐	☐	☐	☐	☐	☐
153. chews a bite of food for a long time (~30 seconds or longer)	☐	☐	☐	☐	☐	☐	☐

154. If you would like to explain any of your responses, please do so here:

Thank you for taking the survey.

Have a nice day!

Appendix 15: Nutrition Society Conference Abstract

medical sciences forum

MDPI

Abstract

Adherence to Breastfeeding and Complementary Feeding Guidelines within the First Foods New Zealand Study †

Kimberley Brown [1], Kathryn Beck [1], Pamela von Hurst [1], Anne-Louise Heath [2,‡], Rachael Taylor [3,‡], Jillian Haszard [4], Lisa Daniels [3], Lisa Te Morenga [5] and Cathryn Conlon [1,*]

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† Presented at the Annual Scientific Meeting of the Nutrition Society of New Zealand 2022, Wellington, New Zealand, 1–2 December 2022.
‡ Joint Principal Investigators.

Abstract: The importance of breastfeeding and the appropriate introduction of complementary feeding are well recognised. Our objective was to investigate adherence to breastfeeding and complementary feeding guidelines in New Zealand (NZ) infants aged 7.0 to 10.0 months, based on the Ministry of Health's healthy eating guidelines for NZ babies and toddlers (0–2 years), which recommend exclusive breastfeeding to "around" six months of age, at which time, complementary feeding should be initiated. This investigation was conducted within the First Foods New Zealand (FFNZ) study. From 2020 to 2022, FFNZ recruited an ethnically diverse sample of 625 infants living in Auckland and Dunedin. Participants completed two study visits, which included two 24-hour diet recalls and the completion of demographic and feeding questionnaires. Infants and caregivers were aged 8.4 (0.8) months (mean (SD)) and 32.7 (4.9) years, respectively. The majority (98%) of caregivers were the infant's mother. More than half of the caregivers had a university education (64.9%) and were not currently employed (66.9%). Approximately half the caregivers were first-time mothers (48.7%). In FFNZ, exclusive breastfeeding was defined as exclusive breastfeeding to at least five and less than seven months of age. Within FFNZ, 43.2% of infants met this guideline. At the time of participation, 66.2% continued to breastfeed. The introduction of solid food at around six months of age was achieved by 75.2% of participants. Most infants were provided puréed foods (80.3%) and were spoon fed (74.1%) when starting solid foods. The findings indicate that most FFNZ infants met guidelines for the age of introduction, texture, and method of feeding complementary foods. However, our guidelines for breastfeeding in NZ were not met to the same extent, indicating the need for further support for NZ whānau to achieve to current breastfeeding recommendations.

Keywords: infant; breastfeeding; complementary feeding; solids; guidelines

check for updates

Citation: Brown, K.; Beck, K.; von Hurst, P.; Heath, A.-L.; Taylor, R.; Haszard, J.; Daniels, L.; Morenga, L.T.; Conlon, C. Adherence to Breastfeeding and Complementary Feeding Guidelines within the First Foods New Zealand Study. *Med. Sci. Forum* **2023**, *18*, 16. https://doi.org/10.3390/msf2023018016

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Abstract

Institutional Review Board Statement: The study has ethical approval from the Health and Disability Ethics Committees New Zealand (19/STH/151), and written informed consent will be obtained prior to the first appointment. The study is registered with the Australian New Zealand Clinical Trials Registry (www.anzctr.org.au, registration number: ACTRN12620000459921).

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data may be available from the senior investigator upon reasonable request.

Conflicts of Interest: The authors declare no conflict of interest.