Insights into feeding preterm infants in Aotearoa, New Zealand: A mixed-method study

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ABSTRACT

Background: Preterm infants face many challenges to achieve exclusive breastfeeding (EBF) recommendations and successful introduction of complementary foods (CF). There is limited evidence of feeding practices of preterm infants in Aotearoa, New Zealand (NZ). This thesis aimed to investigate feeding practices of preterm infants and explore mothers/caregivers' experiences in NZ.

Methods: This was a cross-sectional observational study consisting of a nationwide self-completed electronic questionnaire circulated to mothers/caregivers of preterm infants, including data on hospital feeding, breastfeeding, and CF practices. Relationships between feeding practices and maternal and infant characteristics were explored using SPSS. Qualitative information regarding mothers'/caregivers' experiences with breastfeeding and CF was analysed using NVivo.

Results: A total of 268 mothers/caregivers completed the survey. Most respondents self-identified as NZ European (68%) or Māori (14%) and were between 25-34 (64%) and 35-44 (24%) years old. Most infants were identified as NZ European (73%) or Māori (21%), and were aged between 0-6 months (31%), 7-12 months (30%), or >12 months (39%) chronological age. The rate of EBF at hospital discharge was 60%, 33% EBF for more than or equal to five months chronological age, and 11% of infants received some breastmilk after 12 months. Among infants who had started CF (n=181), most infants (77%) were introduced to CF between five and eight months chronological age, and first foods were primarily vegetables (65%) and fruits (60%). Fussy eating behaviour was reported by 41%. Adherence to the Ministry of Health Healthy Eating Guidelines for Babies and Toddlers was measured using the child feeding index score and was considered suboptimal for infants 7-12 months chronological age (5.4 ±1.3 out of 8) and those >12 months chronological age (6.0 ±1.4 out of 8). Infant ethnicity (Māori vs non-Māori) was significantly associated with the use of intravenous nutrition in-hospital, and maternal/caregiver ethnicity was significantly associated with the timing of CF introduction. Mothers/caregivers found support from health professionals and the use of breast pumps enabled their breastfeeding experience but faced challenges with their infants' poor ability to feed and milk supply. Educational resources and personal experience with CF helped mothers/caregivers with CF; however, fussy eating behaviours and personal fears about CF introduction were commonly reported as challenges.

Conclusion: This survey indicates that EBF practices are suboptimal for most preterm infants in NZ. Despite timely CF introduction, preterm infants often don't meet all healthy eating recommendations. Improved access to education and support for parents of preterm infants could improve early feeding practices. This research can inform the development of future nutrition guidelines for preterm infants.

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GLOASSARY

BFHI = Baby-Friendly Hospital Initiative

BLW = Baby-led weaning

BMI = Body mass index

CF = Complementary feeding

DBM = Donor breastmilk

EBF = Exclusive breastfeeding

EP = Extremely preterm

ESPGHAN = European Society of Paediatric Gastroenterology Hepatology and Nutrition

FFM = Fat-free mass

FM = Fat mass

GA = Gestational age

GUiNZ = Growing Up in New Zealand

IF = Infant formula

IVN = Intravenous nutrition

KC = Kangaroo care

LBW = Low birth weight

LC = Lactation Consultant

LMC = Lead Maternity Carer

LP = Late preterm

MD = Mean Difference

MELAA = Middle Eastern, Latin American, and African

MLP = Moderate to late preterm

MoH = Ministry of Health

MP = Moderate preterm

NEC = Necrotising enterocolitis

NGT = Nasogastric tube

NICU = Neonatal Intensive Care Unit

NZ = New Zealand

NZE = New Zealand European

PN = Parenteral nutrition

RCT = Randomised control trial

SCBU = Special Care Baby Unit

TSF = Traditional spoon-feeding

VP = Very preterm

WHO = World Health Organisation

Chapter 1. Literature Review

1.1 Epidemiology of preterm birth

1.1.1 Definition of preterm birth

The World Health Organization (WHO) defines preterm birth as an infant born alive before 37 completed weeks of gestation [1]. Preterm births are further classified based on gestational age (GA) into extremely preterm (EP, infants born before 28 weeks' gestation), very preterm (VP born between 28 and 31 complete weeks' gestation), moderate preterm (MP, born between 32 and 33 complete weeks' gestation), and late preterm (LP, born between 34 and 36 complete weeks' gestation) [1].

1.1.2 Prevalence of preterm birth

1.1.2.1 Global prevalence

The global prevalence of preterm birth has remained stable between 2010 and 2020 [2]. A recent systematic analysis provided a ten-year overview of preterm birth rates across 103 countries, indicating the global prevalence of preterm birth in 2020 was 9.9%, ranging from 6.8% in eastern Asia, south-eastern Asia, and Oceania (excluding Australia and New Zealand) and 13.2% in southern Asia [2]. Bangladesh was reported as the country with the highest preterm birth rate at 16.2% [2]. The prevalence of preterm birth is highest at moderate to late GA, accounting for 80-90% of all preterm births globally [3].

1.1.2.2 National prevalence

The latest data from the Ministry of Health (MoH) reported a rate of preterm birth of 7.9% in 2021, an increase from 7.4% in 2011 [4]. Regional and ethnic variations were observed in the rates of preterm birth. Auckland reported the lowest rate of 6.8% in 2021, and the West Coast reported the highest rate in New Zealand (NZ) of 10.7% in 2021 [4]. Prevalence of preterm birth was highest among Māori (9%) and Pacific (8.4%) ethnicities and lowest among European (7.3%) and Asian (7.1%) ethnicities [5]. Moreover, in 2021, 82% of preterm births occurred at moderate to late gestation, 10% were born VP, and 8% were born EP [4].

1.1.3 Causes

Preterm birth delivery may occur by spontaneous labour or medically induced birth [3,6]. Spontaneous births account for approximately two-thirds of all preterm births [3,6] and are often associated with premature rupture of membranes, resulting in vaginal or caesarean delivery [3,6].

Common causes of spontaneous preterm birth include pregnancy of multiples, short cervix, uterine anomalies, short interpregnancy interval and a history of spontaneous preterm birth [3]. The remaining one-third of preterm births are medically induced or delivered by caesarean section due to various maternal and fetal complications [6]. The most common underlying conditions include pre-eclampsia, intrauterine growth restriction, abnormal placentation and maternal medical disorders such as obesity, asthma, diabetes, and hypertension [6,7].

1.1.4 Risk factors

Several factors increase the risk of preterm birth. It is important to note that preterm birth often occurs without any known cause. It is likely multifactorial, influenced by a combination of biological (ethnicity, age, genetics, comorbidities, previous preterm birth, pregnancy with multiples), societal (inequitable access to healthcare, housing, income) and environmental (alcohol and substance abuse, smoking, poor diet, stress) factors [7,8]. Some of the key risk factors associated with preterm birth include previous preterm birth [9–11], short inter-pregnancy interval (<18 months) [12,13], pregnancy with multiples [7,14], young (<19 years) and advanced (>35 years) maternal age [5,10,15,16], lifestyle factors such as smoking [10,17], and maternal health conditions such as diabetes and hypertension [3,10,17].

The social determinants of health play a role in the incidence of preterm birth and are influenced by various socioeconomic, environmental and cultural factors [18]. Families with limited financial resources may face challenges accessing quality healthcare, housing, and nutritious food, which contribute to poorer health outcomes such as preterm birth [7,19]. Disparities in access to healthcare can also be influenced by geographic location, education, and cultural barriers [19]. Māori and Pacific populations experience disproportionally higher rates of preterm birth in NZ [5,20]. This may be explained by higher levels of socioeconomic deprivation, barriers to culturally appropriate healthcare, and higher rates of chronic health conditions such as diabetes and obesity experienced among Māori and Pacific ethnicities, increasing their risk of preterm birth [19,20]. Additionally, exposure to such socioeconomic and cultural stressors can impact maternal health and increase the risk of preterm birth risk [21].

1.1.5 Infant mortality

While more than 90% of infants born before 28 weeks in high-income countries survive, only 10% survive in low-income settings, resulting in a significant survival inequality [7]. This

inequality implies an unfair disparity in access to adequate healthcare and resources, resulting in significantly different survival rates for infants based on their birth setting.

The prevalence of mortality increases with decreasing GA. In a Swedish 8-year population-based cohort study of 8396 preterm infants, death rates in infants ranged from 48.6% to 1.4% at 22 weeks and 31 weeks of gestation, respectively [22]. Huff et al. investigated the trends in the mortality rates in late preterm infants in the United States [23], and although deaths only occurred in a fraction of this population, the mortality rate was reported to be three to five times greater than term infants [23]. In NZ, 81% of fetal deaths and 69% of infant deaths registered in 2020 were preterm, with the majority born extremely preterm [24].

1.1.6 Infant morbidity

1.1.6.1 Short-term health outcomes

Preterm infants face a high risk of acute complications after birth compared to infants born at full-term [6,23], such as sepsis, bronchopulmonary dysplasia, intraventricular haemorrhage, necrotising enterocolitis (NEC), retinopathy of prematurity, persistent pulmonary hypertension, respiratory distress syndrome, hyperbilirubinemia, and hypotension [25,26]. The incidence and severity of these complications differ depending on the infant's GA and birth weight, with morbidity significantly reduced with advancing GA and birth weight [27].

Moderate and late preterm (MLP) infants exhibit the highest rates of readmission among all GA, often attributed to insufficient breastmilk intake, causing failure to thrive, jaundice, and dehydration [28]. Additionally, LP infants are particularly vulnerable to feeding difficulties, with 32% experiencing feeding difficulties during hospitalisation compared to 7% of term infants, delaying hospital discharge [29]. Therefore, the burden of prematurity on this population cannot be overlooked [30,31].

1.1.6.2 Long-term health outcomes

Adverse health outcomes in preterm infants significantly increase the economic burden on families and the healthcare system [32]. While some preterm infants live free of disability, some may develop long-term respiratory, cardio-metabolic and neurodevelopmental health outcomes [33,34]. Preterm birth is associated with reduced lung function, increasing the risk of respiratory health morbidities that persist through adolescence and adulthood, such as asthma, chronic lung

disease, wheezing, and airway obstruction function [33,35]. Additionally, preterm birth is associated with impaired lung function and airflow in adulthood [33].

Being born prematurely and missing critical in-utero organ development increases the risk of poor metabolic outcomes through adulthood [33]. Adults born preterm have a significantly higher risk of developing type 1 and type 2 diabetes compared to adults born full-term [36]. Adults born prematurely are found to have a 2-fold incidence of developing chronic kidney disease [37]. Additionally, the risk of ischemic heart disease and heart failure is significantly increased in adults born preterm, including those born early term [33]. Hypertension, metabolic syndrome, obesity, and osteoporosis are also increased in adults born preterm [33,38].

Delayed development and cerebral palsy are the most common neurodevelopmental outcomes in preterm infants [39]. Compared to infants born at 39-40 weeks' gestation, cerebral palsy was highest among infants born at 22-24 weeks' gestation, and the increased risk persisted among infants born at 35-36 weeks' gestation [40]. A systematic review of neurodevelopmental outcomes for children born preterm found unfavourable outcomes in cognition, motor skills, intelligence, autism spectrum disorder, attention-deficit hyperactivity disorder, anxiety, psychiatric disorders, and vision and hearing impairments compared to infants born full-term [41].

1.1.7 Growth trajectory

Compared to full-term, preterm infants often experience slower postnatal growth followed by catch-up growth in weight, length, and head circumference within their first two years of life [42]. Corrected GA is often used to monitor the growth of preterm infants while accounting for their prematurity, assisting to determine when infants are expected to reach certain milestones and tracking their growth to that of a term infant using standardised growth charts, such as WHO Child Growth Standards [43,44]. Preterm infants are found to have significantly lower growth rates in length and weight from birth to three months compared to full-term infants [45]. However, from three to 12 months, preterm infants often experience faster growth in length and weight, catching up with the growth trajectories of full-term infants [45].

Han et al. tracked the growth of 10,624 preterm infants from 40 weeks up to 24 months corrected GA from a population-based database in China from 2010-2017 [46]. Most preterm infants achieved the WHO growth targets for children 0-5 years from 40 weeks' corrected GA

to 24 months corrected GA [46]. However, catch-up growth accompanied the risk of being overweight (infants whose weight for length >90th percentile of the WHO standard), with 14.5% of infants being classified as overweight at 24 months corrected GA [46].

In contrast, a meta-analysis of 16 birth cohorts, including 253,810 children, found that VP and LP infants had a lower body mass index (BMI) than term infants through mid-childhood [42]. This is supported by findings from studies in Australia, Sweden, Brazil, and the United Kingdom from ages two to 12 years [47–50]. By adolescence, most studies found no differences in BMI. However, Vinther et al. reported that the rapid growth and differences in body composition of VP infants may explain the association of increased odds of being overweight in adolescence (<14 to 19 years) compared to full-term peers [42]. Evidence across other population-based cohort studies questions the relationship between catch-up growth in preterm infants and overweight in childhood or adulthood [49,51,52]. Managing the risk of excessive weight gain while simultaneously promoting catch-up growth in preterm infants poses a challenge, highlighting the requirement for tailored assessment tools, as a one-size-fits-all approach is unsuitable.

1.1.8 Body composition

Preterm infants display distinct body composition differences than full-term infants from birth to adulthood, characterised by higher fat mass (FM) and lower fat-free mass (FFM) [49,53,54]. Additionally, differences in fat distribution are observed, with increased intra-abdominal adiposity compared with full-term infants [53]. Deficits in nutrients from preterm birth may explain differences in body composition, particularly the relationship between protein intake and lean body mass accretion [55]. Additionally, increased fat storage for energy reserves postnatally may be a mechanism to promote survival and growth [55].

A systematic review comparing the body composition of preterm infants to term infants concluded that preterm infants have lower FFM and significantly greater body fat percentage at term equivalent age [55]. Contrastingly, other studies have found that preterm-born infants at term-equivalent age and children born preterm present lower FM than those born at term, indicating the evidence is not conclusive [49,50,56]. Furthermore, studies have shown that body composition differences persist through adulthood, with higher FM found among preterm-born adults compared to full-term-born adults [49,57]. Elevated body fat levels, particularly intra-

abdominal fat, can increase the risk of developing metabolic conditions such as cardiovascular disease and type 2 diabetes in the future [55].

Early life nutrition, including the provision of breastmilk to preterm infants, has been linked to favourable deposition of FFM, promoting a positive restoration of body composition and favourable metabolic outcomes in this population [58]. However, preliminary findings of the largest randomised control trial (RCT) of nutrition in 532 MLP infants in NZ found no difference in % FM between different feeding practices [59]. This study measured body composition using air displacement plethysmography, and eligible infants were randomised to different nutrition interventions until they could tolerate full enteral feeds with breastmilk: parenteral nutrition vs dextrose solution; supplemental milk (infant formula (IF), or donor breastmilk, (DBM) vs only breastmilk), and exposure to taste and smell of milk before tube feeds vs no exposure [60]. The mean %FM of infants given supplements such as IF or DBM versus exclusive breastmilk at four months' corrected GA was 26% vs 26.2%, respectively [59]. This study indicates that the nutritional management of MLP infants in-hospital may have little effect on body composition at four months corrected GA [59].

1.2 Feeding preterm infants

Nutrition of preterm infants is critical to neonatal care, directly impacting their growth and development. In recent years, there has been a growing body of research on nutritional practices for preterm infants [61]. Feeding guidelines aim to provide optimal nutrition management while minimising the risks of complications such as faltering growth, feeding intolerance, NEC, dehydration, hyperbilirubinemia and sepsis. Unlike healthy term infants, preterm infants present with numerous difficulties and higher nutrient requirements to support optimal growth and development. The ideal nutritional intake required to support their growth and development varies based on the infants' GA, birth weight, medical condition, feeding modality, and feeding tolerance [61]. Given the complexity of feeding preterm infants, there is a considerable variation in how they are fed across hospitals worldwide and within NZ [62]. This highlights the importance of establishing standardised nutritional guidelines for preterm infants to provide optimal nutritional support and minimise the risk of complications [63].

1.2.1 In-hospital feeding

1.2.1.1 Parenteral nutrition

Preterm infants often have limited digestion abilities due to immature organ systems and require parenteral nutrition (PN) to meet energy and nutrient requirements when full enteral feeding is not possible [64,65]. PN provides nutrition directly into the bloodstream, bypassing the digestive system to provide an intravenous source of energy, fats, carbohydrates, vitamins, and minerals [66]. The PN solutions are made up of glucose and amino acids, providing energy, protein, vitamins and minerals, and a lipid-based solution, providing essential fatty acids, energy and vitamins [67]. The lipid formulations were traditionally soybean-based lipid emulsions; however, composite lipid emulsions containing fish, olive, or coconut oils are recommended to provide sufficient essential fatty acids for improved outcomes in growth and reducing the risk of complications such as sepsis and retinopathy of prematurity [64,68,69]. Infants born prematurely have limited energy stores and immature digestive systems; therefore, delaying the initiation of feeds can lead to rapid depletion of body stores. In clinical situations where enteral feeds will not be tolerated soon after birth, initiation of PN should be implemented within six hours after birth, typically among EP infants and those weighing <1000g [64,67].

PN can be administered through several routes. Central venous catheter is the preferred route of administration for long-term PN in preterm infants [70]. Central venous catheters are inserted into large veins and can reduce the risk of complications such as thrombophlebitis and sepsis and improve nutrient intake [70,71]. Umbilical venous catheters, placed in the umbilical vein shortly after birth, are used as an interim means of delivering PN before a central line can be inserted [71]. Peripheral venous access involves placing a small catheter into a vein, usually in the hand, arm, or foot. However, it is only recommended for short-term use (<5 days) to avoid delays or interruptions in giving PN and if the central venous access is compromised [70]. Unlike central venous catheters, inserting umbilical vessels requires fewer attempts and does not increase the risk of infection or NEC [71]. The overall goal is to provide adequate nutrition while minimising the risk of complications assessed by the medical team [70].

The indications for PN are for all preterm infants with birth weight <1,500g [67]. For infants with birth weight >1,500g or MLP, the use of PN is at the medical team's discretion [67]. A survey completed by health professionals from 40 tertiary and eight non-tertiary neonatal intensive care units (NICUs) within Australia, NZ, Malaysia, Singapore, and India indicated

the prevalence of PN in preterm infants was 97% among EP infants weighing less than 1000g and VP infants weighing 1000-1500g and often initiated within the first day of life [72]. Additionally, 77% of NICUs provided PN to infants weighing over 1500g if they couldn't establish enteral feeds within three to five days of life [72].

Careful monitoring of clinical and laboratory biomarkers is essential [71]. PN poses a risk for hyperglycaemia, metabolic acidosis, hypertriglyceridemia, and hyperbilirubinemia. [71]. Imbalances in nutrient intake can occur as a result of immature metabolic pathways, such as poor glucose regulation [68]. This means that appropriate volumes of PN must be tailored and monitored for each infant. Prolonged provision of PN can increase the risk of infections and metabolic complications [64,66]. The nutritional requirements for PN can be found in **Table 1**.

1.2.1.2 Enteral nutrition

Preterm infants often need assistance with feeding as the coordination of sucking, swallowing, and breathing required for oral feeds typically develops from 34 weeks' gestation [61,73]. Enteral feeds provide an alternative approach to feeding the infant breastmilk or infant formula via an orogastric or a nasogastric feeding tube [74]. The 2022 European Society for Paediatric Gastroenterology Hepatology and Nutrition (ESPGHAN) position paper for enteral nutrition (EN) in preterm infants weighing <1800g recommends initiating enteral feeding with small volumes immediately after birth and advancing the feeds as tolerated by the infant [73]. The initial minimal volumes of EN are also known as trophic feeding, which stimulates the gastrointestinal tract to maintain its function and integrity [73,75]. Trophic feeding typically provides 12-24 ml/kg/d of EN for preterm infants <32 weeks and weighing <1500g for 3-7 days and aims to improve feeding tolerance and growth and reduce the risk of sepsis and NEC; however, several studies cannot conclude effects on these outcomes [73,76–78]. The ESPGHAN recommendations on nutrient intakes are specified for preterm infants weighing <1800g [73]. The recommendations for MLP infants are not well understood, leading to significant variation in the nutritional management of this population [79]. The nutritional requirements for EN can be found in **Table 1.**

Table 1. ESPGHAN recommendations for parenteral and enteral nutrient intakes after the first days of life

	Parenteral Nutrition [69,80–86]	Enteral Nutrition [73]
Fluid, mL/kg/d	140-180	150-180
Energy, kcal/kg/d	90-120	115-140
Protein, g/kg/d	2.5-3.5	3.5-4.0
Fat, g/kg/d	3.0-4.0	4.8-8.1
Carbohydrate, g/kg/d	11.5-14.5	11-15
Sodium, mmol/kg/d	2.0-5.0	3.0-5.0
Chloride, mmol/kg/d	2.0-5.0	3.0-5.0
Potassium, mmol/kg/d	1.0-3.0	2.3-4.6
Calcium, mmol/kg/d	1.6-3.5	3.0-5.0
Phosphorus, mmol/kg/d	1.6-3.5	2.2-3.7
Magnesium, mmol/kg/d	0.2-0.3	0.4-0.5
Iron, mg/kg/d	2.0-2.5	2.0-3.0
Zinc, mg/kg/d	4.0-5.0	2.0-3.0
Copper, ug/kg/d	40	120-230
Selenium, ug/kg/d	7.0	7-10
Iodine, ug/kg/d	1.0-10	11-55
Vitamin A, IU/kg//d	700-1500	1333-3300
Vitamin D, IU/kg/d	80-400	400-700
Vitamin E, mg/kg/d	2.8-3.5	2.2-11
Vitamin K, ug/kg/d	10	4.4-28
Thiamine (B1), ug/kg/d	350-500	140-290
Vitamin B12, ug/kg/d	0.3	0.1-0.6
Folic acid, ug/kg/d	56	23-100
Riboflavin (B2), ug/kg/d	0.15-0.2	200-430
Ascorbic acid, mg/kg/d	15-25	17-43
Pyridoxine, ug/kg/d	150-200	70-290
Niacin, ug/kg/d	4000-6800	1100-5700
Pantothenic acid mg/kg/d	2.5	0.6-2.2
Biotin ug/kg/d	5-8	3.5-15

A systematic review of 14 RCTs involving 1,505 preterm infants investigated the outcomes associated with early initiation (before 72 hours) compared to late initiation of EN (after 72

hours). It concluded early initiation of EN was associated with reduced mortality at discharge or 28 days (RR 0.69, 95% CI 0.48 to 0.99) [87]. Slow advancements in enteral feeding volumes increase the risk of late-onset sepsis and feed intolerance but have little or no effect on developing NEC [88]. Therefore, the goal is to transition to full enteral feeding according to infants' tolerance to increasing EN volumes, followed by oral feeding.

Maternal breastmilk is the preferred choice for EN [73]. Initiation of enteral feeding can wait up to 72 hours for mothers to express breastmilk as there is often a delay in lactogenesis following a premature birth [74,89]. In a survey about the nutritional management of MLP infants in NZ and Australia, clinicians (n=83) reported they would provide 10% dextrose for ≥3 days while breastmilk supply is adequate to reach nutrition and fluid requirements in 31% of MP infants and 49% of LP infants. Additionally, 5% of clinicians were comfortable to wait for five days in MP infants [79]. Mothers should aim to utilise a breast pump immediately after birth in cases where the infant cannot breastfeed directly [89]. In cases where maternal breastmilk is not available, fortified DBM is the next best option for EP and VP infants or infants with a birth weight of <1800g [73]. The benefits of DBM versus formula for EP and VP infants are associated with a reduced risk of feed intolerance and NEC [90]. If maternal breastmilk and DBM are not available, preterm IF can be used for EP and VP infants or infants with a birth weight <1800g until they reach 36 weeks' corrected GA [74,90]. Compared to standard IF, preterm IF is enriched with higher amounts of energy, protein, minerals, vitamins and trace elements to support their appropriate growth and development that mimics the intrauterine environment as closely as possible [91]. There is limited evidence for the nutritional management of MLP infants, and more research is needed on the benefits of DBM and IF when breastmilk is unavailable [92,93].

1.2.1.3 Breastmilk feeding

Maternal breastmilk is recommended as the first choice of feed for preterm infants [7,73,94–97]. The sucking, swallowing, and breathing coordination required for feeding at the breast usually happens from 34 weeks' gestation [61,73]. Among infants that have established direct breastfeeding, they should be breastfed on demand to their hunger cues, but often, they can present sleepy and require waking. Some cannot meet breastmilk intake recommendations from direct breastfeeding; therefore, 'top-ups' via EN may be required [94]. The Baby-Friendly Hospital Initiative (BFHI) for small, sick and preterm infants outlines the importance of expressing breastmilk frequently 7-8 times daily and within 1-2 hours of delivery of a preterm infant to maintain milk supply, and mothers should be provided assistance with this [94,97,98]. If

the mother and infant are separated at birth, the mother should begin hand expression of colostrum [94].

1.2.1.4 Fortification and supplementation of breastmilk

Breastmilk alone may not meet the nutritional needs of some preterm infants. ESPGHAN states that standard volumes of breastmilk (150-180 mL/kg/d) do not supply the recommended amount of energy (115 to 140 kcal/kg/d) or protein (3.5 to 4.0 g/kg/d) for preterm infants weighing <1800g [73,99]. Supplementing breastmilk with multi-nutrient fortifiers containing additional protein, energy, vitamins, and minerals optimises nutrient accretion necessary to meet their heightened nutrient demands [100]. Fortification of DBM may also be required for infants born <32 weeks' gestation or with a birth weight <1500g, as DBM typically contains lower levels of protein, energy, and minerals compared to mothers' breastmilk [73,99]. There is low-to moderate-certainty evidence suggesting that breastmilk fortification with a multi-nutrient fortifier or preterm formula powder increases short-term growth in weight, length and head circumference in hospitalised preterm infants without increasing the risk of NEC compared to unfortified breastmilk [100]. However, there is limited evidence on the long-term growth and development of preterm infants [100,101].

Fortifiers are available in powder or liquid forms and are commonly derived from bovine milk [102]. Recent attention has focused on the potential benefits of using fortifiers derived from human milk instead of bovine milk, suggesting proposed benefits in reducing the risk of NEC and enhancing feeding tolerance [103]. However, there is insufficient evidence to support using human milk-based fortifiers over bovine milk-based fortifiers in reducing the risk of NEC, feeding difficulties, mortality, or improving growth outcomes [103].

1.2.1.5 Alternative feeding methods

Many preterm infants cannot fully breastfeed and require nutritional support, such as through a tube, bottle, or cup, until they have acquired the skills for breastfeeding [104]. Step nine of the BFHI discourages the use of bottles [98]. This is primarily because evidence suggests that the sucking mechanism used by infants on a bottle is very different from that used during breastfeeding, resulting in unfavourable breastfeeding outcomes for bottle-fed infants [105]. Instead, the BFHI recommends transitioning to exclusive breastfeeding (EBF) in neonatal wards by utilising tube feeding or cup feeding [97]. Early and frequent attempts at breastfeeding can help develop the infant's skills needed to establish breastfeeding, and any supplemental

feeds should be provided through nasogastric tubes; bottles and cups are considered when the mother is not around or not willing to breastfeed [96]. Cup feeding can be a useful alternative to bottle feeding in preterm infants and has been demonstrated to help establish the oral-motor and respiratory skills needed for breastfeeding [105]. Two systematic reviews comparing cup and bottle feeding on breastfeeding outcomes in preterm infants (range of GA at birth from 29-32 weeks) found that using a cup instead of a bottle increases the likelihood of EBF at discharge, three and six months after discharge [104,106]. Cup feeding can present considerable risks to preterm infants when done incorrectly, leading to potential complications like aspiration pneumonia and physiological instability such as apnoea, choking/gagging, and inadequate weight gain [104,106]. As such, cup feeding requires dedicated time from nurses to ensure the correct technique is used, making the use of bottles more common.

1.2.2 Breastfeeding outcomes

1.2.2.1 Breastfeeding duration

The American Academy of Paediatrics, WHO, and NZ MoH recommend EBF for about six months from birth and continued breastfeeding until two years and beyond for both term and preterm infants [99,107]. EBF is defined as providing only breastmilk to the infant, without any additional food or drink, except for mineral supplements, vitamins or medicines [108]. It is recommended that complementary foods should be introduced among preterm infants between five and eight months chronological age when breastmilk alone is no longer sufficient to meet nutritional requirements [109]. Therefore, preterm infants should continue EBF for five to eight months from birth until they display signs of readiness for introducing complementary feeding (CF) [98,109].

1.2.2.2 Global prevalence of breastfeeding

Breastfeeding rates in preterm infants can vary depending on several factors, including the country, hospital, and the infant's GA at birth [110–113]. Although studies have shown that breastfeeding rates among preterm infants are generally lower than those of full-term infants, compiling data worldwide has proven challenging due to variations in measurement periods, breastfeeding definitions, regional differences, and inconsistencies in GA classification categories [114]. Despite these challenges, several studies have investigated the prevalence of breastfeeding in preterm infants [110–113].

A birth registry in Sweden determined the prevalence of EBF in preterm infants at discharge from NICUs over ten years and reported that the prevalence of EBF at discharge decreased significantly from 2004 to 2013 across all preterm groups [115]. The rate of EBF at discharge decreased from 55% to 16% in EP infants, 41% to 34% in VP infants, and 64% to 49% in MLP infants [115].

Compared to full-term infants, breastfeeding rates in preterm infants are suboptimal and have not increased over time [115]. A longitudinal study in China reported low rates of EBF at six months corrected GA, with only 18% of VP infants, 24% of MP infants, and 23% of LP infants EBF [110]. Overall, 50% of infants reported mixed feeding at six months corrected GA [110]. A prospective cohort study from three perinatal centres in South Australia involving 270 LP infants found that 74% of infants were EBF at discharge, significantly declining to 35% at three months corrected GA and 29% at six months corrected GA [116]. Notably, this study found only 53% of LP infants were still breastfeeding at six months corrected GA [116]. In a Swedish longitudinal study of 547 preterm infants, 77% of infants received some breastmilk at six months, which declined to 21% at 12 months chronological age [117]. Hence, more research is needed to understand the challenges and enablers of breastfeeding duration in this vulnerable population.

1.2.2.3 New Zealand's prevalence of breastfeeding

There is limited data on the breastfeeding rates of preterm infants in NZ. A prospective cohort analysis of the ProVIDe trial in NZ and Australia involving EP infants (≤31.5 weeks) and extremely low birth weight (LBW) infants (<1000g) found that 99.5% of infants achieved exclusive breastmilk as their enteral feed in week one, reducing to 89% in week four [118]. A prospective cohort analysis of the DIAMOND trial, including 191 MLP infants in Auckland, NZ, found that 78% were EBF at discharge, falling to 19% at four months corrected GA [119].

The Growing Up in New Zealand (GUiNZ) study tracked the development of 6,853 children born between 2009 and 2010, including preterm infants or those with LBW (<2,500g) [120]. Overall, breastfeeding initiation occurred in 97% of infants, EBF for four and six months was achieved for 54% and 16%, respectively, and any breastfeeding at six months, one and two years was 66%, 37% and 13%, respectively [121]. Preterm infants (n=385) were significantly less likely to EBF for five months compared to full-term infants (n=5,788) (30% vs 36%,

P<0.05) [120]. The GUiNZ study also found that preterm infants were less likely to receive any breastmilk at 12 months compared to full-term infants (31% vs 38%, P<0.05) [120].

While there is limited national data on breastfeeding rates among preterm infants in NZ, the MoH reports breastfeeding indicators for all infants. The 2022 national infant feeding report at discharge demonstrated that 78% of infants were EBF, which has remained stable since 2020 [122]. The MoH reported a decreasing trend in the rate of EBF at two weeks, declining from 70% in 2018 to 65% in 2021 [123]. Additionally, in 2022-23, the NZ Health Survey found that only 58% of infants were EBF at four months, and EBF rates dropped drastically to 10% at six months of age [124,125].

With limited population-based data available on breastfeeding rates in preterm infants in NZ, it is not feasible to draw any comparisons between national breastfeeding indicators of full-term infants and international breastfeeding indicators of preterm infants. However, these findings highlight the importance of supporting breastfeeding among all infants and the need for consistent and accurate measurement of breastfeeding rates. The low rates of EBF in NZ suggest that there are gaps in the provision of breastfeeding support and a need for future research to identify effective strategies for improving breastfeeding rates in this vulnerable population.

1.2.3 Factors associated with breastfeeding

1.2.3.1 Infant characteristics

Low birth weight and GA are factors associated with breastfeeding outcomes for preterm infants [126,127]. EP and VP infants are generally at a higher risk for delayed breastfeeding initiation, longer hospital stays, and lower rates of EBF at discharge. In a Danish national cohort of 1,488 preterm infants, Maastrup et al. found that EP infants were three times less likely to EBF at NICU discharge compared to MLP infants (OR 2.9, 95% CI 1.3-6.4, P<0.05) [127]. Being small for GA was also significantly associated with low EBF at discharge in this study [127]. Birth of multiples is a risk factor for reduced breastfeeding initiation and duration [115,127,128]. Mothers of multiples may face significant physical and emotional challenges associated with caring for more than one infant, leading to difficulties with milk production and feeding frequency. Maastrup et al. found that only 18% of multiples were EBF at discharge, compared to 68% of all preterm infants [127].

1.2.3.2 Pacifier use

The BFHI recommends avoiding using pacifiers and teats in full-term infants until breastfeeding is fully established [129]. Pacifiers are usually discouraged as they can replace the infant's suckling at the breast, thereby reducing the stimulation from the mother's breast, potentially reducing breastmilk supply [129]. Furthermore, pacifiers can hinder the recognition of feeding cues, which may underestimate the infant's feeding needs [129]. While most preterm infants experience delays in the suck-swallow-breathing coordination for breastfeeding, pacifiers are not recommended to aid in establishing breastfeeding [97]. In fact, minimising the use of pacifiers in preterm infants has been associated with earlier establishment of EBF [97,127,130]. However, for preterm infants, the use of pacifiers for preterm infants is only warranted for therapeutic purposes when breastfeeding is not possible, such as for pain relief, stress reduction, and soothing purposes [97]. The BFHI promotes the first nutritive sucking experience to occur at the breast [97].

1.2.3.3 Bonding

Among medically stable preterm infants, frequent skin-to-skin contact (also known as kangaroo care (KC)) between the mother and the preterm infant has been shown to promote breastfeeding initiation and duration [98]. Skin-to-skin contact is defined as holding an infant in skin-to-skin contact, prone and upright on the chest, enclosed in the parent's clothing to maintain temperature stability [131]. Skin-to-skin contact provides the infant unrestricted access to the breast, increases milk production, improves infant oxygenation and temperature regulation, and strengthens the maternal-infant bond [94,131]. The Academy of Breastfeeding Medicine clinical protocol recommends initiating skin-to-skin contact immediately after birth to improve early breastfeeding [94]. A systematic review of nine studies, including 1,202 preterm infants, found that KC significantly increased the likelihood of EBF from birth to six months (OR 1.93, 95% CI 1.18-3.17, $P<0.05$) [132].

1.2.3.4 Maternal characteristics

There is a plethora of research on the maternal factors that impact breastfeeding for preterm infants [110,133–135]. Smoking is among the most common factors negatively influencing breastfeeding practices [136]. In a predominantly Māori population of 197 mother/infant participants, smoking was a key predictor for shorter breastfeeding duration (OR 0.51, 95% CI 0.37-0.69) [136]. A retrospective cohort study of 391 VP infants from Canada found that smoking

was the most significant factor associated with early cessation of breastfeeding before discharge (OR 8.0, 95% CI 2.27-28.28, P<0.01) [137].

Both young and advanced maternal age has been associated with longer breastfeeding duration outcomes [110,121,136]. In the GUiNZ study, compared to mothers aged <20 years, those who were aged 20-29 years (RR 1.24, 95% CI 1.04-1.49) and aged ≥30 years (RR 1.36, 95% CI 1.14-1.62) were more likely to EBF their infant for ≥4 months [121]. Similar outcomes were found in a predominantly Māori cohort of 197 mothers and their full-term infants [121,136]. Conversely, a longitudinal observational study including 280 preterm infants in China found that older maternal age was associated with lower odds of EBF at six months (OR 0.51, 95% CI 0.33-0.79, P<0.05) [110].

Most studies indicate that parents or mothers with a higher education and socioeconomic status achieve longer breastfeeding duration outcomes than those with a lower education and socioeconomic status [127,128,133,134]. In a prospective study of 1,221 mothers and their 1,488 preterm infants from Denmark, Maastrup et al. found that mothers with a low and intermediate education level were at a greater risk of an inadequate duration of EBF than mothers with a high education level (OR 2.6, 95% CI 1.7-3.9, P<0.001) and (OR 1.6, 95% CI 1.1-2.3, P<0.05), respectively [127].

EBF rates vary significantly across different ethnic groups in NZ [122,136]. The 2022 national infant feeding data at discharge report shows that EBF rates at discharge from the hospital are highest for NZ European (NZE) infants (83%) compared to NZ Māori infants (81%) and lowest for Asian infants (65%) [122]. Although similar rates of breastfeeding at discharge are found between Māori and NZE ethnicity, studies have shown that Māori women breastfeed for a shorter duration compared to NZE women [121,136]. The GUiNZ study found that EBF for more than 4 months was significantly less likely among infants of Māori mothers compared to NZE (RR 0.8, 95% CI 0.73-0.87, P<0.05) [121]. Disparities in maternal and infant ethnicity for breastfeeding initiation, duration, and exclusivity are also found globally [111,133–135].

Mothers with medical conditions such as diabetes mellitus, obesity, and pregnancy-induced hypertension may have more difficulty producing breastmilk [110,115,138]. Maternal overweight and obesity have been associated with lower rates of breastfeeding initiation and breastfeeding duration[139]. This may be explained by the delayed onset of lactogenesis caused by lower levels

of prolactin, excessive metabolic stress, impaired glucose tolerance and insulin resistance, leading to challenges in establishing breastfeeding [140]. Furthermore, mechanical factors such as excess adipose tissue may make it more challenging for the infant to latch [141]. Moreover, obesity is significantly associated with diabetes mellitus and hypertension [142]. Other maternal factors that can negatively influence breastfeeding initiation and duration include caesarean section, first-time mothers, no previous breastfeeding experience, single marital status and low family support [126,127,134].

Psychological factors, including anxiety, depression, and stress, have been linked to decreased breastmilk production [126,128]. Stress can elevate cortisol levels, which can interfere with the production of prolactin, the hormone responsible for milk supply [143]. Moreover, maternal depressive symptoms tend to increase as infants' GA decreases, likely influenced by the severity of their clinical condition [110,144,145]. A large Swedish population-based register study involving 29,445 preterm infants found a significant association between maternal mental illness (e.g. anxiety, depression, bipolar disorder) and lower rates of EBF at discharge compared to mothers without maternal mental illness for VP infants (OR 2.0, 95% CI 1.38-2.91, P<0.001) and MLP infants (OR 1.59, 95% CI 1.38-1.83, P<0.001) [115].

Many preterm infants spend significant time in the NICU, where the environment is often challenging and unfamiliar to parents, which creates a level of separation between parents and their infants [110]. Mothers may encounter challenges in providing breastmilk to preterm infants within the NICU [110,126], often requiring the use of breast pumps for weeks or months before direct breastfeeding can commence [113]. Access to breast pumps in the hospital is crucial for supporting breastfeeding efforts [128]. Gianni et al. investigated maternal challenges to breastfeeding in 64 mothers of preterm infants, where 30% of mothers reported some difficulty with breastfeeding [145]. Mothers who experienced difficulty pumping breastmilk had a higher risk of the infant being fed formula at discharge (OR 4.6, 95% CI 1.5-13.9) [145].

Although the factors associated with breastfeeding outcomes for preterm infants in NZ have not been investigated, data from two NZ studies found several factors associated with longer breastfeeding duration, including older maternal age, tertiary education, NZE ethnicity, lower household deprivation, non-smoking status, and family support [121,136]. These findings suggest that socioeconomic and cultural factors significantly influence breastfeeding outcomes in NZ.

1.2.4 Health outcomes of breastmilk feeding

Breastmilk is the best source of nutrition for preterm infants as it provides nutrients and immune factors required for growth, immunity, and long-term health [146]. Compared to breastmilk from full-term mothers, preterm breastmilk has elevated quantities of protein, sodium, chloride, calcium, zinc, copper, and folate [147]. Additionally, during the first 24-48 hours after giving birth, lactating parents produce a pre-milk fluid called colostrum, which is low in fat, high in protein and abundant in immunoglobins and immune cells, which provides essential immune protection for the preterm infant [98,148,149]. Early breastmilk feeding helps develop the gut microbiota and activates enzymes and hormones necessary for digestion, absorption, motility, immunity, and feed tolerance [150]. Breastmilk offers advantages over IF due to its immunomodulatory components, which provide protection against NEC, diarrhoea, respiratory and gastrointestinal infections, asthma, inflammatory bowel disease, obesity and diabetes [149,151,152]. Breastmilk also promotes the best outcomes in growth and development, including visual and neural systems, particularly from hormones and long-chain polyunsaturated fatty acids content, such as omega-3 fatty acids [153]. A meta-analysis of four RCTs with a total of 476 preterm infants found that breastmilk from the mother or human milk donor reduced the risk of NEC by 58% compared to infants fed IF (RR 0.42, 95% CI 0.18-0.96, $P<0.05$) [154].

It is well-researched that breastfeeding provides long-term health advantages to the mother and infant. The literature confirms that EBF for up to six months leads to reduced rates of respiratory tract infections, severe diarrhoea, and childhood obesity [99]. A systematic review of the effects of breastfeeding all-cause mortality in the first two years of life among full-term infants and children in developed countries found that EBF for up to six months significantly reduced the risk of infant mortality when compared to mixed feeding (HR 2.84, 95% CI 1.63-4.97) and no breastfeeding (HR 14.4 (6.13-33.9) [155]. WHO's review on the long-term effects of breastfeeding found that breastfeeding positively impacts cognitive development in children, lowers the risk of obesity in children and adults, lowers the risk of hypertension in adults, and lowers the risk of type 2 diabetes in mothers and children [156].

1.2.5 Post-discharge nutrition

According to ESPGHAN guidelines, post-discharge nutrition should be tailored to the infant's postnatal growth [157]. Infants with nutritional deficits are at risk of poor growth outcomes that can persist through childhood and adolescence [158]. This increases their risk of long-term cognitive, educational, metabolic and cardiovascular unfavourable outcomes [91]. Therefore,

ESPGHAN recommends infants with suboptimal weight at discharge for their corrected GA who are fed formula should receive a specialised post-discharge formula (72-74 kcal/100mL) with increased content of protein (±2.5 g/100mL), minerals, trace elements, and long-chain fatty acids until 40-52 weeks corrected GA [157]. Furthermore, infants who are fed breastmilk at discharge with suboptimal weight for their corrected GA should receive supplementation such as adding formula powder to breastmilk [157,159]. However, further research is needed to support these clinical practices and their long-term outcomes [159].

A systematic review including 16 RCTs of 1251 preterm infants compared the impact of nutrient-enriched formula with standard IF on the growth and development of preterm infants following hospital discharge [91]. Young et al. found that there was insufficient evidence to support the use of post-discharge formula (~74 kcal/100ml) over standard IF (~67 kcal/100ml) for promoting growth [91]. However, this review revealed significant heterogeneity between studies and hospital practices [91]. Teller et al. also investigated post-discharge formula feeding in preterm infants and emphasised the importance of specific nutrient concentrations for promoting growth, head circumference and body composition [160]. In contrast to using a nutrient-dense formula, Teller et al. found that a protein-to-energy ratio of more than 2.5 for infants six months of corrected GA supported positive growth outcomes [160]. The studies included in these reviews did not provide follow-up beyond 24 months, which warrants further research on long-term outcomes [91,160]. An RCT which followed 92 preterm-born children from birth to 10 years to investigate cognitive outcomes between a preterm formula (~80 kcal/100ml), standard term formula (~67 kcal/100ml), or a combination of both from discharge to 6 months corrected GA [161]. Embleton et al. found no long-term differences in cognition; however, greater weight gain in the first 12 weeks was associated with improved cognition, highlighting the importance of meeting nutrition requirements [161].

1.2.6 Complementary feeding

Complementary feeding (CF) (also known as weaning or the introduction of solid foods) is defined by the NZ MoH and WHO as "*the process starting when breastmilk (or infant formula) alone is no longer sufficient to meet a baby's nutritional requirement, so other foods and liquids are needed, along with the main milk source*" [108,162]. Adequate and appropriate nutritional management during this time is crucial for preterm infants as they have specific nutritional requirements to optimise their growth and development, which may otherwise be delayed or affected. Following the optimal CF practices for preterm infants is essential for establishing

feeding skills, developing taste preferences, accepting new textures and foods and maintaining healthy sleeping patterns [163]. Therefore, it is particularly crucial to introduce CF at the appropriate time, which is not well established among preterm infants.

1.2.6.1 Current recommendations

It is widely recognised that healthy-term infants should begin to receive solid foods at around 6 months of age when they are showing signs of eating readiness [108,162]. The MoH Healthy Eating Guidelines provide national recommendations for full-term children from birth to two years of age, which align with international recommendations [108]. Signs that a baby is ready to start CF include the ability to hold their head and sit upright with less help, to open their mouth when food approaches, to keep food in their mouth and swallow it, and to show signs of biting and chewing [108,162].

There is considerable variability in the current recommendations for the appropriate time to introduce CF to preterm infants globally [164]. A position paper by Italian Neonatal, Paediatric and Paediatric Gastroenterology joint societies reviewed the current evidence and proposed clear and explicit recommendations for introducing CF in preterm infants [109]. While there was insufficient evidence to draw a specific time for starting CF, an indicative range between five and eight months chronological age is recommended, with a limit of three months' corrected GA to ensure time for the infant to develop a mature digestive system and the skills necessary to consume solid foods [109]. The exact time that the infant should be introduced to CF, between five and eight months, will depend on their developmental cues for showing signs of readiness, which are the same as those for term infants [108,109,163].

Starship Child Health's paediatric dietitians have formulated CF guidelines for preterm infants born before 32 weeks of gestation [165], recommending the introduction of CF between three and four months corrected GA, with too early being before three months corrected GA and too late being more than 7-10 months chronological age [165]. Healthy preterm infants born after 32-34 completed weeks can follow the same guidelines as term infants for introducing CF at six months chronological age [163,165].

The progression of solid food introduction should be carefully monitored, and developmental delays should be considered for preterm infants [163,165]. The progression of textures, flavours, foods and quantity changes over time, which is important as the infant develops new skills and

nutritional needs [108,163]. This supports their overall growth and development, laying the foundation for healthy eating habits [108,163]. Most preterm infants should be offered textured lumpy solid foods by nine months chronological age [163]. Milk feeds should be offered first when introducing CF to any infant, and CF is provided as a top-up [108]. After two months of starting CF, textured and solid food should be offered first [165]. At this stage of development, preterm infants begin to acquire the skill of chewing, and food consistency can transition from a smooth texture into a mashed form with small lumps with the promotion to finger foods, allowing infants to feed themselves [165]. The progression of textures from purees to finger foods early on is critical for developing oral motor skills and food acceptance [163].

1.2.6.2 Prevalence of timely introduction of complementary feeding

Preterm infants are more likely to be introduced to solid foods too early, even when their corrected GA is accounted for [164]. A longitudinal study of preterm infants (n=7650) in the United States found that EP and VP infants had a higher risk of being introduced to CF before 4 months corrected GA compared to term infants (OR 9.9, 95% CI 5.54-18, P<0.001) [166]. Additionally, MLP infants had an increased risk of introducing CF early compared to term infants (OR 6.19, 95% CI 4.58-8.36, P<0.001) [166].

Although there is limited evidence for the introduction of CF among preterm infants in NZ, introducing CF early, before four months, is prevalent among full-term infants in NZ [167]. The GUiNZ cohort found that 57% of infants were introduced to CF before four months of age [167]. The early introduction to CF was associated with maternal characteristics such as lower education, Māori ethnicity, younger age, and smoking during pregnancy [167]. The differences in guidelines and variability in age measurement can make it difficult to compare outcomes and draw conclusions. However, it is evident that compared to term infants, preterm infants are at a greater risk of early introduction to CF [166,168–170].

1.2.6.3 Health outcomes of timely complementary food introduction

Introducing CF at the recommended time between five and eight months is important to support the growth and development of preterm infants, as breastmilk or formula alone is no longer sufficient to meet their nutritional requirements [171]. Although there is limited data available on the specific nutritional needs of preterm infants at the time of CF, delaying the introduction of CF may result in nutritional deficiencies [171].

The timing of CF in preterm infants may be associated with overweight and obesity in childhood and adulthood [109]. In term infants, it is not clear whether there is an association between early (<4 months) and late (>7 months) introduction of CF with increased adiposity, weight, and childhood obesity [172]. A systematic review investigated the relationship between the timing of initiating CF and weight in preterm infants, but no clear conclusions could be made from the five studies included [173]. The lack of clarity on the right time to introduce solids mostly results from the inconsistent classification of early versus late introduction of CF across studies. The authors emphasised the need for further research to assess the effect of the timing of CF introduction and weight and length outcomes in preterm infants [173].

Feeding difficulties are more prominent in preterm infants, which increases the risk of fussy eating tendencies such as refusing to eat certain food groups, choking and gagging, or stress and irritability at meal times [174]. This means the timing of CF is critical to establish healthy feeding behaviours and food acceptance. A delay in introducing textured foods has been associated with feeding problems and poor acceptance, as they could miss a critical period for developing new motor skills [163]. Failure to introduce lumpy foods by nine months is associated with an increased risk of feeding difficulties and refusal of important food groups such as fruit and vegetables in later life [175,176]. The ability to chew with their teeth or gum is crucial as it helps develop their jaw muscles, fosters good dental health, and facilitates a seamless transition to consuming family meals [165].

It is well-researched that the timely introduction of CF and exposure to allergens are important for reducing the risk of developing food allergies [177–179]. Introducing the common allergens (eggs, peanuts, cow's milk, tree nuts, soy, sesame seeds, wheat, fish, and shellfish) before 12 months of age is important for reducing the risk of developing allergies in the future [108]. Preterm infants are thought to be at a heightened risk of developing allergies due to immaturity of the gut and immune system; paired with limited guidelines for the timing of CF, the consideration of introducing allergens in their diet is important to minimise the risk of developing allergies [163]. A systematic review including nine cohort studies and seven RCTs involving full-term infants investigated the association between the early introduction of CF and food allergy and sensitisation. The review found no association between the timing of introducing CF and food allergies [180]. These findings suggest that early exposure to CF in preterm infants may not be associated with the development of allergies [180]. Timely

introduction of CF is also important for reducing the risk of infections, gut immaturity, poor sleeping patterns and feeding problems such as reflux [163].

1.2.6.4 First foods

The quality of first foods for all infants is important [171]. Healthy preterm infants are recommended to follow the nutritional recommendations for term infants [171]. The MoH Healthy Eating Guidelines for NZ Babies and Toddlers (0-2 years old) advise the types of foods and textures to introduce as the first foods that can be used for preterm infants when they are growing and developing well [108]. However, some studies have found that preterm infants' first foods are inadequate in energy and protein [168,169]. Furthermore, there is some evidence that preterm infants may need higher intakes of energy, protein, long-chain polyunsaturated fatty acids, iron, zinc, calcium, and selenium, typically indicated in the early stages of life [171]. Therefore, preterm infants may benefit from nutrient-dense first foods high in energy and protein, particularly among infants who have not met their growth targets. However, the evidence supporting the use of energy dense food for improved growth and development is not conclusive [164,171].

Preterm infants may have an increased risk of iron deficiency compared to term infants, which is essential for immunity, brain development, and growth [163,165]. Iron stores start to deplete in full-term breastfed infants around six months of age, however, this occurs much earlier for preterm infants. Hence, preterm infants are routinely supplemented with iron post-discharge [109,163]. However, from six months of age, iron from supplementation is not sufficient to meet the requirements for preterm infants [109]. Therefore, iron-rich foods, such as lean red meats, chicken, fish, seafood, and legumes, should be incorporated as the first foods to prevent iron deficiency [108,181].

Vegetables and fruit are part of a healthy diet and are recommended as they provide essential nutrients for the growth and development of infants and toddlers. Preterm infants may benefit from high-energy vegetables and fruit, such as avocado, kumara, and banana, as their first foods to support their growth [165]. Offering a variety of food is important to enhance diverse nutrient intake and the infant's taste and texture preferences. Other safe and adequate first foods include grain foods (such as iron-fortified cereal, porridge, bread, pasta, noodles, and rice), dairy products such as yoghurt and cheese, and common allergy-causing foods such as eggs and nut butter (introduced one at a time) [108,165]. Introducing CF while continuing to provide breastmilk

benefits the infant's energy intake and gut microbiome and potentially lowers the risk of developing allergies [181,182].

In the first two years of life, it is recommended to avoid adding sugar and salt to children's food [108]. This approach allows them to experience the natural flavours of foods and helps them develop a taste for various flavours, including savoury and bitter, which are important for a balanced diet [108]. Infants require minimal salt intake as they have a limited capacity to process excess sodium [108,183]. Additionally, eating a diet low in salt is strongly associated with a reduced risk of developing non-communicable diseases such as hypertension and heart disease later in life [183]. Most dietary sodium comes from packaged and processed foods, with only 10-20% from added salt; therefore, it is recommended to introduce CF with a focus on whole and unprocessed foods [184]. Foods and beverages with added sugar should be avoided, as they provide additional energy without nutritional benefits [185]. Excessive sugar consumption is associated with unhealthy weight gain and dental caries in adults and children [186,187].

Once CF is introduced, offering plain water with food [108] is recommended. Water is essential for hydration at this stage since the intake of fluids from breastmilk or IF is reduced [108]. It is also important to continue offering breastmilk or IF when introducing CF [108]. However, drinks with added sugars, sweeteners, caffeine, or alcohol are not recommended or safe for children [108]. These include fruit juice, cordial, flavoured milk, tea and soft drinks [108]. Historically, fruit juice was recommended for children and infants due to its source of vitamin C and hydration benefits [108,188]. However, its lack of fibre and high sugar can contribute to unhealthy weight gain, diarrhoea, displacement of fruit in the diet, and the development of dental caries [188]. Therefore, fruit juice is not recommended for children before 12 months of age [108,188].

Cow's milk as a drink should not be given to children under 12 months of age as it is not nutritionally adequate to support their growth and development compared to breastmilk or IF [108]. Cow's milk is low in iron and can interfere with the absorption of iron from food sources [189]. It has also been linked to gastrointestinal blood loss, particularly before nine months of age [189]. Additionally, cow's milk is high in protein and minerals, which can be hard for an infant's kidneys to manage [189]. However, offering milk products or adding small volumes of cow's milk to complementary foods is acceptable, as it can provide a good source of protein and calcium [189]. After 12 months of age, the nutrients in whole-fat pasteurised cow's milk become important for children's growth and development, including protein, calcium,

riboflavin and vitamin B12 [108]. It is recommended that children have around 350 mL of whole-fat cow's milk per day after 12 months, although breastfed infants may require less [108]. Fortified soy milk is the preferred plant base alternative, providing at least 100 mg of calcium per 100 mL [108].

The GUiNZ study investigated children's adherence to the MoH guidelines at nine months [190]. Although preterm infants (n=402) were excluded from the final analysis, their adherence to the guidelines was reported [120,190]. Only half of the preterm infants ate from the four food groups (fruits and vegetables, bread and cereals, breastmilk or IF, meat and meat alternatives) at least once daily at nine months of age [120]. Almost half of the preterm infants had ever tried drinks that were not recommended at nine months of age (fruit juice, soft drink, tea, herbal drink, coffee), and 15% had tried food or drinks with added salt and sugar [120]. These outcomes were not different between term and preterm infants [120]. Among term infants in this cohort, greater adherence to the MoH guidelines was significantly associated with maternal characteristics such as NZE ethnicity, older maternal age, higher maternal education, and those living in the least deprived areas [120].

The First Foods NZ study also measured adherence to the infant feeding guidelines from the MoH for 625 infants, including 46 preterm infants aged 7-10 months. The findings indicated that most infants met the recommendations for introducing CF [191]. Notably, vegetables (63%) and fruit (54%) were the most commonly reported first foods [191]. Although there is limited evidence on the first foods of preterm infants globally, it is suggested that their adherence to guidelines is suboptimal [168,169], and with minimal evidence of preterm infants' first foods in NZ, it is not clear whether they are meeting the appropriate guidelines for CF.

1.2.6.5 Methods of complementary feeding

There are different approaches to introducing CF. The MoH advises parents to learn and recognise when their infant is ready for solids in response to the readiness for CF cues [108]. Infants are born with the ability to regulate their food intake based on their internal hunger and fullness cues [192]. Responsive feeding fosters a positive feeding environment and supports the development of autonomy and self-regulation, which are important skills for healthy eating habits in the future [108,192]. Forcing or pressuring an infant to eat can lead to a negative relationship with food and may interfere with their ability to recognise their hunger and fullness cues [192].

A traditional spoon-feeding (TSF) approach involves the parent or caregiver introducing purees on a spoon for their first foods and progressing to chewable solids that can be finger foods [108]. Introducing pureed food is initially encouraged for the infant's safety to reduce the risk of choking, iron and other nutrient deficiencies, and growth faltering [193]. This follows Starship's recommendation to introduce more textured and lumpy foods that require chewing after two months of starting CF, which fits well with the trajectory of the development of teeth and the physiological development of chewing [194].

Baby-led weaning (BLW) is an emerging method of introducing solid food. It is gaining popularity due to its potential to improve self-regulation of hunger and satiety cues and may reduce fussy eating compared to TSF infants [195]. BLW is an alternative approach to introducing solid foods in which infants feed themselves all their food from the start of CF [196]. This means that first foods are often finger foods with greater texture and lumps compared to pureed foods [108,196]. However, there is insufficient evidence for the MoH to recommend BLW as an acceptable and safe alternative to the current weaning advice [197]. Although there are some proposed advantages towards healthy feeding behaviours, there are concerns that BLW may delay the introduction to CF, increase the risk of choking, and inadequate nutrient intake [195].

1.2.6.6 Health outcomes of traditional spoon feeding and baby-led weaning

Conflicting evidence exists regarding BLW and the risks of growth faltering (defined as growth much lower than expected or having crossed two major centile lines[198]) and nutrient deficiencies, particularly iron [195]. These outcomes are influenced by the types of first foods and the infant's inability to successfully self-feed enough to maintain sufficient energy and nutrient intake [195].

BLW has been proposed to reduce the risk of overweight and obesity [195]. However, some international studies have suggested that BLW may increase the risk of underweight and growth faltering [195,199]. An RCT, known as the Baby-Led Introduction to Solids (BLISS) study involving 206 mothers and their infants in NZ, examined the effect of BLW versus TSF on infant outcomes [196]. The BLISS study showed no significant improvement in growth or reduction in the risk of being overweight compared to TSF [196]. However, participants in the BLW group were encouraged to include high-energy food at each meal, which may have

mitigated the risk of growth faltering [196]. Additionally, the mothers in the BLW group reported significantly less fussy or picky eating at 12 months of age [196]. These findings are consistent with a cross-sectional study conducted in NZ, which surveyed 876 caregivers to investigate the outcomes of BLW and TSF in infants and found no differences in growth, except for a significantly lower food fussiness score at 6-12 months in the BLW group (MD -0.37, 95% CI -0.51 - -0.24, P<0.05) [193]. Both studies indicated that infants following BLW were EBF longer [193,196].

The method of introducing CF can determine the type of first foods the infant consumes. Studies indicate that infants using a TSF approach often consume more infant rice cereal, which is rich in energy and iron, as their first food [193,196]. A study involving 51 infants from NZ compared unmodified BLW and TSF [200]. They found no difference in energy intakes but significantly higher intakes of saturated fat and lower intakes of iron, zinc, and vitamin B12 in infants following BLW [200]. Importantly, Daniels et al. found no differences in iron deficiency between the BLW and TSF groups, which may have been explained by modifying the BLISS BLW group with high-energy foods and additional education and support [201]. Regardless, neither group achieved the WHO recommendation for iron intake from CF [201]. Although the BLW approach in the BLISS study appears nutritionally adequate, it raises concerns about the nutritional adequacy of unmodified BLW in real-world settings.

There is insufficient evidence to support BLW, particularly among preterm infants [108,195,197]. Therefore, further research is needed to determine the potential effects of BLW on nutrient and energy intake, growth, and feeding behaviours.

1.3 Summary

Preterm infants present with numerous clinical challenges, heightened nutrient demands, feeding difficulties and unfavourable health outcomes that can persist into adolescence and adulthood. Globally, preterm infants encounter significant challenges to breastfeeding, underscoring the urgent need for improved support for this vulnerable population. In NZ, both the rate of breastfeeding beyond discharge and CF practices in the general population are suboptimal. Furthermore, there is a lack of national data on the feeding practices of preterm infants beyond the neonatal period, and there are no specific nutritional guidelines tailored to the care of preterm infants in NZ. The wide variation in nutritional management underscores

the importance of understanding current feeding practices and identifying the factors that enable and challenge optimal nutrition outcomes for preterm infants in NZ.

1.4 Aims

This study aimed to determine the current feeding practices of preterm infants born in New Zealand and the enablers and challenges experienced by parents. The primary outcome was to determine the rate of EBF ≥5 months.

Specific aims

- To determine the prevalence of exclusive breastfeeding and the practices of introducing complementary foods among preterm infants in New Zealand.
- To assess the enablers and challenges associated with exclusive breastfeeding and complementary feeding practices among preterm infants in New Zealand.
- To assess if preterm infants are meeting the recommendations set by the Healthy Eating Guidelines for New Zealand Babies and Toddlers [108].
- To determine any differences in feeding practices between the sub-categories of prematurity in New Zealand.
- To investigate differences in feeding practices across maternal and infant characteristics in New Zealand.

Chapter 2. Methods

2.1 Study design

This study was a self-completed electronic survey. The survey used a mixed-methods design, with open- and closed-ended questions providing quantitative data (counts, frequencies, mean and standard deviation, median and range) and qualitative data (free text, opinions, views, likes/dislikes). The survey was designed using Qualtrics XM [202]. Some questions were not mandatory, and participants were allowed to leave them unanswered to promote survey completion. The survey was available for completion between May 2023 and August 2023.
Ethical approval was granted by the Auckland Health Research Committee on the 3rd of May, 2023, for three years (application number: AH25952).

2.2 Study population

The research participants were recruited across NZ. The survey aimed to reach as many mothers/caregivers of preterm infants as possible. This exploratory study aimed to identify the prevalence of EBF and the timing of the introduction of CF among preterm infants in NZ, which is currently unknown; therefore, no formal sample size calculation was undertaken, and there was no limit on the number of participants.

2.2.1 Inclusion criteria

Participants were required to be the primary caregiver of a single preterm infant (born <37 weeks' gestation) aged up to 24 months chronological age at the time of survey participation; 16 years or older; able to complete the survey in English; and with access to an electronic device with internet connection.

2.2.2 Exclusion criteria

Participants were excluded if they were under the age of 16 years, unable to complete the survey in English, whose preterm infant was older than 24 months chronological age at the time of survey participation, or given birth to multiples (twins, triplets, more).

2.3 Sampling and recruitment

In March 2023, the survey was sent out for consultation to a multi-ethnic group of mothers/caregivers and members of the Liggins Māori Advisory Group, who tested a draft survey, gathering feedback on the content, readability and suitability of the survey questions.

This ensured that important aspects of early nutrition of preterm infants were covered in a culturally appropriate way and questions were at an accessible literacy level. Between May and August 2023, the electronic survey was advertised through the Liggins Institute social media accounts **(Appendix 1).** Emails with a summary of the research, links to the survey and advertisement material were sent out to key organisations/groups. The email recipients were asked to forward the email or circulate the advertisement within their networks of mothers/caregivers of preterm infants. A snowball dissemination method [203] was utilised to increase the research outreach. This was achieved via advertisements and Facebook posts encouraging participants to circulate the survey link to fellow mothers/caregivers of preterm infants.

2.4 Informed consent process

The survey information sheet **(Appendix 2)** provided details on the purpose of the research, eligibility criteria, potential risks and benefits of research participation, confidentiality assurance, and the contact information for the principal investigator in case further questions or concerns are raised, ensuring transparency and respect to the participants' right to an informed decision. Participants were encouraged to discuss the study information with family/whānau, friends, and/or healthcare providers who may help to decide whether they should participate. At the end of the survey information sheet, participants were asked to agree or disagree with the information provided. If participants selected "I agree", their consent was obtained, and the survey commenced. A downloadable copy of the information sheet was available to the participants. A Te Reo Māori version of the survey information sheet was also available to participants **(Appendix 3).**

2.5 Data management and safety

Survey responses were anonymous and securely stored within the browser-based software Qualtrics [202]. The Qualtrics software is accessed within the password-protected University of Auckland server, and only the research investigators had access to the survey responses and data [202]. Deidentified participant data was stored within the Qualtrics software and will be permanently deleted after six years [202]. All responses were anonymous and confidential, and no IP address was collected to ensure participant data security.

2.6 Withdraw

Participants could stop participating in the research by not submitting the survey and simply closing the browser. However, participants could not withdraw after submitting the questionnaire because responses were stored anonymously, and it would not have been possible to determine which data belonged to whom.

2.7 Survey content

The survey structure followed the feeding journey of a preterm infant from birth to solid food introduction and was divided into five blocks related to 1) maternal/caregiver information; 2) infant information; 3) feeding practices during the initial hospital stay; 4) feeding practices after hospital discharge; and 5) the introduction of CF. The survey contained a maximum of 61 questions, and the display logic function was utilised to tailor the survey questions according to participants' responses, ensuring participants were only asked questions relevant to their previous answers. For example, if the participant answered "no" regarding the initiation of CF to their infant, they were directed to the end of the survey, skipping questions relevant to the introduction of CF. A copy of the survey questions can be found in **Appendix 4**. Where relevant, definitions of key medical terms, feeding practices and outcomes were provided to aid in the interpretation of questions, which can be found in **Table 2**.

Table 2. Definitions provided in the survey

Term/phrase	Definition	Reference
Level of prematurity	Prematurity is defined as the total duration of pregnancy/hapūtanga in complete weeks, from conception to birth. - Extremely preterm (EP) less than 27 complete weeks' gestation - Very preterm (VP) 28-31 complete weeks' gestation - Moderate preterm (MP) 32-33 complete weeks' gestation - Late preterm (LP) 34-36 complete weeks' gestation	World Health Organization, 2023 [1]
Exclusive breastfeeding	Exclusive breastfeeding/whāngai ū means that from birth, the baby receives only breastmilk (from the breast	Ministry of Health, 2023 [204]

Term/phrase	Definition	Reference
	or expressed) and prescribed medicines, where necessary.	
Nutritional support	Nutritional support means that your baby/pēpi requires some form of nutrition or feeding mode other than breastfeeding/whāngai ū after birth.	
Breastmilk fortifier	Breastmilk fortifier is a powder added to breastmilk to provide additional energy and nutrients to support baby/pēpi growth.	Starship, 2019 [102]
Skin-to-skin contact	Skin-to-skin contact is also known as Kangaroo Care and is a method of holding your baby/pēpi in skin-to-skin contact with no clothes on, prone and upright on the chest of the parent/caregiver with a cover over baby's/pēpi back.	Starship, 2015 [131]
Signs a baby is ready for solids	- 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	Ministry of Health, 2021 [108]
Spoon-fed feeding	Spoon-fed feeding, also known as the traditional approach to feeding an infant, is to introduce smooth puree foods on a spoon-fed by the parent.	Ministry of Health, 2021 [108]
Baby-led weaning	Baby-led weaning (BLW) is defined as the baby/pēpi picking up their food of choice from what is on offer instead of being fed by someone else.	Ministry of Health, 2021 [108]
Fussy eating	Fussy behaviours towards introducing solid foods include: - Unpredictable food preferences - Uninterested in eating/having a poor appetite - Consumes a limited variety of foods and/or textures - Fear of new foods - Refusal to eat certain foods	Ministry of Health, 2021 [108]

Term/phrase	Definition	Reference
	- Difficult to wean off certain textures/baby foods	

The maternal/caregiver and infant demographic characteristics included maternal/caregiver age, ethnicity, income, education, parity, and the infants' level of prematurity, birth weight and ethnicity. Most questions were multiple-choice questions, and some allowed participants to select more than one answer, such as ethnicity. At the end of the survey, open-text questions covered participants' views about the enablers and challenges to their feeding experience, and potential improvements to support and guidance received.

To investigate adherence to the Ministry of Health Healthy Eating guidelines, food frequency questions (FFQ) were asked about the intake of major food groups, and an open-text entry question was asked regarding the infants' first foods. Participants were asked how often their baby consumed certain foods in the past month, ranging from never, once a week, 2-4 days a week, 5-6 days a week, every day or more.
The following recommendations from the guidelines were analysed [108]:

- "*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 cereal, oats (porridge), bread, rice, noodles, and pasta)*
- *Milk products (such as yoghurt and cheese)*
- *Legumes (such as lentils, tofu, and beans), nut butter.*
- *Animal products (eggs, fish, seafood and chicken or lean red meat)."*

- "*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*".

2.8 Data analysis

Quantitative data were statistically analysed using SPSS Statistics (version 29.0.1.0) [205]. Categorical data are presented as numbers (n) and percentages (%), and continuous data are presented as mean and standard deviations (SD). Associations between categorical outcomes and variables of interest were measured by Pearson's Chi-square test or Fisher Freeman Halton exact test, according to data distribution. A one-way ANOVA test was used to investigate

associations between continuous outcomes and variables of more than two groups. T-tests were used to investigate associations between continuous outcomes and variables with two groups of interest. Mean differences (MD) were used to investigate associations for continuous variables. Post-hoc Bonferroni correction was performed for multiple comparisons. A p-value of less than 0.05 was considered statistically significant. Tables, graphs, and figures were created using Microsoft Excel for Mac (version 16.77.1) [206].

The primary outcome of the survey was the rate of EBF for more than or equal to five months chronological age. Other feeding outcomes during in-hospital and post-discharge were investigated, as well as CF practices. Associations between rates of EBF and infant feeding outcomes with maternal/caregiver and infant characteristics, such as ethnicity and level of prematurity, were explored using Pearson's Chi-square test or Fisher Freeman Halton exact test. To investigate ethnic differences in the outcomes of interest, participants' ethnicity was categorised into Māori and non-Māori.

The timing of CF introduction was investigated as continuous (months) and categorical variables. The categorical outcomes were classified as early (<5 months), timely (5-8 months), or late (>8 months) CF introduction for preterm infants. This classification is guided by the recommendations set from a position by Italian neonatal, paediatric and paediatric gastroenterology joint societies [109].

Maternal/caregiver satisfaction was measured for EBF duration, total breastfeeding duration, and the education and culturally appropriate education received for breastfeeding and CF. Participants were asked to answer how much they agreed with being satisfied with each outcome and scored as: strongly disagree (score 1), somewhat disagree (score 2), neither agree nor disagree (score 3), somewhat agree (score 4), strongly agree (score 5).

A child feeding index (CFI) was adapted from Castro et al. [190]. In the present study, we adapted the CFI to measure the overall adherence to the MoH guidelines for children aged 0-2 years old, which contained eight relevant indicators to the introduction of CF [108]. Participants were asked for the frequency of intake of the recommended food groups (vegetables, fruit, grains, milk products, legumes, and protein) and intakes of food with added sugar and salt. Participants were asked to determine how frequently their infant consumed the specific food in the past month, and answers were scored as: never (score 0), once a week (score 0.25), 2-4 days a week

(score 0.5), 5-6 days a week (score 0.75), and every day or more (score 1.0). The scores were reversed for the questions of added sugar and salt: every day or more (score 0), 5-6 days a week (score 0.25), 2-4 days a week (score 0.5), once a week (score 0.75), never (score 1.0). The maximum score a participant could receive was equal to 8.0. The CFI scores were investigated separately according to the infant's chronological age at the time of survey completion.

The qualitative data was thematically analysed using NVivo 14 [207] and employing tools such as word clouds and identification of common phrases and words by the software. Common phrases and key experiences were identified with different codes and then grouped into relevant thematic sub-groups following the general inductive approach [208]. This thematic analysis approach involves familiarising with the data, generating initial codes, searching for themes, reviewing themes, and defining and naming overarching themes [208]. This method was carried out for all the open-text entry questions. The qualitative data is presented as a tree diagram with each question's overarching themes and the respective identified codes.

2.9 Responsiveness to Māori

Before the survey-roll out, experts in Māori research within the Liggins Institute Māori Advisory Group and Māori health professionals were consulted to ensure that the survey would contribute to and benefit Māori health advancement. Advice on culturally appropriate recruitment and dissemination strategies, survey questions and content of the participant information was provided. To increase Māori participation, the survey information sheet was translated into Te Reo Māori **(Appendix 3).** Social media advertising strategies were used to boost survey circulation among Māori, and health professionals involved in the care of Māori whānau were contacted to help with survey dissemination to Māori. Recommendations regarding appropriate dissemination and communication of findings to Māori were also discussed with the Liggins Institute Māori Advisory Group.

Chapter 3: Results

3.1 Quantitative results

A total of 269 respondents completed the initial consent question. One respondent declined to participate, and no response was recorded. Thus, a total of 268 complete surveys were included in the analysis. As there were multiple response questions, the number of responses obtained for each question is shown in each table.

3.1.1 Study population

Maternal/caregiver and infant characteristics are presented in **Table 3**.

3.1.1.1 Maternal/caregiver characteristics

The majority of participants self-identified as NZ European (NZE, 68%) or Māori (14%) ethnicity. Other ethnic groups identified were Pacific (3%), Asian (7%), Middle Eastern/ Latin American/ African (MELAA, 10%), and 'other' ethnicity (other European, Australian and American, 8%). Maternal/caregiver ethnicity was grouped into Māori (14%) and non-Māori (86%). Most respondents were between 25 and 34 years old at the time of birth (64%), first-time mothers (63%), and had a university (59%) or a post-secondary non-tertiary degree (24%). Total yearly household income was evenly distributed between less than $100,000 (49%) and more than $100,000 (51%). There were no differences between the maternal/caregiver characteristics and infant's level of prematurity.

3.1.1.2 Infant characteristics

Most infants were identified as NZE (73%) or Māori (21%). Other ethnic groups identified were Pacific (8%), Asian (7%), MELAA (10%), and 'other' ethnicity (other European, Australian and American, 8%). Infant ethnicity was grouped into Māori (21%) and non-Māori (79%). Infant ethnicity was not associated with level of prematurity. Most infants were born LP (46%) or MP (24%), and approximately a third were born EP or VP. Most infants received postnatal care in the NICU (51%), or Special Care Baby Unit (SCBU, 34%), and some infants stayed in a postnatal ward or a transitional birthing suite (16%). Most infants were in the hospital for more than three weeks after birth (61%). At the time of survey completion, the infant's chronological age was evenly distributed between 0-6 months (31%), 7-12 months (30%), and >12 months (39%). Infants aged 7-12 months were more commonly born LP than MP (40% vs 19%, respectively, $P<0.05$). Infants >12 months chronological age were more commonly born EP than LP (61% vs 29%, respectively, $P<0.05$). There was no difference in the level of prematurity for infants 0-6 months chronological age.

The infant's birth weight was significantly associated with the level of prematurity (P<0.001), which tended to increase with increasing GA at birth. Infants with a birthweight less than 1000g were most commonly EP infants (82%). Infants with a birth weight of 1000-1499g were most likely MP infants (43%). Infants with a birth weight 1500-1999g were most commonly MP infants (41%). Infants with a birth weight 2000g-2499g and more than 2500g were most commonly LP infants (45% and 29%, respectively).

The hospital location where infants spent the most time was significantly associated with the level of prematurity (P<0.001). Infants who spent the most time in the NICU were significantly more likely to be EP infants (96%) than all other levels of prematurity. Infants who spent the most time in the SCBU were more commonly VP (39%) and MP (53%) infants. Infants who spent the most time in a postnatal ward were significantly more likely to be LP infants (29%) compared to all other levels of prematurity.

The length of hospital stay was significantly associated with the level of prematurity (P<0.001). The infant's length of hospital stay tended to increase with decreasing GA at birth. Infants who spent less than one or two weeks in the hospital were most likely LP infants (24% and 42%, respectively). Infants who spent 3-4 weeks in the hospital were most likely MP infants (32%). Infants who spent more than four weeks in the hospital were significantly more likely to be EP infants (100%) and VP infants (83%) compared to MP infants (39%) and LP infants (7%).

Table 3. Maternal/caregiver and infant characteristics by the level of prematurity

Variables	Extremely preterm	Very preterm	Moderate preterm	Late preterm	Total	P-value
Level of prematurity (n=267)[1]	28 (11)	54 (20)	62 (23)	123 (46)	267 (100)	
Maternal/caregiver ethnicity (n=262)						
Māori	6 (21)	9 (17)	5 (8)	16 (14)	36 (14)	
non-Māori	22 (79)	45 (83)	57 (82)	102 (86)	226 (86)	0.295
Maternal/caregiver age at birth (n=266)						
16-24	4 (14)	2 (4)	7 (11)	19 (16)	32 (12)	
25-34	15 (54)	41 (76)	39 (63)	76 (63)	171 (64)	
35-44	9 (32)	11 (20)	16 (26)	27 (22)	63 (24)	0.227
Maternal/caregiver education (n=263)						
University (Bachelor degree or above)	18 (64)	31 (59)	38 (62)	69 (57)	156 (59)	

Variables	Extremely preterm	Very preterm	Moderate preterm	Late preterm	Total	P-value
Post-secondary non-tertiary	7 (25)	14 (26)	11 (18)	32 (26)	64 (24)	
Secondary education or below	3 (11)	8 (15)	12 (20)	20 (17)	43 (16)	0.864
Total household income (n=253)						
Less than $100,000	10 (37)	26 (49)	36 (61)	52 (46)	124 (49)	
More than $100,000	17 (63)	27 (51)	23 (39)	62 (54)	129 (51)	0.141
First pregnancy (n=267)						
Yes	13 (46)	32 (59)	44 (71)	79 (64)	168 (63)	
No	15 (54)	22 (41)	18 (29)	44 (36)	99 (37)	0.151
Infant's chronological age (n=267)						
0-6 months	5 (18)	17 (32)	21 (34)	39 (32)	82 (31)	
7-12 months	6 (21)[a, b]	13 (24)[a, b]	12 (19)[b]	49 (40)[a]	80 (30)	
>12 months	17 (61)[a]	24 (44)[a, b]	29 (47)[a, b]	35 (29)[b]	105 (39)	0.008*
Infant ethnicity (n=262)						
Māori	8 (29)	10 (19)	8 (13)	29 (24)	55 (21)	
non-Māori	20 (71)	43 (81)	54 (87)	90 (76)	207 (79)	0.209
Infant birth weight (n=266)						
Less than 1000g	23 (82)[a]	10 (19)[b]	4 (7)[b]	0 (0)[c]	37 (14)	
1000-1499g	4 (14)[a, b]	23 (43)[b]	7 (12)[a]	5 (4)[a]	39 (15)	
1500-1999g	0 (0)[a]	18 (33)[b, c]	25 (41)[c]	27 (22)[b]	70 (26)	
2000-2500g	1 (4)[a]	3 (6)[a]	21 (34)[b]	55 (45)[b]	80 (30)	
More than 2500g	0 (0)[a]	0 (0)[a]	4 (7)[a]	36 (29)[b]	40 (15)	<0.001*
Hospital location (n=267)						
Neonatal Intensive Care Unit	27 (96)[a]	31 (57)[b]	25 (40)[b]	52 (42)[b]	135 (51)	
Special Care Baby Unit	1 (4)[a]	21 (39)[b, c]	33 (53)[c]	35 (29)[b]	90 (34)	
Postnatal ward or similar	0 (0)[a]	2 (4)[a]	4 (7)[a]	36 (29)[b]	42 (16)	<0.001*
Length of hospital stay (n=266)						
Less than 1 week	0 (0)[a]	2 (4)[a]	11 (18)[a, b]	29 (24)[b]	42 (16)	
1-2 weeks	0 (0)[a]	4 (8)[a]	7 (11)[a]	51 (42)[b]	62 (23)	
3-4 weeks	0 (0)[a]	3 (5)[a]	20 (32)[b]	34 (28)[b]	57 (21)	
More than 4 weeks	28 (100)[a]	44 (83)[a]	24 (39)[b]	9 (7)[c]	105 (40)	<0.001*

Data are n (%). * Significant using Fisher Freeman Halton exact test. For each significant pair, superscript letters differ. The significance level is <0.05 (Bonferroni method).
[1.] Missing data from one participant.

3.1.2 In-hospital feeding practices

Table 4 presents the in-hospital feeding practices across the levels of prematurity. All EP and VP infants required nutritional support, whereas only few LP (6%) and MP (2%) infants did not require any nutritional support and were directly breastfed. Overall, nasogastric tube feeding (NGT) was the most common mode of nutritional support among preterm infants (78%), followed by oral supplementation with bottle, cup, or syringe (61%) and intravenous

nutrition (IVN, 43%). EP infants were significantly more likely to require IVN compared to MP infants (82% vs 52%, respectively, P<0.05) and LP infants (82% vs 24%, respectively, P<0.001). VP infants were more likely to require IVN compared to LP infants (59% vs 24%, respectively, P<0.001), and MP infants were also more likely to require IVN than LP infants (52% vs 24%, respectively, P<0.001). All EP infants required NGT feeding in the hospital, which was more common compared to MP infants (100% vs 71%, respectively, P<0.05) and LP infants (100% vs 31%, respectively, P<0.05). NGT feeding was also more common among VP infants, and they were more likely to require an NGT compared to MP infants (94% vs 71%, respectively, P<0.05) and LP infants (94% vs 31%, respectively, P<0.05).

The majority of infants received breastmilk (87%), and some received IF (47%) and/or DBM (39%) in the hospital. LP infants were significantly more likely to receive some breastmilk than MP infants (89% vs 74%, P<0.05, respectively). No differences were found between the use of IF and DBM between the levels of prematurity. EBF in the hospital was achieved for 30% of infants, while mixed feeding was reported in 57% of the infants, and 14% of infants received no breastmilk in the hospital. As displayed in **Figure 1**, the level of prematurity was significantly associated with the EBF rate in the hospital. EBF was significantly more common among EP and VP infants compared to LP infants (57% and 46% vs 18%, respectively, P<0.001). Additionally, EBF in the hospital was significantly more common in EP than in MP infants (57% vs 26%, respectively, P<0.05). On the other hand, LP infants were significantly more likely to have mixed feeding compared to EP (72% vs 39%, respectively, P<0.05), VP (72% vs 43%, respectively, P<0.001) and MP (72% vs 48%, respectively, P<0.05). No breastfeeding was significantly more common among MP infants than LP infants (26% vs 11%, respectively, P<0.05). Almost all mothers/caregivers (95%) performed skin-to-skin with their infant in the hospital more than daily (43%) or daily (33%).

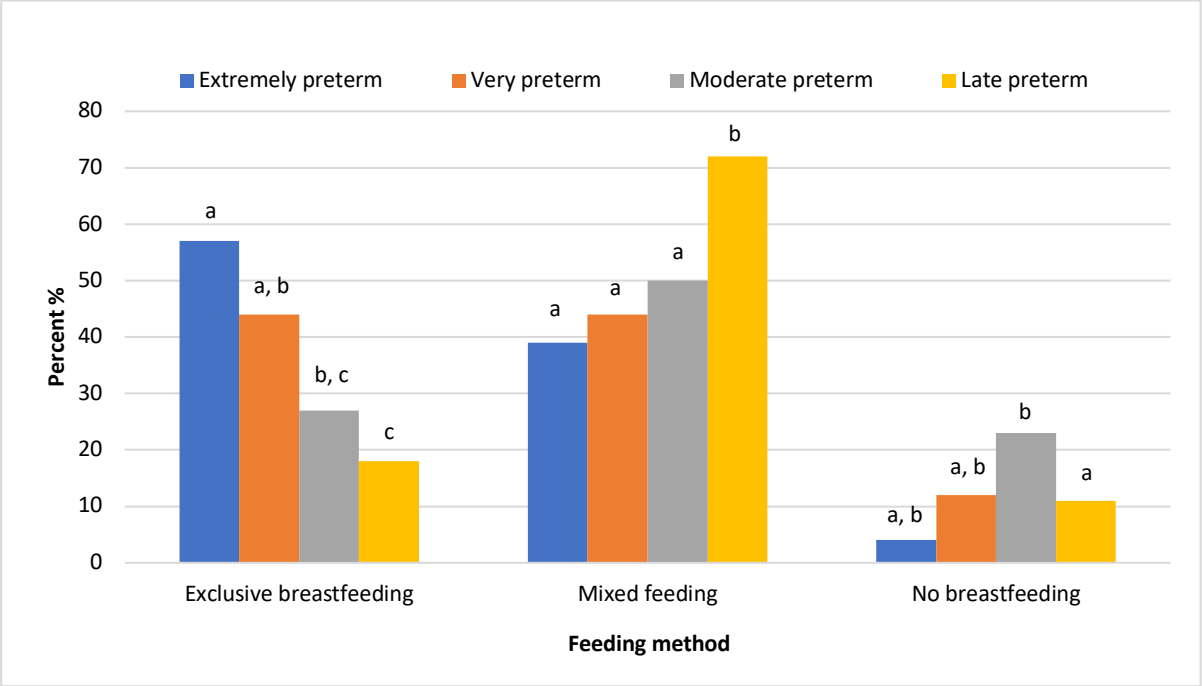

Figure 1. In-hospital feeding method between the levels of prematurity
For each significant pair, superscript letters differ.
Significance level is <0.05 using the Fisher Freeman Halton exact test (Bonferroni corrected).
N=267

Table 4. In-hospital feeding outcomes by the levels of prematurity.

Level of prematurity	Extremely preterm	Very preterm	Moderate preterm	Late preterm	Total	P-value
Nutritional support (n=266, count=495)[1]						
Intravenous nutrition	23 (82)[a]	32 (59)[a, b]	32 (52)[b]	29 (24)[c]	116 (43)	<0.001*
Nasogastric tube	28 (100)[a]	51 (94)[a]	44 (71)[b]	85 (31)[b]	208 (78)	<0.001*
Oral supplementation (bottle/cup/syringe)	15 (54)	32 (59)	42 (68)	74 (60)	163 (61)	0.578
None (direct breastfeeding)	0 (0)	0 (0)	1 (2)	7 (6)	8 (3)	0.167
Type of feed (n=267, count=317)[2]						
Breastmilk (any)	27 (96)[a, b]	48 (89)[a, b]	46 (74)[b]	110 (89)[a]	231 (87)	0.015*
Infant formula	8 (29)	22 (41)	27 (44)	69 (56)	126 (47)	0.029*
Donor breastmilk	6 (21)	20 (37)	29 (47)	48 (39)	103 (39)	0.149
Skin-to-skin duration (n=267)[2]						
More than daily	13 (46)	29 (54)	23 (37)	49 (40)	114 (43)	
Daily	13 (46)	17 (32)	19 (31)	40 (33)	89 (33)	
Less than daily	2 (7)	6 (11)	15 (24)	27 (22)	50 (19)	
None	0 (0)	2 (4)	5 (8)	7 (6)	14 (5)	0.212

Data are n (%). *Significant using the Fisher Freeman Halton exact test. For each significant pair, superscript letters differ. The significance level is <0.05 (Bonferroni corrected).
[1.] Missing data from two participants.
[2.] Missing data from one participant.

3.1.2.1 Maternal/caregiver characteristics and in-hospital feeding method

Maternal/caregiver education, income and age were significantly associated with in-hospital feeding outcomes. Infants of mothers/caregivers with a university degree or above were significantly more likely to receive IVN in the hospital compared to those with secondary education or below (49% vs 27%, P<0.05, respectively). Infants of mothers/caregivers with a total annual household income of more than $100,000 were significantly more likely to receive IVN in the hospital compared to those with a total annual household income of less than $100,000 (52% vs 36%, P<0.05, respectively). Infants of mothers/caregivers with a total annual household income of more than $100,000 were significantly more likely to have required NGT feeding in the hospital compared to those with a total annual household income of less than $100,000 (88% vs 66%, P<0.001, respectively). Infants of younger mothers/caregivers (16-24 years old) less frequently required NGT compared to those who were between 25-34 and 35-44 years old (55% vs 77% and 91%, respectively, P<0.001). Subsequently, infants of younger mothers/caregivers more commonly used oral supplementation (bottle/cup/syringe) for nutritional support compared to mothers/caregivers 35-44 old (76% vs 48%, P<0.05 respectively).

Infant ethnicity was significantly associated with the use of IVN. Infants who were identified as non-Māori were more likely to receive IVN in the hospital compared to infants who were identified as Māori (48% vs 31%, P<0.05, respectively). Maternal/caregiver ethnicity was not associated with the nutritional support outcomes.

Infants of mothers/caregivers with a total annual household income of less than $100,000 were significantly more likely to receive no breastmilk compared to those with a total annual household income of more than $100,000 (19% vs 8%, P<0.05, respectively) **(Figure 2)**. Infants of mothers/caregivers with an education level secondary or below were more likely to receive no breastmilk compared to those with a university degree or above (29% vs 10%, P<0.05, respectively) **(Figure 3)**. Subsequently, infants of mothers/caregivers with a total annual household income less than $100,000 were more likely to receive DBM than those with more than $100,000 (51% vs 27%, P<0.001, respectively). Infants of mothers/caregivers with post-secondary non-tertiary education and secondary education or below were more likely to receive DBM than those with a university degree or above (47% and 61% vs 28%, P<0.001, respectively). Infants of older mothers/caregivers (35-44 years old) were less likely to receive DBM than mothers/caregivers who were 16-24 and 25-34 years old (24% vs 49% and 42%,

P<0.05, respectively). There were no associations between the use of IF and maternal/caregiver characteristics. Maternal/caregiver ethnicity was not associated with the type or method of feeding in the hospital.

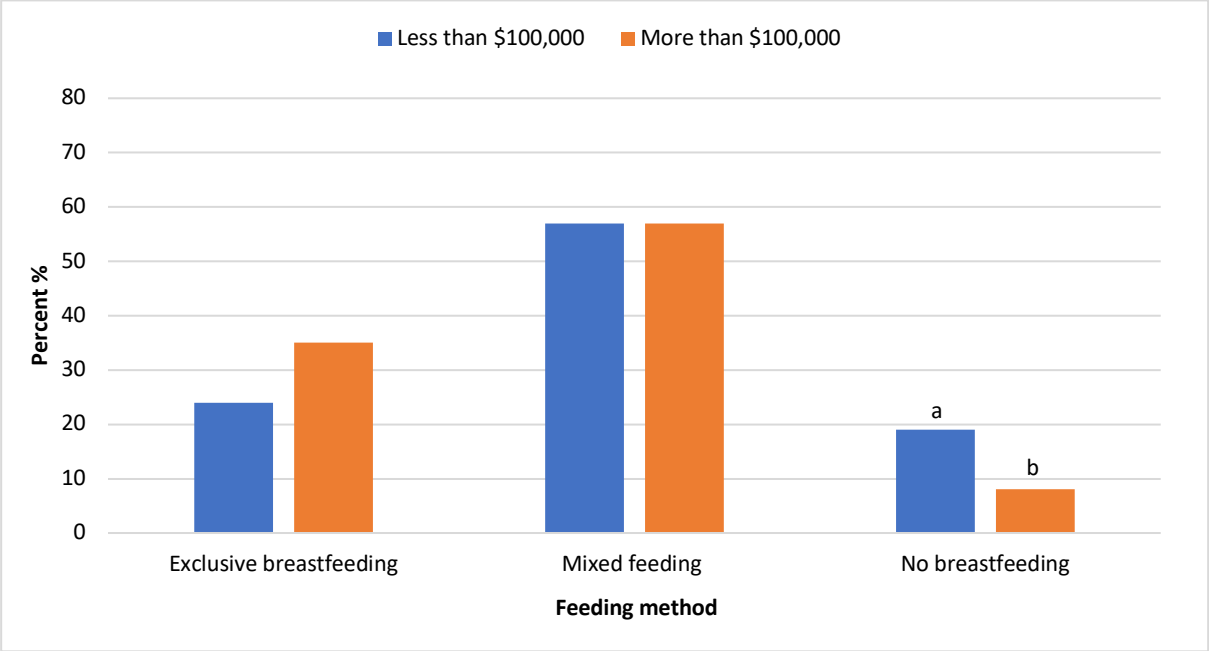

Figure 2. In-hospital feeding method between annual household income levels
For each significant pair, superscript letters differ.
Significance level is <0.05 using the Fisher Freeman Halton exact test (Bonferroni corrected).
N=253

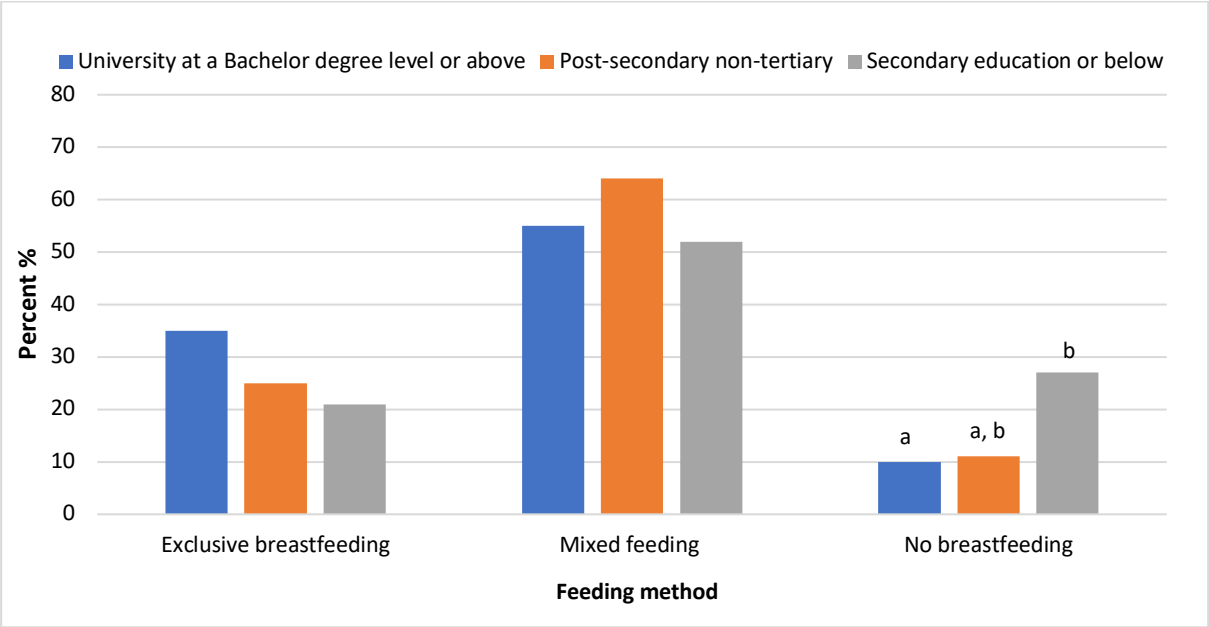

Figure 3. In-hospital feeding method between maternal/caregiver education level
For each significant pair, superscript letters differ.
Significance level is <0.05 using the Fisher Freeman Halton exact test (Bonferroni corrected).
N=263

3.1.3 Feeding practices at discharge

Overall, the infants' mode of feeding at hospital discharge was mostly described as directly breastfeeding (70%) and oral supplementation feeding (bottle/cup/syringe) (54%), and some infants were discharged home with an NGT (23%). The rate of EBF at discharge was 60%, the rate of mixed feeding was 24%, and no breastfeeding was reported among 16% of infants at discharge **(Figure 4)**. Overall, at discharge, most infants received some breastmilk (84%), and some were also fed some IF (33%) and/or some DBM (11%).

The feeding practices at discharge by the level of prematurity are presented in **Table 5.** The feeding mode at discharge was significantly associated with the level of prematurity. NGT feeding at discharge was most common among EP and VP infants compared to MP infants (54% vs 18%; and 46% vs 18%, respectively, P<0.05) and LP infants (54% vs 9%; and 46% vs 9%, respectively, P<0.001).

The feeding method at discharge by the levels of prematurity is shown in **Figure 4**. The rate of EBF and mixed feeding did not differ significantly between the levels of prematurity. However, no breastmilk feeding at discharge was significantly more common among VP and MP compared to LP infants (26% vs 8% and 24% vs 8%, respectively, P<0.05).

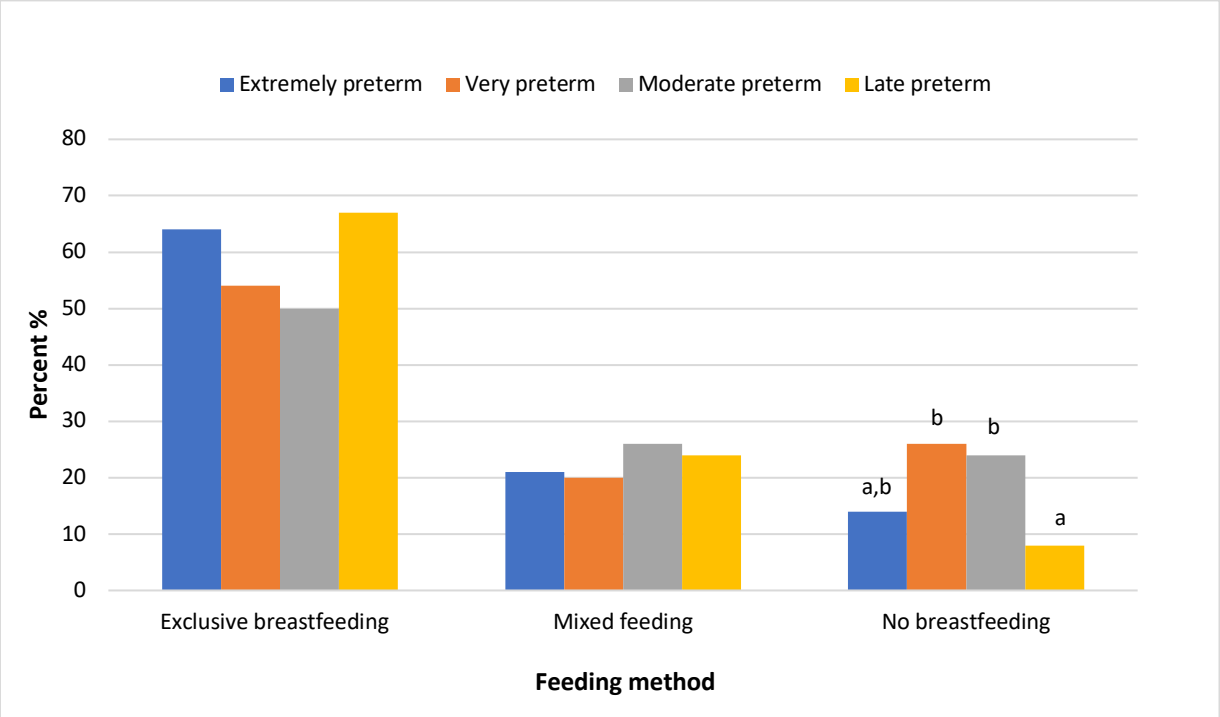

Figure 4. Feeding method at discharge between the levels of prematurity
For each significant pair, superscript letters differ.
Significance level is <0.05 using the Fisher Freeman Halton exact test (Bonferroni corrected).
N=267

Table 5. Feeding practices at discharge by the levels of prematurity

Prematurity	Extremely preterm	Very preterm	Moderate preterm	Late preterm	Total	P-value
Mode of feeding at discharge (n=267, count=393)[1]						
Nasogastric tube	15 (54)[a]	25 (46)[a]	11 (18)[b]	11 (9)[b]	62 (23)	<0.001*
Oral supplementation	11 (39)	28 (52)	41 (66)	64 (52)	144 (54)	0.094
Direct breastfeeding	20 (71)[a, b]	27 (50)[b]	41 (66)[a, b]	99 (81)[a]	187 (70)	<0.001*
Type of milk fed at discharge (n=267, count=343)[1]						
Breastmilk (any)	24 (86)[a, b]	40 (74)[b]	47 (75)[b]	113 (92)[a]	224 (84)	0.004*
Infant formula	10 (36)	22 (41)	25 (40)	32 (26)	89 (33)	0.118
Donor breastmilk	0 (0)	8 (15)	12 (19)	10 (8)	30 (11)	0.009*

Data are n (%). *Significant using the Fisher Freeman Halton exact test.
For each significant pair, superscript letters differ. The significance level is <0.05 (Bonferroni corrected).
[1.] Missing data from one participant.

3.1.3.1 Maternal/caregiver characteristics and feeding practices at discharge

Maternal/caregiver income, education and age were significantly associated with feeding outcomes at discharge. Infants of mothers/caregivers who were 16-24 years old more frequently required oral supplementation (bottle/cup/syringe) at discharge than those 35-44 years old (73% vs 41%, P<0.05). Infants of mothers/caregivers with a total annual household income of less than $100,000 were more likely to require oral supplementation (bottle/cup/syringe) at discharge than those with a total annual household income of more than or equal to $100,000 (63% vs 44%, P<0.05,).

Compared to mothers/caregivers with a total annual household income of more than or equal to $100,000, those with a total annual household income less than $100,000 were less likely to EBF (68% vs 52%, P<0.05), more likely to receive no breastmilk (9% vs 23%, P<0.05), and more likely to receive any IF at hospital discharge (42% vs 26%, P<0.05) (**Figure 5)**. Infants of mothers/caregivers with secondary education or below were significantly more likely to receive no breastmilk than those with a university degree or above (32% vs 11%, P<0.05) **(Figure 6)**. Infants of mothers/caregivers who were 16-25 years old were more likely to receive DBM at discharge than those 35-44 years old (18% vs 3%, P<0.05). Feeding outcomes at discharge were not associated with maternal/caregiver or infant ethnicity.

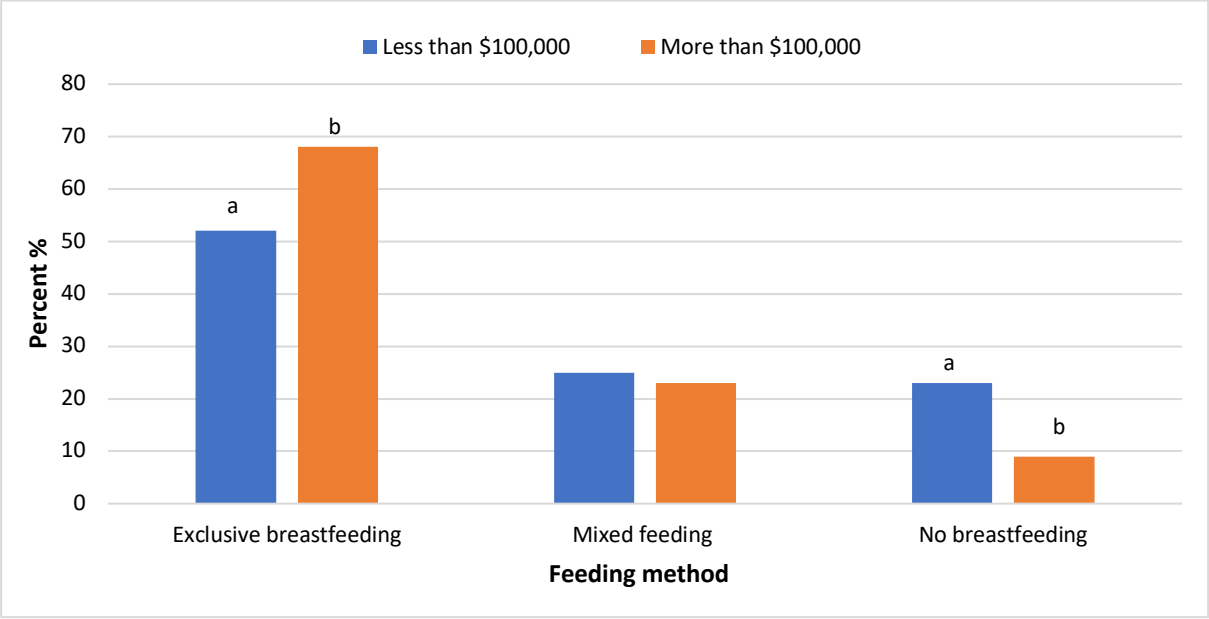

Figure 5. Feeding method at discharge between annual household income levels.
For each significant pair, superscript letters differ.
Significance level is <0.05 using the Fisher Freeman Halton exact test (Bonferroni corrected).
N=253

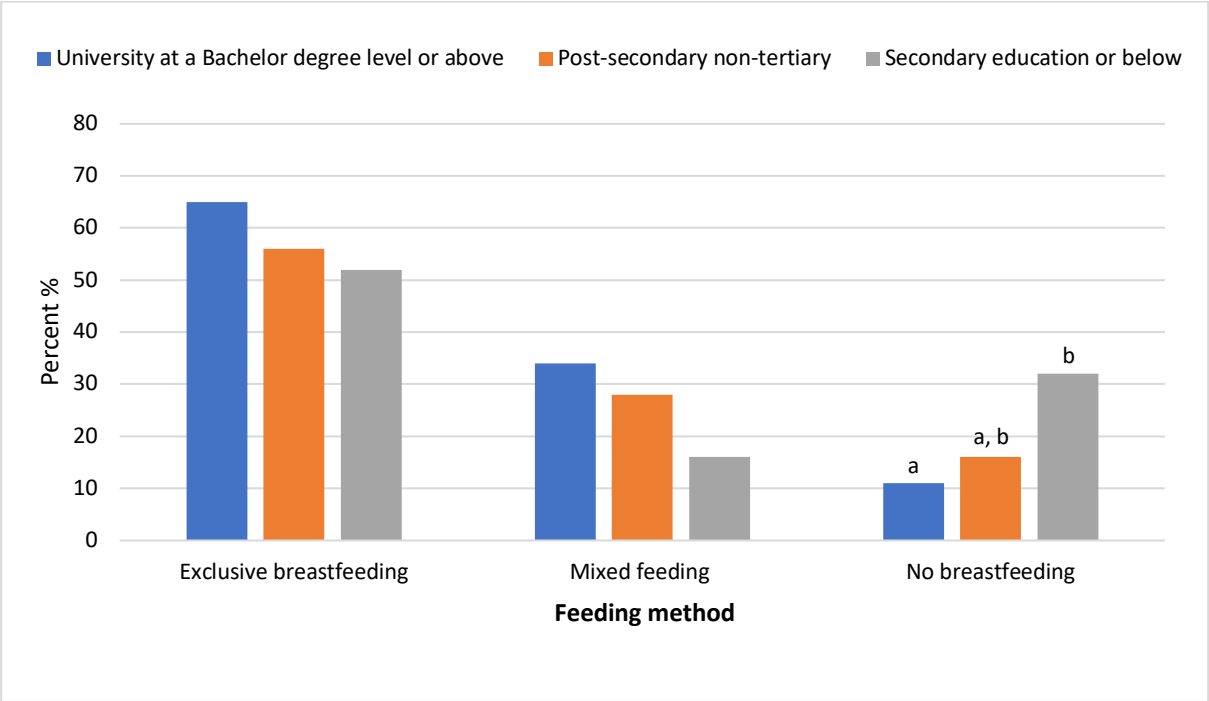

Figure 6. Feeding method at discharge between maternal/caregiver education levels.
For each significant pair, superscript letters differ.
Significance level is <0.05 using the Fisher Freeman Halton exact test (Bonferonni corrected).
N=263

3.1.4 Feeding practices post-discharge

Table 6 presents the breastfeeding practices after hospital discharge. At the time of survey completion, overall, 13% (n=36) of infants were currently EBF, and 28% (n=76) of infants were currently receiving some breastmilk. Furthermore, 55% (n=147) were no longer EBF, and 49% (n=132) of infants were no longer receiving any breastmilk. A total of 85 responses were not included in the outcome for EBF as their duration was contradictory to their chronological age or introduction to other fluids and CF.

Table 6. Breastfeeding outcomes post-discharge

Prematurity	**Extremely preterm**	**Very preterm**	**Moderate preterm**	**Late preterm**	**Total**	**P-value**
Exclusive breastfeeding duration (n=147)[1]						
No exclusive breastfeeding	4 (27)	14 (44)	8 (22)	14 (22)	40 (27)	
1-4 months	5 (33)[a, b]	6 (19)[b]	14 (38)[a, b]	33 (52)[a]	58 (40)	
≥5 months	6 (40)	12 (38)	15 (41)	16 (25)	49 (33)	0.045*
Any breastfeeding duration (n=132)[2]						
No breastmilk provided	1 (6)	5 (16)	2 (7)	3 (6)	11 (8)	
1-6 months	6 (38)	16 (50)	13 (43)	29 (54)	64 (48)	
7-12 months	6 (38)	10 (31)	12 (40)	15 (28)	43 (33)	
>12 months	3 (19)	1 (3)	3 (10)	7 (13)	14 (11)	0.573
Any breastfeeding duration (months), mean (±SD)	7.8 (±5.8)	5.1 (±3.5)	6.0 (±5.2)	6.7 (±4.9)	6.2 (±4.9)	0.183
Fluids other than breastmilk, infant formula, donor breastmilk introduced before complementary feeding (n=267)[3]						
Yes	3 (11)	13 (24)	23 (37)	31 (25)	70 (26)	
No	25 (89)	41 (76)	39 (63)	92 (75)	197 (74)	0.059

Data are n(%). *Significant using the Fisher Freeman Halton exact test.
For each significant pair, superscript letters differ. The significance level is <0.05 (Bonferroni corrected).
[1.] Among participants no longer EBF at time of survey completion.
[2.] Among participants no longer providing any breastmilk at time of survey completion.
[3.] Missing data from one participant.

Overall, among infants who were not currently EBF at the time of survey completion (n=147, 55%), 33% had EBF for more than or equal to 5 months chronological age, 40% had EBF for 1-4 months, and 27% were not EBF. LP infants were significantly more likely to EBF for 1-4 months compared to VP infants (52% vs 19%, P<0.05, respectively). There were no other associations between the duration of EBF and the level of prematurity.

Among infants who were not receiving any breastmilk at the time of survey completion (n=132, 49%), the mean duration of any breastfeeding was 6.2 months (±4.9), and the duration overall of any breastfeeding was most commonly 1-6 months (48%). Some infants received breastmilk for 7-12 months (33%), more than 12 months (11%), and few did not receive any breastmilk (8%). The total duration of any breastfeeding was not different between the levels of prematurity.

At the time of survey completion, some mothers/caregivers were currently EBF (n=36, 13%), and most infants aged six months or less of chronological age (98%). Among infants currently receiving some breastmilk at the time of survey completion (n=76, 28%), the rates of any breastfeeding were 44% among infants 0-6 months chronological age, 42% among infants 7-12 months chronological age, and 15% among infants >12 months chronological age.

The consumption of any fluids other than breastmilk, IF, or DBM before CF was introduced was reported in 26% of participants. Water was the most commonly reported fluid (21%). Other fluids reported included cow's milk, plant-based milk, sugar water, cordial and fizzy drinks. However, there was no difference between the levels of prematurity.

3.1.4.1 Maternal characteristics and post-discharge feeding practices

Infants of mothers/caregivers who had a total annual household income of less than $100,000 were significantly more likely to provide fluids other than breastmilk, IF, or DBM before the introduction of CF compared to those with a total annual household income of more than or equal to $100,000 (37% vs 16%, P<0.001). Infants of first-time mothers/caregivers were also significantly more likely to receive fluids other than breastmilk, IF, or DBM before CF compared to second (or more)-time mothers/caregivers (31% vs 17%, P<0.05).

No other post-discharge feeding outcomes were associated with maternal/caregiver characteristics, and no associations between maternal/caregiver or infant ethnicity and the post-discharge feeding outcomes were identified.

3.1.4.2 Breastfeeding education

Most mothers/caregivers reported to have received breastfeeding education (n=230, 86%), mostly in hospital (77%) and from a Lactation Consultant (LC) (74%). Other sources of breastfeeding support were from Lead Maternity Carers (LMC) (47%), antenatal class (23%),

other health professionals (17%), community groups (8%), and internet/social media (16%). Notably, mothers/caregivers with secondary education or below were significantly more likely to have received no breastfeeding education compared to mothers/caregivers with a university degree or above (27% vs 9%, respectively, P<0.05).

Maternal/caregiver satisfaction with EBF scored on average 3.5 (±1.4) out of 5, and satisfaction with total breastfeeding experience scored on average 2.9 (±1.5) out of 5. The average satisfaction score for breastfeeding education was 3.6 (±1.3) out of 5. The average satisfaction score for the cultural safety and appropriateness of breastfeeding education was significantly higher for non-Māori mothers/caregivers compared to Māori mothers/caregivers (MD 0.45, 95% CI 0.07-0.84, P<0.05). No associations were found between satisfaction scores and other maternal/caregiver factors such as age, education, income, and parity.

3.1.5 Complementary feeding

3.1.5.1 Timing of complementary feeding introduction

CF was introduced amongst 68% of infants of mothers/caregivers who completed the survey (n=181). Most infants (77%) were introduced to CF timely (between 5-8 months of life). Early (1-4 months) and late (≥9 months) introduction to CF occurred in 12% and 11% of respondents, respectively. The mean age infants were introduced to CF was 6.4 months (±2.0).

At the time of survey completion, very few infants 0-6 months chronological age (n=15) had introduced CF. Among these infants, CF was introduced between 1-4 months (47%) and 5-8 months (53%). The majority of infants aged 7-12 months chronological age (n=64) had CF introduced between 5-8 months (86%), and the majority of infants older than 12 months chronological age (n=98) had CF introduced between 5-8 months (75%).

The timing of CF introduction did not differ significantly between the levels of prematurity (**Table 7)**. However, EP had the highest proportion of infants introduced to CF late (≥9 months) (30%) compared to VP (8%), MP (8%), and LP (9%) infants. The timing of CF introduction differed significantly according to maternal/caregiver ethnicity. Māori mothers/caregivers were significantly more likely to introduce CF early (between 1-4 months) compared to non-Māori mothers/caregivers (26% vs 10%, respectively, P<0.05) (**Figure 7**). However, infant ethnicity was not associated with the timing of CF introduction.

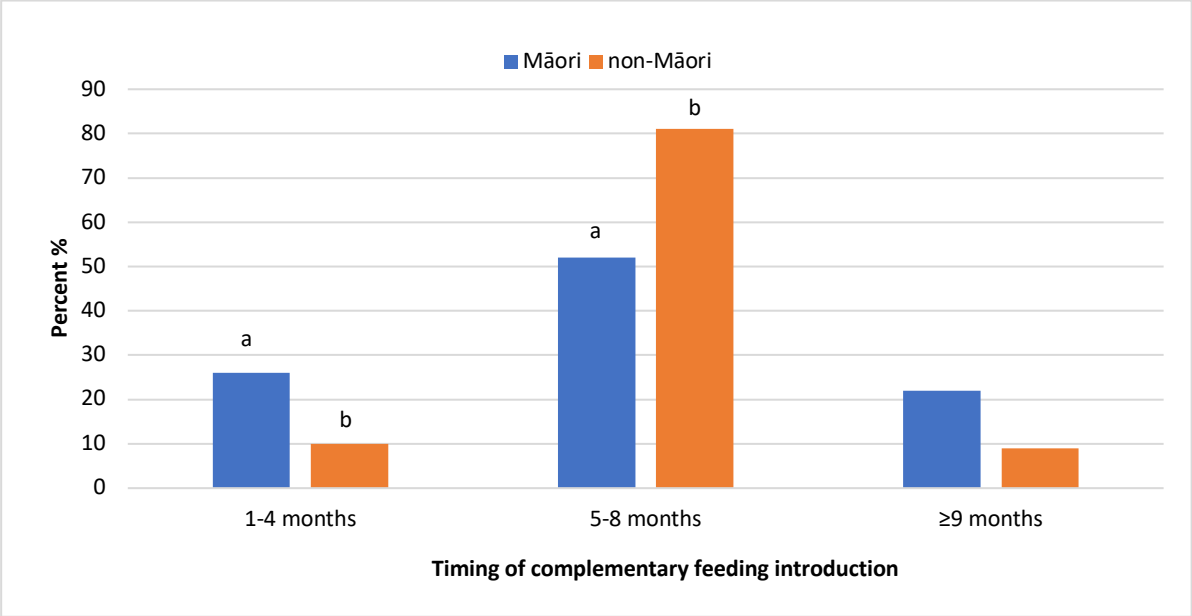

Figure 7. Timing of complementary feeding introduction for Māori and non-Māori mothers/caregivers
For each significant pair, superscript letters differ.
Significance level is <0.05 using the Fisher Freeman Halton exact test (Bonferroni corrected).
N=176

Table 7. Complementary feeding outcomes

Level of prematurity	Extremely preterm	Very preterm	Moderate preterm	Late preterm	Total	P-value
Timing of complementary feeding introduction (n=176)[1]						
1-4 months	2 (9)	2 (6)	8 (21)	8 (10)	20 (11)	
5-8 months	14 (61)	31 (86)	28 (72)	63 (81)	136 (77)	
≥9 months	7 (30)	3 (8)	3 (8)	7 (9)	20 (11)	0.062
Fussy eating (n=170)[1]						
Yes	13 (59)[a]	12 (33)[a, b]	21 (55)[a]	24 (32)[b]	70 (41)	
No	9 (41)[a]	24 (67)[a, b]	17 (45)[a]	50 (68)[b]	100 (59)	0.027*
Method for introducing CF (n=169)[1]						
Spoon Feeding	19 (83)	25 (74)	29 (74)	60 (82)	133 (79)	
Baby Led Weaning	4 (17)	9 (27)	10 (26)	13 (18)	36 (21)	0.632
Child Feeding Index scores (n=167)[1]						
0-6 months chronological age, mean (±SD)		3.9 (±2.3)	4.6 (±1.4)	4.0 (±1.2)	4.2 (±1.3)	0.696
7-12 months chronological age, mean (±SD)	5.4 (±1.9)	5.0 (±1.4)	4.6 (±1.1)	5.7 (±1.2)	5.4 (±1.3)	0.159
>12 months chronological age, mean (±SD)	5.4 (±1.6)	6.2 (±1.4)	5.9 (±1.5)	6.2 (±1.1)	6.0 (±1.4)	0.331

Data are n (%). *Significant using the Fisher Freeman Halton exact test.
For each significant pair, superscript letters differ. The significance level is <0.05 (Bonferroni corrected).
[1.] Among those who had initiated CF at time of survey completion.

3.1.5.2 Maternal/caregiver characteristics and the timing of complementary feeding introduction

Maternal/caregiver income and age were significantly associated with the timing of CF introduction. Mothers/caregivers aged 16-24 were significantly more likely to introduce CF early compared to mothers/caregivers aged 25-34 (38% vs 12%, $P<0.05$) and mothers/caregivers aged 35-44 (38% vs 4%, $P<0.05$). Mothers/caregivers with a total annual household income of less than $100,000 were also significantly more likely to introduce CF early than those with a total annual household income of more than or equal to $100,000 (20% vs 4%, $P<0.001$, respectively). The timing of CF introduction was not associated with other maternal/caregiver characteristics such as education and parity.

3.1.5.3 Fussy eating

Fussy eating behaviours at the time of CF introduction were reported in 41% of infants. The prevalence of fussy eating was significantly associated with the level of prematurity **(Table 7)**. EP infants were significantly more likely to display fussy eating behaviours at the time of CF introduction than LP infants (59% vs 32%, $P<0.05$). MP infants were also significantly more likely to display fussy eating behaviours than LP infants (55% vs 32%, $P<0.05$).

The timing of CF introduction was significantly associated with the prevalence of fussy eating behaviours. Infants who were introduced to CF late (≥9 months) were significantly more likely to display fussy eating behaviours compared to those who were introduced to CF timely (5-8 months) (74% vs 34%, $P<0.05$).

There were no associations between the prevalence of fussy eating and maternal/caregiver characteristics such as age, education, income, and parity. The prevalence of fussy eating did not differ between maternal/caregiver and infant ethnicity.

3.1.5.4 Method for introducing complementary feeding

The most common method for introducing CF was spoon-feeding by an adult (79%), while BLW was the preferred approach for 21% of respondents. The method of CF introduction was not associated with any maternal/caregiver or infant characteristics.

3.1.5.5 Child feeding index score

The child feeding index (CFI) score was measured separately for each infant's chronological age at survey completion. Among infants aged 0-6 months chronological age (n=15), the mean CFI score was 4.2 (±1.3) out of 8 and no associations were found between feeding practices and maternal/caregiver or infant characteristics.

Among infants aged 7-12 months chronological age (n=60), the mean CFI score was 5.4 (±1.3) out of 8. The timing of CF introduction was not associated with the CFI. However, the CFI score was significantly associated with fussy eating behaviours. Infants who did not display fussy eating behaviours scored significantly higher CFI scores than those infants who did display fussy eating behaviours (MD 0.8, 95% CI 0.01-1.5, P<0.05). Maternal education was significantly associated with the CFI. Infants of mothers/caregivers with a university degree or above scored significantly higher CFI scores than those with post-secondary non-tertiary education (MD 1.2, 95% CI 0.31-2.1, P<0.05, respectively).

Among infants aged >12 months chronological age (n=93), the mean CFI score was 6.0 (±1.4) out of 8. The timing of CF introduction and fussy eating were significantly associated with the CFI scores. The mean CFI score for infants who were introduced to CF timely (5-8 months) was significantly higher compared to infants who were introduced to CF early (MD 1.1, 95% CI 0.02-2.1, P<0.05) or late (MD 1.9, 95% CI 1.1-2.7, P<0.001). Additionally, those infants who did not display fussy eating behaviours scored significantly higher CFI scores than those who did display fussy eating behaviours (MD 1.1, 95% CI 0.6-1.7, P<0.001). Maternal/caregiver education and age were significantly associated with the CFI. Infants of mothers/caregivers with a university degree or above scored significantly higher CFI scores than those with a post-secondary, non-tertiary education (MD 1.0, 95% CI 0.11-1.9, P<0.05). Infants of mothers/caregivers aged 16-24 years scored significantly lower CFI scores than those aged 25-34 years (MD -1.8, 95% CI -3.2 - -0.42, P<0.05) and those aged 35-44 years (MD -1.55, 95% CI -3.0 - -0.55, P<0.05).

The CFI did not differ significantly between the levels of prematurity (**Table 7)** and maternal/caregiver or infant ethnicities for all chronological age groups.

3.1.5.6 Food frequency

Variation was reported in the frequency of the intake of different food groups. Among infants 0-6 months chronological age **(Figure 8)**, vegetables (39%), fruit (33%), and grain foods (33%) were most commonly consumed every day. Some infants never consumed dairy products (50%), legumes/nuts (61%), and animal products (50%), and some participants adhered to the guidelines to never add salt (59%) or sugar (63%) to their infants' food.

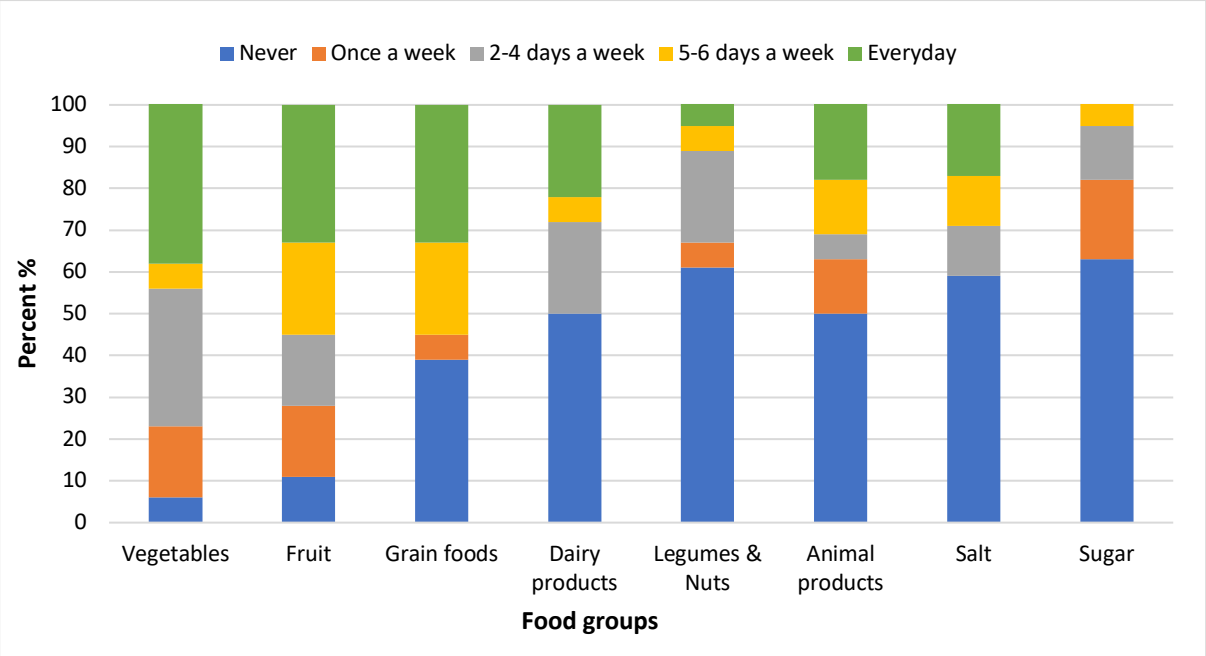

Figure 8. Frequency of consumption of the food groups for infants 0-6 months chronological age

Among infants 7-12 months chronological age **(Figure 9)**, vegetables (62%) and fruit (48%) were most commonly consumed every day. Grain foods were most commonly consumed every day (25%) or 2-4 days a week (25%). Animal products (30%) were most commonly consumed 2-4 days a week. Legumes/nuts were most commonly never consumed (29%). Most participants adhered to the guidelines to never add salt (79%) or sugar (77%) to their infants' food.

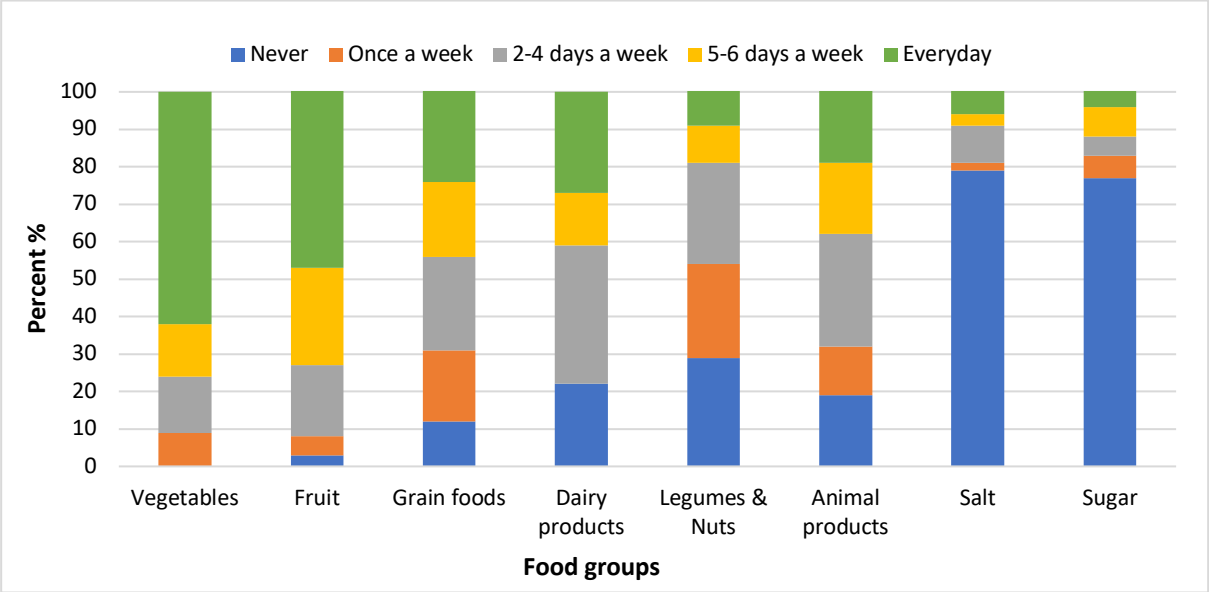

Figure 9. Frequency of consumption of the food groups for infants 7-12 months chronological age

Among infants >12 months chronological age **(Figure 10)**, vegetables (59%), fruit (63%), dairy products (55%), grain foods (59%), and animal products (35%) were most consumed every day. Legumes/nuts were most commonly consumed 2-4 days a week (39%). Most participants adhered to the guidelines to never add salt (61%) or sugar (73%) to their infants' food.

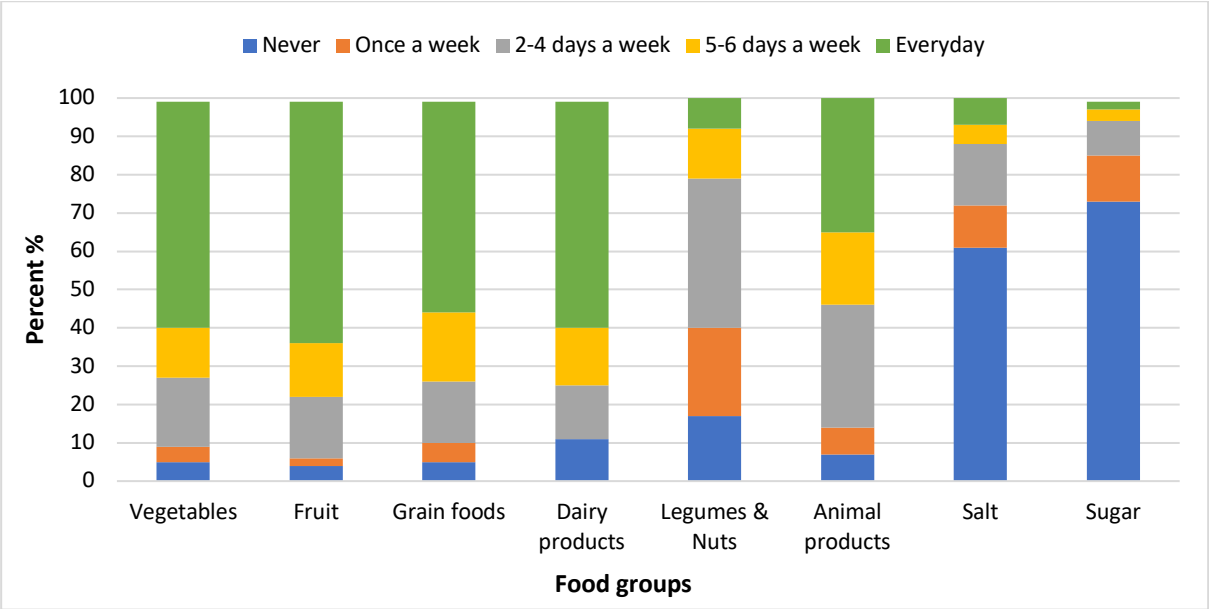

Figure 10. Frequency of consumption of the food groups for infants >12 months chronological age

3.1.5.7 First foods

The survey also asked respondents to list their infants' first foods. The foods introduced within the first two weeks of CF were mainly described as vegetables (73%) and fruit (61%). The most common vegetables were pumpkin, kumara, carrot and avocado, and the most common fruits were apple, banana, and pear. Grain foods such as baby rice cereal, bread, and oats/porridge were also commonly introduced as first foods (27%). Some infants had animal products such as red meat, chicken, and eggs within the first week of CF introduction. Very few infants had dairy/milk products such as yoghurt and cheese (4%), legumes/nuts such as chickpeas and butter beans (4%) and other foods such as unspecified packaged food, chocolate and bone broth (3%) as their first foods.

3.1.5.8 Complementary feeding education

Among mothers/caregivers who have initiated CF, 69% reported receiving some education about CF introduction. The most common types of education received were from other health professionals (36%), the internet or social media (35%), and a dietitian (31%). Other types of education included Plunket (21%), community groups (20%), LMCs (15%) and antenatal classes (11%). The mean satisfaction score with CF education was 3.7 (±1.3) out of 5, and for cultural appropriateness of CF education, the mean satisfaction score was 3.9 (±1.2) out of 5. Mothers of EP infants had the highest mean satisfaction score for CF education, which was significantly greater than the mean satisfaction score for mothers/caregivers of LP infants (MD 0.93, 95% CI 0.08-1.8, $P<0.05$). Mothers of EP infants also had the highest mean satisfaction score for cultural appropriateness of CF education, statistically higher than the mean satisfaction score for mothers/caregivers of LP infants (MD 0.78, 95% CI 0.02-1.5, $P<0.05$). The satisfaction score for CF education and its cultural appropriateness did not differ between maternal/caregiver and infant ethnicity and other maternal/caregiver characteristics.

3.2 Qualitative survey results

The survey had six open-text questions regarding the respondents' experiences and opinions of breastfeeding and introducing CF. The respondents were asked what the perceived enablers and challenges were to breastfeed and to introduce CF, how they felt concerning the type of education they received, and what could be improved. The identified themes and codes relating to breastfeeding are presented in **Figure 11,** and the identified themes and codes relating to CF are presented in **Figure 12.**

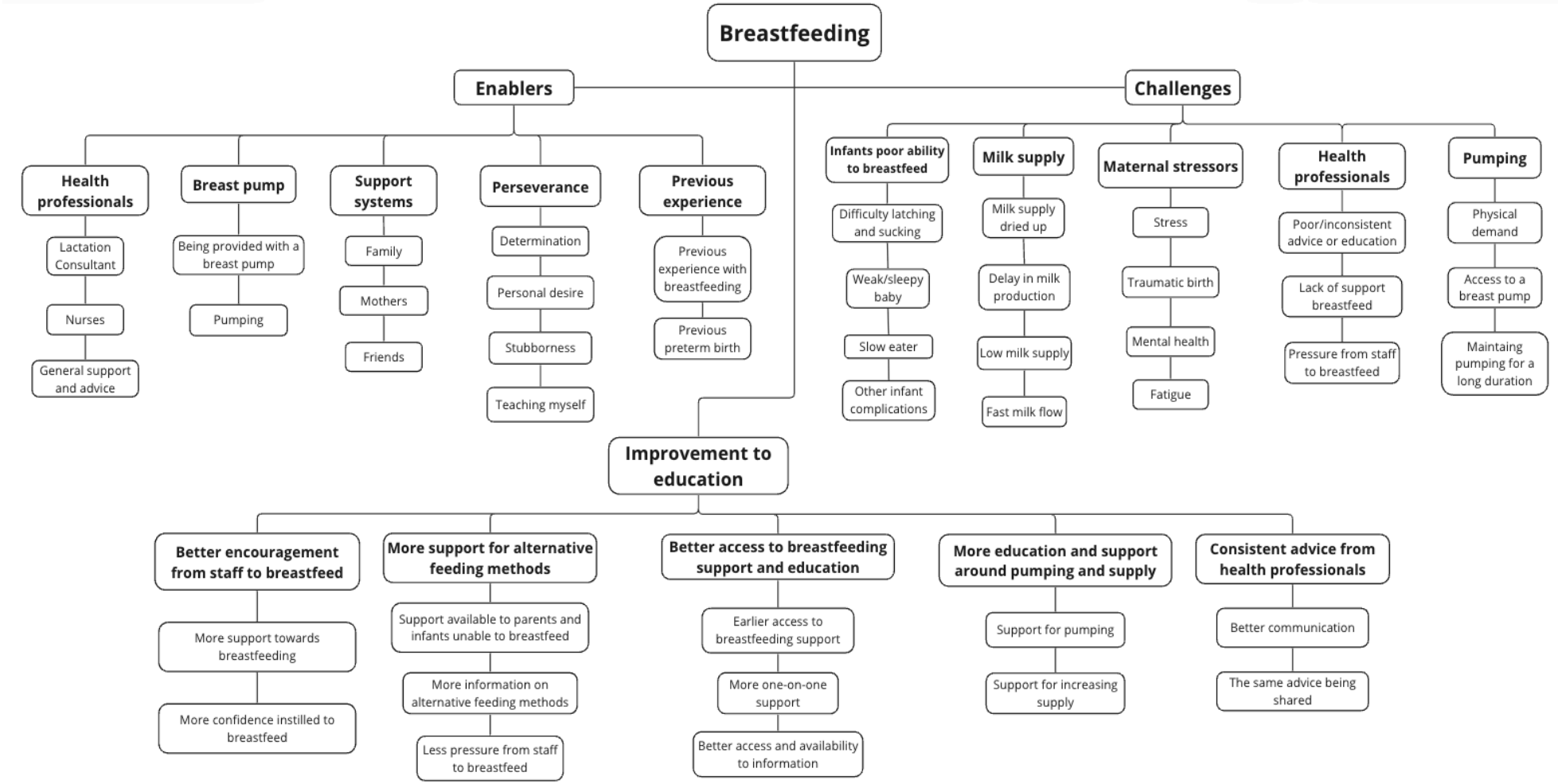

Figure 11. Coding tree of mothers/caregivers enablers, challenges, and opinions on education regarding their breastfeeding experience

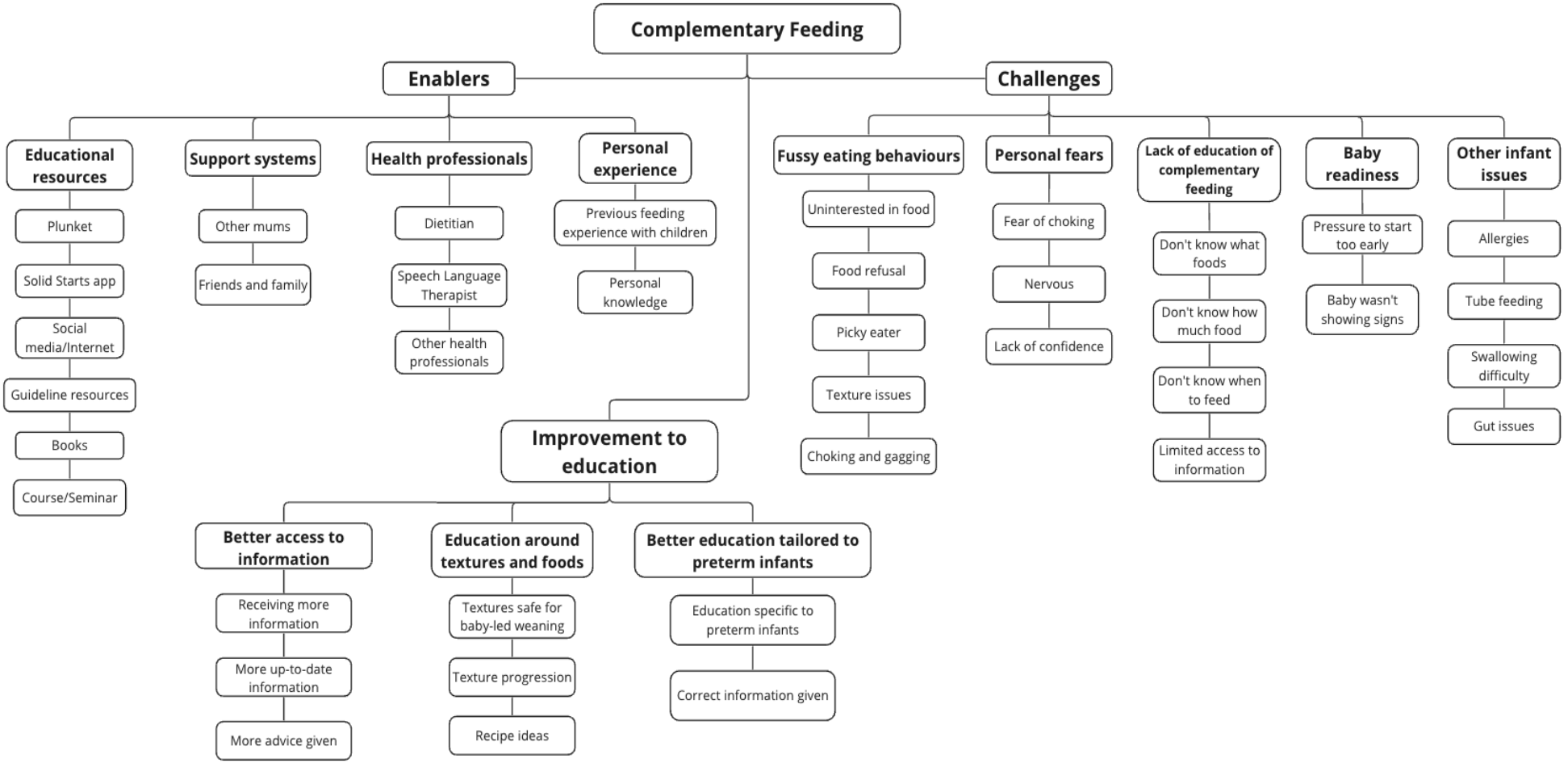

Figure 12. Coding tree of mothers/caregivers enablers, challenges, and opinion on education regarding their complementary feeding experience

3.2.1 Enablers of breastfeeding

A total of 207 (77%) participants responded to the question, *"What helped you the most with your breastfeeding/whāngai ū experience with your preterm baby/pēpi?"*. Five main themes were identified: 1. Health professionals; 2. Breast pump; 3. Previous experience 4. Support Systems; 5. Self-motivation and perseverance. Example quotes are displayed in **Table 8.**

Health professionals

Most respondents reported that health professionals helped them with their breastfeeding experiences. LCs and nurses were the most commonly mentioned health professionals. Mothers reported LC's and nurses as "*amazing*" and "*helpful*" and provided "*support*", "*encouragement*" and "*education*". Other health professionals mentioned include LMCs and doctors, and some mothers/caregivers mentioned general or specific advice or education that resonated with them, such as "*Being given a clear feeding plan about what to do, when to feed my baby, when to stop, etc.*".

Breast pump

Mothers reported that being provided/loaned a breast pump in the hospital and taking it home helped with their breastfeeding experience. *"Pumping"* was also reported by mothers/caregivers as an enabler of their breastfeeding experience by *"increasing milk supply"*.

Previous experience

Mothers' previous experience with breastfeeding prior children or having a previous preterm birth was reported to provide knowledge, education and real expectations around breastfeeding.

Support systems

Family, other mothers/caregivers, and friends were mentioned as providing support, which helped with their breastfeeding experience.

Perseverance

Perseverance was identified as the fifth theme, portraying mothers/caregivers' desire and determination to breastfeed despite their challenges. Some mothers/caregivers highlighted that they were *"stubborn"* and *"determined"*.

Table 8. Themes and codes relating to "*What helped you the most with your breastfeeding/whāngai ū experience with your preterm baby/pēpi*?".

Theme	Codes	Example Quotes
Health professionals	Lactation Consultants	"We had the most amazing lactation consultants in Wellington NICU. They gave me confidence and motivation to persevere and pump for months to get to our breastfeeding goal". "The hospital lactation consultant helping with the positions I hold my baby in so she could latch."
	Nurses	"Being supported by the nurses and positively encouraged to try whenever baby seemed ready." "The nurses were the only reason my baby breastfed- they were awesome." "Kindness and support of SCBU nurses."
	General support and advice	"Being given a clear feeding plan about what to do, when to feed my baby, when to stop, etc." "Always had someone with me in hospital to help me as I breastfed."
Breast pump	Being provided with a breast pump	"Being loaned a breast pump at NICU that I could take home was huge!" "Also, having pumping machines to take home was an incredible help for us and made a huge difference."
	Pumping	"Pumping to increase supply."
Support systems	Family	"Supportive whanau and husband."
	Friends	"Support from family and friends."
	Mothers	"Support of other mums." "My mother."
Previous experience	Previous experience with breastfeeding	"Knowing that I had previously breastfed gave me a degree of familiarity and confidence in feeding despite the complexity of a preterm baby." "Past experiences as my other babies were breastfed, so it was important for me and something to focus on (and I was stubborn about it!)." "Prior breastfeeding of older child."
	Previous preterm birth	"Previous experience of breastfeeding a preterm baby." "Having the knowledge and experience from my first pēpi, who was also preterm, helped with my current and second breastfeeding journey."
Perseverance	Determination	"Determination to keep going, knowing that it was best for my baby. Got sick of expressing (too time-consuming and exhausting), so really persevered with breastfeeding." "Persevering even when it was hard."

	Personal desire	"A strong motivation to breastfeed my baby." "My own desire for connecting with her."
	Stubbornness	"Stubbornness to do it."
	Teaching myself	"Learning every day what my child wants and not forcing it to be the way I was told to do." "Self-education."

3.2.2 Breastfeeding challenges

A total of 216 mothers/caregivers (80%) responded to the question, "*What were/are your main challenges or barriers to breastfeeding/whāngai ū your preterm baby/pēpi?"*. Five main themes were identified: 1. Infants poor ability to breastfeed; 2. Milk supply; 3. Maternal stressors; 4. Health professionals; 5. Breast problems. Example quotes are displayed in **Table 9.**

Infants' poor ability to feed

There were many breastfeeding challenges identified that were related to infants' prematurity. Often, mothers/caregivers described that their infant had difficulty latching and had low stamina, leading to a weak/sleepy baby during breastfeeding. Other reasons included infants' medical complications that made it difficult to breastfeed, including apnoea, aspiration, reflux, chronic lung disease, and tongue tie.

Milk supply

Many mothers/caregivers felt that their milk supply affected their ability to breastfeed. Often, this was due to a perceived low milk supply, but in some instances, mothers/caregivers reported that their flow was too fast for their infant to tolerate. Mothers' low milk supply was often due to milk not coming in initially or their supply *"dried up"* due to stress or the infant's inability to feed.

Maternal stressors

The birth of a preterm infant caused a lot of stress and anxiety for many mothers/caregivers, which impacted their ability to breastfeed and produce sufficient milk supply. Mothers expressed feelings of anxiety, depression, stress, and fatigue during their breastfeeding experience.

Health professionals

The access, support, and education received from health professionals was highlighted as a barrier to breastfeeding. Mothers often found that there was not sufficient advice or education given on how to breastfeed, and sometimes mixed messages were received from different health professionals. Some mothers/caregivers felt that there was a lack of support and help from the hospital staff. Some felt pressured by staff to breastfeed, highlighting that they did not feel supported in their decisions and experiences.

Pumping

The time and energy required for pumping to maintain a milk supply was a significant challenge for some mothers/caregivers. Mothers expressed that this was *"exhausting"* and *"tiring"*. Some mothers/caregivers found that pumping equipment was hard to access, limiting their ability to supply breastmilk.

Table 9. Themes and codes relating to "*What were/are your main challenges or barriers to breastfeeding/whāngai ū your preterm baby/pēpi?*"

Theme	Codes	Example Quotes
Infants' poor ability to breastfeed	Difficulty latching and sucking	"Latching, choking, coordinating breathing and sucking, constant apnoeas." "Trying to latch an unwell baby was challenging." "Baby also had a very shallow latch due to being so premature." "His latch wasn't strong enough."
	Weak/sleepy baby	"She didn't have the energy to breastfeed or wouldn't wake up at all." "Her being too tired to feed properly." "Baby was too weak to suckle." "Too sleepy to BF initially."
	Slow eater	"He also continues to be an extremely slow eater (approximately 40 minutes or more for a full feed)." "My baby is reluctant to eat."
	Other infant complications	"Due to his chronic lung disease, he gets tired from breastfeeding." "Baby didn't have much stamina to breastfeed and struggled to maintain stable blood sugars despite milk fortifiers and IV fluids." "Undiagnosed tongue tie (was finally released at 4 months)."

Theme	Codes	Example Quotes
Milk supply	Milk supply dried up	"His poor feeding skills led to my supply dwindling and him ending up tube-fed." "Losing supply after a couple of weeks." "Traumatic birth and high-stress levels decreased supply."
	Delay in milk production	"I did not produce milk straight away and had to pump." "My milk supply not coming in. I am still trying, but as I had a cesarean and my baby was in the NICU, it has made it harder." "Delay in milk coming in due to shock of early arrival."
	Low milk supply	"Lack of milk production and stress." "With my daughter - having low supply, it was a challenge to keep up supply before she was able to breastfeed." "Not producing enough milk due to stress."
	Fast milk flow	"I ended up with functional lactose overload, and my baby really struggled to manage the very fast flow and huge supply, which led to lots of difficulty when we got home." "Flow/supply was too much for my baby, and they constantly gagged/choked from the influx of too much milk or came off crying whilst breastfeeding as I had a very good supply from pumping."
Maternal stressors	Stress	"Trying to build a milk supply while being so stressed about my baby in NICU." "Also, the stress of leaving him in the hospital worried me so much I was stressed I would have a low milk supply from not being near him all of the time."
	Traumatic birth	"Recovering from a difficult birth." "It created a really difficult emotional experience for me as a mother in a time that was very difficult otherwise in so many ways (traumatic birth and sick baby)."
	Mental health	"Anxiety/PTSD as I had a bad breastfeeding journey with my first child." "Extreme mental health challenges with lack of available treatments after my child was born led to ill feelings towards my baby and ultimately a psychiatric ward admission when he was 4 months old. I didn't want to breastfeed a baby I resented so much. Had I had support for my mental health before this became so severe, I would have continued breastfeeding." "For my mental health, I wasn't able to breastfeed as I needed sleep. And put too much pressure on myself."

Theme	Codes	Example Quotes
	Fatigue	"Not enough rest." "Finding time to express when my baby was in hospital having 22-month-old."
Health professionals	Poor/inconsistent advice or education	"While support was given in the NICU, this was mainly looking at the baby's effort at feeding attempts and did not address the bigger picture of ensuring proper latch and providing support around pumping times and volumes. This was an incredibly difficult time, and I was frequently in tears attempting to feed my baby. I had not received any education or guidance around this while we were in hospital." "And as amazing as the staff were, they all had a different technique, which confused me so much and made it hard to get consistent latching going." "Mixed messages from staff, minimal education or advice on how to BF a very small early baby."
	Lack of support to breastfeed	"Absolutely zero support and refusal to listen to an experienced mother of 4 children, which led to the above." "Every child is different, and I wish there were more positive reinforcement than negative. It felt like I would go 10 steps forward and then 10 back because I would feed her myself, then they would "get busy" and go back to tube feeding her. So in the end, I stayed there more to feed her myself to make sure she was capable." "The lack of hours the one Lactation consultant at our hospital worked." "The breastfeeding support through the DHB outside the hospital was judgemental, unhelpful and ultimately ended my breastfeeding journey. I saw a lactation consultant with no understanding of premature babies, who told me that my baby, at 0 weeks corrected, who was struggling to latch and coordinate their milk transfer, was "very unusual" and "there's nothing I can do to help you" which I found upsetting (triggered significant anxiety during a vulnerable time) and entirely inappropriate. Shortly after this, I stopped breastfeeding due to the anxiety it was causing me and the sense that it wouldn't improve as my baby apparently wasn't capable of it."
	Pressure from staff to breastfeed	"Extreme pressure, which led to a lot of feelings of failure as a mother." "Pressure from nurses in NICU." "When you physically can't breastfeed, but breastfeeding is forced down your throat because that's the only best thing for your baby."
Pumping	Physical demand	"Pumping every 3hrs like a dairy cow was hard." "Expressing was exhausting." "Pumping constantly was hard and tiring."

Theme	Codes	Example Quotes
	Access to a breast pump	"Having to hire a pump so I could pump in my room at Ronald McDonald House, not feeling comfortable to pump in the NICU." "Pumping equipment in NZ is limited."
	Maintaining pumping for a long duration	"I pumped for 5 months until my baby was strong enough to breastfeed. This was such a challenging time but worth it." "Having to pump for so long, have had mastitis 5 times."

3.2.3 Improvement in breastfeeding education

A total of 74 (28%) participants responded to the question, *"What could be improved about the breastfeeding/whāngai ū support or education you received?"*. Five main themes were identified: 1. Better access to breastfeeding support and education; 2. More support for alternative feeding modes; 3. Better encouragement from staff to breastfeed; 4. More education and support for alternative feeding modes; 5. Consistent advice from staff to breastfeed. Example quotes are displayed in **Table 10.**

Better access to breastfeeding support and education

Mothers reported that they would have liked better and earlier access to breastfeeding support and education. Some mothers/caregivers found that their breastfeeding experience would have been more positive if they had been seen *"earlier"*. One infant was in the hospital for three months and was only shown to breastfeed in the final week of their stay, which resulted in bottle feeding. Some mothers/caregivers would have liked more *"one-on-one"* support to understand *"where their breastfeeding journey is at"*. Better access to information and where to obtain appropriate and updated information were also identified as potential improvements to current support.

More support for alternative feeding modes

Some mothers/caregivers did not feel supported using alternative feeding modes such as bottle and formula feeding. They would have liked more support, especially for mothers/caregivers or infants unable to breastfeed. Mothers felt *"ignored"* and *"pressured to breastfeed"*. More information about alternative modes of feeding would have been *"helpful for alleviating concerns about keeping baby nourished"*.

Better encouragement from staff to breastfeed

Some mothers/caregivers did not feel they had enough positive encouragement to breastfeed from the staff while in the hospital. One mother/caregiver described the support as *"judgemental, unhelpful, and ultimately ended my breastfeeding journey".* Mothers would like more confidence instilled in them to try breastfeeding before being told it is not possible.

More education and support for pumping and supply

Some mothers/caregivers would have liked more education and support around pumping and maintaining supply. Mothers would have liked more guidance around pumping and provided education on *"ways to increase supply and things that may cause it to decrease."*

Consistent advice from health professionals

Some mothers/caregivers expressed that the advice from health professionals was inconsistent and *"made things confusing".* One mother/caregiver felt *"very alone as everyone had different approaches, and I felt no communication was made to how I wanted to feed my baby".* This would be improved if better communication with consistent advice was given from health professionals.

Table 10. Themes and codes relating to "*What could be improved about the breastfeeding/whāngai ū support or education you received?*"

Theme	Codes	Example quotes
Better access to breastfeeding support and education	Earlier access to breastfeeding support.	"LC should be made available as soon as baby is born and moved to SCBU or NICU. The mums are vulnerable and likely to need more support." "I received support the support to discover the problems we were having too late to make a difference." "Offering a lactation consultant would have been very beneficial, as when I finally visited one, it was pretty much too late to get my baby to exclusively bf."
	More one-on-one support	"More one one-on-one time with lactation consultant or classes on what to expect as baby develops." "Someone allocated specifically to each mother to check in with the mother and knows exactly where the breastfeeding journey is at."
	Better access and availability to information	"Access to education and updated information that is shared with all the possible educators." "I had to actively ask for support when my daughter was in the hospital. I also suffered postnatal depression, which made asking for help very difficult.

Theme	Codes	Example quotes
		Breastfeeding support should be advertised and made accessible to mothers before discharge after giving birth."
More support for alternative feeding modes	More support available to parents and infants unable to breastfeed	"I was ignored by lactation consultants as my baby was on long-term TPN. I asked for help once he was allowed to latch, but they always said they had no time - so help for mums who are pumping to make a supply when their babies cannot have any milk for a while." "Why is it always about breastfeeding? What about the people that can't breastfeed? I have Raynaud's in my nipples, which means I can't do it and what about the ones with medical reasons like cancer you never hear about formula feeding."
	More information on alternative feeding modes	"The breastfeeding support provided in the hospital (Auckland NICU) was good but, in my opinion, didn't provide enough information about alternatives such as bottle feeding - this would be helpful for alleviating concern about keeping baby nourished after discharge when breastfeeding is a challenge and the sense that we'd be in NICU forever if our baby didn't figure it out." "More information about formula when you can't breastfeed fed is best, but breastfeeding is all that's talked about."
	Less pressure from staff to breastfeed	"More respect around choices of not breastfeeding. I breastfeed and am lucky it comes well, but experience in NICU, I observed pressures and pushing breast is best when parents were openly not comfortable doing this." "I feel if my concerns had been listened to regarding introducing a bottle with EBM, then this journey would've been made significantly easier for me (especially mentally) and that my breastfeeding journey would not have left me with a negative taste in my mouth." "The pressure to breastfeed when supply was low and baby was in NICU caused a lot of stress."
Better encouragement from staff to breastfeed	More support towards breastfeeding	"To me, I feel the way the lactation consultant and nurse pushed me to pump rather than trying to help me try whāngai could change, and I didn't feel supported at all to attempt baby on the breast." “More information and help with breastfeeding, because my baby was prem, I expressed as she was tube fed at first, but I felt like I wasn't encouraged or helped to continue to breastfeed straight from the breast.”
	More confidence instilled to breastfeed	"I would also like more confidence put in mothers' natural ability to provide enough milk for their baby." “I was told that a “24 weeker” won’t / doesn’t normally breastfeed, so basically felt I shouldn’t try.” “It is possible to still exclusively breastfeed once in the comfort of your own home. I was made to feel this was not possible.”

Theme	Codes	Example quotes
More education and support for pumping and supply	Support for pumping	"More information around maintaining supply." “Heads up to control pumping at early stages.”
	Support for increasing supply	"Support with exclusive pumping. I felt the LCs had more knowledge around direct breastfeeding than pumping." "More information on ways to increase supply and things that may cause it to decrease." “It genuinely saddens me how many people chose to stop breastfeeding because they believe their supply has dropped or is not enough when, in fact, that is not the case. I believe better education on how our breasts work is needed and to help understand that our supply dropping is actually our body regulating and not our milk drying up.”
Consistent advice from health professionals	Better communication	“I felt very alone as everyone had different approaches, and I felt no communication was made to how I wanted to feed my baby.” “Too many people involved and trying to give advice and help. Sometimes less is more and just able to listen, instead of giving way too much information.”
	The same advice being shared	"The same advice being shared by all nurses." “There was also a lot of conflicting information given.” “Being on NICU for 7 weeks, I felt that I was getting different opinions and input from nurses and lactation consultant. It confused and upset me”.

3.2.4 Enablers of complementary feeding

Among those who had introduced CF (n=181), 77% (n=139) of them responded to the question, *"What helped/facilitated you the most with introducing solid food to your baby/pēpi?"*. Four main themes were identified*:* 1. Educational resources; 2. Previous experience; 3. Support systems; 4. Health professionals. Example quotes are displayed in **Table 11.**

Educational resources

Many respondents found that educational resources and digital platforms helped them with their journey of introducing CF. Education and resources from Plunket were commonly reported. The Solid Starts website, phone application, and database were also mentioned frequently as providing helpful advice. One respondent described it as *"absolutely amazing"*. Other helpful resources were sourced from the internet, Watties, Starship and health professionals.

Personal experience

The mothers' previous experience of introducing CF to their children was helpful. Respondents described prior experience as providing *"knowledge"* and *"familiarity"*. Mothers/caregivers also found their personal knowledge to be helpful.

Support systems

Some mothers/caregivers found that their friends and family provided guidance and support that helped with their CF experience. Some mothers/caregivers also found discussions with other mothers/caregivers through antenatal groups and friends helpful.

Health professional

Dietitians and speech-language therapists (SLTs) were the most mentioned health professionals who provided *"support"* and *"guidance"* for introducing CF. Other health professionals enabled CF introduction for mothers/caregivers included doctors, nurses, and nutritionists.

Table 11. Themes and codes relating to "*What helped/facilitated you the most with introducing solid foods to your baby/pēpi?*"

Theme	Code	Example quotes
Personal experience	Previous feeding experience with children	"It's my second child, so I knew what to do from first." "I utilised the knowledge and learning I had while feeding my 1st child. It came in handy with my preterm baby." “Having had two previous children, I was familiar with introducing solids”.
	Personal knowledge	“My own research”. “I researched a lot myself”. “Self-education”.
Educational resources	Plunket	"Plunket website with some simple info." "The Plunket sheet that says what babies should be eating at different ages."
	Solid Starts App	"Solid Starts app, showing how to safely prepare food to avoid choking hazards." "Use of app Solid Starts demonstrated how to feed solids at various ages."
	Social media/internet	"Internet mostly, which is sad." "I followed Instagram accounts that gave advice/recipes, etc." "Social media - there's some excellent sources (including paediatric dieticians and SLTs) of information around ideal first foods, safety and transitioning to a sustainable diet that fits in with the family."
	Guideline resources	"Starship guidelines to feeding preterm babies."

Theme	Code	Example quotes
		"The guide from the NICU consultant which indicated to start before 6 months for prems if they seem ready."
	Course/seminar	"Moving and Munching workshop was helpful also." "I joined a seminar about preterm babies and introducing solids run by the Little Miracles Trust."
	Books	"Dr Julie Bhosale, Nourished Baby book." "Julie Bhosale book and Nadia Lim cookbook for family Called "Yum"."
Support systems	Other mums	"Support from other mums from antenatal group." "Discussions with other mums."
	Friends and family	"Other friends and how they'd introduced food." "Friends and family answering questions."
Health professionals	Dietitian	"We were under a dietician for low birth weight and gains, so she gave us lists of things to try and amounts to introduce." "Support/handout from local DHB dietician was very helpful and available to be contacted by phone for any questions." "Starship community dietitian was the biggest help."
	Speech Language Therapist	"Having the speech therapist come to assess my baby and help guide us on when to start and what to start with was very helpful because we were worried about his swallowing and nervous to start." "Support directly from the hospital SLT."
	Other health professionals	"Information from nutritionists about maximising nutritional value of baby's diet." "Baby is under a hospital community nurse due to being born prematurely, so each appointment, we were told about what to expect in terms of cues and milestones leading up to starting solids. I was able to recognise baby's behaviour and slowly introduced puréed food".

3.2.5 Challenges of complementary feeding

For those that had introduced CF (n=181), 78% (n=141) of them responded to the question, "*What were/are your main challenges to introducing solid foods to your baby/pēpi?* Five main themes were identified: 1. Fussy eating behaviours; 2. Personal fears; 3. Lack of education of CF; 4. Baby wasn't ready; 5. Other infant issues. Example quotes are displayed in **Table 12.**

Fussy eating behaviours

Infants' fussy eating behaviours were commonly reported as challenges to introducing CF. Fussy eating behaviours were commonly described as texture issues, picky eating, disinterest and refusal of food, and some presenting with choking and gagging to food.

Personal fears

Mothers described their own fears as interfering with introducing CF. Some mothers/caregivers described having *"fear", "anxiety", being "afraid",* and *"worrying"* around choking and gagging. There were also fears and anxiety around whether their baby was eating enough, allergies and oral development. Some mothers/caregivers reported they did not have enough confidence to introduce foods.

Lack of education around complementary feeding

Another challenge mothers/caregivers faced was their own lack of education regarding the matter. Mothers described they did not know *"what to feed her first", "how to give variety", "when he was ready for solids", "quantity she should be getting", "what food are the most important", and "how to prepare".*

Baby readiness

Mothers found the pressure of feeding their baby when they were not ready was challenging. Some mothers/caregivers said the guidelines seemed too early for their baby's development. They described their babies as *"slow to sit", "unable to sit independently", "too young", "unable to feed himself", "initial disinterest", and "not ready".*

Clinical issues

Mothers reported other infant issues that impacted their CF experience. Some of these included allergies, gut issues, and swallowing difficulties. Few mothers/caregivers of babies who had been on tube feeds found it challenging to introduce CF.

Table 12. Themes and codes relating to "*What were/are your main challenges to introducing solid foods to your baby/pēpi?*".

Theme	Code	Example quotes
Fussy eating behaviours	Uninterested in food	"Initial disinterest when first introduced around 6 months actual age (tried for several weeks, unsuccessful, stopped and tried again at 6 months corrected age at which point she took to it really well)." "He's just not interested. Doesn't know what to do with the food."
	Food refusal	"The food is cooked, but the baby won't eat it." "Refusal to eat and still eat."

Theme	Code	Example quotes
	Picky eater	"We only gave her vegetables for the first two months and then introduced fruit. Now she only wants sweet flavours." "He hates trying new things."
	Texture issues	"My baby does have some texture issues and food allergies, but I put that down to his being tube-fed for so long." "And she doesn't eat anything more than a lumpy puree."
	Choking and gagging	"Sensitive gag reflex due to prematurity." "Gags on purées spits it out, doesn't quite open mouth for foods."
Personal fears	Fear of choking	"Fear of choking delays start to BLW." "Worry about choking and how baby's gut would cope with solid given their history or being preterm."
	Nervous	"My own anxiety around the matter." "Inexperienced, nervous, unprepared."
	Lack of confidence	"Having confidence to let her try things." "Confidence around what foods to provide and how to develop oral skills - introducing food is anxiety-inducing as a parent."
Lack of education around complementary feeding	Don't know what foods	"Knowing what foods he could have." "Introducing was ok. Just thinking of different foods to let her try was difficult, and then ways to cut foods."
	Don't know how much food	"Knowing the quantity of everything she should be getting." "Amounts I found difficult."
	Don't know when to feed	"Working out if he was ready." "Knowing when he was ready for solids."
	Limited access to information	"Finding baby-led information." "Knowing where to turn for support."
Baby readiness	Pressure to start too early	"Being told I needed to start solids as there is a magic window of prem babies 3-4 months old was not helpful, and luckily, this wasn't my first baby, so I was happy to use my instincts instead." "Hospital team pushing at 5-months old to spoon feed a baby with an oral aversion to eat because otherwise, they won't learn to eat. Totally nonsense."
	Baby wasn't showing signs	"Still unable to feed himself with a spoon at 17 months." "When she started on solids, she wasn't showing signs that she was ready but was at an age where it was appropriate to start. I find it hard to take the advice for normal babies and make it work for us as the timelines are so different."
Other infant issues	Allergies	"Allergic reaction with first food introduced." "Baby having CMPI and me being Coeliac."
	Tube feeding	"Being tube fed and oral free for 12 months due to poor lung health."

Theme	Code	Example quotes
	Swallowing difficulty	"Her oral aversion and bad swallowing."
	Gut issues	"Issues with gut, gas, bloating, solids not agreeing with her tummy."

3.2.6 Improvement in education regarding complementary feeding

For those that had introduced CF (n=181), 26% (n=47) of them responded to this question, *"What could be improved about the support and education you received about the introduction of solid foods?"*. Four main themes were identified: 1. Better access to information; 2. Education for textures and foods; 3. Education/information tailored to preterm infants; 4. Better access to support. Example quotes are displayed in **Table 13.**

Better access to information and support

Some respondents reported that they would have liked more information given and been informed where to access further education and information on solids. This would have been helpful as some mothers/caregivers reported that they received *"the bare minimum", "a little bit of advice",* and *"very minimal information"*. Some respondents would have liked to receive more or any support. They described support in the context of *"someone to speak to ", "individually coming up with a plan", "information from paediatric dietitians",* and *"some support"*. One mother/caregiver paid to see a dietitian as they received *"no support"*.

Education specific to textures and foods

Support and education around specific textures and foods would have been helpful for some mothers/caregivers. Some mothers/caregivers would have liked to receive information about textures and foods that are safe for BLW. One mother/caregiver said this would help *"build confidence around new foods and textures"*.

Education/information tailored to preterm infants

Some respondents highlighted the need for tailored education and advice to preterm infants rather than being given advice aimed at term infants. These mothers/caregivers found it hard to find information for preterm infants and reported that educational providers were not experienced in feeding preterm infants. One mother/caregiver described the information as *"conflicting"*.

Table 13. Themes and codes relating to "*What could be improved about the support and education you received about the introduction of solid foods?*".

Theme	Code	Example quotes
Better access to information and support	Receiving more information	"More information on discharge about how/when to introduce for prem babies." "I only received a little bit of advice from the OT just because I happened to be attending the Little Miracles playgroup and did my own research, otherwise, I didn't receive any specific guidance from the hospital. It would have been helpful if this was discussed prior to discharge or at the follow-up appointment."
	More up-to-date information	"I think lots of information regarding baby food is outdated." "I feel it needs updating. E.g. baby cereals are not the best yet still seem to be pushed within healthcare despite grains being difficult for babies to digest also encouragement of vegetables first instead of fruit, which is sweet and high sugar."
	More advice given	"Support from someone, anyone, regarding solid foods and how to introduce them. Someone to speak to about any issues. "To actually have some support would have been good!" “Give the family pamphlets to read and talk to them about it. Not the stock standard. Have you started solids yet. 'Yes' awesome. Puree? Yes. Conversation was done far too quickly for me in hindsight”.
Education around textures and foods	Textures safe for baby-led weaning	"More information about the different types of starting solids, e.g. puree, baby-led weaning." "More options around baby-led weaning and benefits, ways to make and mix foods together - moving away from plain pumpkin, etc."
	Texture progression	"More support around the transition between purée and chunky food."
	Recipe ideas	"Recipes for baby food." "More help in planning meal ideas."
Better education tailored to preterm infants	Education specific to preterm infants	"The information I received was aimed at term babies, and no one that I spoke with knew much about prem babies." "Individually coming up with a plan for the child rather than just guidelines." “Information given in NICU about adjusting age.”
	Correct information given	"Well Child Providers are not experienced in feeding preterm babies. As my child had no medical issues, we were not under any specialist care, so we had to find our own information." “Information was conflicting - Well child providers may need some more education. They said I needed to wait until she grabbed the plate. I then attended a seminar the Little Miracles Trust put on about introducing solids where the speaker said if you get to 7 or 8 months when you introduce solids, you’ve left it too late. She was 8 months by then, so I panicked, and it was a stressful time.”

Chapter 4. Discussion

4.1 Summary of findings

This study investigated the current feeding practices of preterm infants aged 0-24 months in Aotearoa from birth to the introduction of CF. The primary outcome from this study was the rate of EBF for more than five months chronological age, which was achieved by 33% of infants, similar to previous findings among preterm infants in NZ (30%) [120]. During their initial hospital stay, most infants received some breastmilk. However, supplementation with some IF (47%) and/or DBM (33%) was common, and 13% of infants did not receive any breastmilk in-hospital. The rate of EBF at discharge was 60%, much lower than that of the general population in NZ (78%) [122]. Furthermore, very few infants received any breastmilk after 12 months chronological age (11%).

The rate of timely introduction to CF (74%) was greater than the reported rate for the general population (57%)[167]. Fussy eating behaviours were reported in 4 out of 10 infants, and full adherence to the MoH guidelines was very low for infants 4-6 months chronological age (CFI 4.2±1.3 out of 8) and higher among infants >12 months chronological age (CFI 6±1.4 out of 8). Significant differences were found between the CF practices and maternal characteristics, including ethnicity, age, income, and education.

Mothers/caregivers faced many challenges to breastfeeding, such as their infant's poor feeding ability and low milk supply. Their shared experiences highlighted many positive feelings towards the breastfeeding support they received but underscored the need for improved encouragement and support for mothers/caregivers wanting to breastfeed. Additionally, parents stated there was limited education about introducing CF, and recommendations were made for more consistent and specific education around introducing CF for preterm infants. In summary, the findings from this research provide the first insights into the early feeding practices of preterm infants in Aotearoa beyond the neonatal period.

4.2 In-hospital feeding outcomes

4.2.1 Nutritional support in-hospital

In-hospital feeding outcomes revealed that almost all preterm infants required at least one mode of nutritional support. The high incidence of nutritional support across all gestational ages is similar to the outcomes in a retrospective review from six NICUs in NZ involving 647 MLP infants in 2016, where no infants achieved full oral feeding before 33^{+3} weeks' postmenstrual

age [209]. The overall rate of NGT feeding in-hospital in our study was 78%, similar to findings from Jackson et al., in which the majority of MP and LP infants from NZ required an NGT for at least one feed during their initial hospital stay (89%) [209]. In contrast to our results, MP and LP infants in the Jackson et al. study were cared for in the NICU [209]. Thus findings might not be generalisable to our study since some infants in our study were cared for in postnatal wards [209].

The high rates of nutritional support found in our study are expected, as EP and VP infants are born without mature mechanisms for breastfeeding [61], delayed until they reach 34 weeks' gestation [61]. MP and LP infants present with significant immaturity compared to full-term infants, and their ability to breastfeed may persist as a challenge until they reach term equivalent age [28,210]. An immature sucking pattern often leads to fatigue and an increased risk of inadequate caloric intake and poor latching [28,61,210], which can negatively impact breastmilk production [28,61,210]. Many mothers/caregivers expressed that their infants' poor feeding ability was the most challenging factor in their breastfeeding experience. The most common difficulties experienced were latching or the infant being *"too weak", "too tired",* or *"too sleepy"* to feed properly. Therefore, the use of nutritional support to ensure they meet their requirements is common among this population.

Infants identified as non-Māori were significantly more likely to receive IVN compared to infants identified as Māori, despite no association between level of prematurity. This raises concerns about racial influences on the level of medical care and the type of nutrition infants receive. Racial disparities have been previously identified in a NZ prospective cohort of 151 MLP infants enrolled in the DIAMOND trial [211], in which Māori infants were transitioned off intravenous nutrition and/or dextrose earlier and were more likely to receive enteral feeds with formula than infants of other ethnicities [211]. Nonetheless, contrary to the findings in the DIAMOND trial, we found no differences between ethnicity and the type of milk the infant received in-hospital [211]. Furthermore, the significance of the association between infant ethnicity and IVN is ambiguous, as no difference was found between the mode of nutritional support and maternal ethnicity. This may be explained by a higher number of infants (n=55) identified as Māori than mothers/caregivers (n=36). Larger issues, such as systemic racism in the healthcare system may influence clinical practices (i.e., unconscious bias); however, the reasons underlying these outcomes in our study remain uncertain.

4.2.2 Type of feeding in-hospital

Our findings indicate that most infants received some breastmilk during their hospital stay. In the prospective cohort analysis of the ProVIDe trial in NZ and Australia involving 434 EP infants (≤31.5 weeks) and extremely LBW infants (<1000g), nearly all infants achieved exclusive breastmilk feeds through enteral feeding within four weeks; however, achievement of exclusive breastmilk feeding throughout their entire hospital stay was not captured [118]. Contrastingly, fewer than one-third of infants in our study were fed breastmilk exclusively throughout their entire hospital stay, with significantly higher rates among EP and VP infants compared to MP and LP infants.

Most studies show decreasing rates of EBF at discharge and beyond with decreasing GA[110,115,127,212], but some also indicate that MP and LP infants are more likely to receive breastmilk substitutes than EP and VP infants[110,116,130,213]. This might be explained by more intensive medical care, emphasis on exclusive breastmilk feeds and increased breastfeeding support for the most vulnerable infants in the NICU, which may not be as common in postnatal wards, where EP and VP infants are not cared for [213–215]. Similarly, in our study more MP and LP infants received no breastmilk compared to EP infants. This outcome may contribute to the high prevalence of hospital readmission observed in LP infants compared to all other gestational ages, given the risk of adverse health outcomes with IF versus exclusive breastmilk, such as respiratory and gastrointestinal infections [28,215].

Mothers/caregivers' found that support from health professionals helped them with breastfeeding in the hospital. LCs and NICU nurses were the most frequently mentioned sources of support. Breastfeeding support may not have been widely available in postnatal wards, resulting in less support towards preterm infants at later gestational ages. Additionally, in our study, MP and LP infants had a significantly shorter duration of hospital stay than EP and VP infants, likely impacting their access to LC support. A common challenge mothers reported during their breastfeeding experience was low milk supply, often due to milk drying up due to separation, infants' poor feeding ability, or a delay in milk production. Mothers also found the physical demands of expressing *"hard"* and *"tiring"* and that pumping for a long duration was challenging to maintain. In an Italian study involving 92 mothers and 121 LP infants, the availability of an LC was among the strongest enablers for breastfeeding in-hospital, supporting the importance of LCs among this population [128].

The use of DBM in the hospital was high among our study population (39%). Given that few hospitals in NZ have access to human milk banks (none available in Auckland), the high proportion of mothers using DBM may indicate a high rate of informal peer-to-peer sharing [62,216,217]. As reported in a survey by health professionals across 24 NICU sites in Australia and New Zealand, the use of unpasteurised DBM was prevalent and available in 39% of the NICUs [62]. It is important to consider the ethical and safety concerns regarding peer-to-peer donation of unpasteurised DBM, ensuring it is properly screened and that mothers' breastmilk is prioritised [218].

4.3 Discharge feeding outcomes

4.3.1 Nutritional support at discharge

Most infants were discharged home either breastfeeding directly or with oral supplementation using a bottle or cup. However, some infants did not achieve full oral feeding at discharge and were sent home with an NGT. The overall rate of NGT feeding at discharge was 23%, much higher than the prevalence of NGT feeding at hospital discharge in NZ among LP infants (2%) and globally (3-12%) [209,219,220]. It is important to note that the rate of NGT feeding among LP infants is also low in our study, and recent data shows improved survival rates among early and unwell preterm infants [221]. This may influence this outcome in our study as NGT feeding at discharge significantly increased with decreasing GA, with approximately half of EP and VP infants discharged home with NGT feeding. This is consistent with the literature which shows that a longer duration of NGT is significantly more common among lower gestational ages [209,219,222]. The high prevalence of NGT feeding at discharge could indicate high rates of feeding difficulties at hospital discharge among our study population [219]. However, it may also suggest that infants are being discharged home with NGT feeding to reduce the length of hospital stay.

Evidence suggests that early discharge with tube feeding reduces hospital stays and costs and may increase breastfeeding rates as it enhances parent-infant bonding and maternal mental health [159,223]. Two European studies have revealed that early discharge with NGT feeding in preterm infants is received positively among parents [224,225]. With appropriate follow-up care, discharge with NGT feeding appears safe and reduces parental stress [224,225]. In our study, mothers/caregivers found that separation in the NICU caused a lot of stress, resulting in a low milk supply. They shared, *"It is possible to still exclusively breastfeed once in the comfort of your own home. I was made to feel this was not possible."*

4.3.2 Oral feeding at discharge

The rate of EBF at discharge in our study was comparable to rates from previous studies on preterm infants internationally (16%-83%) [116,119,127,128,138,226,227] and nationally, where 78% of full-term infants were EBF at discharge and same rate observed among MP and LP infants in the DIAMOND [119,122]; however, higher than among EP infants from the ProVIDe trial (41%) [228]. In our study, significantly more VP (26%) and MP (24%) infants received no breastmilk at discharge than LP infants (8%). Some mothers/caregivers reported they did not feel supported by health professionals whilst their infant was unable to breastfeed. More support from health professionals guiding mothers towards breastfeeding at discharge could increase rates of EBF at discharge.

Some maternal characteristics were associated with the feeding method at discharge, such as a higher annual household income associated with a higher EBF rate at discharge. Conversely, lower income and education levels were associated with infants receiving no breastmilk at discharge and subsequently receiving more breastmilk substitutes, including IF or DBM. These results are consistent with other research, in that maternal socioeconomic factors, such as higher income and education, are key determinants of greater breastfeeding establishment and duration in preterm and full-term infants [111,113,121,127,134,229–231]. Our study also revealed that mothers/caregivers with the lowest education level were significantly less likely to receive in hospital support with some expressing negative feelings towards health professionals and the support they received, reporting, *"I had absolutely zero support"* and *"minimal education on how to breastfeed".* Other studies have found that mothers/caregivers of preterm infants who receive support and education in-hospital achieve higher breastfeeding rates [135,232], however disparities in support likely contribute to breastfeeding inequities. Ensuring that breastfeeding education and support are catered to individuals with varying education levels and those with less social support is crucial to prevent exacerbating inequities in breastfeeding rates.

4.4 Post-discharge feeding outcomes

4.4.1 Breastfeeding duration

The rate of EBF for up to five months found in our study was consistent with reported rates among preterm infants (30%) and full-term infants (36%) for 5-6 months from the GUiNZ cohort [120] and higher than the rate reported from a cohort of 191 MLP infants from the DIAMOND study at four months corrected GA (19%) [119]. The WHO global nutrition targets aim to achieve EBF for the first six months at 50% by 2025 [233]. However, data from NZ

indicates that achieving EBF for six months remains a public health challenge, with only 16% of full-term infants in the GUiNZ study achieving EBF for up to six months [121,124,234]. Globally, the rate of EBF for more than five months among preterm infants appears lower than in our population (8%-34%)[110,116,126,138,235]. This difference could be due to variations in how and when breastfeeding duration is measured, with most studies using corrected GA rather than chronological age, as in our study. Additionally, classifications and categorisations of EBF duration may vary, making comparisons difficult.

Most mothers/caregivers' in our study had positive attitude towards breastfeeding, such as their perseverance, which could contribute to the high breastfeeding rates observed in this study. Some mothers/caregivers were *"determined to keep going"* and were self-motivated to persevere with expressing breastmilk to ensure they could breastfeed for as long as possible. Moreover, the positive attitudes and behaviours towards EBF could have motivated individuals to participate in our survey [236], which may have influenced the overall prevalence of EBF observed in the present study. Furthermore, mothers/caregivers reported that access to a breast pump they could take home influenced their ability to continue breastfeeding. This finding is supported by other studies, where the availability of a breast pump was highlighted as one of the main breastfeeding enablers [128]. Additionally, support from family and friends was identified as a breastfeeding enabler, consistent with the literature, which suggests that support from family, such as a partner, is a strong factor for longer breastfeeding duration [110,126,134,237].

The WHO and MoH recommend breastfeeding until two years, highlighting suboptimal outcomes in our population [107,108]. The total duration of any breastfeeding for more than one year in our study was much lower than the reported rate for the general population in the GUiNZ cohort (11% vs 37%, respectively) [121] and preterm infants in studies from NZ, Sweden, and Iceland (21-31%)[120,138,144]. Returning to work is a major factor for breastfeeding cessation [110,234,238,239], which is mostly influenced by short duration of paid maternity leave and the lack of support in workplaces promoting a safe environment where mothers can continue pumping and breastfeeding [234]. This underscores the need to improve breastfeeding duration in NZ, particularly by enhancing support for mothers/caregivers beyond hospital discharge [121,191,240]. To mitigate these challenges, it is important to improve the access to paid maternity leave for all parents, increase breastfeeding awareness in workplaces, provide supportive environments for breastfeeding mothers to feel comfortable and safe expressing milk at their workplace.

Interestingly, breastfeeding outcomes in our study were not associated with ethnicity, which is inconsistent with the literature. In NZ, Māori ethnicity is often linked to lower breastfeeding rates [121,136]. This might reflect the health-conscious attitudes of mothers/caregivers who participated in the survey, not capturing the attitudes of mothers/caregivers from the entire population [236]. Moreover, Māori infants in our study were underrepresented compared to the overall Māori birthing population in NZ, while NZE infants were overrepresented [241]. Therefore, the breastfeeding outcomes observed in our study may not accurately reflect the trends seen in NZ, as our study population does not truly represent the birthing population of infants in NZ.

4.5 Complementary feeding outcomes

4.5.1 Timing of complementary feeding introduction

In our study, variations were observed across levels of prematurity regarding the time of CF introduction, with EP infants having the highest proportion of late CF introduction (30%). Since we used chronological age, the age of CF introduction was highest for EP infants, likely reflecting their developmental readiness occurring at a later chronological age compared with VP, MP, and LP infants. Only 11% of the population was introduced to CF early, before five months chronological age, far fewer than the prevalence of early introduction to CF before four months of corrected GA in previous studies among preterm infants (64%-83%) [166,170]. European guidelines suggest starting CF between five and eight months chronological age [109]. Introducing CF too early is not recommended due to concerns regarding underdeveloped organ systems, nutrient displacement of breastmilk, weight gain, and increased allergy risk [109,166,174,242]. Emphasising the minimum corrected GA timeframe when introducing CF is important to minimise these risks [166]. Although the rate of timely introduction to CF was high among our study population, challenges to comparing the prevalence of timely introduction of CF with previous studies include ambiguity in universal guidelines for the correct time to introduce CF, different cut-off months, and the classification of age [109].

Many mothers/caregivers reported enablers towards CF, including health professionals, particularly dietitians, who may have influenced the high prevalence of timely CF introduction. In an Australian longitudinal study involving 85 preterm and 65 full-term infants [170], Cleary et al. found that advice from health professionals (paediatricians and dietitians) enabled CF experience [170]. However, many mothers/caregivers reported a lack of education and support

provided by health professionals regarding CF tailored to preterm infants, leading parents to use personal knowledge and the other resources available, such as Plunket or the Internet.

Early introduction to CF was more common among Māori mothers/caregivers, those with lower income levels, and younger mothers/caregivers. These findings align with the maternal determinants of early CF introduction identified in the GUiNZ study and the 2022/23 NZ Health Survey [167,243]. The disparity in ethnicity may be related to how Māori cultural values and norms influence CF practices [244]. In a study that explored CF practices among Māori whānau, interviews with 10 Māori participants were undertaken and guided by Kaupapa Māori principles and practices [244]. Rapata et al. found that Māori whānau are more inclined to use responsive feeding and natural instincts to guide CF rate than strict timelines or schedules [244]. This approach may be particularly relevant among preterm infants, where current guidelines are ambiguous, and responsive feeding based on the infants' developmental and hunger cues may be more appropriate [109,244].

4.5.2 Fussy eating

The most common challenge mothers/caregivers faced when introducing CF was their infants' fussy eating behaviours, reported by 41% of respondents, mostly related to lack of interest in food, and presenting refusal to eat, picky eating, texture issues, and choking/gagging. This is consistent with the findings from a meta-analysis including 22 studies investigating the prevalence of problematic feeding among preterm infants under the age of four [174], in which the prevalence of problematic feeding across the studies was 42% [174]. It is important to note that the definition and assessment tools for fussy eating and problematic feeding vary across studies, making direct comparisons challenging. Unlike in other studies [174], the prevalence of fussy eating in our study differed between levels of prematurity, with EP infants and those introduced to CF late reporting the highest prevalence of fussy eating behaviours. This suggests that more immature infants could be at increased risk of delayed CF introduction and fussy eating behaviours. Late introduction of CF could impact the progression to textured foods, which is known to be a risk factor for delayed oral motor skills and fussy eating behaviours [245]. Additionally, there was a greater prevalence of tube feeding among EP infants in-hospital (100%) and at discharge (54%), which has been previously associated with increased eating difficulties [246].

4.5.3 Adherence to guidelines

The evidence on adherence to CF guidelines in preterm infants is limited, and our findings are the first in NZ. Overall, very few infants achieved full adherence to the MoH Healthy Eating Guidelines for Babies and Toddlers and high adherence (80% or more) was not achieved for any individual indicators among all age groups, emphasising the need for recommendations on CF tailored to preterm infants [109]. Adherence to dietary guidelines was influenced by maternal characteristics such as older age and higher education levels, who may possess greater infant nutrition knowledge and experience [247]. This finding is also supported by other studies [167,170,247,248].

Currently, there are no specific recommendations regarding the types of foods to choose for CF introduction among preterm infants; therefore, guidelines for term infants remain the standard [108,109]. This is reflected in the challenges mothers/caregivers reported in the survey, expressing they did not receive any education around complementary feeding and felt they did not know what and how much food to introduce. The low consumption of energy and iron-rich foods in the present study could indicate that preterm infants are at risk of inadequate caloric intake and iron deficiency. There needs to be greater emphasis and education regarding the types of foods to introduce and tailor to the nutrient demands of preterm infants. Introducing CF with high-energy, high-protein and iron-rich foods may be desirable to meet their increased nutritional requirements [249].

4.6 Identified improvements for the education and support received

4.6.1 Improvements for breastfeeding education and support

Given the breastfeeding challenges described in the survey, it is not surprising that the most recommended improvement from mothers/caregivers' breastfeeding experience was better access to support and more encouragement from staff to breastfeed. Improving breastfeeding outcomes among this population is imperative and could be achieved by increasing access to breastfeeding support. Support from health professionals, particularly LCs, and access to breastmilk pumps were mostly mentioned as supporting mothers'/caregivers' breastfeeding experience. However, this support is clearly not accessible to everyone, with many mothers/caregivers reporting the need for earlier access to support and more one-on-one help from health professionals to alleviate maternal stress and support the infant's feeding abilities towards breastfeeding. This could be related to staff shortages and little investment in LCs in

NICU and postnatal wards in NZ [250]. Fair pay and working conditions are crucial to attracting and maintaining health professionals such as nurses, LCs, and midwives [250].

Additional support in the hospital has been well-researched as a successful intervention to improve breastfeeding rates among preterm infants [113,135,232,251]. Mothers/caregivers specifically mentioned the need for more education around maintaining milk supply and breastfeeding techniques. Some studies have highlighted the importance of education on milk supply in this population [113,138,252]. In an RCT involving 60 mothers and their preterm infants were randomised to a five-session breastfeeding education program or routine care, those who received breastfeeding education, including training around milk expression, found the intervention was successful in increasing EBF at discharge from 40% in the control group compared to 80% in the intervention group [253].

In our survey, mothers/caregivers also highlighted the need for support towards alternative feeding methods rather than waiting until their infant is ready to breastfeed. Mothers expressed that this would have alleviated concerns for mothers/caregivers who were unable to breastfeed and nourish their infants. Health professionals have a role to encourage and empathise with mothers/caregivers, recognising the emotional strain of having a preterm birth and the challenges it brings. To reduce the stress of mothers/caregivers, consistent advice from all health professionals was identified in the survey as an area for improvement. The mixed messages and lack of communication left mothers feeling *"alone"* and *"confused and upset"*.

4.6.2 Improvements for the complementary feeding education and support received

Few studies have investigated the difficulties parents of preterm infants face when introducing CF. Still, evidence to date suggests fussy eating behaviours as being common, and potentially influenced by the prolonged use of tube feeds[254,255], lower rates of breastfeeding [249,255], and increased motor and behavioural problems at the time of CF introduction [256,257]. To promote optimal feeding behaviours in preterm infants, parents should be educated on strategies to support food acceptance in preterm infants, such as education on responsive feeding and recognising their infants' signs of readiness, avoiding pressure and stress at mealtimes, offering a variety of food with small potions, positive role modelling, and responding to their hunger (opening mouth and turning head side to side, fussing and leaning towards food, increasing physical movements, asking or pointing at foods, and distressed crying) and fullness cues

(pushing away from food, turning head away, sealing lips together, spitting out food, and becoming distracted) [108].

Mothers/caregivers reported experiencing several fears when introducing CF, influenced by fear of choking and a lack of confidence. This is likely influenced by the lack of education and inconsistent messaging around CF reported by mothers/caregivers regarding the types and amounts of food, as well as the knowing when their infant is ready to introduce CF. This lack of consistent education from health professionals is likely due to the limited scientific evidence guiding the introduction of CF among preterm infants [109]. The main improvement identified by mothers/caregivers for CF was better access to information and support whilst ensuring it is up-to-date and tailored to preterm infants. This underscores the need for future research investigating optimal CF practices and health outcomes in preterm infants to inform development of recommendations tailored to preterm infants [258]. Additionally, consistency in disseminating this information to health professionals is critical to ensure it is easily accessible and interpreted by all parents.

4.7 Strengths and limitations

This research has several strengths. It is the first national study to investigate preterm infants' feeding practices and behaviours beyond the neonatal period and to investigate this population's adherence to the MoH guidelines. Additionally, there was a high response rate towards the qualitative questions, which provided rich information on the enablers and challenges mothers/caregivers of preterm infants faced during their feeding journey, and the insights provided can inform how to improve the current education and support.

The survey was advertised through social media and several community groups of mothers/caregivers of preterm infants, reaching a wide range of the preterm population across the country. However, our study found that the breakdown of maternal/caregiver ethnicities did not represent the NZ birthing population in 2021, underrepresenting Māori (14% vs 26%), Pacific (3% vs 10%), and Asian (7% vs 19%) ethnicities [259]. The breakdown of ethnicities in the infant birthing population in NZ in 2021 were European (43%), Māori (28%), Pacific (10%), Asian (10%), and Indian (9%) [241]. Whereas our study population were overrepresented in NZE (73%) and underrepresented in Māori (21%), Pacific (8%), and Asian/Indian (7%). Additionally, preterm birth rates in NZ are higher among Māori (9%), Pacific (8%), and Indian

(8%) compared to European (7%) and Asian (7%) ethnicities [5]. Therefore, our study population was not representative of the NZ birthing population of preterm infants [5,241].

One limitation is the potential for selection bias, as survey participation was restricted to those with internet access, potentially limiting the participation of mothers/caregivers from rural areas in NZ and those with lower economic status [260]. Additionally, most respondents had post-secondary non-tertiary and university-level education, suggesting that the survey may over-represent the experiences and opinions of those with higher education and/or socioeconomic status [261]. Participants with health-conscious attitudes who could be more likely to engage in healthy feeding practices might have been overrepresented, potentially leading to an inaccurate portrayal of the broader population's attitudes and behaviours towards infant feeding [236]. Also, the survey did not collect data on location of residence or hospital care; therefore, we cannot assess differences across regions. This is a limitation of the study as preterm birth rates[4] and hospital feeding practices vary across regions of NZ [79]. Additionally, some responses could be susceptible to recall bias, especially for mothers/caregivers of infants >12 months chronological age, as they were required to recount their feeding experiences from birth to the time of survey completion.

Some answers to the question regarding EBF duration were excluded from the final analysis, likely due to misinterpretation, despite our effort to provide clear definitions of the EBF within the survey. A total of 85 responses were excluded from the EBF outcome as some mothers/caregivers reported they were currently EBF while also providing complementary feeding, and some mothers/caregivers reported EBF durations that exceeded the time at which they had introduced CF. Only accurate responses were included to minimise recall bias; however, this approach may over-represent mothers/caregivers with a better understanding of this specific outcome.

Lastly, the survey asked mothers/caregivers to respond based on their infant's chronological age rather than corrected GA. This limits the ability to account for prematurity with the outcomes related to age, such as EBF duration and timing of CF introduction. This also limits the comparability of the outcomes for healthy-term infants and other studies with preterm infants using corrected GA. Comparing preterm infants' development to that of a term infant at the same corrected GA provides a more accurate assessment of their developmental progress as it considers the number of weeks they were born early from their chronological age [262].

Although the use of chronological age ensured consistency throughout the survey and reduced the risk of recall bias since mothers/caregivers were not required to calculate their infant's corrected GA, we cannot be certain that all participants used chronological age. To minimise potential confounders, the level of prematurity for each infant was collected, and outcomes were analysed by each level of prematurity throughout the study.

4.8 Future directions and recommendations

The survey findings revealed suboptimal outcomes in breastfeeding duration and adherence to CF guidelines. When developing strategies to promote and support optimal early feeding practices in NZ, addressing the disparities found in feeding practices across socioeconomic factors such as income and education levels is crucial. Breastfeeding and CF education and support must be made more accessible and appropriate to ensure those of all education levels can understand and implement the education. It is important to upskill health professionals with up-to-date and consistent advice around breastfeeding and CF practices so that parents and caregivers are equipped with the necessary knowledge of optimal feeding practices.

This research also highlights the need for more support towards mothers/caregivers who face challenges initiating breastfeeding, a common issue among the preterm population [61]. Support around pumping is crucial, particularly the provision of breast pumps that mothers/caregivers can take home, which serves as a strategy to facilitate their breastfeeding experience. Additionally, mothers/caregivers identified the need for more empathetic care towards mothers/caregivers who do not wish to breastfeed or cannot breastfeed by giving guidance around alternative feeding methods.

This research underscores the urgent need to develop and implement practical recommendations tailored to preterm infants in New Zealand. Currently, there are no national guidelines addressing optimal feeding practices for preterm infants beyond the neonatal period. These guidelines should address various aspects, including the recommended duration of EBF and the optimal time to introduce CF, while considering the differences in cultural practices [244]. Recommendations should also specify the types of first foods and the transition through textures and quantities that support preterm infants' growth, development, and food acceptance [107,108]. It is also poorly understood whether MP and LP infants require specific recommendations or should follow the recommendations for healthy-term infants and guidelines should clarify the use of corrected GA versus chronological age [107,108]. Moreover,

much of the existing literature focuses on EP and VP infants, leaving a gap in knowledge regarding MP and LP infants, thus RCTs investigating the effects of early nutrition on short- and long-term health outcomes of preterm infants are required, particularly among MP and LP infants.

4.9 Conclusion

Findings from this thesis demonstrate that EBF rates among preterm infants in NZ are higher than for the general population, and most infants started CF in a timely manner. Nevertheless, it also demonstrated that breastfeeding rates are suboptimal compared to global targets and inequities exist in feeding practices. Furthermore, this thesis adds to the paucity of literature on the feeding behaviours of preterm infants, which may inform the development of future recommendations. The study revealed a need for improved support for breastfeeding practices in hospitals and post-discharge to help mothers/caregivers in establishing and maintaining breastfeeding. Preterm infants showed low adherence to the MoH guidelines, but the suitability of these recommendations for preterm infants remains unclear. Maternal characteristics such as age, income, education, and ethnicity were associated with feeding outcomes, emphasising the need for targeted support and education to the most vulnerable mothers/caregivers in order to reduce health inequities. Overall, these findings provide an opportunity to help improve future nutritional support and education for preterm infants.

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Appendix 1: Social media advertisement

Are you a mother/māmā or caregiver of a preterm baby born in the last 2 years?

Take our survey to help us understand more about your experience of feeding your preterm baby/pēpi and if anything made it easier or harder.

It's a 15-minute anonymous survey and you can choose to take part in a draw for $100 gift voucher.

Scan to start survey:

UNIVERSITY OF AUCKLAND Waipapa Taumata Rau NEW ZEALAND | LIGGINS INSTITUTE

This study was approved by the Auckland Health Research Ethics Committee on 03/05/23 for 3 years. Reference number: AH25952.

Appendix 2. Survey information sheet

Kia ora,

You are invited to contribute to a national survey about early feeding practices of preterm infants in New Zealand.

A Te Reo version of the information sheet is available here.

This survey aims to understand the current early feeding practices of preterm infants in Aotearoa, New Zealand. There will be a range of questions related to your experiences with breastfeeding/whāngai ū and the introduction of solids (also known as complementary feeding).

You are invited to take part in this study if:

1. You are a mother/māmā/caregiver of a single preterm baby/pēpi (preterm birth is defined as baby/pēpi being born before 37 weeks of a complete pregnancy (40 weeks);
2. Your baby/pēpi is 24 months (2 years) or younger (date of birth at or after April 2021);
3. You are the main or primary caregiver;
4. You are 16 years or older; and
5. You are able to complete the survey in English.

We would like to find out about your experience of feeding your preterm baby/pēpi and if anything made the first months of your baby's/pēpi life easier or harder.

We will ask about your experience and opinions regarding different types of feeding practices such as breastfeeding/whāngai ū, formula feeding, and introducing solid foods. This information will help understand how to better support mothers/māmās and preterm babies/pēpi to improve their early nutrition and overall health outcomes.

The survey is estimated to take 15 minutes and is divided into 5 blocks related to:
1- maternal information; 2- infant information; 3- information about feeding in the hospital; 4- information about feeding after the hospital discharge; and 5- information about the introduction of solid foods.

The information below is to help you decide whether you wish to take part in this survey. Please feel free to discuss taking part in this survey with whānau/family, friends and/or health care providers to help you decide whether you wish to take part.

Your participation in this research is **voluntary,** which means that it is your choice, and you are free to refuse if you wish to do so. If you do not wish to take part, you do not need to give a reason and you may stop the survey at any point and close the browser window.

This survey is **anonymous**, and all information collected will not be linked to you or your baby/pēpi personally, therefore, there is no risk to your baby/pēpi. It is possible that some of the questions in this survey may be distressing for mothers/māmas that may have had challenges with feeding their preterm infant.
For free help/counselling services, you can call:

- PLUNKETLINE (0800 933 922) which is a toll-free parent helpline and advice service available to all families, whānau and caregivers 24 hours a day, seven days a week.
- HEALTHLINE (0800 611 116) which is a free helpline providing advice and information from a trusted registered nurse, anytime, 24 hours a day, 7 days a week.

If you change your mind after giving consent, you may withdraw from the survey at any point by closing the browser window and your answers will not be recorded. You will be unable to withdraw from the study after you have submitted the questionnaire because responses are stored anonymously, and it would not be possible to determine which data belongs to who.

This research is part of a Master's in Nutrition and Dietetics project at the University of Auckland, led by Ms Sara Cooper (Master Student), and supervised by Dr Mariana Muelbert (Liggins Institute, University of Auckland) and Dr Tanith Alexander (Te Whatu Ora - Counties Manukau).

The combined results of this survey will be reported within a thesis and may be published in academic journals. Findings of this survey will be publicly posted on Liggins Institute social media platforms in the form of an infographic. If you would like to receive a summary of the results, you can choose to provide an email address via a separate link, at the end of the survey.

In appreciation of your participation, at the end of this survey, you may choose to enter a draw to win a $100 gift voucher. The contact details collected for the draw will not be linked to your survey responses to ensure your answers remain anonymous.

If you have any questions or concerns about this survey, please feel free to contact Dr Mariana Muelbert using the contact information below:
Email: m.muelbert@auckland.ac.nz | Phone: 027 4929059

For concerns of an ethical nature, you can contact the Chair of the Auckland Health Research Ethics Committee by email at ahrec@auckland.ac.nz or by phone 373 7599 ext. 83711, or by post office at Auckland Health Research Ethics Committee, The University of Auckland, Private Bag 92019, Auckland 1142. This study was approved by the Auckland Health Research Ethics Committee on 03/05/23 for three years. Reference number AH25952.

Appendix 3. Te Reo Māori version of the survey information sheet

Kia ora,

He tono tēnei ki a koe kia whai wāhi mai ki tētahi rangahau ā-motu mō ngā tikanga whāngai i ngā pēpi whānau pī mai i Aotearoa.

Ko te whai a tēnei rangahau he rapu māramatanga mō ngā tikanga whāngai i ngā pēpi whānau pī mai i Aotearoa. Kei roto ngā tūmomo pātai e pā ana ki ō wheako whāngai ū me te whāngai kai mō te wā tuatahi (he kai kīnaki tēnei).

He tono tēnei ki a koe ki whakauru mai koe ki tēnei rangahau mēnā:

1. He māmā/kaitiaki koe nō tētahi pēpi i whānau pī (ko te whānau pī he pēpi tērā i whānau mai i mua o te 37 wiki o te hapūtanga tūturu (40 wiki)
2. 24 marama tō pēpi (2 tau), tamariki ake rānei (rā whānau i te Mei 2021, i muri mai rānei); ā,
3. Ko koe te kaitiaki matua, mātāmua rānei; ā,
4. 16 ō tau, neke atu rānei; ā,
5. Ka āhei koe ki te whakaoti i tēnei rangahau ki te reo Ingarihi.

Kei te hiahia mātou ki te mōhio mō tō wheako whāngai i tō pēpi whānau pī, ā, mēnā i māmā ake, i uaua ake ngā marama tuatahi o tō pēpi nā tētahi āhuatanga.

Ka pātai mātou mō tō wheako me ō whakaaro e pā ana ki ngā momo tikanga whāngai rerekē pērā i te whāngai ū, whāngai miraka paura, me te whakauru mai i te kai. Ka āwhina ēnei mōhiohio kia mārama ai me pēhea te tautoko i ngā whaea me ngā pēpi whānau pī kia pai ake ā rātou kai me ngā putanga hauora whānui.

Ko te tikanga kei te takiwā o te 15 meneti te roa o te rangahau, ā, ka wehea ki ngā wāhanga e 5 e pā ana ki te:

1- ngā mōhiohio o te māmā; 2- ngā mōhiohio o te pēpi; 3- ngā mōhiohio mō te whāngai i te hōhipera; 4- ngā mōhiohio mō te whai i muri i te puta i te hōhipera; me te 5; ngā mōhiohio mō te whakauru mai i te kai.

Ko ngā mōhiohio i raro ka āwhina i a koe ki te whakarite mēnā e hiahia ana koe ki te whakauru mai ki tēnei rangahau. Kei te pai noa iho te kōrero mō te whakauru mai ki tēnei rangahau ki te whānau, ngā hoa, ngā kaiwhakarato hauora hoki/rānei hei āwhina i a koe ki te whakatau mēnā me whakauru mai koe.

He mea tūao tō whakauru mai ki tēnei rangahau, arā kei a koe te tikanga, ā, e āhei ana koe ki te whakahē mēnā koinā tō hiahia. Mēnā kāore koe i te hiahia ki te whakauru mai, ehara i te mea me tuku whakamārama mai, ka mutu ka āhei koe ki te whakamutu i te rangahau ahakoa te wā ka kati i te matapihi pūtirotiro.

He kirimuna tēnei rangahau, ā, kāore e honoa ngā mōhiohio katoa ka kohia ki a koe ake, ki tō pēpi rānei, nō reira, kāore e noho mōrea tō pēpi. Ka whakakohuki pea ētahi o ngā pātai o tēnei rangahau mō ētahi māmā he uaua pea te whāngai i ā rātou pēpi i whānau pī. Mō ngā āwhina/ratonga tumu kōrero, ka taea e koe te waea ki:

- PLUNKETLINE (0800 933 922), he ratonga waea koreutu me te tohutohu mā ngā mātua e wātea ana ki ngā whānau me ngā kaitiaki i te 24 haora i te rā, whitu rā i te wiki.
- HEALTHLINE (0800 611 116), he waea āwhina koreutu e tuku tohutohu ana me ngā mōhiohio mai I tētahi nēhi rēhita pono, ahakoa 107ew ā, I te 24 haora I te rā, 7 rā I te wiki.

Mēnā ka huri ō whakaaro i muri i tō tuku whakaae, ka āhei koe ki te wehe mai i te rangahau ahakoa te wā mā te kati i te matapihi pūtirotiro, ā, kāore e hopukia ō whakautu. Kāore e taea e koe te wehe mai i te rangahau i muri i tō tuku i te uiui i te mea ka rokirokitia kirimunatia ngā whakautu, ā, kāore e mōhiotia nā wai ake ngā raraunga.

He wāhanga tēnei rangahau nō tētahi kaupapa Paerua mō te Kaiora me te Mātauranga Kai i Waipapa Taumata Rau, e arahina ana e Ms Sara Cooper (Ākonga Paerua), ā, e whakahaerehia ana e Tākuta Mariana Muelbert (Liggins Institute, Waipapa Taumata Rau) rāua ko Tākuta Tanith Alexander (Te Whatu Ora - Counties Manukau).

Ka pūrongotia ngā otinga o tēnei rangahau i roto i tētahi tuhinga whakapae, ā, ka whakaputaina pea i roto i ngā hautaka mātauranga. Ka whakairihia tūmatanuitia ngā kitenga o tēnei rangahau ki ngā pūhara pāpāho pāpori a Liggins Institute mā ngā pikitia whakairoiro. Mēnā ka hiahia koe ki te whiwhi i tētahi whakarāpopototanga o ngā otinga, ka taea e koe te kōwhiri tētahi wāhitau īmēra mā tētahi hono wehe kē, i te mutunga o te rangahau.

Hei whakamihi mō tō whai wāhitanga, i te mutunga o tēnei rangahau, ka hiahia pea koe ki te whakauru ki tētahi torō mō tētahi tīkiti koha $100. Kāore e honoa ngā taipitopito whakapā ka kohia mō te torō ki ō whakautu rangahau hei whakarite ka noho muna ō whakautu.

Mēnā he pātai, he māharahara rānei ōu mō te whakamahi i te rangahau, me whakapā mai ki a Tākuta Mariana Muelbert mā ngā mōhiohio whakapā i raro:

Īmēra: m.muelbert@auckland.ac.nz | Waea: 027 4929059

Mō ngā māharahara matatika, me whakapā atu ki te Heamana o te Auckland Health Research Ethics Committee mā te īmēra ki ahrec@auckland.ac.nz, mā te waea rānei ki 373 7599 hono. 83711, mā te poutāpeta rānei i Auckland Health Research Ethics Committee, Waipapa Taumata Rau, Private Bag 92019, Auckland 1142.

I whakaaetia tēnei rangahau e te Auckland Health Research Ethics Committee i te 03/05/2023 mō te toru tau. Tau tohutoro AH25952.

Mā te tīpako "E whakaae ana ahau", ka tukua tō whakaae i runga i te mōhio, ā, ka tīmata te rangahau:

Appendix 4: Survey questions

Consent:

By selecting "I agree", your informed consent will be given, and the survey will start:

I agree

I disagree

Skip to: End of survey if = I disagree

End of Block: Information Cover Sheet

Start of Block: Maternal Demographics

This block of questions will cover maternal/caregiver demographic information.

Q1 Which ethnic group do you belong to?

Select all that apply:

New Zealand European

Māori

Pacific

Asian

Middle Eastern, Latin American, and African

Other ethnicity:_____

Prefer not to answer

Q2 How old were you when your preterm baby/pēpi was born?

16-24

25-34

35-44

45+

I prefer not to say

Q3 What is your highest level of education?

University at a Master or Doctoral degree level

University at a Bachelor degree level

Post-secondary non-tertiary (polytechnic or similar certificate)

Upper secondary education (years 12 to 13)

Lower secondary education (years 9 to 11)

Primary school education

Early childhood education

No education

Other education:_____

I prefer not to answer

Q4 Were you employed/working before giving birth to your preterm baby/pēpi?

Yes

No

Display this question if: Were you employed/working before giving birth to your preterm baby/pēpi? = Yes

Q5 What age was your baby/pēpi when you returned to work?

0-3 months

4-6 months

7-12 months

12+ months

I have not returned to work

Q6 What is your average annual household income?

Less than $24,999

$25,000 - $49,999

$50,000 - $99,999

$100,000 - $200,000

More than $200,000

I prefer not to say

Q7 Was this your first pregnancy/hapūtanga?

Yes

No

Display this question if: Was this your first pregnancy/hapūtanga? = No

Q8 What number pregnancy/hapūtanga was your preterm birth?

Select from:

▼ 2, 3, 4, 5+

End of Block: Maternal Demographics

Start of Block: Infant information

This block of questions will cover information about your preterm baby/pēpi.

Q9 How old is your baby/pēpi currently (from their birthday)?

0-3 months

4-6 months

7-9 months

10-12 months

>12 months

Q10 Which ethnic group do you consider your baby/pēpi identify belongs to?

Select all that apply:

New Zealand European

Māori

Pacific

Asian

Middle Eastern, Latin American, and African

Other ethnicity:_____

Prefer not to answer

Q11 How premature was your baby/pēpi at birth?

Prematurity is defined as the total duration of pregnancy/hapūtanga in complete weeks, from conception to birth.

Extremely preterm (less than 27 weeks complete gestation)

Very preterm (28-31 complete weeks gestation)

Moderate preterm (32-33 complete weeks gestation)

Late preterm (34-36 complete weeks gestation)

Don't know

Q12 What was your baby's/pēpi weight at birth?

Less than 1000g

1000-1499g

1500-1999g

2000-2500g

More than 2500g

Don't know

End of Block: Infant information

Start of Block: *The following questions apply to in hospital care, before discharge*

The following block of questions relates to in-hospital care, before your baby/pēpi was discharged home.

Q13 Where did your baby/pēpi spend the most time before being discharged from the hospital?

Neonatal Intensive Care Unit (NICU)

Special Care Baby Unit (SCBU)

Postnatal ward

Labour/birthing suite

Other, please specifiy:_____

Q14 How long was your baby/pēpi in the hospital for?

1-3 days

4-6 days

1-2 weeks

3-4 weeks

More than 4 weeks

Don't know

Q15 Did your baby/pēpi require any form of nutritional support in hospital?

Select all that apply:

Nutritional support means that your baby/pēpi required some form of nutrition or feeding mode other than breastfeeding/whāngai ū after birth.

Intravenous nutrition (e.g. feeding drip, nutrition via a vein)

Oral or nasal feeding tube (small tube through the mouth or nose)

Bottle feeding

Cup feeding

Syringe feeding

None (e.g. feeding directly at the breast)

Other, please specify: _____

Don't know

Q16 Did your baby/pēpi receive donor breastmilk in hospital?

No

Yes, donor milk from a milk bank

Yes, donor milk from informal sharing (peer-to-peer)

Q17 What type of milk did your baby/pēpi receive in hospital, including any milk given via a tube, bottle, or cup?

Select all that apply:

Breastmilk

Donor breastmilk

Infant Formula

Other:_____

Q18 Did your baby/pēpi receive breastmilk fortifier in the hospital?

Breastmilk fortifier is a powder added to breastmilk to provide additional energy and nutrients to support baby/pēpi growth.

Yes

No

Don't know

Q19 Did you have skin-to-skin contact with your baby/pēpi in hospital?

Skin-to-skin contact is also known as Kangaroo Care, and is a method of holding your baby/pēpi in skin-to-skin contact with no clothes on, prone and upright on the chest of the parent/caregiver with a cover over baby's/pēpi back.

Yes

No

Display this question if: Did you have skin-to-skin contact…. = Yes

Q20 How often did you do skin-to-skin contact with your baby/pēpi for?

More than once a day

Daily

2-3 times a week

4-7 times a week

Monthly

Display this question if: Did you have skin-to-skin contact…= No

Q21 Were there any reasons you did not do skin-to-skin contact with you baby/pēpi?

_____

End of Block: The following questions apply to in hospital care, before discharge

Start of Block: Post discharge

The following block of questions relates to feeding practices following discharge from hospital.

Q22 At hospital discharge, what option best describes the type of milk your baby/pēpi received, including any milk given via a tube, bottle, or cup?

Select all that apply:

Breastmilk

Infant formula

Donor breastmilk

Other:_____

Q23 At hospital discharge, what option best describes your baby/pēpi feeding mode?

Select all that apply:

Breast

Bottle

Tube feeding

Cup feeding

Syringe feeding

Other, please specify:_____

Q24 For how long did you exclusively breastfeed/whāngai ū for?

Exclusive breastfeeding/whāngai ū means that from birth, the baby/pēpi receives only breastmilk (from the breast or expressed) and prescribed medicines, where necessary.

Less than 1 months

1-2 months

3-4 months

5-6 months

7+ months

Currently exclusive breastfeeding/whāngai ū

No exclusive breastfeeding/whāngai ū

Don't know

Q25 After hospital discharge, before solids were introduced, did your baby/pēpi receive anything other than breastmilk?

Select all that apply:

Water

Infant formula (any type or amount)

Donor breastmilk

Cow's milk

Plant-based milk (soy, oat)

Cordial

Sugar water

Fizzy drink/Soda

Tea

Other, please specify: _____

Breastmilk only

Display this question if: For how long did you exclusively breastfeed/whāngai ū for? = Currently exclusive breastfeeding/whāngai ū

Q26 Are you currently providing any breastmilk to your baby/pēpi?

Yes

No

Display this question if: For how long did you exclusively breastfeed/whāngai ū for? = Currently exclusive breastfeeding/whāngai ū
And: Are you currently providing any breastmilk to your baby/pēpi? = Yes
Q27 For how long, in months, have you been breastfeeding/whāngai ū or providing breastmilk to your baby/pēpi?
Months:
▼ 1, 2, 3, 4, ... 24+

Display this question if: For how long did you exclusively breastfeed/whāngai ū for?... = Currently exclusive breastfeeding/whāngai ū
And: Are you currently providing any breastmilk to your baby/pēpi? = Yes
Q28 At what age of your baby/pēpi in months do you intend to stop breastfeeding/whāngai ū or providing breastmilk?
Months:
▼ 1, 2, 3, 4, ... 24+

Display this question if: Are you currently providing any breastmilk to your baby/pēpi? = No
Q29 What age was your baby/pēpi, in months, when you stopped providing any breastmilk?
Months:
▼ No breastmilk provided, 1, 2, 3, 4, ... 24+

Q30 Did you receive any breastfeeding/whāngai ū support or education?
Yes
No
Don't know

Display this question if: Did you receive any breastfeeding/whāngai ū support or education?: = Yes
Q31 What type of breastfeeding/whāngai ū support or education did you receive?
Select all that apply:
Breastfeeding/whāngai ū support in the hospital
Breastfeeding/whāngai ū education by a Midwife or Lead Maternity Carer (LMC)
Breastfeeding/whāngai ū education by a Lactation Consultant
Breastfeeding/whāngai ū education by other health professional

Antenatal class
Community group
Internet/Social media
Other, please specify:_____

Q32 How much do you agree or disagree with the following statement:
"I am satisfied with the duration of exclusive breastfeeding/whāngai ū I had with my preterm baby/pēpi."
Strongly disagree
Somewhat disagree
Neither agree nor disagree
Somewhat agree
Strongly agree
Don't know or doesn't apply

Display this question if: Are you currently providing any breastmilk to your baby/pēpi? = No
Q33 How much do you agree or disagree with the following statement:
"I am satisfied with the total duration of breastfeeding/whāngai ū I had with my baby/pēpi."
Strongly disagree
Somewhat disagree
Neither agree nor disagree
Somewhat agree
Strongly agree
Don't know or doesn't apply

Q34 Please state how much you agree or disagree with the following statement:
"I am satisfied with the education and/or support provided by health professionals regarding breastfeeding/whāngai ū."
Strongly disagree
Somewhat disagree
Neither agree nor disagree
Somewhat agree
Strongly agree
I did not receive any education/support

Don't know or doesn't apply

Q35 Please state how much you agree or disagree with the following statement:
"The breastfeeding/whāngai ū support and education I received from health professionals was culturally safe and appropriate"
Strongly disagree
Somewhat disagree
Neither agree nor disagree
Somewhat agree
Strongly agree
I did not receive any education/support
Don't know or doesn't apply

Q36 What could be improved about the breastfeeding/whāngai ū support or education you received?

_____

Q37 What helped you the most with your breastfeeding/whāngai ū experience with your preterm baby/pēpi?

_____

Q38 What were/are your main challenges or barriers to breastfeeding/whāngai ū your preterm baby/pēpi?

_____

End of Block: Post discharge

Start of Block: Introduction to solid foods
The following block of questions relates to introduction of solid foods (also know as complementary food or weaning foods).

Q39 Have you initiated the introduction of solid foods for your preterm baby/pēpi?
Yes
No

Skip to end of block if: Have you initiated the introduction of solid foods for your preterm baby/pēpi? = No

Q40 What age was your baby/pēpi when they first had solids (of any texture)?

Months:

▼ 1, 2, 3, 4, ... 12+

Q41 What age was your baby/pēpi providing signs that they were ready for solid foods?

Signs a baby/pēpi is ready for solid foods may include:

- 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

1-2 months

3-4 months

5-6 months

7-8 months

9+ months

Don't know or doesn't apply

Q42 Select the option that best describes the most common method used to introduce solids to your baby/pēpi:

Spoon-fed by an adult also known as the traditional approach to feeding an infant is to introduce smooth puree foods on a spoon-fed by the parent.

Baby/pēpi feeding themselves also known as baby-led weaning (BLW) defined as the baby/pēpi picking up their food of choice from what is on offer instead of being fed by someone else.

Spoon-fed by an adult

Baby/pēpi feeding themselves

Other: _____

Q43 What were the first food/s your baby/pēpi consumed other than milk (breastmilk or formula) within the first two weeks of introducing solid foods?

E.g. Fruit, Cereal, Vegetables, Legumes, Meat, Cheese, Bread Etc.

Q44 Did/does your baby/pēpi display any fussy eating behaviours at the time of solid food introduction?

Fussy behaviours towards introducing solid foods may include:

- *Unpredictable food preferences*
- *Uninterested in eating/having a poor appetite*
- *Consumes a limited variety of foods and/or textures*
- *Fear of new foods*
- *Refusal to eat certain foods*
- *Difficult to wean off certain textures/baby foods*

Yes

No

Don't know

Display this question if: Did/does your baby/pēpi display any fussy eating behaviours ... = Yes

Q45 Which of the following fussy eating behaviours has your baby/pēpi demonstrated during the time of solid food introduction?

Select all that apply:

Unpredictable food preferences

Uninterested in eating/having a poor appetite

Consumes a limited variety of foods and/or textures

Fear of new foods

Refusal to eat certain foods

Difficult to wean off certain textures/baby foods

Please respond to the following statements based off your baby's/pēpi food consumption in the past month.

Q46 In the past month, how often did your baby/pēpi consume vegetables?

E.g. kumara, pumpkin, taro, carrot, broccoli, bok choy

Never

Once a week

2-4 days a week

5-6 days a week

Everyday

More than once a day

Don't know or doesn't apply

Q47 In the past month, how often did your baby/pēpi consume fruit?

E.g. banana, apple, pear, avocado, mango, kiwifruit, berries

Never

Once a week

2-4 days a week

5-6 days a week

Everyday

More than once a day

Don't know or doesn't apply

Q48 In the past month, how often did your baby/pēpi consume grain foods?

E.g. iron-fortified infant cereal, oats, bread, pasta, noodles, rice

Never

Once a week

2-4 days a week

5-6 days a week

Everyday

More than once a day

Don't know or doesn't apply

Q49 In the past month, how often did your baby/pēpi consume cow's milk?

Never

Once a week

2-4 days a week

5-6 days a week

Everyda

More than once a day

Don't know or doesn't apply

Q50 In the past month, how often did your baby/pēpi consume milk products?

E.g. yoghurt, cheese, butter, cream

Never

2-4 days a week

5-6 days a week

Everyday

More than once a day

Don't know or doesn't apply

Q51 In the past month, how often did your baby/pēpi consume legumes (lentils, tofu, or beans) or nut butters (peanut butter)?

Never

Once a week

2-4 days a week

5-6 days a week

Everyday

More than once a day

Don't know or doesn't apply

Q52 In the past month, how often did your baby/pēpi consume eggs, fish, seafood, chicken or lean red meat?

Never

Once a week

2-4 days a week

5-6 days a week

Everyday

More than once a day

Don't know or doesn't apply

Q53 In the past month, how often did you add salt baby/pēpi food?

Never

Once a week

2-4 days a week

5-6 days a week

Everyday

More than once a day

Don't know or doesn't apply

Q54 In the past month, how often did you add sugar to your baby/pēpi food?

Never

Once a week

2-4 days a week

5-6 days a week

Everyday

More than once a day

Don't know or doesn't apply

Q55 Did you receive any support or education regarding the introduction of solid foods?

Yes

No

Don't know

Display this question if: Did you receive any support or education regarding the introduction of solid…? = Yes

Q56 What type of support or education did you receive regarding the introduction of solid foods?

Select all that apply:

Community group

Internet/Social media

Antenatal class

Midwife or Lead Maternity Carer (LMC)

Dietitian

Other health professional

Other, please specify: _____

Q57 Please state how much you agree or disagree with the following statement:

"I am satisfied with the education I received regarding the introduction of solid foods."

Strongly disagree

Somewhat disagree
Neither agree nor disagree
Somewhat agree
Strongly agree
I didn't receive any education
Don't know

Q58 Please state how much you agree or disagree with the following statement:
"The support and education I received regarding the introduction of solid foods was culturally safe and appropriate"
Strongly disagree
Somewhat disagree
Neither agree nor disagree
Somewhat agree
Strongly agree
I didn't receive any education
Don't know

Q59 What could be improved about the support and education you received about the introduction of solid foods?

_____

Q60 What helped/facilitated you the most with introducing solid foods to your baby/pēpi?

_____

Q61 What were/are your main challenges to introducing solid foods to your baby/pēpi?

_____

End of Block: Introduction to solid foods