Determining the Validity and Reproducibility of a Feeding Assessment Tool to Assess Complementary Food Group Intake in New Zealand infants aged 9-12 months

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Abstract

Background: Collection of information that reflects the dietary intake of infants is challenging. Food frequency questionnaires are commonly used to assess habitual dietary intake, as they are quick and easy to administer. Food frequency questionnaires are used within many studies to assess this aspect of an infant's diet, yet very few have been validated.

Objectives: This study aimed to investigate the relative validity and reproducibility of a complementary food questionnaire designed to assess food group intake in infants aged 9-12 months.

Methods: Participants were a convenience sample of caregivers of infants aged 9-12 months who completed the complementary food questionnaire (CFQ) at baseline (CFQ-1) and four weeks later (CFQ-2) to assess reproducibility. A 4-day weighed food record (4DWFR) was completed between these assessments to determine the validity of CFQ-1. Foods appearing in the 4DWFR were classified into the same 49 food items as the CFQ. Foods from both the 4DWFR and the CFQ were further classified into main food groups (breads and cereals; fruits; vegetables; dairy products; meat and protein; and occasional foods). Agreement between the two methods for intake of main food groups (frequency and grams eaten) was assessed using paired t-tests, correlation coefficients, cross-classification, the weighted κ statistic and Bland and Altman analysis.

Results: For grams of food groups consumed, validity correlations ranged from 0.15 (fruit) to 0.65 (vegetables), with an average correlation of 0.36. Correlations were significant for all food groups with the exception of fruit. Correct classification into the same tertile from the CFQ-1 and 4DWFR ranged from 38.7% (vegetables) to 65.2% (breads and cereals). Misclassification into opposite tertiles ranged from 2.0% (occasional foods) to 16.3% (vegetables). Reproducibility correlations were significant for all six food groups and ranged from 0.37 (fruit) to 0.84 (occasional foods), with an average correlation of 0.58. When comparing CFQ-1 and CFQ-2, participants correctly classified into the same tertile ranged from 48.9% (meat and protein) to 72.6% (breads and cereals). Misclassification ranged from 3.9% (breads and cereals) to 11.8% (meat and protein).

Conclusion: The feeding assessment tool appears to have reasonable validity and good reproducibility for assessing complementary food group intake in infants aged 9-12 months. The CFQ could be used in future research as a simple way to assess complementary food group intake, where it is not feasible or appropriate to employ weighed food records.

Keywords: assessment; diet; infant; nutrition; questionnaire; valid

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Abbreviations list

24HR	Twenty-four hour recall
3DEFR	Three day estimated food record
4DWFR	Four day weighed food record
CI	Confidence Intervals
CFQ	Complementary Food Questionnaire
cm	Centimetre
DLW	Doubly labelled water
e.g.	example
EFR	Estimated food record
FFQ	Food Frequency Questionnaire
g	Gram
GUiNZ	Growing up in New Zealand
ID	Identification
k	Weighted Kappa statistic
Kg	Kilogram
LOA	Limits of Agreement
MoH	Ministry of Health
n	number
NDNS	National diet and nutrition survey
NZ	New Zealand
NZEO	New Zealand European and Others
r	Pearson's correlation coefficient
SD	Standard deviation
SFFQ	Semi-quantitative food frequency questionnaire
SPSS	Statistical Package for the Social Sciences
TBSP	Tablespoon
tsp	teaspoon
WFR	Weighed food record
WHO	World Health Organisation
>	Greater than
<	Less than

Chapter 1: Introduction

Adequate nutrition during the first 1000 days (from pregnancy to two years) can have a profound impact on a child's ability to grow, learn and thrive (Bloem, 2010). Exclusive breastfeeding of infants is recommended until 6 months of age (WHO, 2009) after which, a developmental approach to introducing appropriate complementary foods is recommended. The World Health Organisation (WHO) defines the complementary feeding period as when "breastmilk is no longer sufficient to meet the nutritional requirements of infants, and therefore other foods and liquids are needed, along with breastmilk" (WHO, 2009). Complementary feeding is needed to meet growing energy and micronutrient demands, plays an important role in social and physical development, is a key influence on growth and may influence future feeding patterns and growth trajectory. The New Zealand Ministry of Health (MoH) adopted the WHO recommendations for exclusive breastfeeding in 2008, as did many other countries worldwide (Ministry of Health 2008).

Breastmilk continues to be an important component of an infant's diet after the sixth month of life providing essential nutrients. However, infants require additional sources of key nutrients such as energy and iron, from complementary foods, as the infants nutrient stores begin to deplete (Brown, Dewey, & Allen, 1998). The World Health Organisation defines a complementary food as "any non-breastmilk foods or nutritive liquids that are given to young children during this period" and complementary feeding is defined as "the process of introducing these foods" (WHO, 2003). In many Western countries and in New Zealand (NZ) complementary feeding or complementary foods is often thought of as 'starting solids' or 'solid foods'. During the complementary feeding period, breastmilk provides <50% of an infant's high nutrient requirements for iron, zinc, calcium, thiamine and riboflavin (WHO, 2003). At this time, a variety of complementary foods with a high nutrient density should be provided as snacks and meals, as only a varied diet is likely to supply adequate micronutrients (Brown et al., 1998).

'Growing up in New Zealand (GUiNZ)' is one of the biggest longitudinal study conducted in NZ and has assessed dietary intake (including breastmilk and complementary food intake) in 9 month old infants using a short food frequency questionnaire (FFQ). In NZ it is recommended that infants are exclusively breastfed until 6 months of age (Ministry of Health 2008) and for the majority of infants in GUiNZ,

breastfeeding was attempted, with 97% of the infants having been breastfeed at some point by nine months old (Morgan et al., 2010). However, the prevalence of exclusive breastfeeding dropped at around four months of age. Infant formula or milk, such as cow's milk was reported to have been introduced to 78% of infants at a median age of 3 months. Furthermore, pasteurised or bottled cow's milk had been consumed as a drink by a small percentage of infants (2%). However, few infants received exclusive breastfeeding for the first 6 months of life, with infant formula or milk introduced to 78% at a median age of 3 months. Even though MoH guidelines state that infants not receiving breastmilk should be fed infant formula, and cow's milk should not be introduced as a drink until after the infant's first birthday, as it may increase the risk of depleted iron stores (Ministry of Health 2008), though 2% had received cow's milk.

The New Zealand Ministry of Health Food and Nutrition Guidelines for Healthy Infants and Toddlers (Aged 0-2) recommend that infants should consume a varied food intake from each of the four major food groups (fruit and vegetables; breads and cereals; milk and milk products and meat and poultry), and choose drinks or snacks that are low in salt and have little added sugar (limiting intake of high-sugar foods) (Ministry of Health 2008). However, no guidance is given to parents regarding the number or sizes of servings. This is due to breast milk or infant formula being the primary energy and nutrient source for infants until 12 months of age.

A short FFQ was used in the 'Growing up in NZ' study looking at dietary intake when the infants were nine months old. By this age, infants had consumed a wide variety of foods. The most common first solid food was baby rice, followed by fruit and vegetables. Thereafter, infants were gradually introduced to foods such as meat, bread or toast, milk puddings, rice pudding, yoghurt or custard, and infant breakfast cereal. By 9 months, most of these foods were part of the infants' regular diet. Occasional foods, such as sweets, chocolate, hot chips or potato chips had been eaten at least once by 53% of infants, though few infants consumed these on a daily basis (Morton, 2012).

Other studies in the New Zealand have reported that the length of breastfeeding in infants is inadequate (Heath, Tuttle, Simons, Cleghorn, & Parnell, 2002). Additionally, complementary foods are being introduced at around 4 months of age (Ford, Schluter, & Mitchell, 1995; Grant et al., 2005; Heath et al., 2002; Soh et al., 2002; Wham, 1996), and that infants are being introduced to cow's milk and other unsuitable foods, such as regular breakfast cereals and sweet or salty snacks, prior to 12 months of age (Grant et al., 2005). However, these studies were mostly based on small regional samples.

Assessing food intake in infants is important to gain insight about types of foods and nutrients consumed. However, reliable assessment of food intake has been difficult as there are few validated dietary assessment tools for use in the infant population. Currently, only ten have been validated in infants (Andersen, Lande, Arsky, & Trygg, 2003; Bogle et al., 2001; Gondolf, Tetens, Hills, Michaelsen, & Trolle, 2012; Harbottle & Duggan, 1993; Horst, Obermann-De Boer, & Kromhout, 1988; Lanigan, Wells, Lawson, & Lucas, 2001; Marriott et al., 2008; Marshall, Gilmore, Broffitt, Levy, & Stumbo, 2003; Vähätalo et al., 2006; Williams & Innis, 2005), while none have assessed reproducibility. Previous studies have assessed dietary intake in infants by focusing on specific nutrients (Carlson & Ziegler, 1997; Devaney, Ziegler, Pac, Karwe, & Barr, 2004; Lioret, McNaughton, Spence, Crawford, & Campbell, 2013). Research in New Zealand toddlers have shown a high prevalence of suboptimal iron and zinc status (Morgan et al., 2010; Soh et al., 2002). Currently, there are very limited data available on the intake of nutrients or quality of diets of infants in New Zealand.

There are a number of challenges in assessing food intake in infants, such as reliance on parents (or caregivers) for information, rapid changes in diet and food wastage. An additional challenge, though not specific to dietary assessment in the infant age group, is the estimation of portion size. As the infant begins consuming solid foods, collecting portion size information on the small quantities consumed can be difficult. It is well known that portion size is notoriously difficult to estimate, and is commonly recognized to be the greatest source of error in dietary assessment (Willett, 2013). Across each developmental stage of the life cycle, it is important to use valid and reliable tools to assess diet quality and nutrient intakes.

When infants first start complementary foods only small, amounts are provided, gradually increasing in variety and amounts. Therefore, it is important that validated dietary assessment methods are able to accurately measure food and nutrients intakes. There are many different methods of dietary assessment available for different population groups, and even in the infant population group, these same methods can be applied. Food frequency questionnaires (FFQ) are relatively inexpensive, have a low respondent burden and assess past usual dietary intake. However, current FFQs developed and validated have focused on the adult population, with more recent studies developing questionnaires specific to older children and adolescents. Recently, the development of FFQs has expanded to the toddler population, whereby either the FFQ has to be developed from scratch or an already available FFQ needs to be modified and revalidated. Here in New Zealand, a multi-nutrient Food Frequency Questionnaire (FFQ) developed for infants aged 12-24 months showed food relative validity and high reproducibility (Watson et al., 2015). Although we have data representative of the infant population group from the 'Growing up in NZ' study on complementary food

intakes, the FFQ used was not validated. There are very few FFQs that have been validated in infants younger than 12 months (Andersen et al., 2003; Gondolf et al., 2012; Horst et al., 1988; Marriott et al., 2008; Vähätalo et al., 2006) and none for the New Zealand population.

Many FFQs are designed to assess dietary intakes over an extended time period, ranging from weeks, months to years. As complementary foods are introduced to an infants' diet not only does the variety of foods included expand rapidly, but also the amounts. Thus, increasing the difficulty associated with assessing an FFQs reproducibility. Therefore, in the infant population group it may be more appropriate to assess dietary intakes over shorter periods of time i.e. days to weeks to be able to account for the rapid changes in dietary intakes.

Often dietary assessment methods including FFQs can be developed for one population group and adapted for use in a different population group. For infants this would include consideration of breastmilk, infant formulas, types of foods consumed and the smaller quantity consumed. To our knowledge, there is no feeding assessment tool that has been validated for New Zealand infants in the first year. This study aimed to determine the relative validity and reproducibility of a Complementary Food Questionnaire (CFQ) component of a feeding assessment tool against a 4-day weighed food record.

1.1 Purpose of the study

This study aimed to validate a tool investigating complementary foods in infants that can be used where it is not feasible or appropriate to employ weighed food records. Currently there is no tool available in the New Zealand for the infant population that has been tested for relative validity and reproducibility. Therefore, the purpose of this study is to validate a short complementary food questionnaire as part of a feeding assessment tool that can be used in future research to assess complementary food intake in infants.

1.2 Aims and objectives

Aims

- To determine the relative validity and reproducibility of the CFQ component of an infant feeding assessment tool to assess complementary food group intakes in infants 9-12 months old.

Objectives

- To validate the feeding assessment tool CFQ component against a 4-day weighed food record.
- To assess the reproducibility of the feeding assessment tool CFQ component by having mothers complete the CFQ on two occasions four weeks apart.

1.3 Thesis structure

Chapter one, the introduction, sets the scene and outlines the aims and objectives, and justification for the study. Chapter two reviews the literature on current feeding practices in infants, dietary assessment methods and validation of dietary assessment tools. Chapter three reviews current validated dietary assessment methods for infants between six to less than twelve months of age, and is presented as a manuscript for publication. Chapter four presents the results of the validation and reproducibility studies, and is also presented as a manuscript for publication. Finally, chapter five discusses how the findings of this study relate to the current level of knowledge within this field and how they contribute to wider scientific knowledge. Based on the findings from the study, suggestions are made for use in future research. Supplementary appendices include a study protocol outline, questionnaires used in the study and additional supplementary results not included in the manuscripts.

1.4 Contribution of researchers

Table 1.1 Contribution of researchers to the study

Researcher:	**Contribution to the Research:**
Ashleigh Jackson MSc Nutrition & Dietetic Student	Responsible for writing research proposal, all aspects of recruitment, assisting with ethics application, administration of the questionnaire, weighed food record, statistical analysis, and editing and final preparation of thesis manuscript.
Dr. Cath Conlon Primary Academic Supervisor	Supervision of the progression of the research process through to final thesis including assistance with designing of research and development of questionnaires and protocols. Assistance with ethics application and finalizing of chapters and manuscripts.
Dr. Kathryn Beck Academic Co-supervisor	Assisting with dietary assessment, advising on dietary assessment methods and assisting with statistical analysis. Assisted in the editing and final preparation of thesis chapters and manuscripts.
Dr. Chris McKinlay Professional supervisor	Neonatologist. Providing assistance with research protocols and development of the questionnaire. Assisted in the editing and final preparation of thesis chapters and manuscripts.
Owen Mugridge	Assisting with recruitment, administration of the questionnaire and weighed food record.

Chapter 2: Literature review

2.1 Introduction

Relevant literature was found by searching the following databases: Web of Science, PubMed and Google Scholar. Search terms used were: infant, dietary intake, food intake, dietary assessment, evaluate, validity and reproducibility. Key terms were also used in combination with the two functions 'AND' 'OR'. Full text English journal articles matching search criteria between June 2015 to November 2016 were reviewed, as were relevant citing articles. This review of the literature explores several aspects related to dietary assessment in infancy, including the associations between dietary intake, health, growth and development outcomes.

2.2 Dietary intake and health in infants

In the first two years of life accurate assessment of dietary intake in conjunction with routine monitoring of growth and development helps to identify nutrition and health problems at an early stage, when corrective interventions will be most effective. An optimal diet during infancy is fundamental for infant growth, development and health in later life (Ministry of Health 2008).

In New Zealand, the Ministry of Health (MoH) has proved Food and Nutrition Guidelines (Ministry of Health 2008) that have been specifically designed for 0-2 year olds. These represent "the key principles and recommendations for feeding infants and toddlers to ensure their appropriate growth and development" (Ministry of Health 2008). The guidelines have been developed to promote optimal nutrition and feeding practices during infancy and toddlerhood. The guidelines promote exclusive breastfeeding until around the first 6-months of age at which point gradually introducing appropriate complementary foods and continuing breastfeeding until at least one year of age, or beyond is recommended (Ministry of Health 2008).

Recently, a longitudinal study conducted in New Zealand, 'Growing Up in NZ' provided data on dietary intake of New Zealand infants. Key findings from this study showed that the majority of mothers had attempted to breastfeed their infants, with 97% of the infants being ever breastfeed by nine months old. Exclusive breastfeeding, on average, stopped at around four months and by nine months' infants had been introduced to a wide range of complementary foods (Morton, 2012).

While this research does provide information on breastfeeding and dietary intake in infants in New Zealand, there is a lack of validated dietary assessment methods for use in New Zealand infants. Infants' diet rapidly change to meet their nutrient requirements which makes it difficult to get an accurate assessment of their dietary intake, with potentially large variations in nutrients intakes from one month to another. Controversy exists regarding which dietary assessment is most appropriate to use in toddlers. Many studies in infants and toddlers (0-24 months) have used weighed food records, multiple 24-hour dietary recalls or estimated food records to assess dietary intake (Fisher et al., 2008; Fox, Pac, Devaney, & Jankowski, 2004; Rockett & Colditz, 1997). From reviewing the available literature it is evident that a variety of different types of dietary assessment methods that have been validated and used in children and adult populations have been used to assess dietary intake in infants (Andersen et al., 2003; Bogle et al., 2001; Gondolf et al., 2012; Harbottle & Duggan, 1993; Horst et al., 1988; Lanigan et al., 2001; Marriott et al., 2008; Marshall et al., 2003; Vähätalo et al., 2006; Williams & Innis, 2005).

2.3 Dietary assessment methods used in infants

Since the first recorded use of dietary assessment methods in the 1920's, these methods have been refined, modified and evaluated into the forms used today (Willett & Stampfer, 1998). There are four general types of dietary methods available to collect information on food and nutrient intakes: 24-hour dietary recalls, food records or diaries, diet histories and food frequencies. It is notoriously difficult to measure food intake accurately for all age groups. Food records, weighed records or recall methods all have their strengths and weakness. These methods are reviewed below and the limitations for the infant population group are discussed.

2.3.1 Dietary assessment methods

2.3.1.1 Food record

Using a food record to measure food intake for infants has an obvious dependency on the parent (or caregiver) of the infant. Food records are collected over a specified time period, typically between 3-7 consecutive days or multiple periods within a year. Food records require the parent or caregiver to either weigh (weighed food record, WFR) or estimate (estimated food record, EFR) all foods and beverages consumed. This requires use of household kitchen scales for the WFR or in estimation in terms of household portion sizes for the EFR, ideally as the foods are consumed. Detailed descriptions including the type of food, brand name, preparation method and portion sizes are recorded for both the WFR and EFR. Currently,

collection of multiple weighed food records is considered to be the 'gold standard' method to estimate usual dietary intake (Gibson, 2005).

A major strength of this method is that, the food record does not rely on memory, particularly applicable to infants, as the parent (or caregiver) supplies all dietary intake. However, disadvantages for use of this method in the infant population include, the amount of time required to accurately complete the food record. Caregivers may consider keeping a food record too burden-some, due to frequent feedings and small amounts consumed. It also cannot be used to measure milk intake from the breast (Bingham, 1987; Dwyer, 1994; Hankin, 1992; Pao & Cypel, 1996; Patterson & Berdanier, 2002). Parents (or caregivers) who complete food records are likely to be dedicated, and highly motivated and literate and, thus may not be representative of the general population (Bingham, 1987; Dwyer, 1994; Hankin, 1992; Pao & Cypel, 1996; Patterson & Berdanier, 2002). Parents (or caregivers) are encouraged not to change their infants feeding regime as a result of keeping the food record. However, parents could consciously or unconsciously modify feeding regimes in attempt to present a perceived healthier diet. Furthermore, when the infant is in day care, other caregivers must be involved, who may undertake the task with varying levels of motivation and interest. Other factors such as illness or teething, which are common in infants, may result in the record being atypical.

Finally, estimating the exact amount of food consumed by the infant is difficult, even with extensive training and support of parents completing the food record. It is likely that as the infant begins to progress onto a range of textures and foods as feeding skills develop, food may be wasted on the plate, around or on the child. Additionally, as infants are exposed to a variety of new foods, they may take the food in their mouth and chew it before spitting it out. Measuring the amount of wasted food, even with the use of scales, can be problematic.

2.3.1.2 24-hour recall

This method involves an interviewer obtaining information on all foods and beverages consumed during the past 24-hours, the previous day or a defined 24-hour period. Recalls may be administrated face-to-face or by telephone with similar results (Bogle et al., 2001; Casey, Goolsby, Lensing, Perloff, & Bogle, 1999; Fox, Heimendinger, & Block, 1992; Morgan, Johnson, Rizek, Reese, & Stampley, 1987; Yanek, Moy, Raqueno, & Becker, 2000).

Visual portion estimation guides of age appropriate food for the infant population group, such as two dimensional or three dimensional food models, containers of common baby foods, photographs or household utensils (e.g. bowls, cups and spoons) may be useful to help parents (or caregivers) estimate quantities consumed (Bingham, 1987; Dwyer, 1994; Hankin, 1992; Pao & Cypel, 1996; Patterson & Berdanier, 2002; Yanek et al., 2000). A structured interview process assists in retrieving as much information as possible from participant and eliminates errors in data collection (Gibson, 2005). A standardised interview process has been developed and is recommended to be followed when conducting a 24-hour recall. It includes a three phase approach firstly collating a list of all foods and beverages consumed, then gathering further detailed descriptions including brands, cooking methods and portion size consumed and finally a review to ensure all foods and beverages are recorded (Gibson, 2005).

Participants completing a 24-hour recall are generally more than willing to participate and provide information to the interviewer, whereas other more demanding dietary assessment methods are subject to higher levels omission of some dietary information (Bingham, 1987). Parents are often familiar with the infants feeding routine including the amounts of foods, beverages and commercial baby foods offered, thereby, improving the accuracy of the amounts consumed.

However, the 24-hour dietary recall method has associated limitations. It can be time consuming for both the researchers, as they require adequate training, and parents (or caregivers). Additionally, the interview process may result in parents (or caregivers) omitting or adding foods to present a more desirable diet (Bingham, 1987). In the infant population group, other challenges include determining breast milk intake and gathering dietary intake information from multiple adults who may have cared for the infant during the specified 24-hour period (Bingham, 1987; Dwyer, 1994; Hankin, 1992; Pao & Cypel, 1996; Patterson & Berdanier, 2002).

2.3.1.3 Diet history

Burke originally developed the diet history method in 1947. The diet history usually starts with an interview to determine the usual meal pattern, most frequently from a 24-hour recall. Secondly, a food frequency questionnaire is completed and then finally a 3-day diet record is completed. This method combines dietary assessment methods maximizing the strengths of each method (Biro, Hulshof, Ovesen, & Amorim, 2002). Overall, the diet history method aims to ascertain an individual's intake by gathering descriptive detail and quantifiable information about specific foods and food groups. The method can include

questions about meal patterns, a list of commonly consumed foods, groups or generic foods and/or multiple days of food records (Gibson, 2005).

This method provides information on the habitual intake. However, a disadvantage for the use of this method in the infant population group is the high level of respondent burden on parents (or caregivers), which is further complicated if there are multiple carers of the infant. Furthermore, the method is unable to accurately estimate breastmilk intake. A high level of participant fatigue or boredom is likely to occur with this population group, reducing the accuracy of the data collected. Thus, the use of the diet history method for research in the infant population group is potentially not as practical as the other methods as it far from convenient and easy to complete.

2.3.1.4 Food Frequency Questionnaire

The Food Frequency Questionnaire (FFQ) is used to assess how frequently a list of food items is consumed. Participants report their usual frequency of consumption for each food over a given time period, i.e. one month (Gibson, 2005). The FFQ method is usually in a survey format and self-administered. Some FFQs also inquire about portion sizes of each food consumed or provide a list of standard portion sizes to choose from (Willett & Stampfer, 1998).

Advantages of the FFQ dietary assessment method in the infant population group is that it is relatively inexpensive, dietary food consumption considered over a week is likely to reflect typical diet, it can screen low or high consumers of different foods and can be modified or developed to focus on certain foods, such as infant formula, or foods commonly consumed only by infants (e.g. commercial baby foods). When comparing the FFQ method to other dietary assessment methods, the FFQ has the ability to assess habitual intake from a single self-administration taking between 15-30 minutes depending of number of questions (Gibson, 2005). Therefore, parents may perceive this method as less burden-some than other methods, arguably the most suitable method for large studies.

However, the FFQ has limitations, specific nutrient data and estimates of absolute intakes cannot be ascertained unless serving size is considered, it cannot be used to measure milk intake from the breast, and is subject to participants accurately reporting the frequency of consumption. Parents (or caregivers) may group similar foods together to respond to a question that asks about a series of foods or food groups (e.g. starchy vegetables, potato and kumara).

The MoH Food and Nutrition Guidelines recommends that infants should eat a variety of foods from the major food groups (Ministry of Health 2008). Therefore, use of an FFQ validated in the infant population group could be used to quickly assess whether they are consuming a wide variety of foods and from the four major food groups, rather than looking at a nutrient level.

The use of short FFQs are often used to assess dietary intake over shorter periods, aiming to capture the specific foods or food groups an individual has consumed over the specified period of time. The uniqueness of undertaking a study in the infant population group means assessing a shorter time period is preferable. Dietary intakes are rapidly changing as variety of foods increase during the introduction of more family foods. When assessing the reproducibility of the FFQ, if the time between administrations is too long, differences in the results between administrations may be due to real dietary changes, rather than a poor performance of the FFQ. Each dietary assessment method has strengths and limitations. It is important to carefully consider these in relation to the population group of interest prior to choosing a dietary assessment method.

2.4 Dietary assessment challenges in the infant population

Dietary assessment of the infant population is complex, and. it is essential to understand the challenges faced, so that error can be minimised and data interpreted correctly. These challenges are reviewed below.

2.4.1 Breastfeeding

Dietary assessment of breastfeeding is especially problematic, as it is difficult to assess breast milk intake and composition, and large variation exists between women, from day-to-day and feed-to-feed. New Zealand has a high rate of exclusive breastfeeding initiation with 94% of mothers breastfeeding upon discharge from hospital (National Breastfeeding Committee, 2009). However, breastfeeding rates decline significantly throughout the first six months post-partum (Morton, 2012). A review that investigated the validity and reliability if maternal recall of breastfeeding found that maternal recall is a valid estimate of breastfeeding initiation and duration (Li, Scanlon, & Serdula, 2005). However, this review included only seven studies conducted between 1966 and 2003, and none were conducted in the New Zealand population. The assessment of breastfeeding and breastmilk intake is beyond the scope of this thesis but has been reviewed elsewhere (Riordan & Koehn, 1997).

2.4.2 Estimating portion size and under/over-reporting

All dietary assessment methods are subject to under-reporting or miss-reporting. Over the last two-to-three decades, the prevalence of under-reporting has increased (Heitmann & Lissner, 1995; Hirvonen, Männistö, Roos, & Pietinen, 1997; Ministry of Health, 2013). Portion size estimates, regardless of age, is notoriously reported to be difficult to estimate (Willett, 2012). Inaccuracies in portion size estimation can lead to over and under-reporting, consciously or subconsciously. Over and under-reporting has been shown to occur during assessment, possibly in order to present a more favourable, healthier diet (Anderson, Must, Curtin, & Bandini, 2012). Infants are unable to report their own food intake, and therefore there is a reliance on parents or caregivers for information, which may include reports from additional carers, e.g., early childcare staff (Emmett, 2009).

In general under reporting has been shown to be less problematic in the infant population occurring only about 4% of the time (Livingstone et al., 1992). Research that has assessed the accuracy of mothers reporting their child's dietary intake showed only small differences between mother's reporting and an observers report Klesges, Klesges, Brown, and Frank (1987). Dietary recalls were collected on the same day of observation and thus may reflect less recall bias than usual. However, reporting may be less accurate when there are multiple carers throughout the day. For example, Emmett et al showed that accurately reporting an infant's dietary intake is more difficult when that infant is cared for by multiple people who are responsible for the infants dietary intake (Emmett, 2009).

In the "Growing up in New Zealand" study the main reason that children were cared for by someone other than their parent at 9 months of age was that the parent returned back to work or study (Morton, 2012). As a result, parents often do not know what their child consumes outside of the home environment (Baranowski, Sprague, Baranowski, & Harrison, 1991) and early childcare centre staff are unlikely to provide accurate reports on the many children in their care (Foster & Adamson, 2014). Therefore, gathering required dietary intake information may involve reports from multiple carers, rather than a sole caregiver, responsible for their dietary intake.

Despite this, evidence suggests that parents can reliably report their children's intake in the home environment and parental report is vital in children <8 years of age (Baranowski et al., 1991; Basch et al., 1990; Eck, Klesges, & Hanson, 1989; Klesges et al., 1987). Unfortunately, many of these studies (Baranowski et al., 1991; Basch et al., 1990; Eck et al., 1989; Klesges et al., 1987) included older children and involved

mainly well-educated parents who were present during the observations of their children's food intake and covered less than 24-hours. There is also potential for parents to report what they believe their child should eat in order to present what is perceived as a more favourable, healthier diet, rather than what they do actually eat (Anderson et al., 2012).

2.4.3 Plate wastage

As infants begin to consume complementary foods and feed themselves there can be a high plate waste and spillage, and therefore collecting portion size information on the small quantities consumed is difficult. The amount of food and drink consumed versus the amount offered at a feed must be quantified. Quantifying leftovers accurately requires an attentive parent or caregiver. One of the biggest challenges of dietary assessment in this age group is estimating or measuring the amount of food leftover. This is particularly true for the preschool age group where food may end up on the floor or soaked into clothes making it challenging for even the most diligent parent to accurately report leftovers. However, it is important that the amount of food spilled or leftover is estimated, as pre-schoolers may leave a substantial proportion of the food served to them. Analysis of the National Diet and Nutrition Survey data in the United States shows children under age 4 years left approximately 10% of all foods served to them (Gregory et al., 2000).

2.4.4 Dietary variation

When assessing dietary intake in this age group it is important to gain insight about the variety of foods consumed, however, this has been difficult to measure. Research in adults has shown that some individuals are relatively consistent in their intake of a few foods (e.g. low-fat milk) from day to day but may vary widely in their intake of other foods (e.g. watermelon or corn) (Feskanich et al., 1993). In the adult population, research has shown that variability in food intake is greater within individuals than between individuals (Nelson, Black, Morris, & Cole, 1989), signifying the diversity of foods eaten in adult life. However, in infancy the variation may be greater between individuals rather than within individuals, as dietary intake in this population group tends to be less diverse (Lanigan, Wells, Lawson, Cole, & Lucas, 2004). The benefits of breastfeeding to both the mother and infants are well documented (Ministry of Health 2008). However, the considerable variation in the content of breastmilk between women, and of the same woman from day to day, from feed to feed and during a single lactation all make the measurement of breast milk composition and infant intake challenging. Feeding frequency and duration of feeds also differs among women, making application of current dietary assessment methods difficult.

An infant's diet undergoes rapid progressive change with growth and maturation. By around 6 months of age it is recommended that parents start to introduce complementary foods to their infant. Once infants start to take solid foods a great variety of foods can be introduced. However, the amounts consumed are generally small. Over time, as infants further develop gross and fine motor skills, they move away from specially prepared mashed or softened foods and consume more family-based foods, and at some point in time, they no longer receive breastmilk. Introduction of new foods can result in variation of dietary intake from day-to-day while trialling new foods, some of which might be food that are not eaten daily. It is important to recognize the variations between infants and their developmental readiness for complementary feeding.

2.4.5 Dietary analysis of infants diets

Food Composition Tables form the basis of most dietary software programmes. Regardless of the dietary assessment method used for the study, all dietary data needs to be analysed. Analysis of dietary data will allow for investigation of specific aspects of the diet, relating to the objective and purpose of the study (e.g. macronutrients, micronutrients). A common error when conducting dietary analysis is the use of different food composition database for one dietary assessment method compared with another (e.g. Australia – AUSNUT and New Zealand FOODfiles). By using two different food composition databases, error is inflated. Whereby having the same database matches the error and has less of an impact when assessing validity. Selecting an appropriate database includes consideration of the following: using the national database ensuring the database encompasses the relevant population-specific foods and the nutrient analysis e.g. infant formula and commercial baby foods. When using a database, the latest version should be used, as the composition of foods is constantly changing, introduction of new foods and changes in the cooking methods of foods. Comparison of different databases, there is variations with what foods have been included as well as differences in the nutrient composition of some foods due to different food composition analysis methods used. In selecting a database, it is recommended to choose a database that is complete. This is because the accuracy becomes reduced if a large proportion of foods require substitutions because they are not available in the database.

2.4.6 Selecting a dietary assessment method to be used in research

When choosing an assessment method, the overall purpose and objectives of the study are key factors. Budgetary and time constraints also need to be considered, with some dietary assessment methods

imposing a higher level of researcher and participant burden than others. Willet et al believes that the rigorous procedures involved with some dietary assessment methods (e.g. food record and 24-hour recall) increases the participants perception of the level of burden (Willett, 2013).

Therefore, when conducting dietary assessment in the infant population group, there are associated challenges to contemplate. Taking into consideration these challenges is important so accurate dietary data can be collected.

2.5 Considerations when assessing the validity of a dietary assessment method

A valid dietary assessment method is one that measures what it intended to measure, i.e., it gives accurate results for the aspect of dietary intake of interest during the specified period of time. The use of non-validated dietary methods may result in inaccurate relationships between diet and disease. For research studies investigating dietary intake, a quick and easy dietary assessment method, which still provides accurate information is desirable.

To determine the accuracy of a dietary assessment method, a validation study is undertaken where a 'test' method is compared with 'reference' method. Accuracy is the degree of closeness between values of the reference and test method. However, because all assessment methods have some limitations, the relationship between the test and reference method provides information on the 'relative validity' of the method. The relative validity is unable to determine if the test method is accurate, only whether the results of the two methods are comparable.

2.5.1 Study population

All dietary assessment methods need to be validated in a sample that is representative of the intended study population. Factors such as ethnicity, sex, age and health status can influence how participants answer questions and affect the study results. Participants may alter their dietary report in order to be perceived as healthier, which may be influenced by cultural perspectives.

Dietary diversity can also be affected by socioeconomic status and ethnicity, and therefore can impact on validity (Cade, Thompson, Burley, & Warm, 2002). A diet that is quite diverse decreases the agreement, as more there is more opportunity for recall bias (e.g. consuming a wide range of foods, participants may forget less commonly consumed foods), compared with a less diverse diet (e.g. same foods

consumed from day-to-day). It is also possible that foods included may focus on a particular group of the population and this may result in the variation across subcultures within a population. Therefore, the range of foods in the tools need to be culturally appropriate.

2.5.2 Sample size and recording days required

The required sample size is influenced by statistical methods used to determine reproducibility and validity, the level of precision needed, daily variation of the nutrients of interest, required number of days for the reference method and the time period over which days are recorded. There is a difference across population groups with regard to within- and between-subject variation, which increases the difficulty in accurately assessing the number of participants required.

Cade et al 2002 suggest that Bland and Altman analysis requires a minimum of 50 participants, and ideally more than 100 (Cade, Burley, Warm, Thompson, & Margetts, 2004). For correlation coefficients, approximately 150 participants are required before there is no longer any increase in precision of the confidence intervals (CI) (Cade et al., 2002). However, it is important to note that in these sample size calculations it is presumed the 12 or more days of food intake are recorded, which is not feasible for the majority of validation studies.

In infants, smaller sample sizes may be used because of less variation in dietary intake. The number of days required to estimate usual dietary intake is influenced by the within- to between-person variation. Therefore, the number of days or recalls required to assess a particular nutrient depends on the variability of the intake of that nutrient from day to day. The greater the variance of the nutrient from day to day, the more days recording are required to be able to rank participants correctly. Children <4 years old have been shown to adjust their energy intake at successive meals, so the within-subject daily energy intake is relatively constant (Livingstone & Robson, 2000).

Research conducted by Stram et al (1995) and Willett (1998) conclude that the ideal number of days is five in majority of all situations (including validation studies and dietary assessment). Due to the high respondent burden, collecting more than five days becomes inefficient. This can result in less participants completing the study, and a higher potential of diet to be influenced by recording and an increased awareness of foods consumed may influence the participants responses to the FFQ (Willett, 2012). Collecting more than five days of dietary data in infants may decrease accuracy of data collected. This is due to the

challenges associated with assessing dietary intake in infants such as, rapid changes in diet, multiple carers and portion size estimation. Therefore, five or less days of recording in the infant population group could be applicable to reduce respondent burden and account for the rapid changes in dietary intake.

2.5.3 Reference method

To assess the validity of any dietary assessment method, it must be compared to a reference method. When deciding which reference method to use, the sources of error must be largely independent of the sources of error associated with the 'test' method. A recent systematic review of studies examining the validity of dietary assessment methods with children against doubly labelled water suggested that for younger children weighed food record provided the best estimate (Burrows, Martin, & Collins, 2010).

The main sources of error with FFQs are portion size estimation, recall of foods consumed and an incomplete list of foods on the tool. The weighed food record is the optimum method for comparison, due to having errors which are least likely correlated with the FFQ (Cade et al., 2004). Reliance on memory, errors in portion size estimation and a restricted food list are errors not associated with the weighed food record, as participants completing the food record weigh all foods and drinks at the time of consumption. However, at times it is not possible for participants to weigh food, so portion size estimation can still be an issue.

The food record dietary assessment method has a high respondent burden and often a dietary recall is used instead. This method can be useful in populations with lower levels of education, particularly those with limited literacy (Cade et al., 2002). However, use of this method in a research setting depends on time and budgetary constraints. Therefore, the food record may not be appropriate to use in some research studies. However, errors associated with the food recall include errors in portion size estimation, reliance on memory and therefore these errors are not as independent from the errors associated with the FFQ as those of the food record.

The time frame over which the days of the food record are recorded should cover the time period that the FFQ is asking about. For example, if the FFQ asks about the dietary intake over the past month (four weeks) the food record should cover four weeks, and the recording days evenly spread over that time period i.e. one day a week (Cade et al., 2002). It has been shown that consecutive days recording dietary intake is correlated. Therefore non-consecutive days provide a better representation of the true variation of the participants usual diet (Hartman et al., 1990; Thompson, Byers, & Kohlmeier, 1994).

2.5.4 Sequence of administration

When assessing the validity of a dietary assessment method, it is important to consider the sequence of administering the reference method and the test method, as one may influence the other. Normally, participants will encounter the test method independent of the reference method and the validation process should mimic this. Most validation studies use the weighed food record as the gold standard reference method. As a result of the amount of effort required to complete a food record, weighing all foods consumed, this could increase participants' awareness and therefore falsely increase the accuracy if the test method was administered afterwards. Conversely, administering the FFQ before the food record could result in falsely low associations, as the questionnaire would correlate to the dietary intake before the period assessed during the food record. Therefore, it is recommended that the FFQ is administered twice, prior to and again after the reference method is completed.

Additionally, it is important to consider the time over which both methods will be undertaken. Willett et al (1998) suggests it is appropriate to administer the test method before and after the reference method. Results can then be averaged, or one of the two FFQs completed by the participant randomly selected and compared to the reference method. Administering the FFQ both before and after reduces the disadvantages associated with solely administering the FFQ either before or after. It also allows for the reproducibility of the questionnaire to be analysed (Margetts & Nelson, 1997). To collect dietary data from any population group, it is important that a validated dietary assessment method specific to that population group is employed.

2.6 Statistical analysis of a validation study

2.6.1 Validity

There are a range of statistical techniques available to assess the validity of a dietary assessment methods compared with a reference method However, there is a lack of consensus on which technique is best (Masson et al., 2003).

2.6.1.1 Correlation coefficients

Correlation coefficient statistics are the most commonly used statistic in dietary assessment validation studies (Altman & Bland, 1983). When the data is normally distributed Pearson correlations can be used and when data cannot be normalized by log transformation Spearman rank correlations are used. Also in studies where the objective is to rank participants (e.g. by nutrient intakes) Spearman rank correlation may

be the preferred, as it is less sensitive to extreme values because of its rank order approach (Masson et al., 2003).

Correlation between the two dietary assessment methods will be reduced if there is a large within-subject variation in nutrient intakes. In order to be able to account for this, the within to between-subject variation (the variation ratio) and the number of days recorded by the reference method is used to calculate an attenuation factor. This factor can then be used to adjust the correlation (Gibson, 2005).

The use of correlations to assess validity is debated. Bland and Altman argue that because the two methods are measuring the same thing, there will usually be a strong positive correlation (Bland & Altman, 1986), and that correlation only demonstrates association, not agreements; there can be poor agreement even when there is high correlation between two methods (Serra-Majem et al., 2009). High agreement between two methods is only possible when the two methods produce very similar results. Conversely, if the test method is consistently higher or lower than the reference method (bias), high correlation can still exist (Serra-Majem et al., 2009).

The characteristics of the study population can also impact on the correlations. A high between-subject variation will result in stronger correlation than for a group with a lower between-subject variation (Altman & Bland, 1983; Willett, 1998). The range of values in the sample, which is partially determined by the sample size also affects the correlation (Cade et al., 2002); the smaller the sample the higher the correlation (MacIntyre, Venter, Vorster, & Steyn, 2001).

Therefore, the use of correlations on their own to assess validity is considered to be inappropriate (Bland & Altman, 1986; Bland & Altman, 1999; Cade et al., 2002). However, using correlations in conjunction with other methods is considered to be useful (Cade et al., 2002; Masson et al., 2003), particularly as they permit comparisons between studies (Cade et al., 2004).

2.6.1.2 Paired t-test (comparison of means)

Comparison of the nutrient means or medians of the data obtained from the two dietary assessment methods assesses the relative validity at a group level (Gibson, 2005). Depending on the distribution of the data obtained, a paired t-test or Wilcoxon's signed rank test can be used (Lee, 1980). These tests are helpful when needing to determine absolute intakes, and where differences between participants is required (Cade et al., 2002). When comparing group means, it is important to note that this provides no information

regarding the quality of the questionnaire at an individual level, or the questionnaires ability to describe the distribution of intakes (Block & Hartman, 1989).

2.7 Bland-Altman Analysis

It has been strongly advocated by Bland and Altman 1999 to use of the limits of agreement in method comparison studies (Bland & Altman, 1999). This method requires plotting for each nutrient the difference between the two methods versus the average of the two methods, and calculation of the limits of agreement and their corresponding 95% CI. From this plot, outliers are easily identified and whether there is a trend present with increasing intakes.

Bland and Altman argue this technique to be the best way to look at the agreement between two methods, and this has been recommended for use in dietary assessment studies by an international group of experts (Bland & Altman, 1986; Cade et al., 2004). However, the appropriateness of its use depends on the overall purpose of the questionnaire as this method assesses the validity of the FFQ at an individual level.

2.8 Reproducibility

Factors that are characteristic of the questionnaire can affect the reproducibility. The reproducibility of the questionnaire can be falsely increased if it contains pre-determined portion sizes or limited frequency options because this reduces the amount of variability allowed. Additionally, if there is a long period of time between the questionnaires, it is possible for real life dietary changes to occur which will affect the results (Block & Hartman, 1989; Cade et al., 2002). There is little agreement regarding the most appropriate statistics to use for assessing reproducibility (e.g. repeatability coefficient).

2.9 Agreement analysis

Cross-classification enables participants to be classified into categories (e.g. tertiles, quartiles or quintiles) based on intakes, e.g., nutrients or foods (Gibson, 2005). Participants can be ‘correctly classified’, which includes participants who were classified into the same category by the two assessment methods, expressed as a percentage. ‘Grossly misclassified’ encompasses participants who were classified into opposite categories of the two methods, also expressed as a percentage. Because correct classification of participants can occur by chance alone (Willett, 1998), the Kappa statistic is used to account for the expected number of participants correctly classified by chance (Cohen, 1968). It is suggested that the weighted kappa is used for ordinal variables, as larger differences are given greater emphasis. The category number is used for the Kappa statistic and is dependent on category weightings. A limitation to this is that with high category

numbers the potential for disagreement increases. Therefore, this would result in a lower kappa value and thus would underestimate the agreement. Comparisons with other studies will be limited as category number and weightings will differ.

2.10 Summary

This literature review discusses the challenges associated with dietary assessment using the four main dietary assessment methods (24-hour recall, food record, diet history and food frequency questionnaire). Furthermore, it highlights the importance of validating dietary assessment methods to the specific population intended to be used in, prior to use. In summary, the weighed food record is recognised as the gold-standard reference method for dietary validation studies, and several days of weighed food records should be collected to capture within-person daily variation and provide an estimate of habitual intake. The reference method used should cover the same period of time as the 'test method'. To assess the validity of methods ranking individuals into categories, correlation and cross classification can be used. However, it does not measure agreement and thus use of the Bland and Altman technique is often employed to assess the agreement between methods.

Chapter 3 Review Paper: Assessing what babies eat: A review of validated dietary assessment methods for infants from 6-12 months of age

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3.1 Abstract

Adequate nutrition during infancy and early childhood is critical for human development and influences life-long health. Accurate assessment of dietary intake among infants is important in determining the nutritional adequacy of an infant's diet in clinical practice and research.

The aim of this review is to identify and describe validated instruments for assessing usual food and nutrient intakes in infants from 6 to 12 months of age.

Web of Science, PubMed, SCOPUS and Google Scholar databases were searched for relevant articles published in English prior to November 2016 (search terms: assessment, dietary, evaluate, food intake, infant, intake, reproducibility and validity). Studies were included that assessed the validity of a dietary assessment method against another dietary assessment method (diet history, 24-hour recall, food record or food frequency questionnaire [FFQ]) in infants at 6 to 12 months of age.

Ten studies met the inclusion criteria and were included in the review. All studies reported validated dietary assessment studies which had been developed to assess overall diet in infants 6 -12 months of age. Four evaluated infant's dietary intake, four evaluated infant and toddler's dietary intake, and two evaluated infant and child's dietary intake. Dietary tools validated included food frequency questionnaires (n=5), food records (n=3), and 24-hour recalls (n=2). Studies were predominantly conducted in European and other Western countries. Validity testing revealed that FFQs and food records generally overestimated energy and nutrient intakes compared to the reference method. Overall, most studies showed good agreement between the methods However, results for the 24-hour recall were inconsistent.

Overall, there is a general lack of quick and easy dietary assessment tools assessing overall diet which have been validated in the infant (aged 6 to 12 months) population group. Further studies are needed to investigate the validity and reproducibility of different dietary assessment methods for use in infants 6-12 months.

Keywords: assessment, dietary, evaluate, food intake, infant, intake, reproducibility and validity.

3.2 Introduction

Accurate assessment of infants and young children's food intake is an important factor in determining the nutritional adequacy of an individual's diet in early life. However, collecting accurate and reliable dietary data in this population group is difficult (Livingstone & Robson, 2000).

All dietary assessment methods have limitations and associated methodological issues which may differ between different populations groups. To investigate diet in infancy there is a reliance on the parent or caregiver to provide information and accurate portion size estimates. Portion size estimates, regardless of age, is notoriously reported to be difficult to estimate (Willett, 2012). This can be complicated if multiple caregivers are responsible for the infant's dietary intake (Emmett, 2009). In addition to these challenges, over and under-reporting has been shown to occur during assessment, possibly in order to present a more favourable, healthier diet (Anderson et al., 2012). In early life dietary assessment of breastfeeding is especially problematic, as it is difficult to assess breast milk intake and large variation exists between women, from day-to-day and feed-to-feed. Additionally, as infants get older and are introduced to a range of complementary foods it can be difficult to get an accurate assessment of their habitual dietary intake.

Current recommendations are that infants should be exclusively breastfed for the first six months of life to achieve optimal growth, development and health (Ministry of Health 2008). To meet their evolving nutritional requirements after 6 months of age, infants should receive nutritionally adequate complementary foods while breastfeeding continues for up to two years of age or beyond (Willett & Stampfer, 1998). The challenges of assessing breast milk intake and accurate determination of breast milk composition have been extensively covered elsewhere (Arthur, Hartmann, & Smith, 1987).

Complementary foods aim to complement the nutrients (iron, zinc and vitamin C) and energy supplied through breast milk or infant formula to ensure appropriate growth and development. Assessment of intake in this age group is associated with many challenges. Factors to consider include; high plate waste and spillage (e.g. on the floor or on clothing) or foods chewed and subsequently spat out, introduction of many complementary foods results differing from day-to-day, some of which might be food that are not eaten daily. Small quantities are offered and may be unable to be estimated or weighed. Currently, there is no recommended serving size for food items for infants <12 months, making it difficult to determine amounts or portions accurately.

Guidelines around infant feeding from 6 months of age promote a variety of complementary foods for infants and recommend that these provide an increasing amount of energy and nutrients as the infant grows. Much controversy exists regarding which dietary assessment is most appropriate to use in infants. Although the weighed food record is considered the "Gold standard" of dietary assessment, a variety of other dietary assessment methods have been validated for use in infants including; weighed or estimated food records (Gondolf et al., 2012; Harbottle & Duggan, 1993; Lanigan et al., 2001), multiple 24-hour dietary recalls (Bogle et al., 2001; Horst et al., 1988) or food frequency questionnaires (Fisher et al., 2008; Fox et al., 2004; Rockett & Colditz, 1997). When assessing dietary intake, it is important that validated dietary assessment tools specific to the target population group are used.

Thus, this review aimed to identify and describe validated instruments for assessing usual food and nutrient intakes from complementary foods in infants 6-12 months of age. This review examines studies in which the relative or criterion validity of one dietary assessment method for complementary foods in infants is evaluated by comparisons with measurements obtained from a reference dietary assessment method.

3.3 Methods

A literature search was conducted to identify existing validated dietary assessment methods assessing overall dietary intake in infants from 6 to12 months of age. The online databases of Web of Science, PubMed, SCOPUS and Google scholar were searched for relevant articles published in English prior to November 2016. The search terms were developed and combined under the following headings: (1) infant (0-2 years), for example toddler, baby, pre-schooler and child; (2) diet, for example dietary intake, food, nutrition, food intake; (3) assessment, for example, evaluate, questionnaire, dietary assessment, validity and tool. Articles were included in the review if they were validating a dietary assessment method in infants from 6 to 12 months of age and assessed the validity of dietary assessment methods using one of the four typical dietary assessment methods (diet history, 24-hour recall, food record or FFQ) as the reference method.

3.4 Review

A total of 44 studies were retrieved and screened for inclusion and ten studies met the review inclusion criteria and were subsequently included. The main reasons for exclusion were that studies were performed in older children or adults or that studies examined dietary patterns or diet quality/indexes. The

final manuscripts reported on validated dietary assessment studies developed to assess overall diet in infants aged 6 to 12 months. Four studies evaluated infants' dietary intake (Andersen et al., 2003; Horst et al., 1988; Marriott et al., 2008; Vähätalo et al., 2006), four evaluated infant and toddlers' dietary intake (Gondolf et al., 2012; Harbottle & Duggan, 1993; Lanigan et al., 2001; Williams & Innis, 2005), and two evaluated infant and children's dietary intake (Bogle et al., 2001; Marshall et al., 2003) (Table 3.1). Studies included a range of population groups from predominantly European and other Western countries and were largely published in the early 2000's. The number of participants varied from 41 (Horst et al., 1988) to 240 (Marshall et al., 2003).

Table 3.1 summarises participants, test and reference dietary assessment methods, study design and key findings of each study.

3.4.1 Dietary assessment methods and testing

Across the validation studies included in this review, a range of test dietary assessment methods and reference dietary assessment methods were used. Test methods included FFQs in five studies (Andersen et al., 2003; Marriott et al., 2008; Marshall et al., 2003; Vähätalo et al., 2006; Williams & Innis, 2005), food records in three studies (Gondolf et al., 2012; Harbottle & Duggan, 1993; Lanigan et al., 2001) and 24-hour recalls in two studies (Bogle et al., 2001; Horst et al., 1988). The average FFQ length was 79 items (range 10-191), with two tools containing less than 20 items (Marshall et al., 2003). For the FFQ, the reference period for recalling foods varied from the past week (Marriott et al., 2008; Marshall et al., 2003), two weeks (Andersen et al., 2003; Williams & Innis, 2005) or month (Vähätalo et al., 2006). For the food record, assessment occurred over four (Harbottle & Duggan, 1993), five (Lanigan et al., 2001) or seven days (Gondolf et al., 2012). Repeat 24-hour recalls were either collected on the same day (Horst et al., 1988) or the following day (Bogle et al., 2001) for 24-hour recall tools.

Of the ten studies reviewed, four reported nutrient intake as their main outcome measure (Andersen et al., 2003; Gondolf et al., 2012; Lanigan et al., 2001), one reported only energy intake (Harbottle & Duggan, 1993), three reported both energy and nutrient intakes (Bogle et al., 2001; Horst et al., 1988; Marriott et al., 2008), one reported on food groups and dietary compliance with intervention (Vähätalo et al., 2006) and one reported only diet quality (Marshall et al., 2003).

A range of statistical methods were used to assess validity were reported. Validity was most commonly assessed using correlation (Andersen et al., 2003; Horst et al., 1988; Lanigan et al., 2001; Marriott et al., 2008; Marshall et al., 2003; Williams & Innis, 2005), but two studies also reported agreement statistics

(Andersen et al., 2003; Marriott et al., 2008). Validity was also assessed by Bland-Altman technique (Gondolf et al., 2012; Lanigan et al., 2001), weighted Kappa statistic (Vähätalo et al., 2006) and unpaired t-test and linear regression (Bogle et al., 2001). Three of the included studies looked at cross-classification (Andersen et al., 2003; Marshall et al., 2003; Vähätalo et al., 2006). Of the three studies assessing energy, two adjusted for energy intake (Andersen et al., 2003; Marriott et al., 2008).

3.4.1.1 Food frequency questionnaires

The studies investigating the validity of an FFQ assessed foods, energy and/or nutrient intake and beverage intake. Two studies looked at foods, energy and nutrients, one looked at energy and nutrients, one looked at foods and nutrients and one looked at nutrients and beverages. Two of the studies assessed the validity of interviewer administered FFQs for measuring the intake of infants (Marriott et al., 2008; Vähätalo et al., 2006). The other studies used self-administered FFQs completed by the parent or caregiver of the infant (Marshall et al., 2003; Williams & Innis, 2005). All five were evaluated for validity, using a variety of reference methods including 4-day weighed food record (WFR) (Marriott et al., 2008) or 7 day WFR (Andersen et al., 2003), two 48 hour recalls (Vähätalo et al., 2006), 3 day estimated food record (3DEFR) (Marshall et al., 2003), (Williams & Innis, 2005), One study also used biomarkers.

Of the five studies that validated FFQs, three analysed energy, all of which showed that energy was overestimated, regardless of the reference method used (Andersen et al., 2003; Marriott et al., 2008; Williams & Innis, 2005). These studies included assessment of breastmilk intake, and it is possible that the overestimation resulted from methodological issues around assessment of breastmilk rather than from the foods. One study compared intakes between breastfed infants and formula fed infants, and found that there was less agreement between the two methods in the breastfed group (Marriott et al., 2008).

Two studies showed low to moderate correlations for nutrients and energy, which were slightly higher when energy adjusted (Andersen et al., 2003; Marriott et al., 2008). Three studies looked at cross-classification (Andersen et al., 2003; Marshall et al., 2003; Vähätalo et al., 2006), and the rate of correct classification into the same quartiles was high for all studies. For most nutrient intakes, Bland-Altman plots showed positive bias (Marriott et al., 2008), increasing bias with increasing intake (Andersen et al., 2003) and large limits of agreement (Andersen et al., 2003). One study looking at micronutrient intake using biomarkers as a reference method showed poor correlations with all intakes of nutrients and foods (Williams & Innis, 2005). Correlations for FFQs assessing beverages (including breastmilk, formula and other fluids) tended to

indicate very good agreement (6 months: 0.82 to 0.95, 12 months: 0.83 to 0.99 (Marshall et al., 2003). The correlations for nutrients and food items tended to have a wide range, with the correlations for food items being similar or slightly higher than those for nutrients. Overall, validity testing revealed that FFQs generally overestimate energy and nutrient intakes compared to the selected reference method. None of these five studies evaluated reproducibility of FFQs.

3.4.1.2 Food records

The validity of food records for assessment of energy and nutrient intake in infants was examined in three studies (Gondolf et al., 2012; Harbottle & Duggan, 1993; Lanigan et al., 2001),, including an estimated food record (Lanigan et al., 2001), weighed food record (Harbottle & Duggan, 1993) and a pre-coded food record (Gondolf et al., 2012). The recording period for the test method was four (Harbottle & Duggan, 1993), five (Lanigan et al., 2001) or seven days (Gondolf et al., 2012). Reference methods included doubled labelled water (DLW) combined with either an estimated food record (Lanigan et al., 2001) or 7 day weighed food record (Gondolf et al., 2012) or diet history (Harbottle & Duggan, 1993).

Weighed and estimated food records overestimated energy expenditure by 7% compared to the DLW. However, it was found that neither the estimated food record nor weighed food record was less accurate than the other (Lanigan et al., 2004). Gondolf et al (2012) found that the food record greatly overestimated energy intake by 24% ($p=<0.001$) compared with the metabolisable energy intake assessed by DLW. However, Harbottle et al (1993) found that the diet history method overestimated energy and nutrient intake compared with the weighed food records (7% energy, 9% protein, 3% fat; 9% iron and 6% vitamin C) (Harbottle & Duggan, 1993).

In summary, food records generally overestimated energy and nutrient intake compared to the selected reference method (weighed food record and DLW (Gondolf et al., 2012; Lanigan et al., 2001) or diet history method (Harbottle & Duggan, 1993)). None of the three studies assessed the reproducibility of the food record.

3.4.1.3 24-hour food recall

The validity of the 24-hour food recall for assessing intake in infants was examined in two studies (Bogle et al., 2001; Horst et al., 1988) (Table 3.1). For both studies a complete 24-hour recall was assessed and the reference period of the food recall and the validation standard coincided. The reference method

between the two studies differed, making comparisons difficult. Food recalls were compared with collection of duplicate portions (Horst et al., 1988) and telephone 24-hour recalls with a face-to-face 24-hour recall interview (Bogle et al., 2001). The dietary recalls were obtained from parents or primary caregivers.

The results were inconsistent, one study reported significant overestimation of energy and nutrient intake when compared with duplicate portion (Horst et al., 1988), while the other adequately described energy and nutrient intake when compared to a face-to face 24-hour recall (Bogle et al., 2001). Horst et al also found that the 24-hour recall significantly overestimated the amount (weight) of infant formula, fruit and cooked dishes such as meat, potatoes, eggs and vegetables. This may suggest that for infants there could be a similar difference exists between both methods. However, Bogle et al found there were no significant differences in mean energy intake and nutrient intake between the telephone and in-person 24-hour recalls (171kcal vs 143kcal p = 0.1), (Bogle et al., 2001).

3.5 Discussion

Overall, few tools have been validated in the infant population. The review identified 10 papers reporting on 10 validated dietary assessment methods assessing overall diet in infants <1 year (n=6, infants; n=4, infant and toddlers; n=2 infant and child). Of the 10 studies included, none were tested for reproducibility. The reproducibility of these dietary assessment tools is unknown. The majority of studies relied on only correlations to assess the association between the two methods. However, there is debate about the use of correlations to assess validity. Bland and Altman argue that because the two methods are measuring the same thing, positive correlation is expected (Bland & Altman, 1986). In other words, that correlations does not indicate agreement. Therefore, correlations should not be used alone but along with agreement measures such as Bland-Altman analysis and kappa statistic (Bland & Altman, 1986). Between 6 to 12 months, infants' diets are rapidly changing as they are introduced to new foods throughout this time, with toddlers transitioning to more family foods. Therefore, tools developed will be different for different age groups to take into consideration these changes. To assess reproducibility in older population groups duration between administrations of the repeat questionnaire is normally longer to capture habitual intake and minimize memory of first administration answers. As it is necessary to adapt dietary assessment methods for specific populations the period of time between first and second administration of a dietary assessment method is likely to be shorter in the infant population to account for the rapid dietary changes. A shorter duration between administrations will be a limiting factor when determining reproducibility.

The authors of the studies assessing the validity of the FFQ method generally commented that difficulty reporting portion sizes, resulted in either over and under-reporting. The inaccuracies in reporting dietary data was the main cause for overestimation of energy and nutrient intakes. Portion size guides such as typical household measuring cups and spoons or pictures were provided to participants to assist with portion size estimation. However, due to the relatively small amount of food offered to the infant, rapid dietary changes and spillage, parents and caregivers may still find it difficult to estimate. Serving sizes for foods are often based on commonly consumed amounts such as two slices of bread, one apple or one egg. However, these serving sizes are usually relevant to the adult population and many guidelines do not have a standardised serving size for infants. In one study, a blank box was provided for recording portion sizes other than those stated (Williams & Innis, 2005). It has been shown in adult studies that validity is increased when participants have the opportunity to describe their portion size (Cade et al., 2004). Other possible explanations for overestimation include the differences in time period, sequence of administration, as the one method may influence the answers of the other method, as well as the reference method.

Out of the ten included, five studies had 100 or more participants (Harbottle & Duggan, 1993; Marriott et al., 2008; Marshall et al., 2003; Vähätalo et al., 2006; Williams & Innis, 2005). It is recommended that validation studies have at least 50 participants, desirably more than 100 depending on the number of replicate measures of the reference period and the level of accuracy required.

Limitations commonly associated with the dietary assessment methods included in this review are similar between the methods. Therefore, influencing the findings of this review. Weighed food records, estimated food records, 24-hour recalls and food frequency questionnaires all rely on the periods of assessment being 'typical' of usual intake and are also associated with recall bias.

Overall, this review highlights the few dietary assessment methods validated for infants. Of the studies included, the majority were tested and validated in European countries and thus restricting their generalisability outside of the Europe. Therefore, there is a need for a short dietary assessment tool to be developed for use in other population groups of younger children. Future quick dietary assessment tools looking comprehensively at overall dietary intake should be developed, and tested for reproducibility and validity.

3.6 Conclusion

A key finding from this review is that there is a general lack of quick and easy dietary assessment tools assessing overall diet in the infant population group. It can be concluded that further studies are needed investigating the validity and reproducibility of different dietary assessment methods for use in infants aged between 6 to 12 months.

3.7 Conflicts of interest

The authors declare no conflict of interest.

3.8 Abbreviations

The following abbreviations are used in this manuscript:

24-h	24-hour
BM	Breastmilk
BMI	Body Mass Index
DLW	Doubly labelled water
E.g.	example
FFQ	Food Frequency Questionnaire
FD	Food diary
g	Gram
k	Weighted Kappa statistic
Kg	Kilogram
LOA	Limits of Agreement
n	number
SFA	saturated fatty acids
SFFQ	Semi-quantitative food frequency questionnaire
WFR	Weighed food record
>	Greater than
<	Less than

Table 3.1 Validated dietary assessment methods in infants <12 months

Reference (Author, year, country)	Test method	Reference method	Study population and Design	Outcomes (food, beverages, energy and/or nutrients)	Statistical methods and results	Authors' findings
(Andersen et al., 2003) **Norway**	Semi-quantitative FFQ, 140 food items. Previous 14 days' food intake. Self-administered	7-day weighed food diary (4 consecutive days, 1week interval, 3 consecutive days)	12 months, n = 64. FFQ administered to parents a week before their infant turned 12 months; 1-2 weeks later they recorded a 7-d weighed food diary.	Foods Energy Nutrients	Unadjusted Spearman's correlations (nutrients) range 0.18-0.72; energy adjusted 0.16-0.79. Spearman's correlation s (foods) range 0.28-0.83. Cross-classification of nutrients: same quartile range 22% fibre; 56% SFA.	Ability of the FFQ to rank infants according to intake of nutrients and food items was moderate.
(Marriott et al., 2008) **UK**	FFQ previous 7 days (6 months) or 28 days (12 months) intake; 34 items at 6 months (incl. 10 categories of commercial baby foods); 78 items at 12 months.	4-day weighed food diary. Duration of breastfeed was recorded	6 months, n = 50 12 months, n = 50. Food diary completed within 15 days following FFQ completion.	Energy Nutrients	Unadjusted Spearman's correlations (nutrients) range 0.39-0.86 energy adjusted 0.55-0.89.	Interviewer administered FFQ is a useful tool for energy and nutrient intakes of healthy 6 and 12 month infants

(Marshall et al., 2003) **USA**	Beverage FFQ, 10 beverages.	3-day estimated food diary	6 weeks, n = 240. Followed longitudinally for 5 years. Tools mailed to parents when children were 3, 6 and 9 weeks, and 12 months. FFQ was completed for the week preceding the 3-day food diary and returned by mail.	Nutrients Beverages	Spearman correlations; 6 months: BM 0.95, IF 0.84, cow's milk 0.86, juice/drinks 0.66, water 0.54-0.66. Cross classification: same quartile range 41-98%; 12 months BM 0.95, IF 0.84, cow's milk 0.86, juice/drinks 0.69, water 0.60, soft drinks 0.26-0.35 (liquid or powdered). Cross classification: same quartile range 44-99%	FFQ demonstrated sufficient accuracy assessing fluid intake.
(Vähätalo et al., 2006) **Finland**	Dietary interview	Two 48-h recall interviews	2-3 months, n = 50 5-6 months, n = 50. Dietary interview used at 3 and 6 month interviews containing structured questions and a short FFQ covering the past 1-month period. The two 48 h recalls were conducted during the month prior to the 3 or 6 month dietary interview	Food nutrients	Cross-classification and by Kappa analysis. 3 months; BM 98% k=0.95, study formula 96% k=0.93, food and vit D supplements % in same category range 88-100%, range k=0.52-1.0; 6 months BM 96% k=0.93, study formula 88% k=0.82, food and vit D supplements % in same category range 64-88%, range k=0.33-0.56.	The dietary interview was found to be a useful tool.

(Williams & Innis, 2005) **Canada**	Interview administered FFQ 191 foods, previous 2 weeks food intake	3-day estimated food records Biomarkers (ferritin, haemoglobin)	8-26 months, n = 148. FFQ completed 1 week before estimated food diary.	Foods Energy Nutrients	Spearman's correlations; energy 0.60, nutrients range 0.35-0.75, foods range 0.28-0.99.	FFQ showed relative validity to assess intakes of energy, iron, vitamin C and fibre. FFQ requires further development before being able to be used to assess iron intake and status in infants.
(Gondolf et al., 2012) **Denmark**	7-day pre-coded food record	7-day weighed food diary DLW	9 months, n = 35; 36 months, n = 34. Cross-over design of 7 consecutive days pre-coded food record vs 7 consecutive days weighed food diary. Randomly assigned to 1 method during one week crossing over to alternative in week 2. 1 week between methods. DLW method obtained in 9 month old infants for 7 days while undertaking 7 day pre-coded food record.	Energy Nutrients	Paired t-test and Bland Altman technique. 9 months; pre-coded food record showed mean bias of +726 kJ/day compared with metabolisable energy (DLW). Weighed food record as a reference found no between-method differences. 36 months energy intake was +586kJ/day higher in the pre-coded food record vs weighed food record.	Pre-coded food record may be a valuable tool for measuring energy, energy-yielding nutrients and food groups in 9 and 36 month old children.
(Harbottle & Duggan, 1993) **UK**	Weighed food records/inventories of 4 days (<12 months) or 5 days (>12 months)	Diet history	4-40 months, n = 117. Weighed food diary completed by mother or female family member. Field worker provided participant training in home and did monitoring visit after first 24 h of weighed FD. Diet history collected in home to validate FD	Energy	Wilcoxon's rank sum method. the differences represented 7%, 9%, 3%, 9% and 6% of the mean intakes of energy, protein, fat, iron and vitamin C respectively, and were significant for energy, protein and iron. Weighed food records significantly underestimated 2 of 5 nutrients.	Reasonable relative validity for energy intake/expenditure for both the weighed food record and diet history.

(Lanigan et al., 2001) **UK**	5-day estimated food diary	5-day weighed food diary DLW method (subset of 21 6-12 month infants)	6–12 months, n = 38 12-24 months, n = 34. Crossover design of 5 d weighed FD and 5 d estimated FD. Collection periods separated by approximately 2 weeks. DLW spot urine collected for 7 d. Randomly assigned to one method in week 1, crossing over to other method in week 2. Parents attended 3 training sessions. BM intake estimated based on duration of feed.	Energy Nutrients	Bland Altman technique (bias ± LOA) Weighed intake vs. DLW 243 kJ/day ± 1690 kJ/day. Estimated diary vs. DLW 238 kJ/day ± 1623kJ/day. Correlation between age and absolute between-method difference; energy 0.37, fat 0.38, protein 0.31 and carbohydrate 0.11.	No evidence that estimated food diary is less accurate than weighed food diary for assessing energy and nutrient sub-class intakes in groups of this age, but not appropriate for individuals
(Bogle et al., 2001) **USA**	Telephone 24-hour recall	In person 24-hour recall	0-2 years, n = 32 3-5 years, n = 28. In telephone households caregiver completed 24h recall either in person or by telephone. In non-telephone households 24 h recall completed in person or by cell phone provided by the interviewer.	Energy nutrients	Unpaired t-tests and linear regression (adjusting for gender, age and BMI). No significant difference between telephone and in-person interviews, for telephone households mean differences were -171kcal and for non-telephone households -143kcal. Findings persisted when adjusted.	Telephone surveys adequately describe energy and protein intakes for a rural, low-income population.
(Horst et al., 1988) **Netherlands**	24-hour recall	24-hour duplicate portion method	6 months, n = 41. Parents were instructed in the home to collect a duplicate portion of all foods the infant consumed in 24 h. A 24 h recall interview in home was collected the morning after duplicate portion was collected.	Foods Energy Nutrients	Unadjusted Spearman's correlation: 0.77 energy, 0.90 protein, 0.84 fat. Food groups: recall significantly overestimated amount (weight) of infant formula, fruit and cooked dishes such as meat, potatoes, eggs and vegetables	On a relative level the results of the 24-hour recall and the duplicate portion technique corresponded very well.

Abbreviations: BM breastmilk; BMI body mass index; DLW doubly labelled water; FD food diary; FFQ food frequency questionnaire; LOA Limits of Agreement; 24h 24-hour; SFA saturated fatty acid.

Chapter 4: Research Manuscript: Determining the Validity and Reproducibility of a Feeding Assessment Tool to Assess Complementary Food Group Intake in New Zealand infants aged 9 – 12 months

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4.1 Abstract

Collection of information that reflects the dietary intake of infants is challenging. Food frequency questionnaires are commonly used to assess habitual dietary intake as they are quick and easy to administer. Food frequency questionnaires are used within many studies to assess this aspect of an infant's diet, yet very few have been validated.

This study aimed to investigate the relative validity and reproducibility of a complementary food questionnaire designed to assess food group intake in infants aged 9-12 months.

Participants were a convenience sample of caregivers of infants aged 9-12 months who completed the complementary food questionnaire (CFQ) at baseline (CFQ-1) and four weeks later (CFQ-2) to assess reproducibility. A 4-day weighed food record (4DWFR) was completed between these assessments to determine the validity of CFQ-1. Foods appearing in the 4DWFR were classified into the same 49 food items as the CFQ. Foods from both the 4DWFR and the CFQ were further classified into main food groups (breads and cereals; fruits; vegetables; dairy products; meat and protein; and occasional foods). Agreement between the two methods for intake of main food groups (frequency and grams eaten) was assessed using paired t-tests, correlation coefficients, cross-classification, the weighted κ statistic and Bland and Altman analysis.

For grams of food groups consumed, validity correlations ranged from 0.15 (fruit) to 0.65 (vegetables), with an average correlation of 0.36. Correlations were significant for all food groups with the exception of fruit. Correct classification into the same tertile from the CFQ-1 and 4DWFR ranged from 38.7% (vegetables) to 65.2% (breads and cereals). Misclassification into opposite tertiles ranged from 2.0% (occasional foods) to 16.3% (vegetables). Reproducibility correlations were significant for all six food groups and ranged from 0.37 (fruit) to 0.84 (occasional foods), with an average correlation of 0.58. When comparing CFQ-1 and CFQ-2, participants correctly classified into the same tertile ranged from 48.9% (meat and protein) to 72.6% (breads and cereals). Misclassification ranged from 3.9% (breads and cereals) to 11.8% (meat and protein).

The feeding assessment tool appears to have reasonable validity and good reproducibility for assessing complementary food group intake in infants aged 9-12 months. The CFQ could be used in future research as a simple way to assess complementary food group intake, where it is not feasible or appropriate to employ weighed food records.

Keywords: assessment; diet; infant; nutrition; questionnaire; valid

4.2 Introduction

An optimal diet during infancy is fundamental for growth, development and health in later life (WHO, 2009). The World Health Organisation recommends that breastfeeding is continued until the infant is at least one year of age, or beyond (WHO, 2003). Most countries including New Zealand have adopted these recommendations (Ministry of Health 2008). In New Zealand the Ministry of Health (MoH) has developed Food and Nutrition Guidelines from birth until two years of age. The guidelines promote exclusive breastfeeding until around 6 months, and then the gradual introduction of appropriate complementary foods from around 6 months of age.

Assessing dietary intake in infants is important to gain insight regarding foods consumed, however assessing dietary intake in this age group is challenging. Reasons include, parents often being used as proxy reporters of the child's dietary intake when the infant may be being cared for by multiple people, the rapidly changing dietary habits of infants and that not all food served is consumed (Emmett, 2009).

After infants reach about six months of age, meeting their nutritional requirements through breastmilk alone is difficult (World Health Organization, 2003). Breastmilk or infant formula is advised to remain as a prominent component of an infant's diet until one year of age. However, gradually as infants get older, complementary foods displace breastmilk or infant formula. Complementary foods aim to complement the nutrients (iron, zinc and vitamin C) and energy supplied through breast milk or infant formula to ensure appropriate growth and development.

Assessing complementary food intake in this age groups has many associated challenges. Collecting accurate amounts of the small quantities is difficult and there can be high plate waste and spillage, particularly as infants begin to feed themselves, where some food are chewed and subsequently spat out. Therefore, quantifying leftovers accurately requires an attentive parent or caregiver. Introduction of many different foods results in wide variation of dietary intake from day-to-day while trialling new foods, some of which might be food that are not eaten daily. Thus, making the assessment of habitual dietary intake difficult.

Currently, there is a lack of validated tools to accurately assess either food or nutrient intakes of complementary foods of infants at this age. Much controversy exists regarding which dietary assessment is most appropriate to use in infants. Many of the studies conducted in infants and toddlers (0-24 months) have used weighed or estimated food records, or multiple 24-hour

dietary recalls to assess dietary intake (Fisher et al., 2008; Fox et al., 2004; Rockett & Colditz, 1997). However, these methods are time consuming with a high participant and researcher burden and not suitable for large cohort studies or trials.

An alternative dietary assessment method is the food frequency questionnaire (FFQ) which is relatively inexpensive, has a low respondent burden and is able to assess past usual dietary intake. Food frequency questionnaires can be adapted for use in different population groups including infants. Short food frequency questionnaires can be incorporated into feeding assessment questionnaires to provide a more detailed assessment of dietary intake in infants. Whether an FFQ is newly developed or a current FFQ is modified, it is important that the FFQ is validated in the population group for which it is intended to be used. Currently, few FFQs have been developed and validated in infants younger than 12 months of age (Fisher et al., 2008; Fox et al., 2004; Rockett & Colditz, 1997).

Recent research conducted in New Zealand as part of the 'Growing up in New Zealand (NZ)' study assessed the dietary intake in 9-month old infants using a short food frequency questionnaire (FFQ). However, as far as we are aware this FFQ has not been assessed for its validity. A study conducted by Mills et al (Mills et al., 2014), investigated the validity of a multi-nutrient FFQ in infants aged 12-24 months old living in New Zealand. Reasonable agreement was observed between the FFQ and a 5-day weighed food record. To our knowledge, there is no tool to assess complementary foods that has been validated for infants aged less than one year living in New Zealand. This study aimed to determine the relative validity and reproducibility of a complementary food questionnaire developed to assess complementary food group intake (frequency of consumption and total amount in grams) in infants aged 9-12 months.

4.3 Materials and methods

4.3.1 Participants

Participants in this validation study were parents/primary caregivers of an infant aged between 9-12 months old and were recruited from throughout New Zealand. Ethical approval was granted by the Massey University Human Ethics Committee, Auckland, New Zealand (NOR15/061), and the parent/caregiver provided written informed consent on behalf of their infant and themselves for the participation in this study.

4.3.2 Data collection

Participants were recruited using a convenience sampling method through childcare centres, newsletters and advertisements on social media. Participants completed all aspects of the study off-site and were supported via email and phone calls. Participants completed an online Complementary Food Questionnaire CFQ on two occasions approximately 4 weeks apart (to assess reproducibility). After completing the first online CFQ (CFQ-1) participants completed a 4 day weighed food record (4DWFD) to enable the validity of CFQ-1 to be assessed. The 4DWFR was then emailed or posted back to the main researcher.

At the time of completing CFQ-1, socio-demographic information was gathered using an additional questionnaire. Questions included were the relationship of the person completing the questionnaire to the infant in the study, the ethnicity of the parent/caregivers and infant, date of birth, number of children born to the parent, and gestational age at birth.

4.3.3 Complementary food questionnaire - CFQ

The CFQ was part of a Feeding Assessment Tool developed to assess infant feeding practices at 9-12 months of age. The Feeding Assessment Tool comprised four sections, which focussed on 1) growth, 2) feeding history (milk and fluids), 3) feeding history of solids and 4) current feeding (milk, fluids and solids) which incorporated the complementary food questionnaire (CFQ). However, only the CFQ component assessing current dietary intake from complementary foods (49 food items) was validated and tested for reproducibility. For each question on the CFQ, participants were asked to select the average amount of food consumed and frequency of consumption (See Appendix D).

4.3.4 Weighed food record

Parents/caregivers were asked to complete a weighed food record for four non-consecutive (See Appendix D). A recording day was described as a 24-hour period from midnight-midnight, to account for feeding during the night. When describing foods, the diary instructions asked that the parents/caregivers gave a full description of foods offered (including the name of food or drink, brand, commercial foods and cooking method). Appropriate examples were provided. For home cooked foods, parents/caregivers were asked to provide the recipe, complete with quantities, and detailed descriptions of ingredients including brand and cooking methods. Participants were asked to collect all visible leftovers and re-weigh. In the case where leftovers were unable to be weighed (e.g. soaked into clothes), participants were asked to estimate the amount of spillage.

4.3.5 Data handling – CFQ

The CFQ data was exported from SurveyMonkey into an excel spreadsheet and checked for completeness. Only those CFQs with a corresponding weighed food record were analysed for validity. For assessment of reproducibility, both CFQ-1 and CFQ-2 needed to be available. The frequency of the 49 food items reported by participants over the four days was categorised into appropriate food groups (breads and cereals; fruits; vegetables; dairy products; meat and protein; and occasional foods) and all food items within each food group were added together.

The amount of each food item consumed was listed in the CFQ as an option in metric or unit measurements (e.g. 1 slice of toast or 1 TBSP rolled oats). Both metric and unit measurements were converted into gram amounts using Foodworks 8 to provide gram estimates (see supplementary table 6). The total gram amount of each food item over four days was calculated by multiplying the 'number of times' the food item was consumed over four days by the gram amount of each food item. Gram amounts per day were calculated by dividing total gram amount by four days.

4.3.6 Data handling – Weighed food record

Foods from the food record were converted into the same food items and groups as in the CFQ. A replica spreadsheet of the SurveyMonkey export was created to use for data entry of the food record. Frequency was recorded for each food item as it appeared in the food record (e.g. a banana eaten at breakfast and lunch for each day of the food record equated to a frequency of eight times).

Weighed amounts of all foods recorded in the food record were entered into an excel spreadsheet containing the same 49 food items as the online CFQ. All total gram amounts for each food item were divided by four to provide average gram amount per day. For recipes or mixed dishes, foods were broken down into food groups (e.g., spaghetti bolognaise; pasta, mince, sauce, vegetables, oils). The average gram amount for each food item within a food group was then totalled to provide the average gram amount per day for each food group.

4.3.7 Statistical analysis

Statistical analysis was undertaken using SPSS (IBM SPSS Statistics Version 21). A p-value of <0.05 was considered to indicate statistical significance. Validity was determined by comparing CFQ-1 with the 4DWFR for frequency of food groups consumed in the past four days and daily amounts (grams) of each food group. Reproducibility was investigated by comparing CFQ-1 with CFQ-2. The relative validity and reproducibility of the CFQ for determining frequency of intake and grams of

individual food groups was first determined using paired t-tests. Effect size was calculated to assess significant differences between dietary assessments to obtain an objective measure of the effect's importance. The following formula was used: effect size $r = \sqrt{t^2}/ (t^2 + df)$ (where t = t-statistic produced by paired t-test and df=degrees of freedom. An effect size of ≥0.5 indicates a large effect, 0.3 a medium effect and 0.1 a small effect (Field, 2013).

The relative validity and reproducibility of food groups (frequency and gram amounts) were examined by Pearson correlation coefficients obtained from CFQ-1 and the 4DWFR (relative validity), and CFQ-1 and CFQ-2 (reproducibility). Correlation coefficients greater than 0.80 indicate very good agreement, between 0.61-0.80 good agreement, 0.41-0.60 moderate agreement, 0.21-0.40 fair agreement and <0.20 poor agreement (Altman 1991).

For cross-classification mean daily amounts of each food group were categorized into tertiles separately for CFQ-1, 4DWFR and CFQ-2. The proportion of participants correctly classified into the same tertiles, adjacent tertile or grossly misclassified into opposite tertiles by the CFQ-1 and 4DWFR was calculated. Additionally, the proportion of participants correctly classified into the same tertiles, adjacent tertile or grossly misclassified into opposite tertiles by the CFQ-1 and CFQ-2 was calculated. Masson's et al (2003) (Masson et al., 2003) criteria were used to assess levels of agreement (>50% participants correctly classified in the same third) and misclassification (<10% of participants classified into opposite third) between dietary assessment methods. The level of agreement between the two assessment methods was determined using the weighted κ-statistic (Altman 1991)(Altman & Bland, 1983). A weighting of one was used for participants classified into the same third by each dietary assessment method; 0.5 for adjacent thirds; and zero for opposite thirds. Values of κ greater than 0.80 indicate very good agreement, between 0.61 and 0.80 good agreement, 0.41-0.60 moderate agreement, 0.21-0.40 fair agreement and <0.20 poor agreement (Altman 1991)(Altman & Bland, 1983)

Finally, agreement between food group intake across the range of intakes was determined using the Bland and Altman method (Bland and Altman 1996) (Altman & Bland, 1983), Plots were drawn of the average of food group intakes identified from CFQ1 and the 4DWFR (x-axis) / CFQ-2 versus the average difference of food group intake from CFQ1 and 4DWFR / CFQ-2 (y-axis).

4.4 Results

4.4.1 Participant Characteristics

Forty-nine caregivers completed both CFQ-1 and the 4DWFR (validity), and 51 caregivers completed both CFQ-1 and CFQ-2, as shown in Figure 4.1.

The characteristics of the participants are outlined in Table 4.1. The majority of participants were New Zealand European and other ethnicity, and the mean ± SD age of the infants was 9.6 ± 1.3 months. For participants who did not complete the study demographic data was not available.

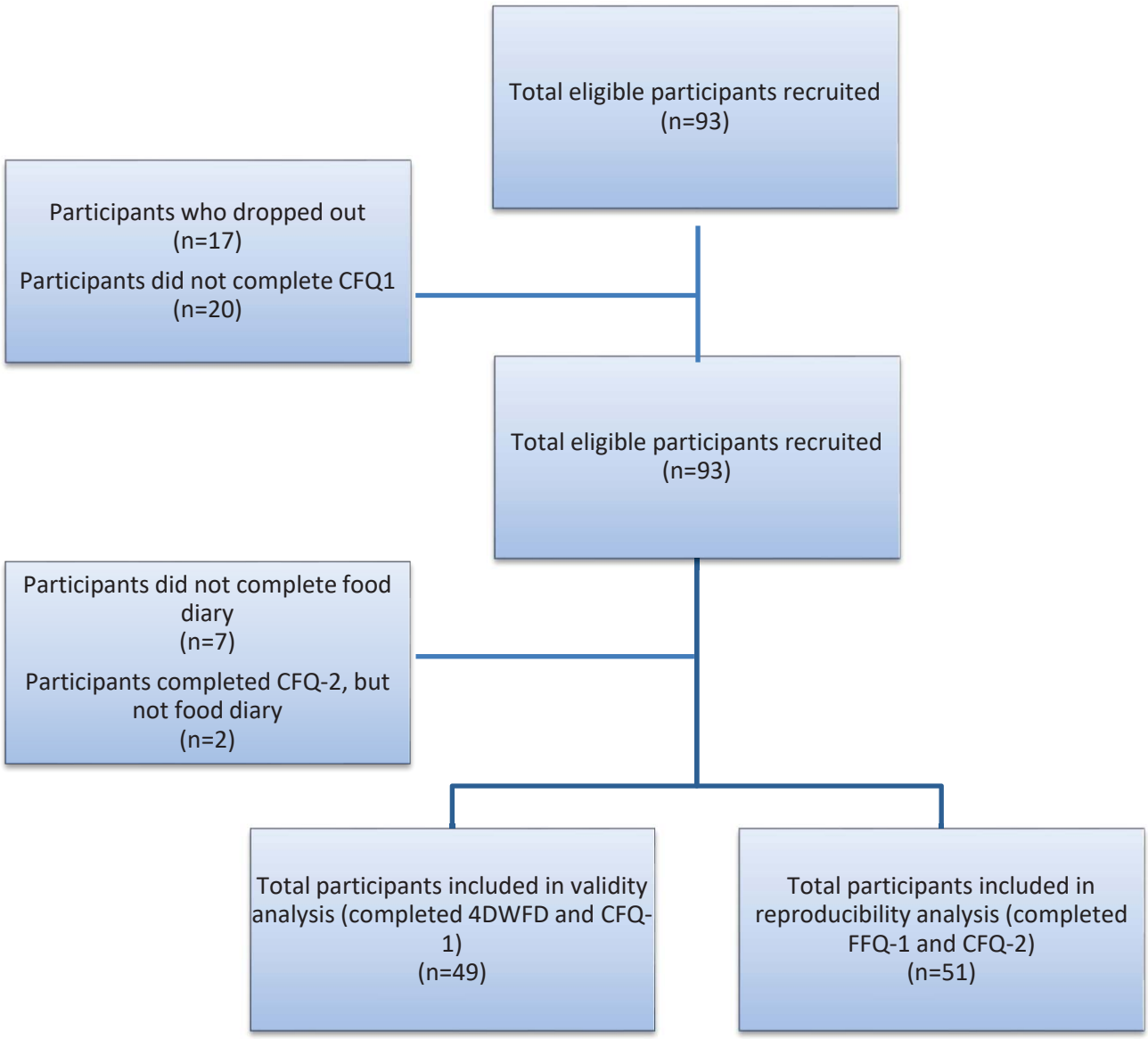


Figure 4.1 Participant flow diagram

Table 4.1 Characteristics of infants parent pairs who completed the study

Characteristics	Study Participants' [a] (n=51) Mean ± SD or n (%)
Gender of infant	
Female	24 (47.1)
Male	27 (52.9)
Age (months)	9.6±1.3
Caregiver completing CFQ	
Mother	50 (98)
Father	1 (2.0)
Length of gestation (weeks)	39.4±1.5
Ethnicity of Infant [d]	
NZEO	41 (80.5)
Asian	5 (9.8)
Māori	3 (5.9)
Ethnicity of Parent/caregiver [d]	
NZEO	42 (83.5)
Asian	5 (9.8)
Māori	2 (3.9)
Siblings	
Only child	25 (49.0)
One sibling	17 (33.3)
Two or more siblings	7 (13.7)
Breastfed at any stage	51 (100)
Still breastfeeding	
Yes	33 (64.7)
No	18 (35.3)

[a] Study participants' are those who completed at least one CFQ and the food record (two participants completed the first and second CFQ only). Abbreviations: NZEO - New Zealand European and Other.

4.4.2 Validity of the CFQ

4.4.2.1 Food group intake frequencies

The frequency of consumption over four days for each food group from the CFQ been compared with the 4DWFR is shown in supplementary results table 1. Individual food item frequencies from CFQ-1 and 4DWFR and their correlations are shown in supplementary results table 2. Food group intake frequencies from CFQ-1 were comparable to the 4DWFR, with four food groups having a mean difference in frequency of less than 0.5 times over the four days (Table 4.2). The biggest differences were observed for breads and cereals where the CFQ overestimated the frequency of bread and cereal consumption (medium effect size; p=0.03). Validity correlations were significant between methods for frequency of consumption for all food groups, ranging from 0.30 (fruit) to 0.58 (occasional foods), mean r= 0.55) (Table 4.2).

Table 4.2 Validity of CFQ for frequency of food group intake compared with WFR

Food groups (frequency over 4 days)	CFQ mean ± SD[a]	Food record mean ± SD	Mean difference ± SD	Paired t-test (p-value)	Effect size	Pearson's correlation coefficient (r)	Pearson's correlation - significance
Breads and cereals	12.1±5.5	10.2±6.1	1.9±6.2	0.03*	0.30	0.43	<0.01
Fruit	9.3±6.6	9.2±6.2	0.1±7.5	0.96		0.30	0.04
Vegetables	13.1±6.7	12.0±9.0	1.1±8.9	0.40		0.39	0.01
Dairy products	5.4±4.3	5.7±5.0	-0.3±4.4	0.63		0.56	<0.01
Meat and protein	6.0±3.4	6.1±3.9	-0.1±3.7	0.82		0.49	<0.01
Occasional foods	1.8±2.2	1.6±2.4	0.1±2.1	0.64		0.58	<0.01

[a] Mean and standard deviation
* p=<0.05, significant difference

4.4.2.2 Food group intakes amounts

Individual food item intake in gram amounts from CFQ-1 and 4DWFR and their correlations are shown in supplementary results table 4. Food group amounts from CFQ-1 were comparable to the 4DWFR. A significant difference in the amount consumed was observed for vegetables, where the CFQ overestimated the amount of vegetable consumption by 22.9±64.2g compared to the 4DWFR (medium effect size; p=0.02). Validity correlations for daily amount for all food groups

between CFQ-1 and 4DWFR ranged from 0.15 (fruit) to 0.65 (vegetables), mean 0.36. All correlations were significant with the exception of fruit (Table 4.3).

Table 4.3 Validity using comparison of daily amount of food groups consumed over four days between the CFQ-1 and the 4DWFR.

Food groups (g)	CFQ mean ± SD[a]	Food record mean ± SD	Mean difference ± SD	Paired t-test (p-value)	Effect size	Pearson's correlation coefficient (r)	Pearson's correlation - significance
Breads and cereals	75.4±59.7	59.8±61.5	15.6±71.8	0.13		0.30	0.04
Fruit	87.0±89.5	104.7±88.2	-17.7±15.8	0.29		0.15	0.30
Vegetables	89.3±84.6	66.4±60.4	22.9±64.2	0.02*	0.34	0.65	<0.01
Dairy products	64.3±77.8	60.2±88.8	4.12±98.8	0.77		0.30	0.04
Meat and protein	41.8±34.7	39.5±32.6	2.35±37.5	0.66		0.38	0.01
Occasional foods	7.6±13.9	5.34±8.4	2.30±13.4	0.23		0.37	0.01

[a] Mean and standard deviation
* p=<0.05, significant difference

4.4.2.3 Cross-classification and weighted kappa statistic validity

The percentage of correctly classified participants using tertiles ranged from 38.7% (vegetables) through to 65.2% (breads and cereals) between CFQ-1 and 4DWFR, with an average of 52.7%, as shown in Table 6. Gross misclassification between CFQ-1 and the 4DWFR ranged from 2.0% (occasional foods) to 16.3% (vegetables). In conjunction with the cross-classification analysis, the weighted k-statistic was calculated for each food group to assess the agreement between CFQ-1 and the 4DWFR. Vegetables was the only food group that had poor agreement (k= <0.20), the majority of food groups had fair to moderate agreement (k=0.21-0.6) (Table 4.4).

Table 4.4 Cross-classification and Weighted Kappa for daily amount consumed between CFQ-1 and 4DWFR (n=49)

	Cross classification		Weighted Kappa statistic
Food group	Correctly classified into same tertile (%)	Grossly misclassified (%)	
Breads and cereals	65.2	10.2	0.49
Dairy	59.1	4.1	0.49
Meat and protein	44.9	14.3	0.22
Occasional foods	53.0	2	0.44
Vegetables	38.7	16.3	0.12
Fruit	55.2	12.3	0.35

4.4.2.4 Bland-Altman Analysis

Bland-Altman plots (Appendix B.1) were constructed to assess the bias and limits of agreement between frequency of consumption and daily amount consumed for food groups from CFQ-1 and the 4DWFR. Examples of Bland-Altman plots for breads and cereals are shown in figure 4.2, with a solid line representing the mean difference between the two dietary assessment methods, and the dashed lines representing the limits of agreement (LOA = mean difference ± 2 standard deviations).

(A) (B)

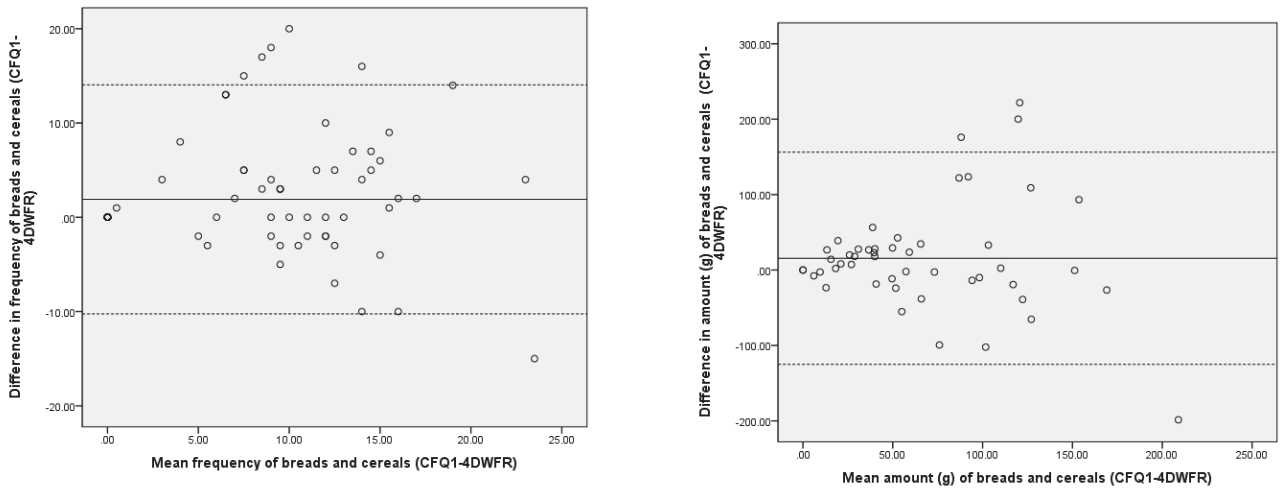


Figure 4.2 Bland-Altman plots of agreement for (A) frequency of breads and cereals and (B) mean daily amount of breads and cereals between CFQ-1 and 4DWFR.

4.4.2.5 Reproducibility of the complementary food questionnaire

Frequency of consumption over four days for each food group and the daily gram amount of each food group was compared between the first and second administration of the CFQ. Intake frequencies were similar for CFQ-1 and CFQ-2 except for vegetables with CFQ-1 estimating a difference in vegetable intake of 2.30±7.57 times consumed compared with CFQ-2. Reproducibility correlations for frequency of food groups consumed between CFQ-1 and CFQ-2, ranged from 0.32 (vegetables) to 0.73 (dairy products) (mean 0.58). All were significantly correlated (Table 4.5).

Table 4.5 Determination of reproducibility using comparison of frequency of food groups consumed over four days between CFQ-1 and CFQ-2

Food group (frequency over 4 days)	CFQ – 1[a] Mean ± SD	CFQ – 2[b] mean ± SD	Mean difference ± SD	Paired t-test (p-value)	Effect size	Pearson's correlation coefficient (r)	Pearson's correlation - significance
Breads and cereals	11.9±5.6	11.5±6.6	0.39±5.2	0.59		0.65	<0.01
Fruit	9.3±6.4	8.8±4.4	0.43±6.1	0.62		0.41	<0.01
Vegetables	13.3±6.7	11.0±6.3	2.30±7.6	0.04*	0.29	0.32	0.02
Dairy products	5.2±4.3	5.3±4.3	-0.12±3.2	0.79		0.73	<0.01
Protein	6.0±3.5	5.9±3.4	0.80±2.8	0.84		0.67	<0.01
Occasional foods	1.8±2.2	1.7±2.2	0.08±1.8	0.75		0.68	<0.01

[a] CFQ-1 was completed at baseline and [b] CFQ-2 was completed on average 4.8 weeks later (range 3.0 to 11 weeks).
* p=<0.05, significant difference

Individual food item intake amounts from CFQ-1 and CFQ-2 and their correlations are shown in supplementary results table 5. Similar daily amounts consumed were observed for CFQ-1 and CFQ-2 for all food groups. Reproducibility correlations between CFQ-1 and CFQ-2 ranged from 0.37 (fruit) to 0.84 (occasional foods) (mean 0.56), and all correlations were significant (Table 4.6).

Table 4.6 Reproducibility using comparison of daily amount of food groups consumed over four days between CFQ-1 and CFQ-2

Food group (g)	CFQ – 1[a] mean ± SD	CFQ – 2[b] mean ± SD	Mean difference ± SD	Paired t-test (p-value)	Pearson's correlation coefficient (r)	Pearson's correlation - significance
Breads and cereals	73.3±59.6	73.8±66.8	-0.52±40.8	0.93	0.80	<0.01†
Fruit	86.4±87.8	90.2±74.1	-3.9±91.4	0.76	0.37	0.01*
Vegetables	89.3±83.1	81.7±94.2	7.5±89.2	0.55	0.50	<0.01†
Dairy products	61.8±77.3	84.4±127.7	-22.6±121.3	0.19	0.38	0.01*
Protein	41.6±34.7	48.1±31.6	-6.5±31.1	0.15	0.56	<0.01†
Occasional foods	7.5±13.7	7.2±14.2	0.3±7.9	0.80	0.84	<0.01†

[a] CFQ-1 was completed at baseline and [b] CFQ-2 was completed on average 4.8 weeks later (range 3.0 to 11 weeks).
* p-value <0.05 is significant.
† p-value <0.01 is significant.

Table 4.7 Cross-classification and Weighted Kappa for daily amount consumed between CFQ-1 and CFQ-2 (n=51)

	Cross classification		Weighted Kappa statistic
Food group	Correctly classified into same tertile (%)	Grossly misclassified (%)	
Breads and cereals	72.6	3.9	0.71
Dairy	70.6	5.9	0.66
Meat and protein	48.9	11.8	0.32
Occasional foods	49.1	7.8	0.37
Vegetables	54.9	9.8	0.42
Fruit	62.7	5.9	0.56

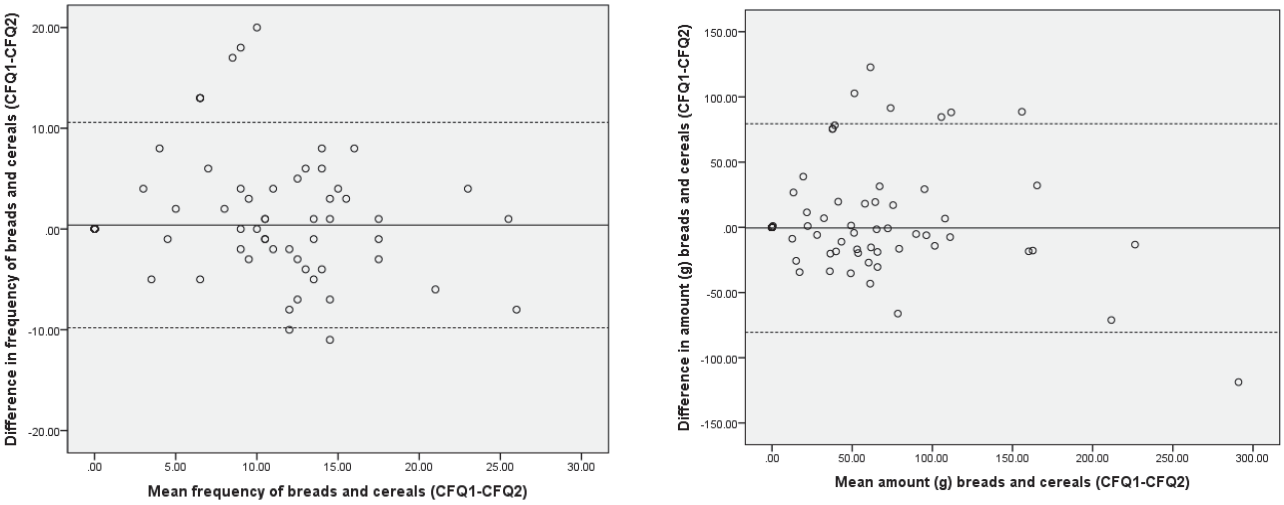
4.4.2.6 Cross-classification and weighted kappa statistic reproducibility

Correct classification between CFQ-1 and CFQ-2 for participants ranged from 48.9% (meat and protein) through to 72.6% (breads and cereals), with an average of 71.8% as shown in Table 4.7. Gross misclassification ranged from 3.9% (breads and cereals) through to 11.8% (meat and protein) between CFQ-1 and CFQ-2. The weighted k-statistic was also calculated for each food group to

assess the agreement between the CFQ-1 and CFQ-2 (Table 4.7). Meat and protein and occasional foods were the only food groups that had fair agreement (0.21-0.6), the majority of food groups had moderate to good agreement (k=0.41-0.80).

4.4.2.7 Bland-Altman Analysis

Bland-Altman plots were constructed to assess the strength of agreement between frequency of consumption and daily amount consumed for food groups from CFQ-1 and the CFQ-2. Examples of Bland-Altman plots for breads and cereals are shown in figure 4.3, with a solid line representing the mean difference between the two dietary assessment methods, and the dashed lines representing the limits of agreement (LOA = mean difference ± 2 standard deviations). The majority of the measures fell between the limits of agreement. Visually looking at the Bland-Altman plots, the difference between the CFQ and 4DWFR increased as the mean frequency and daily amounts of food group intake increased.



(A) (B)

Figure 4.3 Bland-Altman plots of agreement for (A) frequency of breads and cereals and (B) mean daily amount of breads and cereals between CFQ-1 and CFQ-

4.5 Discussion

The feeding assessment tool CFQ component was compared to a 4-day weighed food record (4DWFR) to assess relative validity of complementary food group intake in infants aged 9-12 months. Reproducibility was assessed by having participants complete the CFQ on two occasions, approximately four weeks apart. The CFQ demonstrated reasonable relative validity and good reproducibility for frequency and daily amount of food group intakes. This suggests that the feeding assessment tool CFQ is a useful tool to assess complementary food group intake in New Zealand infants 9-12 months of age.

4.5.1 Validity for food groups

Overall, the CFQ showed reasonable relative validity when compared against the 4DWFR. Validity correlations commonly range from 0.4 to 0.7 for nutrients, but may be more variable with foods/food groups because daily fluctuations in food intake are typically greater than fluctuations in nutrients (Nelson, 1997). Validity correlations in the present study for frequency of food group intake ranged from 0.30 (fruit) to 0.58 (occasional foods), with an average correlation of 0.55. Similarly, validity correlations for daily amounts of food groups in the present study ranged from 0.15 for fruit to 0.65 for vegetables (mean 0.36). The biggest mean difference in frequency was seen for breads and cereals, where the CFQ overestimated frequency. Similarly, the CFQ also overestimated daily amounts of vegetables compared to the 4DWFR. Categorisation into tertiles by food groups between the CFQ and 4DWFR ranged from 38.7% for vegetables to 65.2% for breads and cereals.

4.5.2 Reasons for poorer performance for some food groups

It is likely that the significantly higher frequency reported in the CFQ for some food groups was a result of parents overestimating intakes. Literature suggests that listing vegetables singularly rather than in groups leads to overestimation of intakes (Cade et al., 2002). The literature states that obtaining accurate reports for foods that are typically eaten alone or in mixed dishes (e.g. vegetables) is particularly difficult. It is possible that the overestimation of vegetable intake seen with CFQ-1 was as a result of parents having difficulties in reporting. In addition, over-reporting of healthy foods such as vegetables is not uncommon (Fox et al., 2004). Previous studies in infants/toddlers and young children examining the validity of food groups reported both slight overestimation and underestimation by food frequency questionnaires (FFQ) as compared with diet records (Andersen et al., 2003; Marshall et al., 2003). In adult validation studies, FFQs generally overestimate foods or food groups as compared with diet records (Erkkola et al., 2001; Rockett, Wolf, & Colditz, 1995; Salvini, 1989; Torheim et al., 2001).

A probable reason for the discrepancy between food group frequencies and amounts from the two instruments in our study may be that the parents had difficulty reporting accurately frequencies and amounts on the CFQ. Although portion sizes or servings were not specifically looked at in this study (due to no specific dietary guidelines for portion sizes or servings for this population group), other studies have cited participants difficulties with portion size estimation as a cause for lower validity correlations between questionnaires and diet records (Haraldsdottir, Tjonneland, &

Overvad, 1994; Salvini, 1989). One study conducted in New Zealand toddlers asked parents to describe portion size in terms of the child's palm volume (e.g. 'number of palms' of rice eaten) (Watson et al., 2015). Undoubtedly, one possibility is also that some of the differences simply are caused by the fact that the infants had different intakes at the time the CFQ and 4DWFR were completed.

The average validity correlation in this study for frequency of food group consumption of 0.42 for infants was comparable with or lower than similar validation studies in infants and toddler populations assessing food group intake which have been reported as 0.41 (Klohe et al., 2005) and 0.62 (Andersen et al., 2003). Compared with adult validation studies our results were comparable with or lower, presumably because of the greater variability of food intake as infants transition to complementary foods (Fox et al., 2004).

Currently, in New Zealand there are no recommended servings of each food groups for 0-2 year old infants and toddler. Many of the other studies in toddlers and older children have presented correlations comparing number of servings of each food groups between two dietary assessment methods. As servings were unable to be looked at and compared in this study, comparison of our results from the present study to other literature is limited.

Limited studies report cross-classification of intakes by food groups. In infants and young children correct classification into quartiles by food groups was 38% (Andersen et al., 2003) and 36% (Klohe et al., 2005), respectively. As tertiles were used in the present study it is difficult to compare studies. The percentage of participants grossly misclassified ranged from 2.0 to 16.3% for daily amounts between CFQ-1 and 4DWFR.

Visual inspection of the Bland-Altman plots suggests the difference between the CFQ and the 4DWFR increased as the mean increased. For frequency and amount the majority of measures fell between the limits of agreement for all food groups, indicating good agreement between the CFQ and 4DWFR.

4.5.3 Reproducibility for food groups

The frequency for which each food group was consumed over four days was not significantly different between CFQ-1 and CFQ-2, except for vegetables (eaten on 2.3 occasions more in CFQ-1 compared with CFQ-2). Lower frequencies of vegetables seen in CFQ-2 may be highlighting parents

including a wider range of complementary food groups as their infants grow. With the exception of the vegetable food group, CFQ-2 did not show significant under or overestimation compared with CFQ-1. Other studies in adults have shown significant overestimation (Erkkola et al., 2001; Flagg et al., 2000) or underestimation (Domel et al., 1994; Rockett et al., 1995; Warneke, Davis, De Moor, & Baranowski, 2001) compared with FFQ-1.

In reproducibility studies using FFQs, correlations between foods/food groups at first administration and second administration ranged from 0.29 to 0.75 (Klohe et al., 2005) In our study reproducibility correlations for frequency of food groups ranged from 0.32 (vegetables) to 0.73 (dairy) with an average correlation of r=0.58, and for gram amounts of food groups correlations ranged from 0.38 (dairy) to 0.84 (occasional foods). Our results were similar or higher than mean reproducibility correlations reported in other studies conducted in older children, which were 0.43 (Vioque et al., 2016), 0.57 (Salvini, 1989), 0.66 (Erkkola et al., 2001) and 0.75 (Ocke et al., 1997), thus, this CFQ shows good reproducibility in the infant population tested. However, there are no studies in the infant population group that have assessed reproducibility.

The higher correlations shown in this study between first and second administration may be attributable to the shorter time period between administrations (4 weeks) compared with others (months to years). As well as the CFQ and 4DWFR both focussing on the same duration (four days). In the infant population there are rapid changes in dietary intake. Therefore, as test-retest correlations diminish with time between administrations it may be inappropriate to have long periods between tests. Long durations between administrations, capturing rapid changes in dietary intake, may result in the tool being mistaken for poor performance of the questionnaire over time. However, it is important that the two administrations of a dietary assessment methods are not completed too closely together due to the possible effects of memory when completing the second administration of the FFQ.

Cross-classification between CFQ-1 and CFQ-2 was fairly good. Correct classification percentages ranged from 48.9% for meat and protein to 72.6% for breads and cereals. The percentage of participants grossly misclassified ranged from CFQ-1 and CFQ-2 ranged from 3.9 to 11.8%, but some degree of misclassification by this dietary method is inevitable. Other studies in adults have reported similar ranges for foods or food groups ranging from 0 to 23% (Erkkola et al., 2001), 0 to 4.8% (Bohlscheid-Thomas, Hoting, Boeing, & Wahrendorf, 1997), 3 to 20% (Männistö, Virtanen, Mikkonen, & Pietinen, 1996) and 5 to 9% (Torheim et al., 2001), however these studies

were in older populations and used quartiles. Visual inspection of the Bland-Altman plots suggests the difference between the CFQ-1 and the CFQ-2 increased as the mean increased. For frequency and amount the majority of measures fell between the limits of agreement for all food groups.

4.5.4 Strengths and Limitations

The present study has a number of strengths. These included the use of the gold standard reference method of a four day weighed food record, the assessment of both relative validity and reproducibility, as well as employing a range of statistical assessment methods. However, this study also has some limitations. The participant burden is high for the weighed food record. Having to weigh every food item increases participant burden, this can lead to misreporting, or selection of foods that are not as difficult to weigh. Biomarkers are often used in validation studies alongside food records due to the limitations associated with dietary assessment. This method is expensive and invasive to the participant and nutrient specific. However, biomarkers are advantageous as they are able to estimate dietary intake independently of the participants reported intake (Cade et al., 2002). As the purpose of this study was to validate the CFQ at a food group level not a nutrient level, biomarkers were not used. Further research should aim to assess the validity and reliability of the CFQ at the nutrient level.

Participants may have experienced some confusion with some of the questions (e.g. whether 'rice' included baby rice). Clarification with examples of some foods (e.g. baby cereal including baby rice) may be one way to enhance the CFQ. A major limitation to the present study is the high dropout rate. Therefore, the sample size of the present study was relatively small. However, the sample size is consistent with other validation studies using this technique (Anderson et al., 2012; Marriott et al., 2008; Marriott et al., 2009; Parrish, Marshall, Krebs, Rewers, & Norris, 2003; Wong, Parnell, Howe, Black, & Skidmore, 2013). It was unable to be determined how participants who dropped out of the study compared with those who completed the study. The participants of the study were volunteers and therefore were more likely to be motivated, possibly increasing the apparent validity and reproducibility of the CFQ. The study did not include a representative sample of the New Zealand population, and would require further investigation in Māori, Pacific and Asian populations.

4.6 Conclusions

Compared with a 4DWFR the CFQ showed reasonable relative validity and good reproducibility for complementary food groups in infants aged 9-12 months. This self administered online CFQ would be a valid tool to use in future research to assess complementary food group

intake in infants, where the use of weighed food record dietary assessment is not feasible or appropriate. Future research should aim at validating this CFQ in a larger study population, and validating this CFQ at a energy and nutrient level.

4.7 Acknowledgements

We gratefully acknowledge the contribution of all the 51 participants and their families who took part in the study.

4.8 Author contributions

Ashleigh Jackson – assisted with ethics application and approval, project leader, all aspects of recruitment, did statistical analysis editing and drafting of the manuscript. Dr Cath Conlon assisted with ethics application, supervised the progression of the research process through to the final manuscripts, including assistance with designing of the research and development of questionnaires and protocols. Dr Kathryn Beck assisted with dietary assessment methods, advising on methods and assisting with statistical analysis. Dr Chris McKinlay provision of assistance with research protocols and development of the feeding assessment tool and editing of all chapters. Owen Mudridge assistance with recruitment and administration of dietary assessment methods. All authors have reviewed the final manuscript.

4.9 Conflicts of Interest

The authors declare no conflicts of interest.

4.10 Abbreviations

The following abbreviations are used in this manuscript:

24HR	Twenty-four hour recall
3DEFR	Three day estimated food record
4DWFR	Four day weighed food record
CI	Confidence Intervals
CFQ	Complementary Food Questionnaire
cm	Centimetre
DLW	Doubly labelled water
e.g.	example
EFR	Estimated food record
FFQ	Food Frequency Questionnaire
g	Gram
GUiNZ	Growing up in New Zealand
ID	Identification
k	Weighted Kappa statistic
Kg	Kilogram
LOA	Limits of Agreement
MoH	Ministry of Health
n	number
NDNS	National diet and nutrition survey
NZ	New Zealand
NZEO	New Zealand European and Others
r	Pearson's correlation coefficient
SD	Standard deviation
SFFQ	Semi-quantitative food frequency questionnaire
SPSS	Statistical Package for the Social Sciences
TBSP	Tablespoon
tsp	teaspoon
WFR	Weighed food record
WHO	World Health Organisation

Chapter 5: Conclusions

5.1 Strengths and limitations

There are a number of challenges associated with dietary assessment, particularly in younger population groups such as the infants, where there is a reliance on a surrogate reporter. These challenges include study population, study design and reference method accuracy. Their potential effects on the results of the study are discussed in this section.

5.1.1 Choice of reference method

There is no dietary assessment method that can accurately measure usual dietary intake. The choice to use a weighed food record was due to having the least correlated errors with the CFQ which is similar to a short FFQ. Therefore, the weighed food record method was employed as the reference method in this study.

Other validation studies of FFQs in the infant population group have also used 4-day weighed food records (Gondolf et al., 2012; Harbottle & Duggan, 1993; Lanigan et al., 2001). During the recording period of the 4-day weighed food record participants were asked to maintain their infant's normal diet, in order to capture usual dietary intake. It is well known that having to weigh every food item increases the participant burden and may have resulted in modification of the infant's usual dietary intake. Conscious or unconscious modification of usual dietary habits on recording days are also likely in an attempt to present a more healthful picture, as well as, omissions or additions, especially if the food record was completed retrospectively. Although parents were asked to complete the food diary at the time of consumption this may not always have been possible. Parents or main caregivers were asked to complete the food record, however it is possible that some infants had other caregivers involved in the dietary intake on recording days, such as day care staff. Staff members might have approached the task of recording with varying levels of motivation and interest. Additionally, it is very challenging for parents to report the exact amount of food eaten by the infant. Foods may have been wasted by spillage, chewed but then spat out or absorbed into clothing. Even with using the scale to record amounts left over this is very difficult.

5.1.2 Recording days and sequence of administration

A strength of this study was the number of recording days. Research by Stram et al (1995) states that the recommended number of recording days in validation studies to be four or five. Similar to the present study, two similar studies conducted in the infant population had four or five recording days (Harbottle &

Duggan, 1993; Lanigan et al., 2004). However, as infants are introduced to a range of new foods, this can result in increased variation of dietary intake from day-to-day while trialling new foods, some of which might be food that are not eaten daily. Therefore, recording dietary intake over four days in the infant population may not capture specific foods that are not consumed daily or may not accurately represent the variety of foods consumed.

In addition, possible discrepancies between methods, which cannot be quantified, arise from inbuilt differences between the CFQ and 4DWFR: in methodology (retrospective vs prospective) and from the 4DWFR commencing after the CFQ had been completed.

5.1.3 Reproducibility

A strength of this study is that reproducibility of the feeding assessment tool was also assessed. There are currently no studies in infants that have assessed reproducibility. One study conducted in children aged 1 to 3 years assessed both validity and reproducibility. Similar to the results of this study their yielded excellent reproducibility, correlations were all significant for all food groups (9 food groups) ranging from 0.53 through to 0.84 (Klohe et al., 2005).

Specific factors of the FFQ can affect the reproducibility. The reproducibility of the FFQ can be increased if it contains pre-determined portion sizes or limited options for frequency. A limitation of the reproducibility of the current study could be a possible memory effect during completion of the second CFQ, as parents could possibly still remember what they filled in four weeks ago. However, if there is a long period of time between the questionnaires, it is possible for real life dietary changes to occur which will affect the results (Block & Hartman, 1989; Cade et al., 2002). This is especially applicable to the infant population group who have rapid dietary changes in the first 12 months

5.1.4 Statistical analysis

A strength of the study was the comprehensive statistical analysis, using a range of statistical methods; paired t-tests, correlations coefficients, cross-classification, weighted kappa statistics and Bland-Altman statistics. Literature by Cade et al recommends that to assess validity two or more statistical method should be included (Cade et al., 2002).

5.1.5 Recruitment

It is recommended for validation studies that a minimum of 50 participants is required, ideally 100-200. A major limitation to this present study is the relatively small sample size for 49 participants for validity analysis due to difficulty recruiting participants and high level of dropout. Recruitment of mothers and their infants for the specific age group was difficult due to the level of participation required and may highlight the need for a quick and simple dietary assessment tool to gather dietary data in this age group. Other limitations of this study include infants included being of the age of experiencing teething, which may have altered the types of foods consumed and/or the amounts which may not be typical of usual dietary intakes.

5.1.6 Dietary analysis of food groups

Not all foods consumed fall into a food group (e.g. sauces and spreads) and therefore there is a need for nutrient data analysis to be able to accurately estimate energy and nutrient intakes.

5.2 Recommendations for further development and future research

- Assess the validity and reproducibility of the CFQ in Māori and Pacific population groups
- Clarification of some food items within the CFQ providing examples (e.g. breakfast cereals (including cornflakes, ricies). Additional other enhancements can be found in supplementary results table 6.
- It is possible that TBSP measures may not have been appropriate or were too large for some food items. Therefore, changes to tsp, cups or unit measures for some food items may improve the accuracy of the CFQ (e.g. butter/margarine tsp, popcorn cups or eggs unit measure).
- Being more specific regarding water intake. Specification of water as a drink not including water used for making up infant formula
- Assess validity and reproducibility of the CFQ at a nutrient level.
- Assess validity and reproducibility of the CFQ for breastmilk, infant formula and other fluids.

5.3 Conclusion

To our knowledge this is the first dietary assessment tool in New Zealand that has been tested for relative validity and reproducibility to assess complementary food groups in infants aged 9 – 12 months old. A comprehensive literature review was conducted on dietary assessment tools in infants. A key finding was that there is a lack of tools that are valid and reliable in the infants aged less than 12 months.

Furthermore, none of which have been conducted in New Zealand and therefore may not be generalizable to the New Zealand infant population. This gap formed the objective of the present study, which was to investigate the relative validity and reproducibility of a complementary food questionnaire component of an infant feeding tool specifically designed to assess complementary food group intakes in infants (9-12months).

Relative validity of the complementary food questionnaire was assessed using another dietary assessment method (four day weighed food record). The relative validity of the CFQ was determined by comparing both frequency and daily amount of food group consumed from the CFQ to the 4DWFR. When compared the 4DWFR, the finding show that the CFQ had good relative validity for frequency (over four days) and the daily amounts of complementary food groups consumed and reproducibility. The complementary food questionnaire is a valid reproducible tool that could be used in future research studies to investigate complementary foods in infants aged 9 – 12 months old.

Appendices

Appendix A: Study Protocol

The preceding validation study was conducted in line with the study protocol outlined below. This study was designed to assess the validity and reproducibility of a CFQ to assess complementary food groups intakes in infants aged 9-12 months old.

The validation study design

This study is designed to develop and validate a complementary food questionnaire that against a 4-day weighed food record, to assess complementary food groups intakes intake of healthy term babies aged 9-12 months from a convenience sample in the New Zealand (Figure A.1).

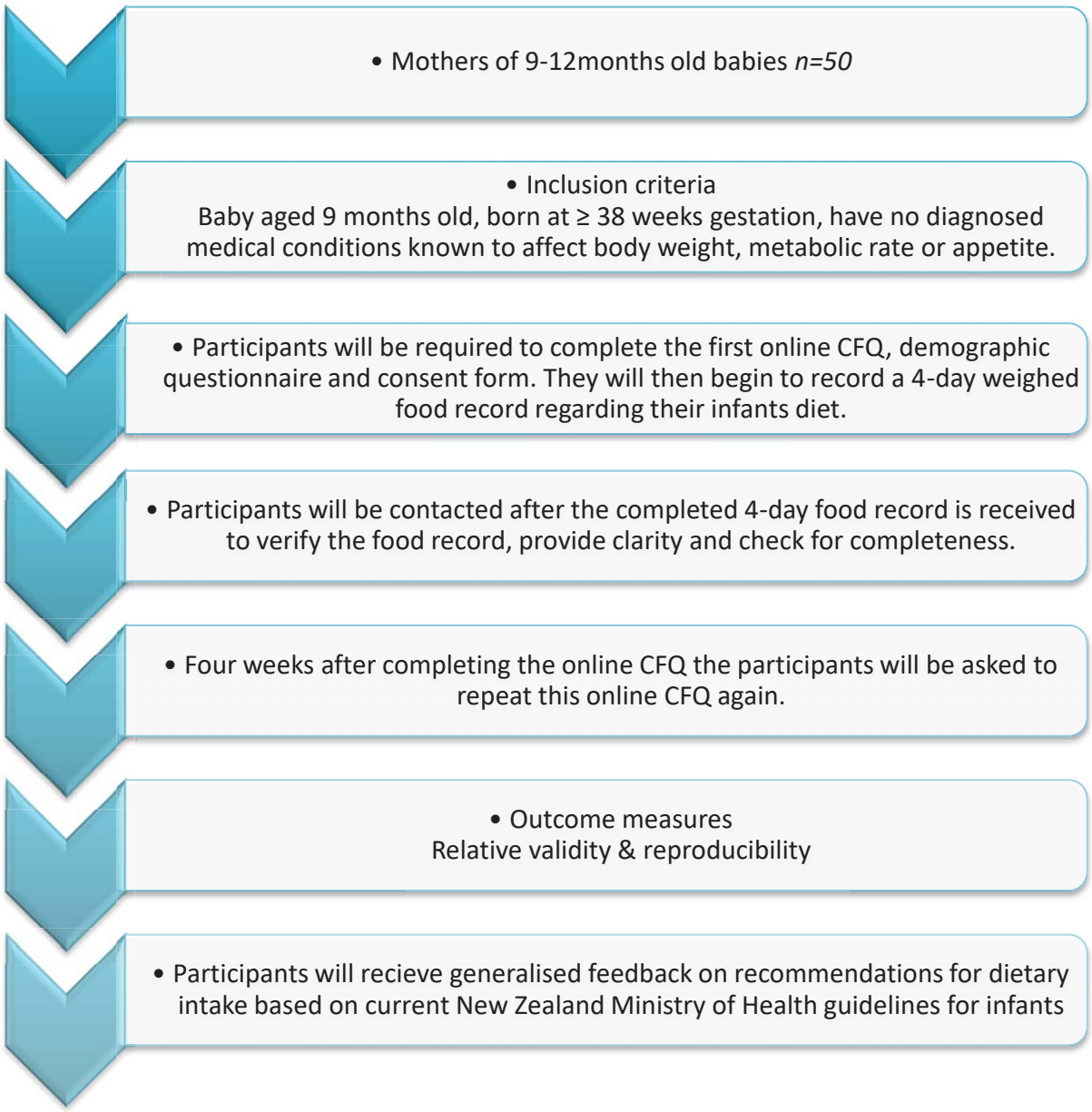


Figure A.1 Validation of a complementary food questionnaire (CFQ) against a 4 day weighed food record in 9-12 month old infants study flow diagram.

Ethical approval

This study was conducted by researchers from Department of Human Nutrition and Dietetics, Massey University. Ethical approval for this study was obtained from Massey University Human Ethics Committee, Southern A, Application NOR 15/061. Written informed consent was obtained from all participants.

Recruitment and the Study population

Based on previous validation studies, a required sample size of 50 was estimated to assess the relative validity and reproducibility of feeding questions measuring diet (Anderson et al., 2012; Marriott et al., 2008; Marriott et al., 2009; Parrish et al., 2003; Wong et al., 2013). This is further supported by Cade et al (Cade et al., 2004), whereby it is suggested that for validation study a sample size of at least 50 is recommended.

Participants were recruited from May 2016 through to October 2016, in cities throughout New Zealand. A convenience sampling method was employed using email advertisement, invitation via mail and poster advertisement in early childcare centres, newsletter and on internet webpages and social media (Facebook and Twitter). All participants received general feedback on recommendations for dietary intake based on current New Zealand Ministry of Health guidelines for infants (Wilson, 2012)

Participants were infants aged between 9 and 12 months and their primary caregivers. Participants were eligible to participate if infants were aged between 9 and 12 months old, born at >36weeks gestation and had no medical conditions.

Once parents/primary caregivers had signified their interest they received an email containing an information sheet, demographic questionnaire, and consent form and food diary. If participants preferred, they received the further information as a hard copy in the mail.

Data collection

After participants have registered interest in the study participants received a detailed information pack in the mail or via email about the study including a demographic questionnaire and a consent form. In order to be included in the study, participants were required to provide a completed and signed consent form and met the eligibility criteria Once written consent was obtained, participants were allocated a study ID number and provided with an online link to the questionnaire. Over the next two weeks participants were instructed to complete the 4-day weighed food diary as per the instructions provided. Approximately 4 weeks after completion of the first online questionnaire, participants were emailed another link to the same questionnaire to complete for a second time

Background characteristics

Before participants completed their first online CFQ they were asked to complete a demographic questionnaire containing socio-demographic questions which relate to themselves and their infant. Socio-demographic questions included the primary caregivers' age, relationship to child in the study, parity, and the caregivers and child's ethnicity. Questions relating to ethnicity were taken from the NZ census.

Feeding assessment tool - CFQ component data collection

The questionnaire was completed twice, approximately four weeks apart. Participants were emailed an online link to follow for the questionnaire on Survey Monkey; they also received another online link to the questionnaire 4 weeks later. This questionnaire was completed online and caregivers were encouraged to be honest and keep in mind their child's dietary intake over the past four weeks. For details of the contents of the questionnaire see Appendix D.

Four -day weighed food record

After participants had completed their first questionnaire, all participants received instructions on how to complete their four day weighed food record. If required, they were also provided with a set of dietary scales. The dietary scales were accurate to within ± one gram. The food diary contained written instructions on the first five pages, including examples of how to fill it out and how to use the dietary scales.

Their primary caregiver completed the infants weighed food record for four non-consecutive days, including one weekend day, over a four-week period. The 4-day weighed food record will be completed over a two-week time frame, including three non-consecutive weekdays and one weekend day. All participants received an email after the first week to check if they had any questions or concerns.

A recording day was defined as midnight to midnight. On a recording day participants were asked to weigh and record all foods and drinks consumed including water and any breastfeeds were also to be recorded. The food diary also asked participants to record details such as the time, location where food was eaten as well as the name, brand and cooking method used when preparing food.

Participants were instructed to weigh each food item individually or mixed dishes prior to offering to the infant and record the amount in their food diary. For the estimation of wastage or foods not consumed, participants will be asked to collect all leftovers or spillage and re-weigh this on a clean plate, thus providing a better representation of actual intake, or estimate if not possible (e.g. food mushed into clothing). For mixed dishes, participants will be requested to estimate the contribution of the different components to the leftovers.

For any kind of food that gets reconstituted, the participants will be instructed to weigh out the powder first and record the measured amount of liquid added, e.g. infant formula. Participants will then be asked to record the total volume offered to the infant and also the amount that is left over.

For mothers that are still breastfeeding they will be asked to record the duration and frequency of the breastfeeding episodes. The amount of breast milk consumed by the infant will then be estimated based on research findings by Dewey et al (Dewey, Finley, & Lönnerdal, 1984). For infants receiving six or more feeds per day 130mL per feed is estimated, infants receiving four to five feeds per day 101mL is estimated and infants receiving up to three feeds per day 55mL per feed is estimated. Participants will record all food and beverages consumed and were encouraged to maintain the infants' normal diet over the duration of the study.

Data entry and Nutrient calculations

Data from the demographics questionnaire and assigned study ID numbers were entered into an Excel spreadsheet (2007 Microsoft Office Corporation).

Four-day weighed food records

The 4-day weighed food records were entered into Food Works, which uses the New Zealand Food Composition Database for all foods to calculate energy and nutrient intakes. In the 4-day weighed food record, participants were asked to provide details of all ingredients for homemade recipes and either the proportion of the recipe the infant had or the gram amount. To ensure the quality of all the 4-day weighed food records, upon completion of the 4-day weighed diet record, each individual record will be checked. Where further information was required, participants were contacted via email to go through the food record and provide additional information.

Feeding Assessment tool CFQ component

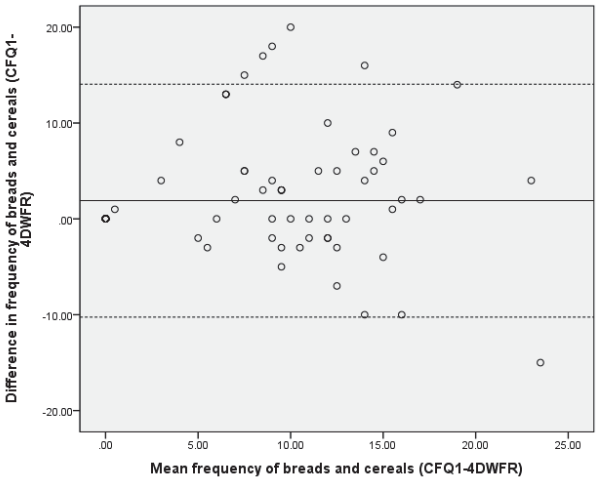
The feeding assessment tool was completed online by the infants parent or caregiver. The questionnaire comprised of sections, which looked at the following; growth, feeding history fluids and solids, feeding skills (parent fed, child fed or both) and current intake of fluids (e.g. breast milk, infant formula, soft drinks or cow's milk) and common complementary foods. The CFQ component of the tool asked about 49 food items. Portion size responses were based on metric TBSPs to account for the small portions offered.

Statistical analysis

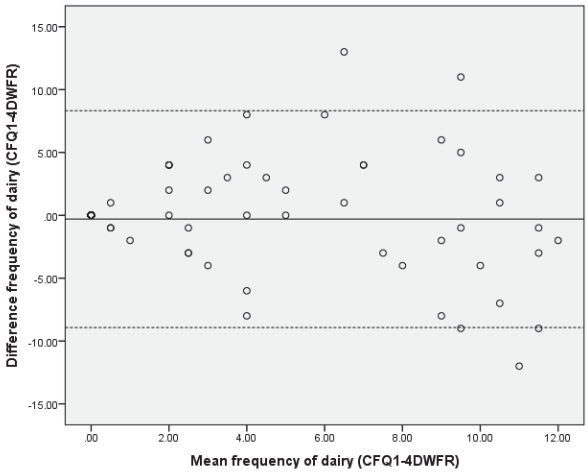
All statistical analyses were conducted using SPSS 21.0 for windows. All data was treated as normal and further statistical methods used were methods for normal data.

Relative validity of the FFQ for assessing the number of serves from each food groups was calculated by using participants first FFQ response and comparing this with the food record data. Reproducibility of the FFQ for the number of serves from each food groups was calculated by comparing participants first FFQ data with their corresponding second FFQ data.

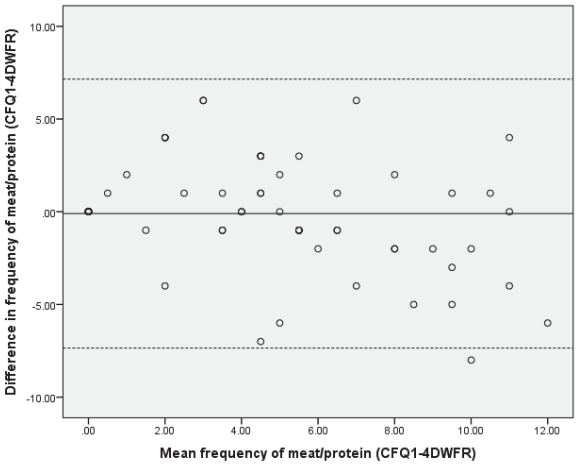
Appendix B: Bland-Altman Plots



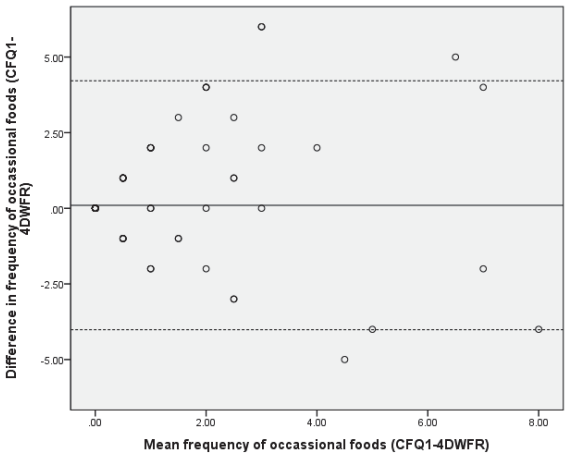
(A): Bland-Altman plot of breads and cereals



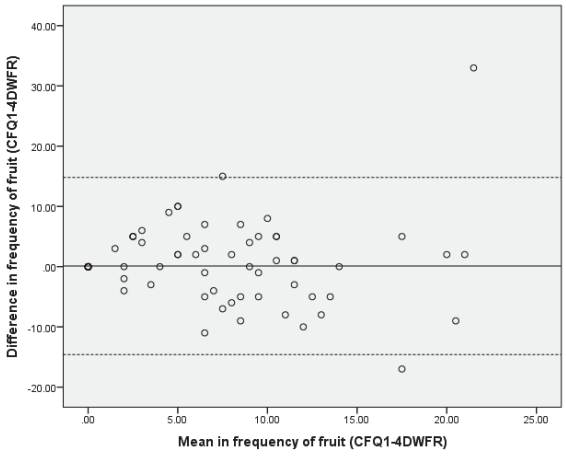
(B): Bland-Altman plot of dairy



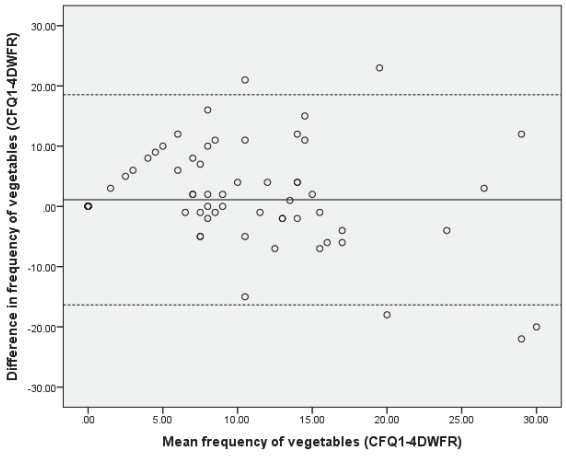
(C): Bland-Altman plot of meat protein



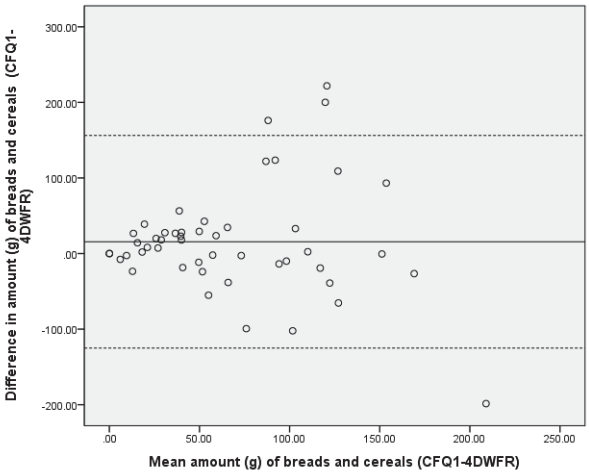
(D): Bland-Altman plot of occasional foods



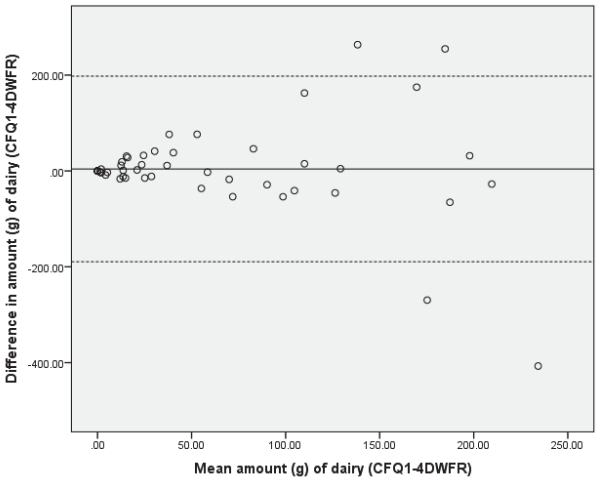
(E): Bland-Altman plot of fruit



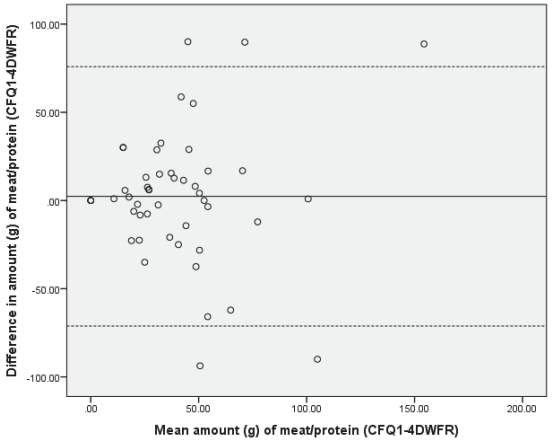
(F): Bland-Altman plot of vegetables



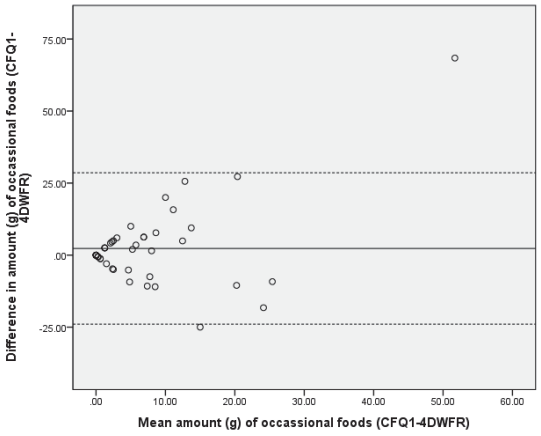
(G): Bland-Altman plot of breads and cereals



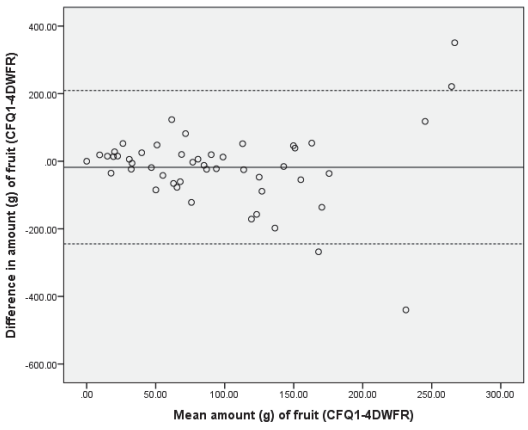
(H): Bland-Altman plot of dairy



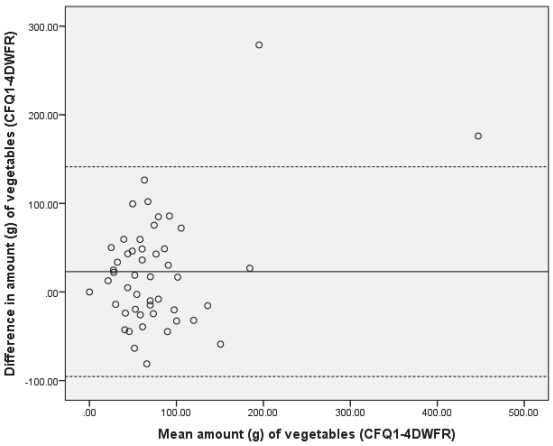
(I): Bland-Altman plot of meat/protein



(J): Bland-Altman plot of occasional foods



(K): Bland-Altman plot of fruit



(L): Bland-Altman plot of vegetables

Figure B.1 Bland-Altman plots of agreement between frequency for (A) Breads and cereals, (B) Dairy, (C) Meat and protein, (D) Occasional foods, (E) Fruit, (F): Vegetables. Bland-Altman plots of agreement between amounts for (G): Breads and Cereals (H): Dairy, (I): Meat and protein, (J): Occasional foods, (K): Fruit, (L): Vegetables. The mean difference is represented by the solid line and the limits of agreement (LOA) by the dashed lines (LOA = mean difference ± 2 standard deviations

Appendix C: Recommended changes to further enhance the Complementary Food Questionnaire

- Fluids
    - Options for “number of times per day” fluids consumed listed as individual frequencies rather than ranges (once, twice rather than 1 to 2 times, 3 to 4 times)
    - Expressed breastmilk or infant formula asked as an entirely separate question to other fluids that may be consumed (e.g. juice, water)
    - Options for mL amounts of fluids asked as individual options (e.g. 100mL, 125mL) rather than ranges (100-150mL)
- Breads and cereals
    - Further clarification for some food items (e.g. breakfast cereals incl. ricies, cornflakes cocoa pops) (e.g. baby cereals including baby rice) (rice e.g. brown or white not including baby rice)
- Dairy
    - Consider smaller metric measure for butter/margarine e.g. tsp or ½ tbsp. It is likely that TBSP was too large for portion size estimation
- Meat/Protein
    - Provide a conversion for all food items e.g. 1TBSP of beef mince is equal to 15g
    - Change eggs to be a unit measure (e.g. ½ a medium egg)
    - Provide slice estimates for some meats (e.g. ham 1 slice shaved ham equals 1TBSP or 15g)
    - Specify weights are cooked weights (e.g. meats)
- Occasional foods
    - Choice of unit measure for popcorn ¼, ½ or 1 cup rather than TBSP.
    - Unit measure for some food items e.g. plain and chocolate biscuits, plain and chocolate muesli bars instead of TBSP
    - Hot chips and chips/crisps provide a conversion (e.g. 3 hot chip = 15g equal to 1 TBSP)
- Fruit and vegetables
    - Provision of conversions for both puree and whole fruits and vegetables (e.g. 1 TBSP mashed potato = 15g, or ½ small apple = 45g = 3TBSP)
    - ‘Other fruits’ that commonly were reported to be included and asked individually (e.g. apple and grapes)

Appendix D: Questionnaires and material used in conducting the research

Feeding Assessment Tool (including CFQ)

1. Section 1. Growth

We are recruiting ALL parents and caregivers of babies (healthy term) aged 9+ months who are currently living in New Zealand.

This questionnaire asks about how your baby has been fed over the last 4 days. There are no "right" or "wrong" answers.

All of the data collected is anonymous and your answers will be held in strict confidence.

* 1. Please enter your six digit study ID number. You can find this number on your food diary provided in your information pack

2. What is your child's date of birth?

Date / Time DD / MM / YYYY

* 3. Do you consent to taking part in this study?

- ◯ Yes
- ◯ No

* 4. Please record the most recent growth measurements from the **Well Child Book**

Weight

(_ _ . _kg)
(DD/MM/YYYY)

Head circumference

(_ _ . _cm)
(DD/MM/YYYY)

Height

(_ _ . _cm)
(DD/MM/YYYY)

2. Section 2. Feeding history - Milk & fluids

* 1. Was your baby ever breastfed?

- ◯ Yes
- ◯ No

* 2. Are you still breastfeeding

- ◯ Yes
- ◯ No

* 3. If no longer breastfeeding, how old was your baby when you stopped?

- ◯ Still breastfeeding
- ◯ 1-2 weeks
- ◯ 3-4 weeks
- ◯ 1-2 months
- ◯ 3 months
- ◯ 4 months
- ◯ 5 months
- ◯ 6 months
- ◯ 7 months
- ◯ 8 months
- ◯ 9 months
- ◯ 10 months
- ◯ 11 months

* 4. What were the main reasons for stopping breast feeding (tick all that apply)?

- [ ] Personal choice
- [ ] Going back to work
- [ ] Unable to express at work
- [ ] Breastfeeding was difficult
- [ ] I didn't have enough milk
- [ ] Baby seemed hungry
- [ ] Other (please describe)
- [ ] Concerned about baby's growth
- [ ] Recommended by family / friend
- [ ] Recommended by a health professional
- [ ] Found out I was pregnant
- [ ] Prefer not to answer

* 5. Has baby had infant formula at any stage?

- ◯ Yes
- ◯ No

* 6. If yes, how old was your baby when formula was first introduced?

- ◯ No formula introduced
- ◯ 1-2 weeks
- ◯ 3-4 weeks
- ◯ 1-2 months
- ◯ 3 months
- ◯ 4 months
- ◯ 5 months
- ◯ 6 months
- ◯ 7 months
- ◯ 8 months
- ◯ 9 months
- ◯ 10 months
- ◯ 11 months

* 7. Has baby ever had standard milk?

Yes ◯ No

* 8. If yes, how old was your baby when standard milk was first introduced?

- ○ Never
- ○ 1-2 weeks
- ○ 3-4 weeks
- ○ 1-2 months
- ○ 3 months
- ○ 4 months
- ○ 5 months
- ○ 6 months
- ○ 7 months
- ○ 8 months
- ○ 9 months
- ○ 10 months
- ○ 11 months

* 9. Aside from breastmilk, formula or standard milk, has your baby had water?

- ○ Yes
- ○ No

* 10. What other fluids has baby had and when were they first introduced

	Not introduced	Yes at 1-2 weeks old	Yes at 3-4 weeks old	Yes at 1-2 months old	Yes at 3 months old	Yes at 4 months old	Yes at 5 months old	Yes at 6 months old	Yes at 7 months old	Yes 8 months old	Yes 9 months old	Yes 10 months old	Yes 11 old
Cordial (raro)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Fizzy drinks	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Juice	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Milo	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Tea	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Other (please specify)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Other (please specify)

3. Section 3. Feeding history - solids

* 1. How many months old was baby when he/she started eating solid food?(appeared to swallow at least some of the food)

- ◯ 4 or less
- ◯ 5
- ◯ 5 and a half
- ◯ 6
- ◯ 6 and a half
- ◯ 7
- ◯ 7 and a half
- ◯ 8
- ◯ 8 and a half
- ◯ 9
- ◯ 9 and a half
- ◯ 10
- ◯ 10 and a half
- ◯ 11 or more

* 2. Which foods did you introduce to your baby in the first 2 weeks after starting solids? (tick all that apply)

- [ ] Rusk
- [ ] Baby cereal or baby rice
- [ ] Breakfast cereal
- [ ] Yoghurt
- [ ] Red Meat
- [ ] Chicken
- [ ] Fish
- [ ] Ready-made baby food
- [ ] Taro
- [ ] Cassava
- [ ] Bok Choy
- [ ] Noodles
- [ ] Puha
- [ ] Fruit (please specify e.g. banana, apple etc)
- [ ] Vegetables (please specify e.g. kumara carrot etc)

Fruit or Vegetables (please specify)

3. If you used baby rice, which type did you give baby

- ( ) Homemade
- ( ) Commercial, please specify brand (eg Watties)
- ( ) Not applicable

If commercial, please specify brand here

4. When baby first started eating solid foods, how were they fed?

- Fed by adult
- Mostly fed by adult, some self-feeding
- About half fed by adult and half self-feeding
- Baby mostly fed themselves, some feeding by adult
- Baby fed themselves

5. How is baby fed now?

- Fed by adult
- Mostly fed by adult, some self-feeding
- About half fed by adult and half self-feeding
- Baby mostly fed themselves, some feeding by adult
- Baby fed themselves

6. When feeding baby, which do you give first?

- Milk before solids
- Solids before milk

7. Currently, how many solid meals does your baby usually have per day?

- 0
- 1
- 2
- 3
- 4
- 5
- 6
- 7 or more

8. Currently, how many solid snacks does your baby usually have per day?

- 0
- 1
- 2
- 3
- 4
- 5
- 6
- 7 or more

9. What type of foods do you use for baby most often?

- Homemade foods
- Commercially prepared foods (e.g. Watties)
- Combination

If using all or combination of commercial, please specify brand here

10. Has baby started eating red meat?

- Yes
- No
- Other (please specify)

11. If yes, how many months old was baby when red meat was first introduced?

- 4 or less
- 5
- 6
- 7
- 8
- 9
- 10

11

12. Does your baby have a special diet?

- ◯ Yes
- ◯ No

13. If yes, tick all that apply

- ☐ Vegetarian
- ☐ Vegan
- ☐ Gluten free
- ☐ Dairy free
- ☐ Other (please specify)
- ☐ Other (please specify)

4. Section 4. Current intake - milk & fluid

* 1. Please indicate all milk and fluids that your baby has drunk in the last 4 days:

	Has baby drunk this in the last 4 days?	How many days in the last 4 days?	How many times per day?
Breastfeed			
Expressed breast milk			
Standard infant formula			
Low allergy formula			
Soy formula			
Goat's milk formula			
Standard milk (dark blue)			
Standard milk (light blue)			
Juice			
Water			
Fizzy drink			
Other			

If you selected other milk, please describe, including brand

* 2. If breast feeding, how many minutes does baby usually suck for at each feed in the last 4 days (tick one)

- ◯ Not breast feeding
- ◯ 5-10 minutes
- ◯ 10-15 minutes
- ◯ 20-25 minutes
- ◯ 25-30 minutes
- ◯ 30-35 minutes
- ◯ 35-40minutes
- ◯ 40 minutes or more

* 3. For bottle/cup feeds (any milk or formula) how much does baby usually drink at each feed in the last 4 days?

- ◯ Fully breastfed
- ◯ 50-100ml
- ◯ 100-150ml
- ◯ 150-200ml
- ◯ 200-250ml
- ◯ 250-300ml

* 4. In the last 4 days, how often did your baby eat cereals/carbohydrates

	Total number of times in last 4 days	Typical amount at each feed
Rolled oats		
Breakfast cereal		
Baby cereal		
Pasta		
Rice		
Other cereals/carbohydrates (please specify total number in last 4 days and typical amount at each feed)		

* 5. Please specify the type and brand of the following foods e.g. Cornflakes - Skippy or white rice - Uncle Bens

Rolled oats

Breakfast cereal

Baby cereal

Pasta

Rice

Other

* 6. In the last 4 days, how often did your baby eat cereals/carbohydrates

	Total number of times in last 4 days	Typical amount at each feed
Weetbix		
Bread/toast		
Crackers		
Rusks		
Chapatti/Rotti		

Other cereals/carbohydrates (please specify total number in last 4 days and typical amount at each feed)

* 7. Please specify the type and brand of the following foods e.g. Wholemeal toast - homebrand or plain rice crackers - peckish or homemade

Weetbix

Bread/toast

Crackers

Rusks

Chapatti/roti

Other

* 8. In the last 4 days, how often did your baby eat dairy products

	Total number of times in last 4 days	Typical amount at each feed
Butter or margarine		
Cheese		
Yoghurt		
Ice-cream		
Custard		

Other dairy products (please specify total number in last 4 days and typical amount at each feed)

* 9. Please specify the type and brand of the following foods e.g. olivani lite margarine or apricot yoghurt - yoplait or homemade

Butter or margarine	
Cheese	
Yoghurt	
Ice-cream	
Custard	
Other	

* 10. In the last 4 days, how often did your baby eat meat/protein?

	Total number of times in last 4 days	Typical amount at each feed
Beef		
Lamb		
Pork		
Ham		
Chicken and poultry		
Fish		
Luncheon sausage		
Eggs		
Beans/Lentils		
Chickpea		
Tofu		

Other meat/protein foods (please specify total number in last 4 days and typical amount at each feed)

* 11. In the last 4 days, how often did your baby eat the following

	Total number of times in last 4 days	Typical amount at each feed
Dried fruit (e.g raisins)		
Popcorn		
Sweets and lollies		
Plain biscuits		
Chocolate biscuits		
Cake		
Chocolate		
Plain muesli bar		
Chocolate coated muesli bar		
Chips/crisps		
Hot chips/fries		

Other (please specify total number in last 4 days and typical amount at each feed)

* 12. In the last 4 days, how often did your baby eat vegetables and fruits?

	Total number of times in last 4 days	Typical amount at each feed
Starchy (e.g. potato, kumara)		
Cruciferous (e.g broccoli, cauliflower, cabbage)		
Leafy green (e.g spinach silverbeet)		
Red and orange (e.g carrot, pumpkin, capsicum)		
Beans and peas		
Citrus (e.g. orange, mandarin)		
Berries (e.g. blueberry, strawberry)		
Melon (e.g watermelon, honeydew)		
Stone fruit (e.g. apricot, peach)		
Tropical (e.g banana, mango)		
Cucumber		
Avocado		
Other fruit (e.g apples, grapes, pears)		

Other fruits and vegetables (please specify total number of times in last 4 days and typical amount at each feed)

Participant consent form

Feeding Babies study

PARTICIPANT CONSENT FORM

I have read the Information Sheet and have had the details of the study explained to me. My questions have been answered to my satisfaction, and I understand that I may ask further questions at any time.

I agree for my baby and I to participate in this study under the conditions set out in the Information Sheet.

Individual consent

Printed signature ..... **Date:** .....

Parent/Caregiver
Full Name - printed .....

Baby
Full Name - printed .....

Would you like to be contact occasionally regarding research studies taking place at Massey University? Please delete as appropriate.

Yes / No

Feeding Babies Demographic questionnaire

Feeding Babies study

Demographic questionnaire

1. Primary caregiver name: _____
2. Primary email address: _____
3. Contact telephone number: _____
4. Please tick which best describes your relationship with the baby participating in this study
   a. □ Mother □ Father □ Primary caregiver
   (please describe your relationship)_____
5. What is your baby's gender? Male / Female (please circle)
6. What is your baby's date of birth? (DD/MM/YYYY) _____
7. How many other children do you have? _____
8. To which ethnic group(s) do you identify with? Please tick all the boxes which apply

   □ New Zealand European
   □ Māori
   □ Pacific peoples
   □ Asian
   □ Middle Eastern/Latin American/African
   □ Other ethnicity
   If other, please state:_____
9. If Māori, please provide your tribal affiliations _____
10. Which ethnic group(s) does your baby identify with? Please tick all the boxes which apply

    □ New Zealand European
    □ Māori
    □ Pacific peoples
    □ Asian
    □ Middle Eastern/Latin American/African
    □ Other ethnicity
    If other, please state: _____
10. At how many weeks gestation was your child born? _____
11. Does your baby have any medical conditions?
    □ Yes □ No
    If yes, please specify _____

MASSEY UNIVERSITY
COLLEGE OF HEALTH
TE KURA HAUORA TANGATA

Feeding babies study

INFORMATION SHEET

We would like to invite you to take part in the Feeding babies study, which aims to develop and validate a tool to assess dietary quality in infants aged approximately 9-months. This study is being led by Ashleigh Jackson and supervised by Dr Cath Conlon and Dr Kathryn Beck, School of Food and Nutrition, College of Health, Massey University.

Please read this Information Sheet carefully before deciding whether or not to participate.

Researcher(s) Introduction

The lead researchers for this study are Ashleigh Jackson and Dr Cath Conlon

Ashleigh Jackson
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Dr Cath Conlon
Senior Lecturer
School of Food and Nutrition
Massey University, Albany
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Phone: (09) 213 6662

Why is this research important?

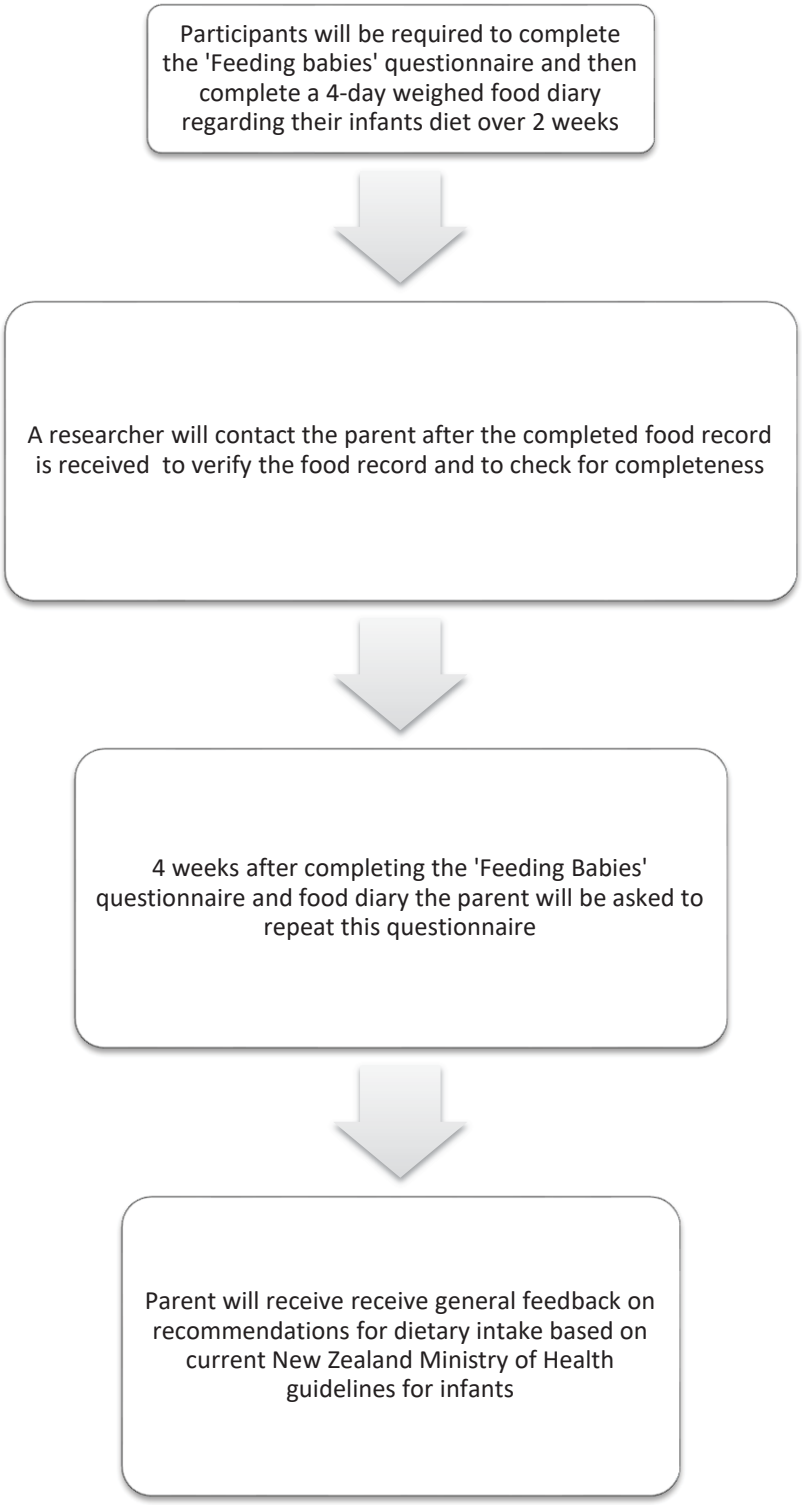
It is well known that a baby's diet is important for their early growth and development. To assess a baby's diet there is a range of dietary assessment methods available. Some of the traditional dietary assessment methods are time consuming and not appropriate to the infant population. These methods also focus on nutrients rather than food groups. Therefore, the aim of this study is to validate a new quick and easy dietary assessment tool, a dietary questionnaire against a traditional gold standard method (food diary) to assess its validity and accuracy to assess diet.

Participant Identification and Recruitment
We are looking to recruit 100 mothers and their 9+ month old infants

Project Procedures

Participants will be required to complete the following:

Feeding babies study flow diagram



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

Participants will receive general feedback on recommendations for dietary intake based on current New Zealand Ministry of Health guidelines. If participants do not have their own set of food scales, participants will be provided with a set to complete their infants weighed food diary. At the completion of the study, participants will be allowed to keep these scales. There is minimal risk associated with participating in this study

Data Management

How will the data be used?

The data will be used for the purposes of this study. Results of this study may be published or presented at conferences or seminars; however, no individual will be identifiable. Only the investigators of the study will have access to personal information and this will be kept secure and strictly confidential.

How will the data be stored?

Participants will be identified only by a unique study identification code and all data forms will use this code. The data forms will be stored in a locked filing cabinet in the Human Nutrition Research Unit, Albany Campus, Massey University. The electronic data will be stored on computers, which are protected by passwords, in locked offices of the Human Nutrition Research Unit.

How will the data be disposed of?

At the end of this study the list of participants and their study identification codes will be disposed of. Information collected from Survey Monkey will be downloaded and online files deleted. Any raw data on which the results of the project depend will be retained in secure storage for 16 years, after which time it will be destroyed.

How will I access a summary of the project findings?

A summary of the project findings will be available to all study participants and you will be sent this information by email.

Participant's Rights

You are under no obligation to accept this invitation. If you decide to participate, you have the right to:

- decline to answer any particular question;
- withdraw from the study until data collection is complete;
- ask any questions about the study at any time during participation;
- provide information on the understanding that your name will not be used unless you give permission to the researcher;
- be given access to a summary of the project findings when it is concluded.

Committee Approval Statement

This project has been reviewed and approved by the Massey University Human Ethics Committee: Northern, Application (NOR 15/061). If you have any concerns about the conduct of this research, please contact Dr Andrew Chrystall, Chair, Massey University Human Ethics Committee: Northern, telephone 09 414 0800 x 43317, email humanethicsnorth@massey.ac.nz.

"This project has been evaluated by peer review and judged to be low risk. Consequently, it has not been reviewed by one of the University's Human Ethics Committees. The researcher(s) named above are responsible for the ethical conduct of this research.

Thank you for your consideration regarding participation in this study! ☺

Feeding Babies Study

Weighed Food Diary

To be completed by infants' primary carer(s)

Date started

DD MM YYY

Instructions for completing food diary:

- This diary requires **all** the foods and fluids your infant consumes to be weighed and recorded on **four** non-consecutive days, including **one** weekend day. E.g. Monday, Wednesday, Friday, Sunday.
- Please try not to change what you give your child as a result of keeping a food diary!

Instructions for using food scales

Weigh EVERYTHING (food and liquids) in gram (g) amounts with weighing scales

Step 1: Turn on the scales

- Firstly, set scales up on a flat surface such as kitchen bench.
- Push the ON/ZERO key
- Ensure the display screen then appears with “0g”
- If the unit is in ”oz”, change to “g” on the back of the scales

Step 2: Place plate or bowl on scales

- Place the EMPTY plate or bowl you intend to serve the food or liquid in on the scale.
- Push the ON/ZERO key
- Ensure the display screen then appears with “0g” with the plate on the scale

Step 3: Weigh the plate or bowl with food (before eating)

- Add first food to the scale and record the weight in the “Amount” column.
- Push the ON/ZERO key
- Ensure the display screen then appears with “0g” with the plate on the scale and first food
- Add second food to the scale and record the weight in the “Amount” column.
- Repeat for as needed.

Step 4: Weigh the plate or bowl with leftover food (after eating)

- Place the EMPTY plate or bowl you intend to serve the food or liquid in on the scale.
- Push the ON/ZERO key
- Ensure the display screen then appears with “0g” with the plate on the scale
- Record the weight of the first food left over in the “weight of food leftover column”
- Push the ON/ZERO key

- Ensure the display screen then appears with “0g” with the plate on the scale
- Record weight of second food left over in the “weight of food leftover column”
- Repeat as needed.

Step 5: Estimate the leftovers unable to be weighed

- For any foods that may have been spilt on the floor, or on the infant estimate as accurately as possible amounts and record in “leftovers column” (e.g. 2tsp apple puree)

How to estimate amounts of food and drink when you can’t weigh them?

If unable to weigh and estimate the amounts, please record this in the “weight of all meals and snacks”

- Household measures – cups, tablespoons and teaspoons. Be specific whether it’s heaped or level.
- Weights marked on packages – weights on packaged foods. E.g. ½ of a 110g tin of Watties baby food apple and pear puree.
- Bread – number and size of the slices. E.g. 1/2 slice homebrand multigrain, toast slice.
- Fruit – infants palm size used to estimate portion size. E.g. 4 green grapes, ¼ banana, ¼ granny smith apple.
- Takeaway foods – record the amount consumed and the corresponding weight of the food using the weights in the pictures of “the commonly consumed takeaway food” pictures provided

KEEP IN MIND: We are not looking for a “HEALTHY” diet, we want to know what your infant eats!

EXAMPLE A: How to describe recipes Day: Monday Date: 22/08/15

Food diary: Filled out by the primary carer(s) of the infant

Step 1		Step 2			Step 3	Step 4			Milk before solids Or Solids before milk
Time	Meal or snack	Name of food or drink	Brand of food or drink	Cooking method	Weight of each food or drink	Leftovers: Weight of food left over	Leftovers: Estimation of food leftover	Child fed (C) parent fed (P) or both (B)	
7:00am	Meal	Breastfed - 10minutes							Milk before solids
		1 slice wholegrain toast	Tip Top		25g		Almost all		
		Apple, blueberry, muesli	Heinz for baby	Microwaved	45g	13g	2 tsp		
10:00am	Snack	Banana	Bobby banana		¼ banana – palm size				
		Chocolate cake	Homemade		50g				
12:00pm	Meal	4 Chicken nuggets	Tegal	Baked	70g				Solids before milk
		Potato	Agria washed	Oven roasted	20g	6g	1tsp		
		Whole baby carrots frozen	Signature range	Steamed	28g		none		
3:00pm	Snack	Breastfeed – 15minutes							
6:00pm	Meal	Spaghetti bolognaise	Homemade – see recipe		60g		none		Solids before milk
8:00pm	Snack	Infant formula	Karicare – stage 2		200ml		none		

Please record sandwich or toast slice bread

Please weigh total amount of food leftover

If having fruit, and don't have scales, you can estimate using infants palm

Of total amount leftover that is unable to be weighed, please estimate each food, e.g. half banana, ¼ muesli

Record homemade recipes separately

EXAMPLE B: How to record recipes

Step 1	Step 2	Step 3	Step 4	Step 5
Name of recipe	Amount of each ingredient including any water added (e.g. 3 medium carrots, 500g lean mince, 1 medium onion, 60mL water etc)	Cooking method	Proportion or recipe served to your child	Time of day
Home-made spaghetti bolognaise	300g lean beef mince (1Tbsp olive oil to brown) 50g, diced onion 50g, carrot diced 1 clove garlic, minced 60g, beef stock (Campbells) 30g tomato paste (Watties) 50g, frozen mixed vegetables (signature range) 60g water 5g white flour (homebrand) 400g dried spaghetti (budget)	Mince was shallow fried in a pan. Spaghetti was boiled in a pot	One tenth (1/10)	6pm

Day: _____ Date: _____

Food diary: Filled out by the primary carer(s) of the infant ***Please state any supplements your infant is having e.g. Vitadol C***

Step 1		Step 2			Step 3	Step 4			Milk before solids Or Solids before milk
Time	Meal or snack	Name of food or drink	Brand of food or drink	Cooking method	Weight of each food or drink	Leftovers: Weight of food left over	Leftovers: Estimation of food leftover	Child fed (C) parent fed (P) or both (B)	

Day: _____ Date: _____

Food diary: Filled out by the primary carer(s) of the infant

Please state any supplements your infant is having e.g. Vitadol C

Step 1		Step 2			Step 3	Step 4			Milk before solids Or Solids before milk
Time	Meal or snack	Name of food or drink	Brand of food or drink	Cooking method	Weight of each food or drink	Leftovers		Child fed (C) parent fed (P) or both (B)	
						Weight of food left over	Estimation of food leftover		

Day: _____ Date: _____

Food diary: Filled out by the primary carer(s) of the infant ***Please state any supplements your infant is having e.g. Vitadol C***

Step 1		Step 2			Step 3	Step 4			Milk before solids Or Solids before milk
Time	Meal or snack	Name of food or drink	Brand of food or drink	Cooking method	Weight of each food or drink	Leftovers: Weight of food left over	Leftovers: Estimation of food leftover	Child fed (C) parent fed (P) or both (B)	

Day: _____ Date: _____

Food diary: Filled out by the primary carer(s) of the infant ***Please state any supplements your infant is having e.g. Vitadol C***

Step 1		Step 2			Step 3	Step 4			Milk before solids Or Solids before milk
Time	Meal or snack	Name of food or drink	Brand of food or drink	Cooking method	Weight of each food or drink	Leftovers		Child fed (C) parent fed (P) or both (B)	
						Weight of food left over	Estimation of food leftover		

Recording recipes

Step 1	Step 2	Step 3	Step 4	Step 5
Name of recipe	Amount of each ingredient including any water added (e.g. 3 medium carrots, 500g lean mince, 1 medium onion, 60mL water etc)	Cooking method	Proportion or recipe served to your child	Time of day

Recording recipes

Step 1	Step 2	Step 3	Step 4	Step 5
Name of recipe	Amount of each ingredient including any water added (e.g. 3 medium carrots, 500g lean mince, 1 medium onion, 60mL water etc)	Cooking method	Proportion or recipe served to your child	Time of day

Recording recipes

Step 1	Step 2	Step 3	Step 4	Step 5
Name of recipe	Amount of each ingredient including any water added (e.g. 3 medium carrots, 500g lean mince, 1 medium onion, 60mL water etc)	Cooking method	Proportion or recipe served to your child	Time of day

THANK YOU!

Remember if you have any questions, please contact us. You can email or call us and we will get back to you ☺

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Supplementary results

Validity of FFQ food items

Validity correlations for frequency of consumption for all food items showed good to very good agreement were shown for majority of all food items (correlations ranged from -0.08 to 0.81, mean r=0.40) between CFQ-1 and 4DWFR (supplementary results table 2). Food item intake frequencies from CFQ-1 were comparable to the 4DWFR with nineteen of the fifty-one items having a mean difference in frequency intake of 0.1 of fewer over the four days (supplementary results table 2). The biggest differences were observed for rolled oats, breakfast cereals, crackers, butter/margarine, standard dark blue milk, ham, luncheon, hot chips, citrus fruits, where the CFQ overestimated eight food items (rolled oats 0.39±1.00, breakfast cereals 0.51±1.52, crackers 0.76±2.54, butter/margarine 0.96±1.81, ham 0.25±0.78, hot chips 0.22±0.62, cruciferous vegetables 0.22±0.62 citrus fruits 0.78±1.50) and the CFQ underestimated two food items (standard dark blue milk -0.71±2.21 and luncheon -0.22±0.72).

Validity correlations for daily amount for all food items showed good agreement was shown for majority of all food items (range -0.15 to 0.99, mean 0.34) between CFQ-1 and 4DWFR (supplementary results table 2). Food item amounts from CFQ-1 were comparable to the 4DWFR (supplementary results table 2). There was a significant difference in mean daily amount consumed for breakfast cereals, pasta, rice, butter/margarine, ham, plain biscuits, cruciferous vegetables, leafy greens, and red/orange vegetables. The CFQ overestimated mean daily amount consumed for eight food items breakfast cereals 1.96±5.94, pasta 3.64±12.21, rice 7.43±21.38, butter/margarine 4.09±6.56, ham 0.69±2.17, plain biscuits 1.78±50.6, cruciferous vegetables 4.96±14.5, and red/orange vegetables (12.04±23.4) and underestimated mean daily amount consumed for one food item, leafy greens -5.27±10.52. Food item mean daily amounts were similar for CFQ-1 and CFQ-2 (supplementary results table 2), with the exception of breakfast cereals and citrus fruits. CFQ-2 estimated higher intakes of breakfast cereals compared to FFQ 1 -1.76±5.62. Conversely, CFQ-2 estimated lower intakes of citrus fruits compared with CFQ-1 -5.44±18.33.

Reproducibility of the CFQ food items

Good to very good correlations between CFQ-1 and CFQ-2 for frequency of food items consumed was found for the majority (range -0.41 to 0.86, mean 0.46) (supplementary result table 3).

Food item intake frequencies were similar for CFQ-1 and CFQ-2 (supplementary result table 3), with the exemption of breakfast cereals, starchy vegetables, cruciferous vegetables and red orange vegetables, where CFQ-1 estimated higher intakes than CFQ-2 for starchy vegetables 1.08±2.66 and red orange vegetables 1.12±2.46. CFQ-1 estimated lower intakes than CFQ-2 for breakfast cereals -0.53±1.43 and cruciferous vegetables 0.59±1.90.

Good to very good correlations between CFQ-1 and CFQ-2 for daily amount of food items was found for the majority (range -0.07 to 0.93, mean 0.47) (supplementary result table 5). Food item mean daily intakes were similar for CFQ-1 and CFQ-2 (supplementary result table 5), with the exception of breakfast cereals and citrus fruits. Where CFQ-1 estimated higher intakes for citrus fruits -5.44±18.83 than CFQ-1. Conversely, higher intakes of breakfast cereals were seen in CFQ-2 compared with CFQ-1-1.76±5.62.

Supplementary Table 1

Table 1 Frequency of participants by frequency of consumption of food items over four days between CFQ-1 and CFQ-2

CFQ food groups	Number of serves in 4 days	CFQ n (%)	Food record n (%)
Breads and cereals			
Rolled oats	0	28 (54.9)	35 (68.6)
	1	6 (11.8)	7 (13.7)
	2	5 (9.8)	1 (2)
	3	3 (5.9)	2 (3.9)
	4	9 (17.6)	6 (11.8)
Breakfast cereal	0	40 (78.4)	47 (92.2)
	1	1 (2)	3 (5.9)
	2	3 (5.9)	0
	3	1 (2)	0
	4	6 (11.8)	1 (2)
Baby cereals	0	35 (68.6)	36 (70.6)
	1	5 (9.8)	4 (7.8)
	2	2 (3.9)	2 (3.9)
	3	2 (3.9)	4 (7.8)
	4	6 (11.8)	4 (7.8)
	5	0	1 (2)
	6	1 (2)	0
Pasta	0	22 (43.1)	23 (45.1)
	1	11 (21.6)	15 (29.4)
	2	14 (27.5)	7 (13.7)
	3	4 (7.8)	3 (5.9)
	4	0	2 (3.9)
	5	0	1 (2)
Rice	0	27 (52.9)	26 (51)
	1	10 (19.6)	11 (21.6)
	2	8 (15.7)	5 (9.8)
	3	1 (2)	5 (9.8)
	4	2 (3.9)	1 (2)
	5	0	1 (2)
	6	1 (2)	2 (3.9)
	8	1 (2)	0
	10	1 (2)	0
Weet-Bix	0	35 (68.6)	37 (72.5)
	1	4 (7.8)	4 (7.8)
	2	4 (7.8)	3 (5.9)
	3	1 (2)	3 (5.9)
	4	7 (13.7)	4 (7.8)
Bread/toast	0	9 (17.6)	9 (17.6)
	1	5 (9.8)	5 (9.8)

	2	11 (21.6)	10 (19.6)
	3	5 (9.8)	3 (5.9)
	4	12 (23.5)	8 (15.7)
	5	0	9 (17.6)
	6	5 (9.8)	1 (2)
	7	1 (2)	2 (3.9)
	8	3 (5.9)	1 (2)
	9	0	0
	10	0	3 (5.9)
Crackers	0	20 (39.2)	21 (41.2)
	1	5 (9.8)	9 (17.6)
	2	5 (9.8)	11 (21.6)
	3	6 (11.8)	5 (9.8)
	4	11 (21.6)	2 (3.9)
	5	1 (2)	0
	6	0	2 (3.9)
	7	0	1 (2)
	8	1 (2)	0
	10	2 (3.9)	0
Rusks	0	34 (66.7)	38 (74.5)
	1	4 (7.8)	7 (13.7)
	2	5 (9.8)	3 (5.9)
	3	1 (2)	1 (2)
	4	6 (11.8)	1 (2)
	5	0	1 (2)
	8	1 (2)	0
Chapatti/roti	0	49 (96.1)	50 (98)
	1	2 (3.9)	1 (2)
Dairy products			
Butter/margarine	0	27 (52.9)	37 (72.5)
	1	2 (3.9)	3 (5.9)
	2	8 (15.7)	8 (15.7)
	3	3 (5.9)	1 (2)
	4	8 (15.7)	2 (3.9)
	5	1 (2)	0
	6	1 (2)	0
	7	1 (2)	0
Cheese	0	15 (29.4)	14 (27.5)
	1	8 (15.7)	5 (9.8)
	2	12 (23.5)	12 (23.5)
	3	4 (7.8)	8 (15.7)
	4	11 (21.6)	6 (11.8)
	5	0	3 (5.9)
	6	0	1 (2)
	7	1 (2)	1 (2)
	8	0	1 (2)
Yoghurt	0	25 (49)	25 (49)
	1	6 (11.8)	5 (9.8)

	2	5 (9.8)	6 (11.8)
	3	6 (11.8)	5 (9.8)
	4	7 (13.7)	8 (15.7)
	5	1 (2)	0
	6	1 (2)	0
	7	0	2 (3.9)
Ice-cream	0	48 (94.1)	51 (100)
	1	3 (5.9)	0
Custard	0	41 (80.4)	39 (76.5)
	1	6 (11.8)	5 (9.8)
	2	3 (5.9)	4 (7.8)
	3	0	2 (3.9)
	4	1 (2)	1 (2)
Standard dark blue milk	0	51 (100)	41 (80.4)
	1	0	5 (9.8)
	2	0	2 (3.9)
	5	0	1 (2)
	10	0	1 (2)
	11	0	1 (2)
Standard light blue milk	0	51 (100)	51 (100)
Meat and protein			
Beef	0	15 (29.4)	18 (35.3)
	1	10 (19.6)	15 (29.4)
	2	17 (33.3)	11 (21.6)
	3	4 (7.8)	4 (7.8)
	4	2 (3.9)	1 (2)
	5	1 (2)	0
	6	1 (2)	0
	7	1 (2)	0
	8	0	0
	9	0	1 (2)
	10	0	1 (2)
Lamb	0	43 (84.3)	38 (74.5)
	1	4 (7.8)	10 (19.6)
	2	3 (5.9)	2 (3.9)
	4	0	1 (2)
	7	1 (2)	0
Pork	0	42 (82.4)	45 (88.2)
	1	6 (11.8)	5 (9.8)
	2	3 (5.9)	1 (2)
Ham	0	33 (64.7)	39 (76.5)
	1	9 (17.6)	7 (13.7)
	2	6 (11.8)	2 (3.9)
	3	1 (2)	3 (5.9)
	4	2 (3.9)	0
Chicken	0	18 (35.3)	18 (35.3)
	1	17 (33.3)	14 (27.5)
	2	12 (23.5)	10 (19.6)

	3	3 (5.9)	5 (9.8)
	4	1 (2)	1 (2)
	5	0	3 (5.9)
Fish	0	29 (56.9)	31 (60.8)
	1	18 (35.3)	14 (27.5)
	2	4 (7.8)	6 (11.8)
Luncheon	0	48 (94.1)	42 (82.4)
	1	2 (3.9)	4 (7.8)
	2	1 (2)	4 (7.8)
	3	0	1 (2)
Eggs	0	25 (49)	30 (58.8)
	1	15 (29.4)	8 (15.7)
	2	6 (11.8)	7 (13.7)
	3	3 (5.9)	4 (7.8)
	4	2 (3.9)	2 (3.9)
Beans/lentils	0	41 (80.4)	41 (80.4)
	1	7 (13.7)	8 (15.7)
	2	1 (2)	1 (2)
	3	0	1 (2)
	4	1 (2)	0
	10	1 (2)	0
Chickpea	0	44 (86.3)	44 (86.3)
	1	6 (11.8)	3 (5.9)
	2	1 (2)	3 (5.9)
	4	0	1 (2)
Tofu	0	48 (94.1)	49 (96.1)
	1	3 (5.9)	1 (2)
	3	0	1 (2)
Occasional foods			
Dried fruit	0	35 (68.6)	34 (66.7)
	1	9 (17.6)	9 (17.6)
	2	3 (5.9)	4 (7.8)
	3	3 (5.9)	2 (3.9)
	4	1 (2)	0
	6	0	2 (3.9)
Popcorn	0	47 (92.2)	50 (98)
	1	4 (7.8)	1 (2)
Sweets/lollies	0	51 (100)	50 (98)
	1	0	1 (2)
Plain biscuits	0	37 (72.5)	41 (80.4)
	1	4 (7.8)	5 (9.8)
	2	7 (13.7)	3 (5.9)
	3	0	1 (2)
	4	3 (5.9)	1 (2)
Chocolate biscuits	0	51 (100)	49 (96.1)
	1	0	1 (2)
	2	0	1 (2)
Cake	0	45 (88.2)	40 (78.4)

	1	6 (11.8)	8 (15.7)
	2	0	1 (2)
	3	0	2 (3.9)
Chocolate	0	50 (98)	50 (98)
	1	1 (2)	1 (2)
Plain muesli bars	0	48 (94.1)	50 (98)
	1	2 (3.9)	1 (2)
	2	1 (2)	0
Chocolate coated muesli bars	0	51 (100)	51 (100)
Chips/crisps	0	50 (98)	49 (96.1)
	1	1 (2)	2 (3.9)
Hot chips	0	39 (76.5)	47 (92.2)
	1	7 (13.7)	4 (7.8)
	2	4 (7.8)	0
	3	1 (2)	0
Fruits and vegetables			
Starchy vegetables	0	3 (5.9)	9 (17.6)
	1	2 (3.9)	4 (7.8)
	2	15 (29.4)	9 (17.6)
	3	7 (13.7)	8 (15.7)
	4	11 (21.6)	11 (21.6)
	5	2 (3.9)	2 (3.9)
	6	3 (5.9)	2 (3.9)
	7	1 (2)	2 (3.9)
	8	3 (5.9)	1 (2)
	9	1 (2)	0
	10	3 (5.9)	0
Cruciferous	0	7 (13.7)	21 (41.2)
	1	12 (23.5)	10 (19.6)
	2	12 (23.5)	10 (19.6)
	3	5 (9.8)	3 (5.9)
	4	10 (19.6)	1 (2)
	5	3 (5.9)	3 (5.9)
	6	2 (3.9)	2 (3.9)
	9	0	1 (2)
Leafy greens	0	26 (51)	23 (45.1)
	1	9 (17.6)	11 (21.6)
	2	10 (19.6)	11 (21.6)
	3	1 (2)	2 (3.9)
	4	5 (9.8)	0
	5	0	2 (3.9)
	8	0	1 (2)
	10	0	1 (2)
Red orange (carrot, pumpkin, capsicum)	0	3 (5.9)	10 (19.6)
	1	7 (13.7)	6 (11.8)
	2	12 (23.5)	6 (11.8)
	3	7 (13.7)	6 (11.8)

	4	11 (21.6)	3 (5.9)
	5	1 (2)	6 (11.8)
	6	4 (7.8)	6 (11.8)
	8	3 (5.9)	3 (5.9)
	10	3 (5.9)	1 (2)
Beans/peas	0	27 (52.9)	29 (56.9)
	1	8 (15.7)	8 (15.7)
	2	7 (13.7)	5 (9.8)
	3	4 (7.8)	4 (7.8)
	4	2 (3.9)	3 (5.9)
	5	1 (2)	1 (2)
	7	0	1 (2)
	8	1 (2)	0
	10	1 (2)	0
Citrus	0	17 (33.3)	28 (54.9)
	1	7 (13.7)	10 (19.6)
	2	13 (25.5)	4 (7.8)
	3	4 (7.8)	4 (7.8)
	4	6 (11.8)	3 (5.9)
	5	1 (2)	1 (2)
	6	2 (3.9)	1 (2)
	8	1 (2)	0
Berries	0	30 (58.8)	35 (68.6)
	1	10 (19.6)	6 (11.8)
	2	5 (9.8)	4 (7.8)
	3	2 (3.9)	2 (3.9)
	4	1 (2)	3 (5.9)
	5	1 (2)	0
	6	1 (2)	1 (2)
	10	1 (2)	0
Melon	0	47 (92.2)	49 (96.1)
	1	2 (3.9)	2 (3.9)
	2	1 (2)	0
	3	1 (2)	0
Stone fruit	0	44 (86.3)	44 (86.3)
	1	2 (3.9)	3 (5.9)
	2	4 (7.8)	4 (7.8)
	6	1 (2)	0
Tropical fruit	0	10 (19.6)	9 (17.6)
	1	4 (7.8)	9 (17.6)
	2	11 (21.6)	8 (15.7)
	3	7 (13.7)	3 (5.9)
	4	11 (21.6)	6 (11.8)
	5	2 (3.9)	4 (7.8)
	6	4 (7.8)	3 (5.9)
	7	0	5 (9.8)
	8	0	2 (3.9)
	10	2 (3.9)	2 (3.9)

Cucumber	0	38 (74.5)	44 (86.3)
	1	5 (9.8)	1 (2)
	2	5 (9.8)	2 (3.9)
	3	1 (2)	3 (5.9)
	4	1 (2)	0
	10	1 (2)	0
Avocado	0	32 (62.7)	37 (72.5)
	1	9 (17.6)	7 (13.7)
	2	7 (13.7)	3 (5.9)
	3	1 (2)	3 (5.9)
	4	1 (2)	0
	5	1 (2)	0
	7	0	0
Other fruit	0	10 (19.6)	9 (17.6)
	1	3 (5.9)	8 (15.7)
	2	11 (21.6)	6 (11.8)
	3	8 (15.7)	6 (11.8)
	4	9 (17.6)	5 (9.8)
	5	2 (3.9)	2 (3.9)
	6	2 (3.9)	5 (9.8)
	7	1 (2)	3 (5.9)
	8	2 (3.9)	3 (5.9)
	9	0	3 (5.9)
	10	3 (5.9)	1 (2)

Supplementary Table 2

Table 2 Validity using comparison of frequency of food items consumed over four days between the CFQ and the 4-day weighed food record.

Food groups	CFQ mean ± SD[a]	Food record mean ± SD	Mean difference ± SD	Paired t-test (p-value)	Effect size	Pearson's correlation coefficient (r)	Pearson's correlation - significance
Breads and cereals							
Rolled oats	1.18±1.60	0.80±1.40	0.39±1.00	0.01*	0.37	0.78	<0.01†
Breakfast cereals	0.65±1.39	0.14±0.61	0.51±1.52	0.02*	0.32	0.01	0.94
Baby cereals	0.92±1.59	0.84±1.46	0.08±1.32	0.67		0.63	<0.01†
Pasta	0.98±0.99	1.04±1.24	-0.06±1.33	0.75		0.31	0.03*
Rice	1.24±2.08	1.16±1.60	0.08±2.05	0.78		0.40	<0.01†
Weet-bix	0.84±1.46	0.71±1.31	0.12±0.95	0.37		0.77	<0.01†
Bread/Toast	3.04±2.28	3.45±2.66	-0.41±2.62	0.28		0.45	<0.01†
Crackers	2.24±2.49	1.49±1.72	0.76±2.54	0.04*	0.29	0.32	0.03*
Rusks	0.96±1.73	0.51±1.08	0.45±1.87	0.10		0.18	0.22
Chapatti/Roti	0.04±0.20	0.02±0.14	0.20±0.25	0.57		-0.03	0.84
Dairy products							
Butter/margarine	1.57±1.93	0.61±1.10	0.96±1.81	<0.01†	0.47	0.38	<0.01†
Cheese	1.94±1.66	2.31±1.96	-0.37±1.97	0.20		0.42	<0.01†
yoghurt	1.49±1.73	1.59±1.91	-0.10±1.25	0.57		0.77	<0.01†
Ice-cream	0.06±0.24	0.00±0.00	0.06±0.24	0.08			

Custard	0.33±0.77	0.47±0.96	-0.14±1.00	0.32		0.35	<0.01†
Standard dark blue milk	0.00±0.00	0.71±2.21	-0.71±2.21	0.03*	0.31	-	-
Standard light blue milk	0.00±0.00	0.00±0.00	-	-		-	-
Meat and protein							
Beef	1.63±1.59	1.47±1.97	0.16±1.76	0.52		0.53	<0.01†
Lamb	0.31±1.08	0.37±0.75	-0.06±1.33	0.75		-0.01	0.93
Pork	0.24±0.56	0.14±0.41	0.10±0.47	0.13		0.57	<0.01†
Ham	0.65±1.05	0.41±0.84	0.25±0.78	0.03*	0.30	0.68	<0.01†
chicken	1.06±1.01	1.39±1.41	-0.33±1.30	0.08		0.47	<0.01†
Fish	0.47±0.62	0.53±0.71	-0.06±0.69	0.54		0.47	<0.01†
Luncheon	0.08±0.34	0.31±0.71	-0.22±0.72	0.03*	-0.30	0.24	0.10
Eggs	0.84±1.07	0.86±1.19	-0.02±1.09	0.90		0.54	<0.01†
Beans/lentils	0.47±1.56	0.27±0.61	0.20±1.67	0.40		-0.00	0.99
Chickpea	0.14±0.41	0.27±0.76	-0.12±0.83	0.31		0.08	0.60
Tofu	0.06±0.24	0.08±0.45	-0.02±0.32	0.66		0.72	<0.01†
Occasional foods							
Dried fruit	0.57±1.00	0.71±1.37	-0.14±1.21	0.41		0.52	<0.01†
Popcorn	0.08±0.28	0.02±0.14	0.06±0.24	0.08		0.48	<0.01†
Sweets/lollies	0.00±0.00	0.02±0.14	-0.02±0.14	0.32		-	-
Plain biscuits	0.61±1.13	0.37±0.86	0.25±0.88	0.06		0.64	<0.01†

Chocolate biscuits	0.00±0.00	0.06±0.32	-0.06±0.32	0.18		-	-
Cake	0.12±0.33	0.33±0.72	-0.20±0.82	0.09		-0.08	0.57
Chocolate	0.02±0.14	0.02±0.14	0.00±0.20	1.00		-0.02	0.89
Plain muesli bars	0.08±0.34	0.02±0.14	0.06±0.21	0.08		0.81	<0.01†
Chocolate coated muesli bars	0.00±0.00	0.00±0.00	-	-		-	-
Chips/crisps	0.02±0.14	0.04±0.20	-0.02±0.14	0.32		0.70	<0.01†
Hot chips	0.31±0.68	0.08±0.28	0.22±0.62	0.02*	0.34	0.42	<0.01†
Fruits and vegetables							
Starchy veg	3.69±2.53	3.35±2.59	0.35±3.05	0.43		0.29	0.04*
Cruciferous	2.24±1.61	1.61±2.01	0.63±1.87	0.02*	0.32	0.49	<0.01†
Leafy greens	1.04±1.32	1.37±2.02	-0.33±1.98	0.26		0.35	0.01*
Red orange (carrot, pumpkin, capsicum)	3.49±2.58	3.61±2.75	-0.12±3.36	0.80		0.20	0.17
Beans/peas	1.29±2.08	1.10±1.62	0.18±2.68	0.63		-0.03	0.82
Citrus	1.86±1.90	1.08±1.54	0.78±1.50	<0.01†	0.46	0.64	<0.01†
Berries	1.04±1.89	0.78±1.40	0.27±1.98	0.35		0.31	0.03*
Melon	0.14±0.54	0.04±0.20	0.10±0.55	0.53		0.14	0.35
Stone fruit	0.33±1.01	0.22±0.59	0.10±1.14	0.53		0.05	0.74
Tropical fruit	2.90±2.33	3.41±2.80	-0.51±2.68	0.19		0.47	<0.01†
Cucumber	0.65±1.64	0.41±1.15	0.25±1.01	0.10		0.79	<0.01†

Avocado	0.71±1.14	0.59±1.27	0.12±1.15	0.46	0.55	<0.01†
Other fruit	3.00±2.55	3.67±2.95	-0.67±3.44	0.18	0.22	0.13

[a] Mean ± standard deviation
* p=<0.05, significant difference
† p=<0.01, significant difference

Supplementary Table 3

Table 3 Determination of reproducibility using comparison of frequency of food items consumed over four days between the CFQ-2 and CFQ-2

Food groups	CFQ-1 mean ± SD[a]	CFQ-2 mean ± SD	Mean difference ± SD	Paired t-test (p-value)	Effect size	Pearson's correlation coefficient (r)	Pearson's correlation - significance
Breads and cereals							
Rolled oats	1.20±1.56	0.90±1.46	0.29±1.03	0.05		0.77	<0.01†
Breakfast cereals	0.67±1.38	1.20±1.63	-0.53±1.43	0.01*	0.35	0.56	<0.01†
Baby cereals	0.88±1.57	0.63±1.31	0.26±1.62	0.27		0.38	0.01*
Pasta	1.00±1.02	0.86±1.02	0.14±1.08	0.37		0.44	<0.01†
Rice	1.20±2.05	0.88±1.55	0.31±1.68	0.19		0.60	<0.01†
Weet-bix	0.84±1.45	1.06±1.48	-0.22±1.38	0.27		0.56	<0.01†
Bread	2.96±2.28	2.92±2.17	0.04±2.35	0.91		0.44	<0.01†
Crackers	2.16±2.48	2.16±2.50	0.00±2.04	1.00		0.66	<0.01†
Rusks	0.96±1.71	0.82±2.03	0.14±1.83	0.60		0.53	<0.01†
Chapatti/Roti	0.04±0.20	0.08±0.39	-0.04±0.34	0.42		0.48	<0.01†
Dairy products							
Butter/margarine	1.51±1.91	1.51±1.94	0.00±1.69	1.00		0.62	<0.01†
Cheese	1.86±1.67	1.88±1.53	-0.02±1.23	0.91		0.71	<0.01†
yoghurt	1.43±1.72	1.47±1.64	-0.04±1.36	0.84		0.68	<0.01†
Ice-cream	0.06±0.24	0.06±0.24	0.00±0.20	1.00		0.65	<0.01†
Custard	0.31±0.76	0.37±0.77	-0.06±0.76	0.58		0.51	<0.01†

Standard dark blue milk	0.00±0.00	0.00±0.00	-	-	-	-
Standard light blue milk	0.00±0.00	0.00±0.00	-	-	-	-
Meat and protein						
Beef	1.61±1.58	1.18±1.28	0.43±1.51	0.05	0.45	<0.01†
Lamb	0.33±1.09	0.37±1.06	-0.04±0.57	0.62	0.86	<0.01†
Pork	0.24±0.55	0.27±0.57	-0.04±0.45	0.53	0.68	<0.01†
Ham	0.63±1.04	0.57±0.96	0.06±0.93	0.65	0.58	<0.01†
chicken	1.06±1.01	1.12±1.07	-0.06±1.01	0.68	0.53	<0.01†
Fish	0.51±0.64	0.61±0.80	-0.10±0.94	0.46	0.16	0.26
Luncheon	0.08±0.34	0.08±0.34	0.00±0.28	1.00	0.65	<0.01†
Eggs	0.86±1.10	1.08±1.44	-0.22±1.53	0.32	0.30	0.03*
Beans/lentils	0.45±1.53	0.39±0.80	0.06±1.68	0.80	0.80	0.65
Chickpea	0.16±0.42	0.20±0.66	-0.04±0.80	0.73	-0.41	0.78
Tofu	0.06±0.24	0.04±0.20	0.02±0.24	0.57	0.38	0.01*
Occasional foods						
Dried fruit	0.55±0.99	0.45±0.78	0.10±0.81	0.39	0.61	<0.01†
Popcorn	0.08±0.27	0.14±0.53	-0.06±0.51	0.41	0.34	0.01*
Sweets/lollies	0.00±0.00	0.00±0.00	-	-	-	-
Plain biscuits	0.59±1.12	0.47±0.81	0.12±0.97	0.39	0.53	<0.01†
Chocolate biscuits	0.00±0.00	0.04±0.20	-0.04±0.20	0.16	-	-

Cake	0.12±0.33	0.14±0.35	-0.02±0.37	0.71		0.39	0.01*
Chocolate	0.02±0.14	0.06±0.24	-0.04±0.20	0.16		0.57	<0.01†
Plain muesli bars	0.08±0.34	0.06±3.1	0.02±0.24	0.57		0.72	<0.01†
Chocolate coated muesli bars	0.00±0.00	0.00±0.00	-	-		-	-
Chips/crisps	0.02±0.14	0.08±0.34	-0.06±0.37	0.26		-0.03	0.82
Hot chips	0.35±0.72	0.29±0.54	0.06±0.61	0.50		0.55	<0.01†
Fruits and vegetables							
Starchy veg	3.82±5.59	2.75±2.04	1.08±2.66	0.01*	0.38	0.36	0.01*
Cruciferous	2.31±1.67	1.73±1.73	0.59±1.90	0.03*	-0.30	0.38	0.01*
Leafy greens	1.02±1.30	1.29±1.88	-0.28±1.95	0.32		0.29	0.04*
Red orange (carrot, pumpkin, capsicum)	3.51±2.56	2.39±1.74	1.12±2.46	<0.01†	0.42	0.40	<0.01†
Beans/peas	1.27±2.05	1.00±1.36	0.28±2.40	0.42		0.05	0.73
Citrus	1.84±1.89	2.00±1.80	-0.16±1.80	0.54		0.52	<0.01†
Berries	1.00±1.87	1.08±1.43	-0.08±1.68	0.74		0.50	<0.01†
Melon	0.14±0.53	0.16±0.46	-0.02±0.68	0.84		0.07	0.61
Stone fruit	0.31±0.99	0.08±0.27	0.24±0.99	0.10		0.13	0.36
Tropical fruit	2.84±2.32	2.67±2.00	0.18±2.4	0.60		0.40	<0.01†
Cucumber	0.63±1.61	0.67±1.47	-0.04±1.20	0.81		0.72	<0.01†
Avocado	0.69±1.12	1.18±1.93	-0.49±1.89	0.07		0.32	0.02*

Other fruit	3.14±2.68	2.86±2.10	0.28±2.55	0.45	0.46	<0.01†

[a] Mean ± standard deviation
* p=<0.05, significant difference
† p=<0.01, significant difference

Supplementary Table 4

Table 4 Validity using comparison of daily amount of food items consumed over four days between the CFQ and the 4-day weighed food record.

Food groups (g)	CFQ mean ± SD[a]	Food record mean ± SD	Mean difference ± SD	Paired t-test (p-value)	Effect size	Pearson's correlation coefficient (r)	Pearson's correlation - significance
Breads and cereals							
Rolled oats	16.18±27.70	13.42±28.82	2.76±21.58	0.38		0.71	<0.01†
Breakfast cereals	2.33±5.61	0.36±1.58	1.96±5.94	0.03*	0.32	-0.07	0.62
Baby cereals	10.10±23.00	18.31±38.82	-8.21±34.74	0.11		0.46	<0.01†
Pasta	8.21±11.03	4.58±9.70	3.64±12.21	0.04*	0.29	0.31	0.03*
Rice	8.57±21.24	1.14±2.43	7.43±21.38	0.02*	0.33	0.00	1.00
Weet-bix	3.88±10.09	2.07±4.30	1.81±9.36	0.18		0.38	<0.01†
Bread/Toast	22.59±26.46	17.18±15.94	5.41±23.25	0.11		0.49	<0.01†
Crackers	2.94±5.14	2.13±2.73	0.81±5.48	0.31		0.13	0.36
Rusks	0.50±1.04	0.53±0.68	-0.03±1.33	0.86		-0.15	0.31
Chapatti/Roti	0.07±0.46	0.02±0.14	0.06±0.48	0.51		-0.02	0.89
Dairy products							
Butter/margarine	4.79±6.78	0.67±1.45	4.09±6.56	<0.01†	0.53	0.25	0.08
Cheese	10.64±10.97	7.78±8.86	2.86±11 65	0.09		0.33	0.02
yoghurt	22.86±33.92	21.98±31.68	0.88±23.70	0.80		0.74	<0.01†
Ice-cream	0.12±0.48	0.00±0.00	0.12±0.48	0.08		-	-
Custard	4.49±11.14	9.91±22.36	-5.42±19.4	0.06		0.50	<0.01†

Standard dark blue milk	16.01±51.92	19.84±60.64	-3.77±75.96	0.73		0.10	0.51
Standard light blue milk	5.36±37.50	0.00±0.00	5.36±37.50	0.32		-	-
Meat and protein							
Beef	11.6±13.80	12.38±23.76	-0.75±19.78	0.79		0.56	<0.01†
Lamb	1.68±4.96	2.82±7.29	-1.13±8.73	0.37		0.02	0.88
Pork	2.07±5.73	0.75±2.39	1.32±4.49	0.05		0.67	<0.01†
Ham	1.51±2.47	0.82±2.31	0.69±2.17	0.03*	0.31	0.59	<0.01†
chicken	8.72±11.16	8.76±9.77	-0.03±13.23	0.98		0.21	0.16
Fish	3.29±5.28	4.21±6.82	-0.92±6.72	0.34		0.41	0.01*
Luncheon	0.84±3.69	1.73±4.37	-0.89±4.77	0.20		0.31	0.03
Eggs	7.96±15.45	5.18±7.99	2.78±12.7	0.13		0.56	<0.01†
Beans/lentils	2.68±6.72	1.58±4.45	1.10±7.55	0.31		0.13	0.36
Chickpea	0.85±2.88	0.87±2.72	0.20±3.92	0.97		0.02	0.90
Tofu	0.54±2.42	0.37±1.94	0.17±1.16	0.31		0.88	<0.01†
Occasional foods							
Dried fruit	1.74±3.43	1.78±4.17	-0.05±3.80	0.93		0.61	<0.01†
Popcorn	0.03±0.13	0.02±0.14	0.01±0.12	0.65		0.58	<0.01†
Sweets/lollies	0.00±0.00	0.05±0.36	-0.05±0.35	0.32		-	-
Plain biscuits	2.76±5.46	0.97±2.37	1.78±50.6	0.02*	0.31	0.38	<0.01†
Chocolate biscuits	0.00±0.00	0.15±0.79	-0.15±0.79	0.18		-	-

Cake	0.53±1.52	1.36±3.5	-0.82±3.91	0.15		-0.07	0.65
Chocolate	0.08±0.56	0.05±0.36	0.03±0.67	0.77		-0.02	0.89
Plain muesli bars	0.77±4.33	0.06±0.43	0.70±3.91	0.21		0.99	<0.01†
Chocolate coated muesli bars	0.00±0.00	0.00±0.00	-	-		-	-
Chips/crisps	0.02±0.11	0.23±1.19	-0.21±1.09	0.18		0.89	<0.01†
Hot chips	1.74±5.23	0.67±2.13	1.07±4.59	0.11		0.48	<0.01†
Fruits and vegetables							
Starchy veg	35.9±44.3	29.4±29.7	6.53±39.03	0.25		0.50	<0.01†
Cruciferous	12.44±11.82	7.48±11.77	4.96±14.5	0.02*	0.33	0.64	0.09
Leafy greens	2.15±3.14	7.42±11.09	-5.27±10.52	<0.01†	0.45	0.32	0.03*
Red orange (carrot, pumpkin, capsicum)	20.0±23.81	7.96±7.81	12.04±23.4	<0.01†	0.46	0.21	0.15
Beans/peas	7.27±11.16	5.64±12.06	1.63±17.09	0.51		-0.08	0.57
Citrus	14.77±20.59	10.82±20.76	3.95±20.83	0.19		0.49	<0.01†
Berries	7.58±16.20	4.66±9.75	2.91±18.49	0.28		0.05	0.73
Melon	0.69±3.40	0.31±1.53	0.38±3.63	0.47		0.07	0.65
Stone fruit	3.48±14.12	1.52±4.18	1.6±14.86	0.36		-0.04	0.81
Tropical fruit	33.9±45.10	48.5±48.07	-14.61±58.86	0.09		0.20	0.16
Cucumber	4.36±16.46	2.01±8.42	2.35±10.89	0.14		0.81	<0.01†
Avocado	7.19±15.46	6.50±22.15	0.69±15.00	0.75		0.74	<0.01†

Other fruit	26.56±30.89	33.87±46.19	-12.31±51.47	0.10		0.15	0.29

[a] Mean ± standard deviation
* p=<0.05, significant difference
† p=<0.01, significant difference

Supplementary Table 5

Table 5 Determination of reproducibility using comparison daily amount of food items consumed over four days between the CFQ-1 and CFQ-2

Food groups (g)	CFQ-1 mean ± SD[a]	CFQ-2 mean ± SD	Mean difference ± SD	Paired t-test (p-value)	Effect size	Pearson's correlation coefficient (r)	Pearson's correlation - significance
Breads and cereals							
Rolled oats	15.85±27.23	15.10±26.19	0.76±14.71	0.72		0.85	<0.01 †
Breakfast cereals	2.28±5.50	4.04±6.62	-1.76±5.62	0.03 *	0.30	0.58	<0.01 †
Baby cereals	9.71±22.63	5.44±14.99	4.26±25.18	0.23		0.15	0.29
Pasta	8.19±10.91	5.74±7.93	2.45±10.76	0.11		0.38	0.06
Rice	8.24±20.88	6.42±13.11	1.81±13.53	0.34		0.78	<0.01†
Weet-bix	3.81±9.90	5.55±12.27	-1.75±8.50	0.15		0.73	<0.01 †
Bread	21.88±26.18	28.32±36.27	-6.44±32.38	0.16		0.50	<0.01 †
Crackers	2.83±5.07	2.18±3.07	0.65±3.76	0.22		0.67	<0.01 †
Rusks	0.49±1.02	0.86±2.56	-0.37±2.21	0.23		0.52	<0.01 †
Chapatti/Roti	0.06±0.46	0.19±1.01	-0.13±0.64	0.16		0.89	<0.01 †
Dairy products							
Butter/margarine	4.60±6.70	4.46±6.68	0.14±5.47	0.86		0.67	<0.01 †
Cheese	10.22±10.95	12.13±13.88	-1.91±9.76	0.17		0.72	<0.01 †
yoghurt	21.97±33.54	21.44±31.19	0.53±19.62	0.85		0.82	<0.01†
Ice-cream	0.12±0.46	0.12±0.46	0.00±0.40	1.00		0.65	<0.01 †

Custard	4.31±10.95	6.30±16.63	-1.95±12.57	0.27	0.66	<0.01 †
Standard dark blue milk	15.44±50.97	39.95±107.24	-24.51±104.46	0.10	0.29	0.04 *
Standard light blue milk	5.15±36.76	0.00±0.00	5.15±36.76	0.32	-	-
Meat and protein						
Beef	11.32±13.63	10.15±12.67	1.18±15.41	0.59	0.32	0.02 *
Lamb	1.9±5.22	3.09±8.44	-1.18±6.30	0.19	0.67	<0.01 †
Pork	1.99±5.63	1.99±4.65	0.00±4.31	1.00	0.66	<0.01 †
Ham	1.45±2.44	1.45±2.73	0.00±2.96	1.00	0.35	0.01
chicken	8.68±11.04	10.00±12.48	-1.32±12.21	0.44	0.47	<0.01 †
Fish	3.38±5.21	5.66±13.17	-2.28±14.07	0.25	0.02	0.90
Luncheon	0.81±3.62	0.52±2.37	0.29±2.47	0.40	0.74	<0.01 †
Eggs	8.09±15.32	11.10±17.57	-3.01±14.75	0.15	0.61	<0.01 †
Beans/lentils	2.57±6.60	2.87±7.45	-0.29±9.86	0.83	0.02	0.90
Chickpea	0.90±2.83	1.10±4.54	-0.20±5.51	0.80	-0.07	0.63
Tofu	0.52±2.37	0.15±0.74	0.38±2.02	0.20	0.60	<0.01 †
Occasional foods						
Dried fruit	1.67±3.38	1.28±2.37	0.39±2.84	0.33	0.56	<0.01 †
Popcorn	0.03±0.12	0.05±0.19	-0.02±0.22	0.50	0.05	0.74
Sweets/lollies	0.00±0.00	0.00±0.00	-	-	-	-
Plain biscuits	2.65±5.37	2.60±5.89	0.05±4.37	0.94	0.70	<0.01 †

Chocolate biscuits	0.00±0.00	0.14±0.78	-0.15±0.78	0.18		-	-
Cake	0.51±1.49	0.59±1.66	-0.08±1.44	0.70		0.59	<0.01 †
Chocolate	0.08±0.55	0.31±1.32	-0.23±1.21	0.18		0.39	<0.01†
Plain muesli bars	0.74±4.24	0.44±2.33	0.29±2.47	0.40		0.88	<0.01 †
Chocolate coated muesli bars	0.00±0.00	0.00±0.00	-	-		-	-
Chips/crisps	0.02±0.11	0.08±0.32	-0.06±0.34	0.21		-0.03	0.81
Hot chips	1.79±5.13	1.71±4.25	0.08±4.27	0.89		0.60	<0.01 †
Fruits and vegetables							
Starchy veg	36.54±43.66	29.85±39.09	6.69±39.89	0.24		0.54	<0.01 †
Cruciferous	12.10±11.64	1.56±18.43	0.85±19.25	0.76		0.24	0.09
Leafy greens	2.10±3.09	3.30±5.29	-1.20±5.38	0.12		0.26	0.06
Red orange (carrot, pumpkin, capsicum)	19.98±23.41	13.50±15.52	6.49±22.70	0.05		0.38	0.01 †
Beans/peas	7.13±10.98	7.21±10.98	-0.07±15.18	0.97		0.36	0.01 †
Citrus	14.63±20.31	10.07±24.99	-5.44±18.83	0.04 *	0.28	0.67	<0.01 †
Berries	7.28±15.94	7.51±11.99	-0.23±18.06	0.93		0.19	0.19
Melon	0.66±3.33	1.69±7.05	-1.03±7.90	0.36		-0.04	0.80
Stone fruit	3.34±13.85	0.30±1.12	3.04±13.83	0.12		0.06	0.69
Tropical fruit	33.02±44.47	33.31±38.35	-0.29±48.23	0.97		0.33	0.02 *
Cucumber	4.19±16.15	4.56±17.34	-0.37±6.33	0.68		0.93	<0.01 †

Avocado	6.91±15.21	11.77±35.27	-4.85±32.98	0.30	0.37	0.01 *
Other fruit	27.43±31.03	27.35±26.78	0.07±29.69	0.99	0.48	<0.01 †

[a] Mean ± standard deviation
* p=<0.05, significant difference
† p=<0.01, significant difference

Supplementary Table 6

Table 6 Weights (g) used for statistical analysis of daily amount used for each food item from FoodWorks8

Food item	Measure	Gram amount (g)
Breads and Cereals		
Rolled oats	1 TBSP	15.4
Breakfast cereals	1 TBSP	4
Baby cereals	1 TBSP	15
Pasta	1 TBSP	9.2
Rice	1 TBSP	10
Weet-bix	1	15
Bread	1	36
Crackers	1	2.7
Rusk	1	8
Chapatti	1	26
Dairy		
Butter/margarine	1 TBSP	14
Cheese	1 TBSP	15
Yoghurt	1 TBSP	15.4
Ice-cream	1 TBSP	8
Custard	1 TBSP	16.6
Dark blue milk	1 TBSP	15.2
Light blue milk	1 TBSP	15.2
Meat/Protein		
Beef	1 TBSP	15
Lamb	1 TBSP	15
Pork	1 TBSP	15
Ham	1 TBSP	7.4
Chicken	1 TBSP	15
Fish	1 TBSP	15
Luncheon	1 TBSP	15
Egg	1 TBSP	15

Beans	1 TBSP	15
Chickpea	1 TBSP	10.2
Tofu	1 TBSP	15
Occasional foods		
Dried fruit	1 TBSP	10
Popcorn	1 TBSP	0.7
Lollies	1 TBSP	20
Plain biscuit	1	10
Chocolate biscuit	1	15
Cake	1 TBSP	8
Chocolate	1 TBSP	15.6
Muesli bar	1 TBSP	15
Choc coated	1 TBSP	15
Chips/crisps	1 TBSP	3.1
Hot chips	1 TBSP	8.3
Fruit and vegetables		
Starchy	1 TBSP	15
Broccoli	1 TBSP	11.5
Leafy	1 TBSP	6.8
Carrot	1 TBSP	9.8
Citrus	1 TBSP	15
Berries	1 TBSP	15.8
Stone fruit	1 TBSP	12.4
Tropical	1 TBSP	15
Cucumber	1 TBSP	15
Avocado	1 TBSP	15
Other fruit	1 TBSP	15

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