Characterising whole-of-diet patterns of Australian toddlers to inform the development of a short dietary risk assessment tool

Lucinda Kate Bell

B Nut Diet (Hons)

Nutrition and Dietetics, School of Health Sciences,
Faculty of Medicine, Nursing and Health Sciences,
Flinders University, Adelaide

A thesis submitted in the fulfilment of the requirements for the degree of Doctor of Philosophy

March 2015

TABLE OF CONTENTS

THESIS SUMMARY

Toddlerhood is an important period of life when nutritional experiences shape children's growth, health and development. Exposure to foods during this period influences the development of food preferences and thus current and future eating patterns. Yet toddlers begin to exert their independence in food choices and demonstrate fussy eating behaviours, placing them at risk of poor nutrition. Current dietary intakes of toddlers fall short of dietary recommendations, suggesting many are at 'dietary risk', a term used to describe 'inappropriate dietary patterns' that may impair health. As poor dietary behaviours may persist over time and influence short- and long-term health, early risk identification is important so that intervention can be initiated. Traditional dietary assessment methods are associated with limitations, such as being costly, time-intensive and burdensome on researchers and responders. Short questionnaires are an attractive alternative to assess dietary intake. The literature review presented in **chapter one** highlights that there are no short (<50 item) valid and reliable dietary assessment tools to measure diet of Australian toddlers. Thus, the primary aim of this thesis was to develop and validate a short dietary assessment tool for measuring dietary risk in Australian toddlers aged 12 - 36 months.

Dietary patterns of Australian toddlers were characterised by applying principal components analysis to food intake data collected for two Australian studies. This analysis guided selection of tool items and is described in **chapter two**. Patterns were similar at two ages, 14 and 24 months, representing 'core' (items recommended to be consumed every day, such as fruit, vegetables, lean meat, dairy, high-fibre bread and water) and 'non-core' (high-fat, -sugar and/or -salt items not included in the 'core' food groups such as spreads, snacks, chocolate, processed meat and sweetened beverages) intake. Based on extracted patterns and the Australian Dietary Guidelines a 19-item Toddler Dietary Questionnaire (TDQ) that assesses the previous week's food-group intake was developed, and is described in **chapter three.** Intake is evaluated using a scoring system to determine dietary risk (0 - 100;

higher score = higher risk) and stratified into four risk categories (low, moderate, high, very high).

Evaluation of the TDQ psychometric properties, detailed in **chapter three,** showed that risk scores were highly correlated and not significantly different between administrations or compared with a valid and reliable FFQ. Further, all participants were classified into the same or adjacent risk category (low – very high). However, analyses were conducted on data collected from a relatively advantaged sample of Australian toddlers. Thus, the TDQ has reliability and comparative validity as a short toddler dietary risk assessment tool for Australian toddlers from relatively advantaged backgrounds. Further testing was undertaken to determine the convergent validity of the dietary risk construct, and is presented in **chapter four**. Risk scores were associated with nutrient intakes in expected directions; lower and higher risk scores reflect better and poorer nutrient intakes, respectively. Risk scores were positively associated with socio-demographic factors but not BMI z-scores. These findings demonstrate that dietary risk scores measure intake that may impair health but currently do not specifically assess obesity risk. The key findings, strengths and limitations, the implications for practice, and areas for further research are summarised in **chapter five**. In conclusion, the newly developed TDQ is a valid and reliable screening tool for assessing dietary risk of relatively advantaged populations of toddlers, and may therefore be useful in early childhood nutrition promotion.

DECLARATION

'I certify that this thesis does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any university; and that to the best of my knowledge and belief it does not contain any material previously published or written by another person except where due reference is made in the text.'

Lucinda K Bell

August 2014

ACKNOWLEDGEMENTS

This thesis would not have been possible without the support of a number of significant people whom I would like to formally acknowledge and thank.

Firstly, I would like to thank, from the bottom of my heart, my primary supervisors, Associate Professor Anthea Magarey and Dr Rebecca Golley, for their ongoing direction, constructive criticism, patience and encouragement throughout this journey. Their expertise and knowledge has been invaluable and their quality of supervision has fostered great working relationships and friendships which I truly value and which has allowed me to grow substantially as a nutrition researcher. I thank them for the trust, belief and independence they placed in me and for their contribution to publications arising from this thesis. Special thanks to Professor Jane Scott for encouraging me to undertake a PhD and for her wisdom, support and feedback throughout the process. I would also like to acknowledge and thank Professor Lynne Daniels, a key investigator for the NOURISH study, for fostering the data used in this thesis and for her contribution to a resulting publication.

Many thanks to the NOURISH and SAIDI study teams at Flinders University and the Queensland University of Technology for their contributions to data used in this thesis. I gratefully acknowledge; Anthea Magarey and Lynne Daniels for coordinating the studies; Dr Rebecca Perry, Chelsea Mauch, Kylie Markow, Rachel Elovaris, Jo Meedeniya, and Rebecca Byrne who assisted in recruitment, data collection and entry; and PhD researchers Gloria Koh and Foorough Kavian who assisted in recruitment and data collection. Without the contribution of each and every member of the team, my PhD journey would not have been a success.

An important thank you to all families who enthusiastically gave up their time to participate in the three studies encompassed in this thesis; NOURISH, SAIDI and the Toddler Dietary Intake study. This thesis would not have been possible without your interest in, and dedication to, your child's dietary behaviours and health.

I'd further like to thank the funding support, primarily the National Health and Medical Research Council (NHMRC), SA Health and Meat and Livestock Australia for funding the NOURISH and SAIDI studies. Thank you also to the Australian Government and Flinders University who provided an Australian Postgraduate Award and Flinders University top-up scholarships, respectively.

A huge thank you to all staff and students of the Nutrition and Dietetics department at Flinders University who have made me feel a welcome and valued member of the Nutrition and Dietetics 'family'. I have appreciated all of the support and friendship you have provided me which has truly made my PhD journey all the more enjoyable. Special thanks to the Childhood Obesity Research Team for your continual motivation and, most of all, true friendship, over the years. You hold a very special place in my heart and I look forward to working with you all again in the future.

Finally, much love and thanks to my incredibly supportive family and friends, in particular my parents Jo and Geoff and partner Rohan. To my parents, thank you for your endless praise and encouragement which gave me the confidence to believe that I can achieve my goals. To Rohan – my rock - thank you for the sacrifices you made to make this thesis possible. You gave me the freedom to pursue my goals and supported me every step of the way. I will forever be grateful for your love, patience and understanding.

ABBREVIATIONS

ALSPAC	Avon Longitudinal Study of Parents and Children
ANOVA	Analysis of Variance
BMI	Body Mass Index
CVD	Cardiovascular disease
DOB	Date of birth
DQI	Diet quality index
EDR	Estimated dietary record
EDNP	Energy-dense nutrient-poor
FFQ	Food Frequency Questionnaire
FITS	Feeding Infants and Toddlers Study
FSANZ	Food Standards Australia New Zealand
HEI	Healthy Eating Index
ICC	Intraclass correlation coefficient
IQ	Intelligence Quotient
IQR	Interquartile range
kJ	Kilojoule
KMO	Kaiser-Meyer-Olkin
MD	Mixed dishes
MJ	Megajoule
LOA	Limits of agreement
NHMRC	National Health and Medical Research Council
MD	Mixed dishes
PCA	Principal components analysis
Q	Quartile
RCT	Randomised controlled trial
SAIDI`	South Australian Infant Dietary Intake
SEIFA	Socio-Economic Indices for Areas
SES	Socio-economic status
SD	Standard deviation
SPSS	Statistical Package for the Social Sciences
SWS	Southampton Women's Survey
TAFE	Technical and Further Education
TDQ	Toddler Dietary Questionnaire
UK	United Kingdom
USA	United States of America
WDR	Weighed dietary record
WHO	World Health Organisation
%E	Percent energy

LIST OF TABLES

LIST OF FIGURES

OVERVIEW OF THESIS STRUCTURE

This thesis is structured as five chapters, with four comprising material already published or accepted for publication, summarised in Table 0-1 (see Appendix 1 - Papers, conference presentations and awards/prizes arising from this thesis).

Chapter one provides the thesis context, outlining the aims and significance of the research. Included in this chapter is a systematic review of the literature on short dietary assessment tools for children aged less than five years, published in the *Journal of Obesity*.

Chapter two characterises dietary patterns of Australian toddlers aged 14 and 24 months by applying principal components analysis (PCA) to dietary data from two Australian studies. This work has been published in the *European Journal of Clinical Nutrition*.

The next two chapters detail the development and testing of a short dietary risk assessment tool for Australian toddlers, the Toddler Dietary Questionnaire (TDQ). Two published papers were derived from these chapters: (1) the development of the TDQ and testing of its test-retest reliability and relative validity, published in the *British Journal of Nutrition* (**chapter three**) and, (2) testing of the convergent validity of the TDQ, *accepted for publication in Nutrition & Dietetics* (**chapter four**).

Chapter five brings together the thesis findings. The relevance of the findings to clinical practice and research are discussed in the context of the thesis strengths and limitations, leading to a thesis conclusion.

Table 0-1 Summary of publications contributing to this thesis; their full citation and publication status at the time of submission

Chapter	Full citation	Status
1	**Bell L,** Golley R, Magarey A (2013) Short tools to assess young children's dietary intake: a systematic review focusing on application to dietary index research, *Journal of Obesity*, Article ID 709626, 17 pages, Epub 26 Sept 2013.	Published[1] [1]
2	**Bell L**, Golley R, Daniels L, Magarey A (2013) Dietary patterns of Australian children aged 14 and 24 months and associations with socio-demographic factors and adiposity, *European Journal of Clinical Nutrition*, 67(6): 638-45	Published[2] [2]
3	**Bell L,** Golley R, Magarey A (2014) A short food-group based dietary questionnaire is reliable and valid for assessing toddlers' dietary risk, *British Journal of Nutrition*, 112(4): 627-37	Published[2] [3]
4	**Bell L**, Golley R, Magarey A (2014) Dietary risk scores of Australian toddlers are associated with nutrient intakes and socio-demographic factors, but not adiposity, *accepted 8th March 2015 Nutrition & Dietetics*	Accepted[2] [4]

[1]The review was conceived and designed by AM, RG and LB. LB was responsible for the review's conduct and synthesis with input from AM and RG. LB drafted the initial manuscript and AM and RG provided critical review and feedback. All authors read and approved the final manuscript.
[2]The study was conceived and designed by AM, RG and LB. LB was responsible for the study's conduct and performed all statistical analysis with input from AM and RG. LB drafted the initial manuscript and AM and RG provided critical review and feedback. All authors read and approved the final manuscript

1 ASSESSMENT OF TODDLERS' DIETARY INTAKE

1.1 Overview

This chapter discusses the importance of assessing toddlers' dietary intakes using brief and accurate measures to determine dietary risk. It comprises three sections. The first section details why adequate nutrition in early life, in particular toddlerhood (1 - 3 years), is important, and describes the health consequences of poor diet during this period of life. The current state of toddlers' dietary intakes is compared to age-appropriate dietary guidelines leading to a conclusion on toddlers' dietary risk status. The second section of this chapter describes the strengths and limitations of traditional versus more novel dietary assessment methodologies, highlighting the benefits of short dietary assessment methods. A review of the literature on short tools that assess young children's dietary intake highlights the need for brief methods that assess whole diets of Australian toddlers. This review has been published in the *Journal of Obesity*. The third section discusses development of a dietary assessment tool based on whole-of-diet analysis, including how current dietary patterns of Australian toddlers can inform tool items and how a dietary index can be applied to collected dietary data to derive a measure of toddlers' dietary risk. The chapter concludes with the formulation of the aims which this thesis will address.

1.2 Early life nutrition

Human nutrition is the requirement to obtain essential nutrients necessary to support life and provides the foundation for physical and mental growth and development, performance, and health and well-being [5]. Optimal nutrition is fundamental across the entire life span, from conception, foetal development and birth, through to infancy, childhood, adolescence and adulthood [5]. However the role of nutrition in the first years of life is of particular interest as it can have lasting effects on an individual's diet, health and development [6, 7].

1.2.1 Importance of nutrition in early life

Adequate nutrition in the early years is of high importance for optimal growth, health and development. This important period of life is defined by rapid dietary change and the establishment of nutrition-related skills, and food preferences and habits. These are the foundations for adequate nutrition throughout life. This section reviews the evidence on why nutrition in early life is crucial for life-long health.

1.2.1.1 Early life nutritional requirements for growth, health and development

Up until five years of age children experience rapid physical, social, emotional and cognitive growth [8]. It has been demonstrated that dietary practices during this period impact on children's growth and development. For example, breastfeeding in infancy has been shown to slow a child's growth trajectory [9] and enhance their cognitive development [10-12], whilst consumption of meat between four and 16 months of age has been positively associated with psychomotor developments at 22 months of age [13]. Further, a "junk food" diet pattern at 3 - 4 years of age has been shown to be associated with poorer school attainment, measured as Key Stage scores, at 6 - 7 years and 10 - 11 years of age [14] and increased hyperactivity, measured using the Strengths and Difficulties Questionnaire, at age seven [15]. These findings highlight the importance of adequate nutrition in the first years of life.

Studies have also demonstrated the influence of early life diet on later adiposity and cardiovascular health. For example, consumption of a diet pattern by 12 month olds that was consistent with infant guidelines was associated with better lean mass at four years of age [16], whilst a meat-based diet pattern at three [17] and five [18] years of age was associated with increased odds of being overweight. Further, less healthy dietary patterns between six and 24 months of age were associated with higher blood pressure at seven and a half years of age [19]. Other studies have also demonstrated a positive association between sodium intake in the first few months of life and blood pressure in childhood and adolescence [20, 21]. Together these findings demonstrate the potential role of diet in infancy and toddlerhood in chronic disease development.

1.2.1.2 Early life is a period of rapid dietary change

The role of early nutrition in health, growth and development occurs within the context of rapid dietary change. Up to about six months of age breast milk and/or formula is the sole source of nutrition [22]. From this point, dietary patterns change rapidly over a short period [23]. Complementary foods are consumed in addition to breast milk and formula milk until one year of age, at which time toddlers expand their variety of foods and beverages to reflect the family diet [22]. The transition from a milk-based diet to a diet based on a variety of family foods continues throughout the second year of life and represents a change from a high-fat, low-protein, low-fibre single food to a diversified diet that is ideally low to medium-fat and fibre, and high protein [23]. Rapid dietary change is characteristic of nutritional experiences in the first years of life.

1.2.1.3 Early life is the period when food-related skills are developed

Food-related skills are also established in the early years of life to support the ability to self-feed. It is a period when developments in motor and cognitive function are occurring [24]. Specifically, these years are characterised by the acquisition of gross and fine food-related motor skills [24]. For example, in a sample of 4 - 24 month old children, the mean age of “reaching for a spoon when hungry” was 5.5 months, “using fingers to push food towards self” was 8.9 months, “chewing and swallowing firmer foods without choking” was 12.2 months and the establishment of self-feeding was 13.5 months [25]. In a similar sample of infants and toddlers aged 4 - 24 months, the majority of children could grasp food with their hand by one year of age, whilst most were able to drink from a sippy cup unassisted and eat foods that required chewing by two years of age [26]. These years are important for the development of food-related skills and coincide with transitioning to the family diet.

1.2.1.4 Early life is the period when dietary preferences and habits are formed

Early life dietary experiences can shape food-related behaviours throughout life. Dietary preferences and habits are believed to be well established by the age of five years [27-29]. More recent studies have shown that children’s likes and dislikes are established as early as 2 - 3 years of age [30]. Studies have also demonstrated that these food preferences and subsequent habits persist over time [27-29], highlighting that the first years of life are a critical period for the formation of positive life-long dietary preferences and habits.

Children’s food preferences and subsequent eating behaviours are known to be shaped by a combination of genetic predispositions and the eating environment [31, 32]. A study that assessed 3 – 4 year olds’ food preferences found that approximately half the variance in the preference for a particular food was due to its sweetness (genetically determined) and its familiarity (experience via the eating environment) [33]. Genetically humans are predisposed to prefer sweet and salty food, to reject sour and bitter flavours, and to reject novel foods [28]. However, young children’s innate food preferences and unwillingness to try unfamiliar foods, known as neophobia [28], is readily modified by experience and repeated exposure [34]. Thus, exposure to foods of various flavours and textures in early life is important for shaping children’s food likes and dislikes.

Children’s food preferences further predict their dietary patterns and dietary variety. For example, dietary exposures and food preferences in children as young as two predict their food preferences and dietary variety at eight years of age [35]. Dietary patterns have further been shown to track across infancy and toddlerhood [36], middle childhood [14] and from adolescence into adulthood [37]. Dietary preferences and behaviours are established over the first years of life, and influence dietary patterns that track throughout the life course.

1.2.1.5 Summary – the importance of nutrition in early life

Adequate early life nutrition is vital for optimal health, growth and development. During these years, children transition from a milk-based diet to a diversified family diet whilst developing food-related gross and fine motor skills. Experiences with food, flavours and textures during this transitional period shape the development of present and future food preferences and behaviours. Early childhood is therefore a critical time for learning to like a wide variety of tastes and textures which influence dietary intake. Therefore, it is clear that monitoring and optimising early life diet is important for health and development in both childhood and later life.

1.2.2 A focus on nutrition in toddlerhood (1 - 3 years)

Early life nutrition research has tended to focus on breastfeeding, formula feeding and the complementary feeding period, with less focus on the toddler years. Although nutrition is essential throughout all stages of early childhood, ensuring toddlers, aged 1 - 3 years [23, 38, 39], consume a balanced diet is challenged by several factors. This section discusses the nutritional and developmental context of toddlerhood and the challenges faced in ensuring adequate intake.

1.2.2.1 Nutritional and developmental context of toddlerhood

With increased activity [23] from infancy (birth – 12 months) into toddlerhood (1 – 3 years), toddlers' energy and nutrient needs become high relative to their size [38, 40]. Yet together with a slowing of weight gain [41], particularly after two years of age [23], they experience a physiological decrease in appetite [42]. The rate of weight gain between two and five years of age is 1 - 2kg per year, which is approximately 20 - 30 percent of that in the first year of life [42]. As a result refusal of foods normally desired is common in toddlerhood [38]. This contributes to the large variation in the amount of food consumed from day-to-day and meal-to-meal by toddlers [43]. Adding to this is that children become more autonomous through this transitional phase [24] and consequently begin to exert their independence in food choices [38, 39]. With increasing age, children also develop language, motor and social skills [44, 45] and are therefore able to better communicate their likes and dislikes [46]. They therefore begin to have a decisive say in what they will and will not eat [39]. Parents may perceive their child's ability to verbalise their preferences and subsequent rejection of common foods as being stronger as they move through to toddlerhood [46].

It is also common for toddlers to be unwilling to try new foods that are offered to them. Neophobia, the innate rejection of novel foods [28], is believed to peak between two and six years of age [47] and despite being developmentally normal [27], may be perceived by parents as 'picky' or 'fussy' eating. Repeated exposure to new foods and flavours can assist in overcoming neophobia and can therefore enhance the acceptance of foods by toddlers [44]. However, this is more difficult in toddlerhood than infancy, with studies showing that the number of exposures required to improve food acceptance increases from very few in infancy [48, 49] to approximately 5 - 10 in two year olds [50]. Thus, ensuring adequate nutrition in toddlerhood is challenged by developmental changes within the nutrition context.

1.2.2.2 Fussy eating behaviours in toddlers

Despite being developmentally normal for young children's' dietary behaviours to change as they transition into toddlerhood, parents of toddlers who reject certain foods or food groups may perceive their child to be a 'picky' or 'fussy' eater [51]. Fussy eating, whether real or perceived by parents, is a common phenomenon in toddlers' world-wide. In the US, 35 - 50% of toddlers aged 12 - 24 months (n = 3022, 4 - 24 months) were described by their parents as picky eaters [51]. In a study of 30 month old UK toddlers (n = 455) 15% were described as 'maybe' fussy and 8% described as 'definitely' fussy [40]. Similarly, in a cross-sectional study conducted with 740 Australian toddlers aged 12 - 36 months 20% were perceived by their mothers as a picky eater [52]. Given the high prevalence of toddlers being classified as picky or fussy eaters, this behavioural problem has been said to be a normal feature of toddler life [40].

Fussy eating behaviours in toddlers can be exacerbated by parental expectations and perceptions. Parental concern may lead to inappropriate parental responses, such as pressuring fussy eaters to eat [42]. This can in turn aggravate a child's refusal to eat [32, 53] as they exert their autonomy and resist eating [54], resulting in a decrease, rather than the intended increase, in intake [55]. For example, a study of Australian 2 - 4 year olds found that greater use of "pressure to eat" predicted higher child food fussiness and lower child interest in food [56]. Toddlers' refusal to eat can further exacerbate parental concern for their child's eating, fuelling the cycle of fussy eating behaviours. They can also be heightened by their parents' responses to their unwillingness to try a new food. Despite the ability to overcome neophobia through repeated exposure to the food or flavour [44], a high proportion of toddlers do not experience the level of exposure required, as parents commonly perceive the initial rejection of the food as a genuine dislike for the food [34]. This cycle of fussy eating is a challenge to ensuring toddlers consume a nutritionally complete diet.

1.2.2.3 Summary – the nutritional context and challenges of toddlerhood

The desire of parents to ensure their toddler has a balanced, nutritionally complete diet is challenged by toddlers' characteristic or perceived fussy eating behaviours that result from a decreased appetite, an emerging independence in food choices and food neophobia. Such behaviours are exacerbated by inappropriate parental responses and are a significant barrier to adequate nutrition during these years. Consequently toddlerhood may be a particularly vulnerable stage of life nutritionally. Thus, toddlers are an important population group to monitor and ensure adequate nutrition is established.

1.2.3 Consequences of poor nutrition in toddlerhood

For toddlers, poor nutrition runs the spectrum from under-nutrition to over-nutrition. In developing countries, communicable diseases result from under-nutrition and thus early life nutrition strategies primarily focus on ensuring toddlers receive adequate nutrition that confers protection and supports adequate growth [57]. Yet in developed countries, the focus has shifted from adequate nutrition to the role of early life nutrition in laying the foundation of dietary habits that reduce the risk of non-communicable diseases, such as cardiovascular disease (CVD) and obesity, later in life. This section focuses on nutritional consequences in toddlerhood in the developed world context. Inappropriate milk intake, iron deficiency and energy imbalance are three major concerns.

1.2.3.1 Inappropriate milk consumption

Over-consumption of milk or consumption of an inappropriate milk type can lead to nutritional issues for toddlers in the developed world. The Australian dietary guidelines recommend one and a half serves of dairy foods daily, equivalent to 375ml milk, for children aged 2 - 3 years (Table 1-2). Yet, over-consumption is common in the toddler years. For example, in British 1.5 – 4.5 year olds, 26% consumed more than 400g of milk daily over a four day weighed record period [58].

In Australian 2 - 3 year olds, the average consumption of milk products and dishes was 425g per day [59]. As overuse of milk reduces the variety of other foods consumed, nutritional deficiencies can result. One major concern is iron deficiency. The inverse association between cow's milk intake and iron status in toddlers has been well documented [58, 60, 61]. For example, British children aged 1.5 – 4.5 years consuming more than 400g per day of milk and cream were more likely to have poor iron status than those consuming less than 400g per day [58].

Consumption of an appropriate milk type is also important in toddlerhood. The Australian dietary guidelines recommend whole fat milk for toddlers aged 1 - 2 years and reduced fat milk for toddlers aged 2 - 3 years [62] (Table 1-2). Yet studies have reported intake inconsistent with these recommendations. For example, approximately 90% of Australian 2 - 3 year olds consume regular fat milk products and dishes, whilst approximately 71% consume regular fat dairy milk [63]. This is nutritionally concerning as consumption of regular fat milk products beyond two years of age can increase the saturated fat and energy content of the diet [64] and thus increase toddlers' potential for excess weight gain. However, emerging evidence is demonstrating a positive relationship between whole fat dairy foods and health. For example, the recent review of evidence that informed the 2013 Australian Dietary Guidelines suggests that consumption of any dairy by adults, regardless of the type i.e. regular or reduced fat is associated with a reduced risk of hypertension [62]. Regardless, inappropriate milk consumption in toddlerhood can negatively influence toddlers' iron and/or weight status.

1.2.3.2 Iron deficiency

Iron deficiency is one of the most common micronutrient deficiencies seen in young children world-wide. Although its prevalence is higher in developing countries, the average prevalence among children aged 6 - 24 months in the developed world is approximately 3% [65]. Specifically, in Australia, the prevalence of iron deficiency in toddlers ranges from 1 - 6% [66]. A common reason for iron deficiency in toddlerhood is the overuse of cows' milk, mentioned earlier. Consumption of large volumes of milk displaces the intake of iron-rich foods, such as meat, poultry or fish, or iron-enhancing foods, such as vitamin C containing fruits [38].

Iron deficiency in toddlerhood negatively impacts on health and development as iron is a component of many body proteins, including haemoglobin, which is particularly important for the transport of oxygen to body tissues such as the brain [67]. Chronic iron deficiency in toddlerhood is therefore associated with impaired mental and psychomotor development [7, 65] and can impact on immunity, growth and development [68]. For example, in a study of 12 – 23 month old toddlers, those with iron deficiency anaemia had significantly lower mental and motor test scores, which had persisted at age five years [69]. This is because the second year of life is the period of rapid brain growth, which is vital for the development of fundamental mental and psychomotor processes [70]. Thus, iron deficiency in toddlerhood is a great concern for life-long psychomotor and cognitive function.

1.2.3.3 Energy imbalance

Energy imbalance, resulting from greater energy consumption than energy expenditure, is common across the ages. Over recent decades, there has been changes towards a high fat, energy-dense diet and a sedentary lifestyle resulting from increased westernisation, urbanisation and mechanisation [71, 72]. This is true for toddlers. The 2007 Australian National Children's Nutrition and Physical Activity Survey found that the greatest contributors to energy intakes of children aged 2 - 3 years were total fat (30.4%), as predominately saturated fat (14.2%), and total sugar (25.9%) [59]. This is compounded by the fact that in 2011 - 2012 Australian children aged 2 – 4 years participated in sedentary activities, such as watching TV, DVDs or playing electronic games, for nearly one and a half hours daily [73]. These consumption and lifestyle patterns contribute excess energy consumption in Australian toddlers, with the potential to lead to overweight and obesity.

Overweight in childhood is one of the greatest current public health concerns [74, 75]. Despite reports suggesting stabilisation in rates of childhood overweight in Australia [76] and internationally [77-80] over the last 10 years, and more recently a decline in prevalence rates of obesity among 2 - 5 year old American children [81], levels remain high. Recent statistics show that approximately one-fifth of Australian children aged 2 - 3 years are overweight (15.5%) or obese (4%) [59], with higher levels seen in American 2 - 5 year olds (overweight 27%, obese 12%) [81]. The consequences of overweight in childhood are well-known and range from biological and physical (for example, cardiovascular, endocrine, orthopaedic, respiratory, reproductive, musculoskeletal and gastro-intestinal system complications [82]) to psychological and social (for example, isolation and discrimination from peers resulting in poor quality of life, and low body image and self-esteem [83]). Even more severe consequences are the increased risk of premature illness and death later in life [20, 83-85].

Compounding the problem of childhood obesity and its associated complications is the tracking of childhood obesity into later life [86]. This is considered to be one of the most significant independent long-term health consequences of excess weight in childhood [87, 88] because obesity in adulthood is well-known to be an independent risk factor for CVD, type 2 diabetes and its associated retinal and renal comorbidities, polycystic ovary syndrome, liver disease, obstructive sleep apnoea, mental health illness and certain cancers [71, 89, 90]. Further, there is evidence suggesting that excess weight in childhood is an independent risk factor for the majority of chronic diseases such as CVD [91], diabetes [90], and even cancer [92]. For example, Barker et al 2005 [93] demonstrated that excessive weight gain from 2 - 11 years of age was associated with later coronary events. Given that childhood obesity independently influences chronic disease development and predicts adult obesity and its associated disorders, overweight in toddlerhood is a concern for life-long health.

1.2.3.4 *Summary - health consequences of poor nutrition in toddlerhood*

Poor nutrition in toddlerhood can result in micronutrient deficiencies, such as iron deficiency, and a positive energy balance. Of concern is that these inadequacies can impair cognitive and psychomotor development and lead to the development of childhood obesity and its associated chronic diseases, such as CVD. As poor diet and overweight in early life have the potential to track across life, perpetuating the diet-disease relationship, preventing present and future ill-health begins with addressing one of the major underlying causes; poor diet in toddlerhood.

1.2.4 What are the recommendations for food intake in toddlerhood?

To assist in reducing the risk of diet-related disease and improving health and well-being, dietary guidelines are provided by health departments worldwide. They identify the food groups and dietary patterns that promote good nutrition and health, providing a guide to the public for food selection [8]. This section examines the dietary guidelines for three major countries of the developed world; Australia, the USA and the UK.

1.2.4.1 *The Australian Dietary Guidelines*

The Australian Dietary Guidelines, developed by the National Health and Medical Research Council (NHMRC), provide dietary advice for all Australians. The 2013 Eat for Health guidelines are composed of five key guidelines applicable beyond 12 months of age (Table 1-1**)** [62]. Of high importance are guidelines one and two, which emphasis consuming nutritious foods to meet energy needs, and consuming a wide variety of foods from the five ‘core’ food groups (that is, foods recommended to be consumed every day [8, 94]: (1) grain (cereal) foods, (2) vegetables and legumes/beans, (3) fruit, (4) milk, yoghurt, cheese and/or alternatives, and (5) lean meats, poultry, fish, eggs, tofu, nuts and seeds, and legumes/beans [62]. This is represented pictorially in the Australian Guide to Healthy Eating (AGHE) [95] (Figure 1-1), providing the public with a guide on the proportions of each food group that should be consumed each day. There are also guidelines for the recommended amounts (serving sizes and servings per day) of the five ‘core’ food groups that children, according to their age, should consume daily [96]. The recommendations for toddlers are detailed in Table 1-2. Further, the consumption of high-fat, -salt and/or -sugar foods, otherwise termed ‘non-core’[1] or ‘discretionary’ foods, should be limited, as stated in guideline three [62]. These are energy-dense, nutrient-poor (EDNP) foods that are not included in the ‘core’ food groups [8, 94]. Continued breastfeeding beyond 12 months of age is also recommended (guideline four) [62].

1. [1] ‘non-core’ foods are referred to as ‘discretionary’ foods in the latest 2013 Australian Dietary Guidelines. However, the term ‘non-core’ foods will be used throughout the thesis to reflect the term that was in common usage at the time the literature review and studies of this thesis were conducted.

Figure 1-1 2013 Australian Guide to Healthy Eating (AGHE) [95]

Table 1-1 2013 Australian Dietary Guidelines. Adapted from the 2013 Eat for Health Dietary Guidelines [62]

Guideline	Message	Sub-message
1	To achieve and maintain a healthy weight, be physically active and choose amounts of nutritious foods and drinks to meet your energy needs	Children and adolescents should eat sufficient nutritious foods to grow and develop normally and be physically active every day. Their growth should be checked regularly.
2	Enjoy a wide- variety or nutritious foods from these five food groups every day	(1) Vegetables and legumes/beans; consume plenty and include different types and colours (2) Fruit (3) Grain (cereal) foods; such as breads, cereals, rice, pasta, noodles, polenta, couscous, oats, quinoa and barley. Consume mostly wholegrain and/or high cereal fibre varieties, (4) Lean meats and poultry, fish, eggs, tofu, nuts and seeds and legumes/beans (5) Milk, yoghurt, cheese and/or their alternatives; consume mostly reduced fat (reduced fat milks are not suitable for children under the age of 2 years)
	….and drink plenty of water	
3:	Limit intake of foods containing saturated fat, added salt, added sugars and alcohol	Limit intake of foods high in saturated fat; such as many biscuits, cakes, pastries, pies, processed meats, commercial burgers, pizza, fried foods, potato chips, crisps, and other savoury snacks Limit intake of foods and drinks containing added salt Do not add salt to foods in cooking or at the table Limit intake of foods and drinks containing added sugars; such as confectionary, sugar-sweetened soft drinks and cordials, fruit drinks, vitamin waters, energy and sports drinks
4	Encourage, support and promote breastfeeding	
5	Care for your food; prepare and store it safely	

Table 1-2 Minimum number of serves per day of the five 'core' foods groups recommended for Australian children aged 2 - 3 years [96]

Vegetables and legumes/beans[1]	Fruit[2]	Grain (cereal) foods[3]	Lean meats and poultry, fish, eggs, tofu, nuts and seeds, and legumes/beans[4]	Milk, yoghurt, cheese[5]
2.5	1	4	1	1.5

[1]1 serve = ½ cup cooked green or orange vegetables (for example, broccoli, spinach, carrots or pumpkin); ½ cup cooked, dried or canned beans, peas or lentils; 1 cup green leafy or raw salad vegetables; ½ cup sweet corn; ½ medium potato or other starchy vegetables (sweet potato, taro or cassava); 1 medium tomato
[2]1 serve = 1 medium apple, banana, orange or pear; 2 small apricots, kiwi fruits or plums; 1 cup diced or canned fruit (with no added sugar); or only occasionally: 125ml (½cup) fruit juice (with no added sugar); 30g dried fruit (for example, 4 dried apricot halves, 1½ tablespoons of sultanas)
[3]1 serve = 1 slice (40g) bread; ½ medium (40g) roll or flat bread; ½ cup (75 – 120g) cooked rice, pasta, noodles, barley, buckwheat, semolina, polenta, bulgur or quinoa; ½ cup (120g) cooked porridge; 2/3 cup (30g) wheat cereal flakes; ¼ cup (30g) muesli; 3 (35g) crispbreads; 1 (60g) crumpet; 1 small (35g) English muffin or scone
[4] 1 serve = 65g cooked lean meats such as beef, lamb, veal, pork, goat or kangaroo (about 90-100g raw); 80g cooked lean poultry such as chicken or turkey (100g raw); 100g cooked fish fillet (about 115g raw weight) or one small can of fish; 2 large (120g) eggs; 1 cup (150g) cooked or canned legumes/beans such as lentils, chick peas or split peas(preferably with no added salt; 170g tofu; 30g nuts, seeds, peanut or almond butter or tahini or other nut or seed past (no added salt)
[5]1 serve = 1 cup (250ml) fresh, UHT long life, reconstituted powdered milk or buttermilk; ½ cup (120ml) evaporated milk; 2 slices (50g) or 4 x 3 x 2cm (40g) of hard cheese, such as cheddar; ½ cup (120g) ricotta cheese; ¾ cup (200g) yoghurt; 1 cup (250ml) soy, rice, or other cereal drink with at least 100mg of added calcium per 100ml

1.2.4.2 Dietary Guidelines from other western developed countries

The 2010 Dietary Guidelines for Americans [97] aged two years and over comprise five guidelines that cover two main concepts: (1) maintain calorie balance over time to achieve and sustain a healthy weight, through decreasing calorie consumption and increasing calorie expenditure, (2) consume nutrient-dense foods and beverages such as vegetables, fruits, whole grains, fat-free or low-fat milk/milk products, seafood, lean meats and poultry, eggs, beans and peas, and nuts and seeds. The guidelines also advise limiting consumption of high-fat, -sugar and/or –salt foods by replacing sugary drinks with water, using spices or herbs for flavour instead of salt, and choosing foods high in saturated fat only occasionally [97]. The pictorial representation of the American Dietary Guidelines is “My Plate” [97], designed to illustrate the five essential food groups (fruits, vegetables, dairy, grains and protein) using a mealtime place setting. For children under two, the Start Healthy Feeding Guidelines for Infants and Toddlers [98, 99] are applicable. These guidelines encourage consumption of a variety of foods from all the food groups beyond 12 months of age, including whole milk, other dairy, iron-fortified cereal, fruits, vegetables, whole grains, meat or alternatives, and margarines or vegetable oils. Iron-rich foods such as red meats are encouraged, as are other protein foods such as chicken, legumes, and eggs. Water is recommended as the drink of choice.

The UK Food Standards Agency recently developed the “the eatwell plate” [100], previously known as “the balance of good health” [101]. The eatwell plate is a visual representation of what constitutes a healthy balanced diet, illustrating the five main food groups and their recommended proportions in the diet of people over two years of age. Consumption of a wide variety of foods from four of the five food groups is recommended: (1) fruit and vegetables (at least five portions per day), (2) milk and dairy (primarily low-fat), (3) bread, other cereals and potatoes (primarily wholegrain varieties), and (4) meat, fish and alternatives. The smallest proportion of the diet should be the fifth food group; high-fat or -sugar foods and beverages, which are encouraged to be limited [102]. Specifically, the guidelines encourage foods that are rich in fibre, that is, wholemeal, wholegrain, brown or high-fibre versions, limited saturated fat and sugar intake, and consumption of plenty of water [102].

1.2.4.3 Summary - dietary guidelines for toddlers in developed countries

Dietary guidelines recommend culturally relevant dietary patterns that promote health and wellbeing and reduce the risk of nutritional deficiencies and chronic disease. Although there are variations in dietary guidelines for toddlers in developed countries world-wide, for example, whether fruits and vegetables are grouped together (UK) or separately (Australia), the overall key messages are consistent. All guidelines encourage consumption of a wide variety of ‘core’ foods such as fruits, vegetables, meat and alternatives, dairy and alternatives, and high-fibre grain foods, which confer protection against diet-related disease, and limited consumption of high-fat, high-salt and/or high-sugar foods and beverages, known as ‘non-core’ items, that confer risk for diet-related diseases. Dietary intake in line with these recommendations is encouraged to promote health and wellbeing.

1.2.5 Do toddlers’ intakes meet the recommendations?

Historically, little is known about what toddlers eat. However, in the last 20 years dietary intake studies have been conducted in Australia and other developed countries, providing information on toddlers’ food and nutrient intakes. The aim of this section is to understand toddlers’ current eating patterns to determine how they compare to dietary guideline recommendations and thus establish whether toddlers are at risk of nutritional consequences.

1.2.5.1 Patterns of toddlers’ intakes in Australia

In recent decades, studies of Australian toddlers have identified patterns of insufficient ‘core’ food intake and excessive ‘non-core’ food intake. The most recent nationally representative data collected in 2007 for the National Children’s Nutrition and Physical Activity Survey showed that of 2 - 3 year olds’ energy intake, approximately 70% came from ‘core’ foods and 30% from ‘non-core’ foods [59]. In total, approximately 2.9 serves of ‘non-core’ foods were consumed on the day of recall [59]. A 2005 study that assessed diet of Australian toddlers aged 12 - 36 months using a 24-hour checklist found that 15% and 11% consumed no vegetables or fruit, respectively, less than one-quarter consumed eggs, fish and legumes and 89% consumed at least one ‘non-core’ item in the previous 24 hours [52].

These data are supported by earlier studies. A study of intakes recorded during 2002 - 2003 revealed that by 12 months of age over three-quarters of children had been introduced to hot chips and half to takeaway foods [103]. Three day weighed food record data of 16 - 24 month old toddlers from 1998 - 2000 revealed that ‘non-core’ foods contributed 27% of daily energy intake, with 90% of children consuming these foods at least once a day [104]. Similarly, the 1995 National Nutrition Survey found that for 2 - 3 year olds, ‘non-core’ foods contributed approximately one-third of energy intake in a 24-hour period [105] and ‘non-core beverages’ contributed approximately a quarter of 2 - 4 year olds’ energy intake [106]. Clearly, dietary intakes of toddlers are not in line with dietary recommendations.

Studies have also demonstrated the decline in adherence to dietary guidelines as children progress through toddlerhood. In 2008 - 2009, 24-hour recalls showed that the proportion of children (n = 177) consuming ‘non-core’ foods, such as sweetened beverages (13 v 31%), sweet snacks (38 v 86%), savoury snacks (20 v 63%) and meat products (12 v 47%), doubled from infancy (9 months) to toddlerhood (18 months), whilst median consumption of vegetables declined (84 v 70g) [36]. The pattern of increasing over-consumption of ‘non-core’ food and under-consumption of ‘core’ food with age in Australian toddlers is concerning.

1.2.5.2 Patterns of toddlers’ intakes in America

Studies of American toddlers have also identified patterns of intake not in line with dietary guidelines. The 2008 [107] and 2002 [108] Feeding Infants and Toddlers Study (FITS) revealed poor intakes of ‘core’ foods and frequent consumption of ‘non-core’ foods in the previous 24 hours. In 2008, desserts and candy (12 - 24 months – 24 - 36 months; 58 - 68%), salty snacks (16 - 24%), sweetened beverages (28 - 44%), French fries (15 - 19%) and pre-sweetened cereals (24 - 30%) were commonly consumed by toddlers aged 1 - 3 years, whilst several did not consume any fruit (23 – 22%) or vegetables (29 - 29%) [107, 109]. Notably, the percentage consumers of several 'non-core' food items increased between the ages of 12 - 24 months and 24 - 36 months of age [107], highlighting that adherence to dietary guidelines declines through toddlerhood. Further, consumption of hot dogs, sausages and cold cuts (23%) by toddlers aged 12 - 24 months (data not available for 24 - 36 month olds) was greater than that of beef (13%) and fish and shellfish (5%) [109], demonstrating consumption of 'non-core' meat products in place of 'core' meat products.

In 2002, 'non-core' products were also commonly consumed by 12 - 24 month old American toddlers. For example, desserts and candy (71%), sweetened beverages (36%), pre-sweetened cereals (22%) and snacks (21%) were consumed by more than one-fifth of toddlers in the previous 24 hours [108]. Hot dogs, sausages and cold cuts (21%) were more commonly consumed than beef (17%) and fish and shellfish (7%) and approximately a quarter of children did not consume any discrete servings of fruit (28%) or vegetables (21%) [108]. In fact, one of the most commonly consumed vegetables was French fries [108]. Investigation of the main contributors of energy to toddlers' (12 - 24 month olds) diets showed these to be largely 'non-core' foods and drinks such as juice and other sweetened beverages, spreading fats, cookies and processed meats [110]. Small improvements, however, were observed between the 2002 and 2008 FITS studies, with reductions in the percentage of toddlers aged 12 - 24 months consuming desserts and candy (71% 2002, 58 – 68% 2008) [109]. Despite these slight improvements, intake of 'core' and 'non-core' foods remained inadequate and common, respectively, in 2008, highlighting that there is still a long way to go to ensuring toddlers intakes meet the recommendations.

1.2.5.3 Patterns of toddlers' intakes in the UK

Similar patterns of 'core' and 'non-core' food intake have been identified in UK toddlers. The 2008 - 2009 UK National Diet and Nutrition Survey revealed that approximately half of 1.5 - 3 year olds consumed cakes, bacon and ham, sausages, fried potato products, chocolate confectionary, fruit juice or soft drinks at least once over the four day estimated food diary period [111]. Further, approximately one-quarter consumed ice-cream, meat pies and pastries, or sugar confectionary [111]. Although nearly all toddlers consumed fruit (95%) and cooked vegetables (87%) at least once over this period, less than half consumed raw vegetables, fish, and eggs [111]. Despite these data not being representative of daily intake, it is evident that dietary patterns of UK toddlers are not in line with dietary recommendations.

1.2.5.4 Summary - patterns of toddlers' intakes in developed countries

Cross-sectional data from local and international studies show that toddlers' dietary intakes fall well short of recommendations. The balance between 'core' and 'non-core' food intake is not ideal, with inadequate consumption of fruit, vegetables, legumes, fish and eggs and common consumption of EDNP foods such as processed meats, fried potato products, sweets and sugar-sweetened beverages. Consequently, the contribution of 'core' and 'non-core' intake to energy intake is unbalanced.

1.2.6 Summary – toddlers' diets place them at 'dietary risk'

During the first years of life, children experience a rapid change in diet that is not experienced in any other life stage. Dietary experiences during this period shape food-related behaviours that are likely to persist [86, 112] and influence health across the lifespan [7, 113]. Therefore, early life is an important time to set the foundation for positive eating habits later in life [114]. The period from 1 - 3 years of age is particularly important as children transition from a milk-based diet to a diet consisting of family foods. During this transition toddlers experience a decrease in appetite whilst developing self-feeding skills, food preferences, communication skills and a desire to exert their independence in food choices, leading to rejection of foods normally consumed. They also display food neophobia, an unwillingness to try new foods. This rebellion around foods can potentially make it difficult for toddlers to receive the nutrition they need for adequate health, growth and development. Thus, toddlerhood is a vulnerable period of life nutritionally.

Diet is a risk factor for short- and long-term health consequences. Poor intakes during toddlerhood can have immediate adverse health outcomes, including iron deficiency and energy imbalance, which contribute to poor growth and development and lead to the establishment of obesity and associated comorbidities. Childhood obesity is one of the most well-known health consequences of poor diet in early life, affecting children as young as two globally, and impacting on multiple domains of child and adult health, both physically and psychosocially, in the short- and long-term. Therefore, an adequate diet in toddlerhood is essential for ensuring children are well placed to achieve life-long good health.

Age- and population-specific age-appropriate dietary guidelines specify the types and amounts of foods toddlers need to prevent diet-related health consequences. These guidelines are consistent between western developed countries. They encourage the consumption of a wide variety of ‘core’ items (fruits, vegetables, whole grains, dairy and lean protein sources) which confer protection against diet-related diseases, and limited consumption of ‘non-core’ items (high-fat, -sugar and/or -salt foods and/or beverages) that confer risk for diet-related diseases. Current intakes of toddlers fall well short of these guidelines. ‘Non-core’ items are commonly consumed at the expense of ‘core’ foods. These discrepancies between toddler’s intakes and dietary guidelines suggest that toddlers’ dietary patterns are inappropriate and place them at risk of short- (energy imbalance, nutrient deficiencies) and long- (obesity, CVD) term health consequences. That is, they are at ‘dietary risk’, a term used to describe ‘any inappropriate dietary pattern’ that may impair health [115]. This concept reflects poor adherence to a package of dietary guidelines in terms of both inadequate and excessive intakes [115].

1.3 Dietary assessment of toddlers

As dietary habits are a modifiable exposure, the established dietary risk in Australian toddlers highlights the need to assess and monitor their intakes. Assessing toddlers' intakes against dietary guidelines will allow for early risk identification and subsequent targeted interventions to improve dietary patterns and thus reduce the risk of diet-related health consequences. This section begins by highlighting the need to assess whole diet to determine dietary risk and presents an overview of the strengths and limitations of traditional versus novel dietary assessment methodologies such as short tools. The importance of determining the reliability and validity of a dietary assessment tool is discussed. This section includes a review of the literature on short dietary assessment tools that assess total diet of young children.

1.3.1 Assessment of whole diet to determine dietary risk

As dietary risk is a concept that reflects overall 'dietary patterns' [115], encompassing the relationship between health-promoting (for example, fruit and vegetables, whole grains) and risk-promoting (for example, high-fat, -sugar and/or salt) foods and nutrients, a dietary intake assessment tool that assesses dietary risk must assess whole diet. The assessment of whole diets refers to capturing the intake of all five 'core' food groups (fruit, vegetables, grains, meat and alternatives, and dairy products) and 'non-core' food groups (EDNP items) [8, 62], rather than individual dietary components. Whole diet assessment is advantageous as it takes into consideration (1) the synergistic effect of foods and nutrients consumed together [116, 117], (2) that greater consumption of some foods usually means lower consumption of others [118], and (3) that whole diet provides the complete nourishment of an individual, reflecting the balance between protective and harmful components [119]. Further, whole diet assessment allows comparison of intake with current food-based dietary guidelines [120, 121]. Overall, whole diet assessment provides a holistic approach to investigating diet, necessary for measuring dietary risk of Australian toddlers.

1.3.2 Dietary assessment methods

There are various methods to assess dietary intake of individuals and populations. The appropriate choice of a method depends on the study question, design and population, with all methods associated with limitations. For example, whether food diaries or dietary recalls are the best method for assessing intake depends on the exposure being characterised, which has implications for the number of days needed to be evaluated [122]. This section aims to describe major dietary assessment methods and their advantages and disadvantages.

1.3.2.1 Traditional dietary assessment methods - recalls and records

Diet has traditionally been assessed by quantifying the intake of energy and nutrients through the use of common methods such as 24-hour dietary recalls, food records or diaries, and weighed food intake measures [123]. Despite being advantageous regarding the comprehensiveness of data obtained, these methods are associated with several difficulties and limitations (summarised in Table 1-3). Administration and analysis are generally costly and time-intensive for the researcher and completion is burdensome for respondents [121, 124, 125]. Furthermore, while energy and nutrient intakes can easily be derived from these detailed methods, it is often difficult to extrapolate detailed food intake data in a way that allows easy comparison against food-group based healthy eating guidelines [120]. These limitations restrict easy comparison of intake with dietary guidelines to determine dietary risk.

1.3.2.2 Alternative dietary assessment methods - questionnaires

Alternative dietary assessment methods that focus more broadly on the intake of foods and/or food groups allow easy comparison of food intake against dietary guidelines. Food Frequency Questionnaires (FFQ), for example, assess usual intake of individual foods and/or food groups over weeks or months, whereby individuals are ranked based on their responses [126]. Despite variations in design based on their intended purpose and outcomes of interest, in general they are based on a list of foods consumed within a set time period, requiring respondents to simply tick boxes relating to the food consumed, the frequency of consumption (for example, range, never to six times per week), and on occasion indicate the portion size usually consumed [127]. The food items are study-, population- and age-specific, chosen from a range of possible foods [128]. They allow the collection of information moderately quickly [129] and from a large sample of participants [121, 130].

FFQ and other questionnaire-style tools are advantageous as they are associated with reduced cost, participant burden, and data handling and processing in comparison to traditional dietary assessment methods [121, 127, 130]. However, this may not be the case if they are poorly designed. For example, respondents may be required to recall foods consumed over periods of up to 12 months [131, 132]. Further, respondents may be required to recall intake of a large number of food items. For example, FFQ typically include 100 or more items [126, 133], and sometimes up to 350 items [127, 128], to capture the range of foods in the diet [126]. Yet, longer questionnaires are associated with increasing participant burden, which can result in a lack of completion [134]. It has been suggested that those FFQ's that include more than 100 food items likely take 30 - 60 minutes to complete [126] and consequently response and completion rates are likely to be affected due to respondent burden [134]. In light of this, several research groups have shortened longer questionnaires and re-validated the resultant FFQ. Results [135, 136], cited in Willett et al [137], have suggested that there is a rapidly decreasing marginal gain in information obtained with increasingly detailed questionnaires [128]. Thus, short, simple dietary assessment tools are an attractive alternative to collect dietary data to determine dietary risk.

1.3.2.3 Short questionnaire-based dietary assessment methods

Short dietary assessment tools are appealing as they are likely to result in higher compliance and completion rates than longer dietary assessment tools due to lower respondent burden. These methods are further associated with reduced researcher burden due to reduced administration and analysis time and cost. Although the definition of 'short' is subjective, a previous review defined brief tools as those that take less than 15 minutes to complete, or more specifically, comprise less than 50 items [133]. As they are quick to complete, short dietary assessment tools are useful methods for “screening” dietary intakes to determine those in greatest need of intervention or education. They can allow for identification of those at dietary risk and are ideal in clinical settings or where health promotion is the goal [126].

1.3.2.4 Summary – methods for assessing dietary risk

Traditional dietary assessment methods, such as recalls and records, measure the intake of energy, nutrients or certain foods in a manner that is costly and time-intensive and therefore they are impractical for quick screening of dietary intakes against dietary guidelines to determine dietary risk. Comparatively, questionnaires that measure food or food group intake are ideal as they are associated with reduced participant and researcher burden and allow easy comparison of food intake with dietary guidelines. Yet these latter methods are often limited by increasing length. Given the benefits of short dietary assessment tools and the need to assess whole dietary patterns to determine toddlers’ dietary risk, an ideal toddler dietary risk screening tool would be short and assess total diet at the food or food group level.

Table 1-3 Advantages and disadvantages of respondent-based dietary assessment methods; recalls, records, FFQ, and targeted questionnaires. Adapted from Magarey et al 2010 [121] and Collins et al 2010 [125]

Dietary Assessment Method	Description	Information Obtained	Advantages	Disadvantages	Analysis
Food Record	Written accounts of food and drink intake over a specific time, e.g. 3 or 7 days Can be weighed or estimated records Prospective[1]	Quantitative and qualitative Several days (week and weekend days) required to estimate usual intake	• 7-day weighed food record is referred to as a 'gold standard' • Does not rely on participants' memory • Covers a defined recording period • Researcher-related • Training of researchers can be group administered • Single day record only required for reporting the usual intake of a group • Provides absolute and relative intakes • Provides a reasonable estimate of individual intake. • Recipes and product information can be collected	• Weighed records are expensive and labour intensive for participant and researcher • High respondent burden, requires moderate to high motivation • Food eaten away from home less accurately reported • Procedure may influence habitual dietary habits • Reliability decreases over time • Requires literacy and numeracy skills • Requires cooperative participants • Expensive to collect and code by researchers • Not feasible for epidemiological studies • Multiple records needed for usual intake	• Nutritional database required and need continual up-dating • Time-intensive and expensive • Requires some nutritional knowledge and skill for coding of foods
Food Recalls	A trained interviewer (in person or phone) asks	Assesses group means Multiple records needed for	• Does not require participants to have literacy or numeracy skills • Procedure does not alter participants food intake patterns	• Recall relies on participants memory • Portion size difficult to estimate • Higher respondent burden for multiple days	As above

Dietary Assessment Method	Description	Information Obtained	Advantages	Disadvantages	Analysis
	participants to recall all food and drink consumed (usually 24h or 3-day period) Retrospective[2]	assessing individual intake Several days required to estimate usual intake	• Low response burden • Short administration time for researchers • Defined recall period • Can be telephone administered • Data entry can be automated • Single day record only required for reporting the usual intake of a group	• Interviewer training required • Expensive to collect and code data (phone interviewing could be cheaper) • Not feasible for most epidemiological studies • Multiple records needed to report usual intake	
Food Frequency Questionnaires (FFQ)	Respondents report their usual frequency of consumption of each food (from a list) for a specific time (e.g. 1, 6 or 12 months) Self- or interviewer-administered on paper,	Designed to capture usual food intake; but some can be nutrient specific Collects less detail regarding foods, cooking method and portion size; quantification of intake is considered less accurate	• Procedure does not influence participants habitual dietary habits • Low respondent burden • Trained interviewers not required • Quick and inexpensive to administer • Data entry can be automated • Practical for large-scale studies • Possible to assess total diet or selected foods or nutrients • Can rank individuals according to intake • Can assess current or past diet	• Recall depends on participants memory • Literacy and numeracy skills required (unless interviewer-administered); high level of conceptual skills required • Portion size difficult to estimate; food specifications limited by categorical nature of frequency of response categories • Specific food descriptions not obtained • Resources involved in development and validation of FFQ • Does not usually provide information on meal patterns • Limited to most commonly consumed	• Nutritional database often required • Is faster if computer used; questionnaires can be scanned by computer

Dietary Assessment Method	Description	Information Obtained	Advantages	Disadvantages	Analysis
	computer, web Retrospective[2]		• Can assess long-term intake, food patterns and disease outcomes.	foods • Nutrient specific FFQ provides limited intake data and no assessment of total energy intake, limiting range of analysis (unable to adjust for energy intake)	
Targeted methods	Respondents report their usual frequency of consumption of specific foods or behaviours Retrospective[2]	Designed to measure specific foods, food groups or eating patterns (e.g. fruit and vegetables; "junk" food) and/or food-related risk behaviours (e.g. skipping breakfast, eating in front of TV, fast food consumption).	• Procedure does not influence habitual dietary habits • Low respondent burden • Simple and inexpensive for researchers to administer and analyse • Suitable for large-scale studies • Data entry can be automated • Outcome is food/food group data, behavioural/attitudinal or environmental information relevant to food intake • Able to monitor trends	• Relies on participants memory • Requires participant literacy skills unless interviewer-administered • Requires researching prior to questionnaire development • Can be difficult to assess validity • Not able to estimate nutrient intakes • Limited information gathered on food intake • A restricted range of hypotheses can be investigated	As above

[1]Prospective - collects information about current intake
[2]Retrospective - collects information about food intake from previous months or years

1.3.3 The reliability and validity of dietary assessment methods

The accurate assessment of dietary intake depends upon the reliability and validity of the dietary intake assessment method. Reliability refers to the extent to which a tool can produce the same result when used repeatedly in the same circumstances [138], whilst validity refers to the ability of a tool to accurately measure what it is supposed to measure [139].

1.3.3.1 What is reliability?

Reliability, otherwise referred to as reproducibility, repeatability, consistency or test-re-test variability [140], is the ability of a measure to produce the same result on repeated occasions [121]. Reliable measures are those that are subject to little random error [141]. Values obtained from reliable measures are approximately the same on several occasions, even if completed under different conditions, for example, at a different time or by a different person [142]. If a measurement is unreliable, confidence cannot be placed in the measure giving accurate values on any given occasion [142]. Conversely, if a measurement is reliable, confidence can be placed in the value as it is not influenced by the measurement process [142].

Different measures of reliability are used in nutrition research; test-retest reliability (same reporter on two occasions), intra-observer (same observer on two occasions) or inter-observer (different observers), and inter-rater reliability (different raters) (Table 1-4). Test re-test reliability is determined by evaluating the extent to which an instrument produces the same or similar results when performed under similar circumstances by a given individual on more than one occasion [140, 142]. Inter-rater reliability is determined when values of a measure are determined by more than one individual, whilst inter-item reliability is determined when an unobserved construct is measured based on a set of indicators of the construct [142].

1.3.3.2 What is validity?

Validity is the accuracy of a measure or the ability of a measure to capture the underlying concept it is intended to reflect [139, 142]. In nutrition research, validity refers to a dietary assessment tool measuring food consumption data that represents the 'true' dietary intake of the individual [140]. That is, valid measures are those that are subject to little systematic error [141].

Different constructs are used to understand a measure's validity; absolute validity, criterion validity, relative validity, convergent validity, discriminant validity, face validity, internal validity and external validity (Table 1-4) [142]. The highest standard of validity is absolute validity, sometimes referred to as criterion validity, determined by comparing against a perfect indicator, or a gold standard assessment technique [142]. However, there is no absolute measure of true exposure in many situations [143], particularly for dietary intake, as measurement to complete precision is impossible in free-living populations [124]. Therefore, in the absence of a gold standard dietary assessment technique, only relative validity can be determined. Relative validity is established when a tool is compared with a reference method believed to be more accurate, that is, with a greater degree of demonstrated validity [121, 144].

Convergent validity and discriminant validity, subtypes of relative validity, are established when two similar constructs agree with each other in a way that is expected (convergent; also referred to as construct validity) [140, 142], or when two dissimilar constructs are easily differentiated (discriminant) [142]. Face validity and content validity are subjective measures. The former indicates that a variable appears to capture the concept it is trying to measure whilst the latter indicates whether a measure covers all dimensions present in the concept [142]. Internal validity refers to a measure being valid for individuals in the study sample, whilst external validity relates to how generalisable the validity is to the broader population [138, 142].

Table 1-4 Descriptions of measures of reliability and validity. Adapted from Gleason et al 2010 [142]

Term	Description
Reliability	Extent to which a measurement process gives the same or similar results when repeated under similar circumstances
Test-retest reliability	Extent to which repeated measurements of the same concept for a given individual will be similar to one another.
Inter-Item Reliability	Extent to which multiple indicators of a single construct are correlated.
Inter-Rater/observer Reliability	Extent to which different raters or observers of a given measure come up with the same value of the measure for a given case
Validity	Extent to which a variable or measure captures the underlying concept it is intended to reflect.
Absolute validity	Extent to which a measure exactly captures the concept it is intended to reflect
Criterion validity	Any type of validity based on a comparison of a test measure to a criterion intended to reflect the exact value of the concept the measure is intended to reflect.
Relative validity	Extent to which a test measure of a concept agrees with a reference measure of that concept that has a greater degree of demonstrated validity.
Face Validity	Extent to which a measure appears to most observers to capture the concept it is intended to reflect.
Content validity	Extent to which a measure covers all dimensions present in the concept it is intended to reflect.
Convergent validity	Extent to which several different measures of a concept agree with each other and with a test measure of that concept
Discriminant validity	Extent to which a measure of a concept disagrees with each another measure intended to reflect the opposite of that concept
Internal validity	Extent to which a measure captures the concept is it is intended to reflect among the sample of individuals being studied
External validity	Extent to which a measure captures the concept is it is intended to reflect not only among the sample of individuals being studied, but also in the broader population represented by that sample.

1.3.3.3 Statistical testing of reliability and validity

Several statistics can be used to describe reliability and validity. These are listed in Table 1-5 together with a definition and, where relevant, criteria for evaluating the results.

Correlation coefficients describe the strength of the relationship between variables [142]. That is, the extent to which variation in one measurement is explained by another [140]. For reliability testing, values obtained in the original test are compared with those obtained in the retest for the same set of individuals. For validity testing, values of the test measure are compared with that of the reference measure for the same set of individuals. Higher correlation coefficients, that is those closer to +1.0, indicate stronger reliability or validity, whilst values closer to zero indicate weaker reliability or validity [139]. Pearson's correlation coefficient is used for ratio or interval scales [139], the Spearman's non-parametric rank correlation for ordinal measures [142], and the intra-class correlation coefficient (ICC) for continuous measurements [140].

Comparison of mean values of two administrations or two methods for continuous data can also be undertaken to describe the reliability or validity, respectively, of a tool. A paired t-test or one-sample t-test can be used to determine if there is a statistically significant difference between mean values of two measures; between the initial test and retest (reliability), or between the test measure and the reference measure (validity) [140]. If there is no statistically significant difference between the two measures then the measurement tool is considered reliable and/or valid [142]. To determine whether there is a pattern to any agreement or disagreement, values can be shown graphically using a Bland-Altman plot [145, 146]. The Bland Altman analysis identifies the mean bias (difference) and 95% limits of agreement (±2SD of the difference) between methods to illustrate the level of agreement. The mean of the two measures are then plotted against the difference between the two measures [146], with agreement based on author interpretation [138].

Correlations, T-tests and the Bland-Altman analysis, however, are not appropriate or possible with categorical variables. In this case, the percentage of subjects classified into the same category (correct classification) or into the opposite category (gross misclassification) can be determined. This is otherwise known as percentage agreement and can be used to determine the reliability and validity between two measures. However, often agreement of some cases is by chance, especially when the measure has a limited number of possible values [142]. Cohen's kappa coefficient, a summary measure of cross-classification [147], measures the level of agreement between two categorical measures over and above chance [142]. That is, the kappa coefficient estimates the proportion of agreement between two administrations of a questionnaire after correcting for chance or random agreement [140]. However, for ordinal categories, weighted kappa is often used to reflect the degree of disagreement [148], where disagreements are weighted by the magnitude of the discrepancy [149]. . Thus, with unweighted kappa, all disagreements are treated equally, whereas with weighted kappa, disagreements are penalized in terms of their size [148].

The usefulness of these statistical tests depends not only on the nature of the data but also on their limitations. For example, despite correlation coefficients showing the degree to which measures are associated, they do not measure their level of agreement [150]. That is, data may poorly agree yet produce high correlations [150]. Further, the range of values, including outliers, strongly influence the size of correlation coefficients for the same relationship, with values becoming larger and therefore more significant as the range of values increases [140]. Therefore, correlations should not be used alone, but alongside agreement measures such as kappa statistic and Bland-Altman analysis. Yet as these methods are also associated with limitations, for example the dependency of kappa on the number of categories used [151], it is necessary to use more than one statistical method to test for reliability and/or validity in order to give strength to the results.

1.3.3.4 Summary – accurate assessment of dietary intake

Dietary assessment tools that provide reliable estimates over time and that measure the ‘true’ dietary intake of the individual are essential. Reliability is not useful on its own as a tool can yield a consistent value even if it doesn’t accurately reflect what it is intended to measure [142]. Further, to be valid, a measure should also be relatively free of random error [142]. Thus, unreliable measures cannot be truly valid [142]. Dietary assessment methods should therefore be both reliable and valid at assessing dietary intake. Various tests can be used to test for reliability and validity, with agreement methods more accurate than correlations. Ideally a combination of statistics is used to assess the reliability and validity of a dietary assessment tool.

Table 1-5 Definitions of statistical terms for measuring reliability and validity

Terminology	Definition	Criteria
Correlation	A measure of the extent to which two or more variables are related to one another, usually expressed as a correlation coefficient [141].	
Correlation coefficient (r)	A number, ranging from -1.0 to +1.0, used to describe the strength and direction of the linear relationship between two variables [139].	
Pearson's correlation coefficient	Used for parametric data to describe the relationship between two variables measure on ratio or interval scales [139].	Low ≤0.50; Moderate 0.51-0.69; High ≥0.70
Spearman's correlation coefficient	Used for non-parametric data to describe the relationship between two variables measured on ordinal or ranked scales [139].	Low ≤0.50; Moderate 0.51-0.69; High ≥0.70
Intra-class correlation coefficient (ICC)	A measure of the extent to which multiple measurements taken from the same subject are related, for continuous variables [140]. A high value of 0.9 indicates that 90% of the variance is due to 'true' variance between subjects and 10% is due to measurement error, or within-subject variance [140]	Poor <0.50 Good ≥0.50 [152]
T-tests	Identifies whether there is a significant difference between the average values of two measures [140]	
Cohen's Kappa coefficient (k)	A measure of agreement between two different diagnostic tests for categorical data [139], used to determine reliability [142] Kappa is 1.0 when agreement is perfect and 0.0 when agreement is no better than would be expected by chance [141]	Poor <0.20, Fair 0.21-0.40 Moderate 0.41-0.60 Good 0.61-0.80 very good 0.81-1.00 [153]
Weighted kappa	Use for ordinal variables to reflect the degree of disagreement. Kappa coefficients are weighted so greater emphasis is placed on large differences between ratings than to small differences [250]. Various methods of weighting are available, including linear weighting and quadratic weighting [250, 253].	As per Cohen's Kappa coefficient (above)
Bland Altman analysis	Identifies the mean bias and 95% limits of agreement (± 2SD of the difference) between methods, providing an indication of whether a tool is valid for the assessment of intake at the individual and/or population level [145, 146]	-
Bland-Altman plot	A plot of the difference (bias) between two methods against the average of the two methods; used to evaluate the strength of agreement [145, 146].	Observed agreement based on author interpretation [138]

Wilcoxon Signed Rank Test	Non-parametric test of statistical significance of the differences in means for use with ordinal data comparing repeated measures by ranking them first [139] e.g. for use with two correlated samples such as the same subjects on a before-and-after measure [141].	$p>0.05$ = NS difference between means $p<0.05$ = significant difference between means
Cross classification analysis	Used with categorical data to classify each respondent or their responses into two or more mutually exclusive groups	-

1.3.4 Short toddler dietary assessment tools – a review of the evidence

Given the benefits of short dietary assessment tools, combined with the need to assess total diet to determine toddlers' dietary risk and the importance of assessing the reliability and validity of dietary assessment methods, an ideal dietary risk assessment tool would be valid and reliable at measuring overall diet whilst also being short and simple to complete. Therefore the aim of the following review is to identify whether any short, reliable and valid tools that assess total diet of young children, aged 0 – 5 years, exist. The focus is expanded beyond toddlerhood (1 - 3 years) to ensure all tools applicable to toddlers are captured, whilst also identifying whether any tools outside the 1 - 3 year age range could easily be adapted to toddlers based on similarities in food consumption patterns.

The following section contains material from:

Bell L, Golley R, Magarey A (2013) Short tools to assess young children's dietary intake: a systematic review focusing on application to dietary index research, *Journal of Obesity*, Article ID 709626, 17 pages, Epub 26 Sept 2013

As this section is based on the above paper (presented in Appendix 1 - Papers, conference presentations and awards/prizes arising from this thesis), some repetition with previous sections might be encountered. Small modifications have been made to the review content from that which was published. Searches were re-run in February 2014, with no new papers meeting the review inclusion criteria For this review, dietary risk is conceptualised as a dietary index. The use of dietary indices is an emerging area of interest in nutrition research. Indices assess whole dietary intake against pre-determined criteria, termed index components, which generally reflect current dietary guidelines, to derive a summary score reflecting overall diet. The level of adherence to dietary guidelines is a reflection of dietary risk.

1.3.4.1 Introduction

Individuals do not consume single nutrients, foods or food groups, but rather combinations of foods [118]. Therefore in nutrition research it is appealing to capture the mix of foods and/or nutrients likely to influence health [116]. Dietary indices, for example, evaluate diet quality by assessing dietary intake against pre-determined criteria, usually reflecting current dietary guidelines [154].

Childhood overweight and obesity is a global health problem with 40 million children under the age of five classified as overweight [74]. Given the consequences of obesity and the persistence of obesity from childhood into adulthood [86], it is of major importance to address overweight early in life. As recommendations for overweight prevention and treatment are consistent with food-based dietary guidelines [8, 155], dietary indices offer a way of understanding the contribution of early life food intake to obesity risk.

Evaluation of diet against food-based dietary guidelines using an index [120] still requires accurate assessment of dietary intake at the food or food group level. In children under five, indices have commonly been applied to dietary data collected by 24-hour recalls, diet diaries or weighed food records [156]. Yet, these methods are associated with high respondent burden and are cost and time-intensive in terms of administration and analysis [121]. The use of these dietary assessment methods is a challenge in large epidemiological studies. Additionally, while energy and nutrient intakes can easily be derived from these detailed methods, it is often difficult to extract food intake data in a way that allows meaningful comparison with food-based dietary guidelines [8, 155].

Short, simple dietary assessment instruments are an attractive alternative to collect data from which to derive a diet quality score, as they are associated with reduced participant burden, data handling and processing, and costs. They are consequently suitable for survey or epidemiological research [129]. Further, as they supply information quickly [129] they are useful in clinical settings for the rapid assessment of individuals' food intake against food-based dietary guidelines. In view of the high worldwide childhood obesity rates, simple tools that assess early life obesogenic dietary habits are crucial. Given their advantages, short tools that enable evaluation of young children's dietary intake against food-based dietary guidelines using a dietary index are required.

Thus, this review aimed to: (1) examine short tools, including their reliability and validity, that measure whole diets of children aged 0 – 5 years; (2) identify the short tools that could be used in dietary index research, including screening of obesogenic dietary behaviours.

1.3.4.2 Methods

1.3.4.2.1 Search and selection strategy

A six-stage systematic search (Appendix 2 - Literature review search process) was conducted to identify existing short tools that measure whole diets in young children. The search strategy and article selection are summarised in Figure 1-2. In stage one, MEDLINE via PubMed, Web of Science and SCOPUS were searched for relevant articles published prior to June 2011. The search terms were developed and combined under the following headings: (1) *child (birth-5 years)*, for example, infant, toddler, preschooler, child; (2) *diet*, for example, food, nutrition, dietary intake, dietary pattern, eating pattern, food intake; (3) *assessment tool*, for example, tool, dietary assessment, evaluate, questionnaire, checklist, validity, reproducibility. Search term lists were comprehensive with small adaptations made for individual databases searched. Stage two involved elimination of irrelevant articles in Endnote using specific term searches through 'title' and 'keywords' (all terms presented in Appendix 2 - Literature review search process). At stage three, the title and abstract of the remaining 3303 articles were screened against the review inclusion and exclusion criteria, outlined below. Stage four involved screening of the full article. In stage five, reference lists of all included articles and relevant reviews were searched for additional studies. Lastly, searches were re-run in April 2013 to identify and screen articles published after June 2011 (stage six). All articles were assessed for eligibility independently by the primary author but in consultation with all co-authors.

1.3.4.2.2 Inclusion and exclusion criteria

The included studies were determined using the following criteria:

Types of outcome measures: Studies with whole-of diet intake data (that is, those covering the five ‘core food groups: fruits; vegetables; cereals [e.g. bread, rice, pasta, noodles]; meat and alternatives [e.g. fish, eggs, nuts]; dairy; with or without capturing intake of ‘non-core’ (energy-dense, low nutrient) items) were included. Those assessing individual foods, food groups, nutrients or behaviours and/or household, family or group consumption were excluded.

Types of dietary assessment methods: Studies assessing dietary intake using a short dietary assessment tool were included. For example food frequency questionnaires, checklists and other dietary questionnaires, classified as 50 food intake questions or less. This criterion was set by the authors as a previous review by Calfas et al 2000 [133] defined brief tools as those that comprise less than 50 items or take less than 15 minutes to complete. Articles were excluded if dietary assessment tools such as 24-hour recalls, diet histories or food records were used to measure food intake, as they are considered standardised methods that are limited by complex researcher-based administration [157]. If the number of questionnaire items was not reported, or if the tool had been captured in a previously identified paper, articles were excluded.

Types of participants: Studies assessing dietary intake of healthy children aged 0 – 5 years, reported by a parent or primary caregiver without assistance from the child, were included. Studies not applicable to the general population (for example, preterm infants or children with disabilities, health conditions, or behavioural/learning difficulties) were excluded.

Other: Studies were limited to the English language, humans and those with an abstract. Review studies, reports, conference papers, and similar documents were excluded.

1.3.4.2.3 Data extraction and analysis

Data, including sample characteristics, questionnaire details and measures of reliability and validity were extracted into standardized tables by the principal author and checked for completion and accuracy by co-authors. Data synthesis comprised grouping studies by age group and comparing in terms of dietary assessment characteristics; reliability (that is, tool reproducibility or repeatability using a test-retest procedure [142]); validity (that is, the ability to accurately measure food consumption data that represents the true intake of the individual [139], determined by comparison with an already validated method); and usefulness for current dietary index applications and screening obesogenic dietary behaviours. Applicability of tools to dietary indices was determined by comparing tool characteristics with characteristics of available indices for children aged up to five years, based on those identified in a recent review [156]. Tools were defined as applicable to dietary indices if all index components could be assessed both easily and accurately. Indices covering the five ‘core’ food groups (that is, foods recommended to be consumed every day including fruits; vegetables; cereals [for example, bread, rice, pasta, noodles]; meat and alternatives [for example, fish, eggs, nuts]; dairy), are highlighted. Indices suitable for screening obesogenic dietary behaviours were defined by the assessment of foods not included in the ‘core’ food groups, described as ‘non-core’ foods and recommended to be consumed in minimal amounts [8, 94].

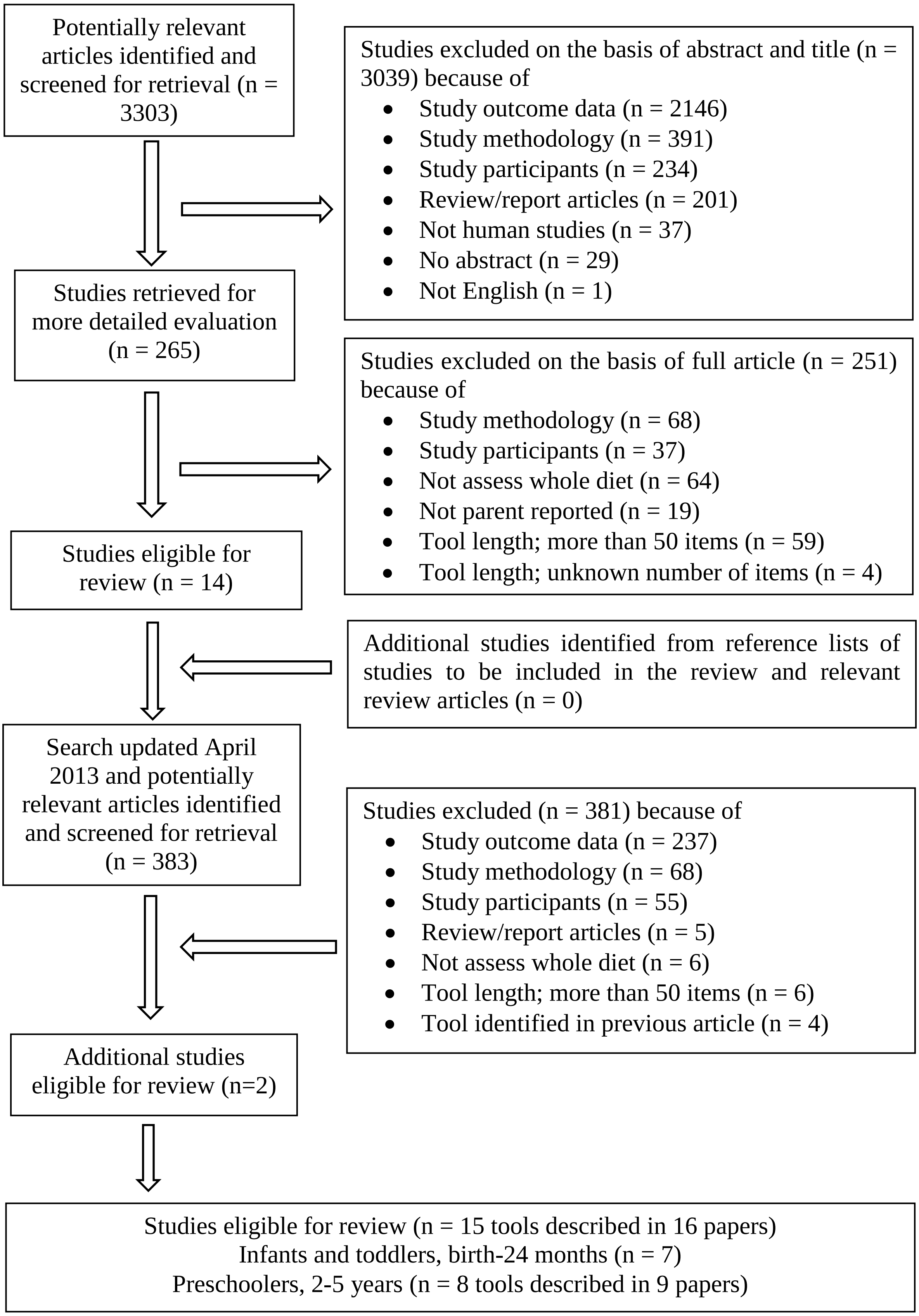


Figure 1-2 Quorum statement flow diagram. Studies assessing whole-of-diet intake of infants and toddlers (birth – 24 months) and preschoolers (2 – 5 years) using a short assessment tool

1.3.4.3 Results

1.3.4.3.1 General description of included studies

Sixteen studies met the review inclusion criteria (Table 1-6). The most common reason for exclusion was the type of outcome data (n = 2383), followed by study assessment methodology (n = 526) and study participants (n = 322). The final 16 papers reported on 15 tools developed to assess dietary intake in early childhood (birth - 5 years); seven evaluate infant and toddler (birth – 24 months) dietary intake [158-164] and eight evaluate preschoolers 2 – 5 years) dietary intake [131, 165-172]). Studies included a range of population groups from predominately European [131, 159-164, 166-168, 171] and other western countries [163, 165, 169, 170, 172] and were largely published from 2006 onwards [131, 159, 162, 163, 165-172], with no retrieved papers published prior to 2000. The number of participants varied from 44 [167] to 27 763 [160], with three studies presenting data from large, prospective birth cohorts; UK Southampton Women's Study (SWS) [159], UK Avon Longitudinal Study of Parents and Children (ALSPAC) [162] and the Norwegian Mother and Child Cohort Study (MoBa) [160].

1.3.4.3.2 Dietary assessment methods and testing

Most (n = 14 of 15) tools used a Food Frequency Questionnaire (FFQ) format [131, 158-162, 164-168, 170-172], with one innovative tool, the NutriSTEP nutrition screening tool for preschoolers, identified [169]. The majority of tools were self-administered [131, 160-169, 171, 172] and non-quantitative [158, 160, 162, 163, 165-167, 169, 172]. The average tool length was 33 items (range 6-47), with 5 tools comprising less than 25 items [161, 163-165, 169]. Reference periods for recalling foods varied from the past week [158, 159, 163] to past year [171]. Fourteen of the 16 studies reviewed reported food or food group intake as a tool outcome measure [131, 158, 160-170, 172], whilst two reported energy and nutrient intakes only [159, 171]. Overall, testing was undertaken on approximately half of identified tools (n = 7/15, described in eight papers) (Table 1-7). A range of tests to assess reliability and validity were reported. Validity (Table 1-8) and/or reliability (Table 1-9) were most commonly tested using correlations, although agreement statistics were also used.

1.3.4.3.2.1 Infants and toddlers (Birth - 24 months)

All seven [158-164] tools assessing infant and toddler dietary intakes were FFQ's, ranging in length from 15 [161] to 43 [162] items. Three tools were evaluated for relative validity [159, 161, 164] (Table 1-8) whilst none were evaluated for reliability.

Validity testing revealed that the FFQ's overestimated energy and nutrient intakes compared with the selected reference standard (all weighed dietary records, WDR) [159, 161, 164]. Correlations for energy and nutrients were low to moderate and slightly higher when energy-adjusted [161, 164]. Bland Altman plots for nutrient intakes showed mostly positive mean differences [159], systematic increases in difference with increasing intake for most nutrients [161, 164] and large limits of agreement [161, 164]. Little gross misclassification (3% [164], 5% [161]), defined as classification of intake by the tool in the opposite quartile or tertile of intake, was reported with over one-third of subjects (38% [164], 36% [161]) classified into the same category of nutrient intake. At the food level, FFQ's generally revealed higher median intakes for several food items (11/17 [164] and 7/15 foods [161]) than the WDR [161, 164]. Correlations for most foods were low or moderate with low ($r = 0.48$ [161]) and moderate ($r = 0.62$ [164]) overall median correlations. Importantly, no studies used agreement statistics at the food level.

1.3.4.3.2.2 Preschool children (2 - 5 years)

Of the eight tools evaluating preschoolers' dietary intakes, described in nine papers [131, 165-172], seven were FFQ's [131, 165-168, 170-172] but length varied widely (six [169] to 47 [131, 171, 172] items). Overall, three tools were assessed for reliability only [166, 167, 169] and one for reliability and validity of food [131] and nutrient [171] intake (Table 1-8 and Table 1-9).

To assess test-retest reliability [131, 166, 167, 169, 171] the period between administrations varied, ranging from two to four weeks [169] to an average of four months (range 0 - 364 days) [166]. No tool was assessed for reliability of energy intake and only one for nutrients [171]. The latter revealed that for average daily calcium intakes re-administrations were not significantly different ($p = 0.26$), were highly correlated ($r = 0.80$) with moderate agreement ($k = 0.60$) and that nearly all subjects were classified into the same or adjacent quartile of intake (93%) [171]. The reproducibility of food intake was assessed for four tools [131, 166, 167, 169] and showed no statistically significant differences for most foods (38/43 [166], 13/13 foods [131]). Mean spearman's correlations were moderate ($r = 0.59$ [166], $r = 0.62$ [167] and $r = 0.64$ [131]) with good Intraclass correlation coefficients (ICC's) reported for many food items ($n = 28/39$ [167]; $n = 13/13$ [131]) and moderate overall mean ICC's ($r = 0.59$ [131, 167]). Two studies showed moderate overall agreement for food items ($k = 0.48$ [166], $k = 0.55$ [169]).

Only one tool was assessed for validity, reported in two studies [131, 171]. This tool significantly underestimated calcium intake measured by an estimated dietary record (EDR), yet methods were moderately correlated ($r = 0.52$, adjusted $r = 0.59$) [171]. Sensitivity and specificity of calcium intake was 62% and 77% respectively [171] and nearly half (42%) of subjects were correctly classified [171]. Agreement statistics showed fair agreement ($k = 0.38$) and large differences for higher average nutrient intakes (Bland-Altman plot) [171]. For food intake, mean differences were predominately less than 30% (12/13 foods) [131], whilst the median correlation was low ($r = 0.48$ [131]) and agreement mostly poor (4/13 foods) or fair (4/13 foods) [131]. Gross misclassification was less than 10% for all food groups whilst classification into the same or adjacent category ranged from 67% (meat products) to 88% (fruit juice) [131].

Table 1-6 Characteristics of included studies (n=16) and their tools (n=15)

Reference details, country	Age diet assessed, sample size (gender	Dietary intake measurement						Outcomes (food, energy and/or nutrient intakes)
		Type[1] and name (if provided) of tool	Number of *food* items	Tool reference period	Self- or interviewer administered [2]	Number response categories (Range)	Other tool details	
Infants and toddlers (birth - 24months)								
Smithers et al (2012) [162]; UK	6 mo, n=7052 (NR)	Non-quantitative FFQ	43	"nowadays"	Self	Report "x" times a week	Items include milk drinks (including formula, BM), cereals (baby, other), rusks, bread/toast, biscuits, ready-to-eat meat/fish/vegetables/baby puddings (fruit, milk), home-cooked meat/fish/vegetables/potatoes/other vegetables/puddings (fruit, milk), raw fruit/vegetables, beverages (juice, fizzy drinks, tea, coffee, water), sweets, crisps, chocolate	Foods
Ystrom et al (2009) [160]; Norway	18 mo, n=27763 (51% boys)	Non-quantitative FFQ	36	"Current diet"; NFS	Self	Drinks, never to ≥5 times/day; Foods, never to ≥3 times/day)	Items include dairy products (milk, yoghurt), meat, fish, fruit, vegetables, potato, porridge, bread, rice, water, fruit juice, soda, chocolate, sweets, desserts, cakes.	Foods
Dee et al (2008) [163]; USA	6 mo, n=1984 (NR)	Non-quantitative FFQ	21	1 wk	Self	Report number of feedings per day or per	Items include milk (BM, formula, cows, rice, goat, soy), other dairy (yoghurt, cheese, ice-cream, pudding), other soy foods (tofu, soy desserts), fruit and	Foods Nutrients

Reference details, country	Age diet assessed, sample size (gender	Dietary intake measurement						Outcomes (food, energy and/or nutrient intakes)
		Type[1] and name (if provided) of tool	Number of *food* items	Tool reference period	Self- or interviewer administered [2]	Number response categories (Range)	Other tool details	
						week	vegetable juice, sweet drinks, baby cereal, other cereals (breakfast cereals, biscuits, breads, rice, pasta etc.), fruit, vegetables, French fries, meat and chicken, fish, nut-based foods, eggs, sweet foods (candy, cookies, cake etc.), other.	
Marriott et al (2008) [159]; UK	6 mo, n=50 (50% boys)	Quantitative FFQ	34	1wk	Interviewer	Open responses	Items include meat, fish, vegetables, fruits, cereals and snack foods and commercial baby foods, non-milk drinks and human milk, baby formulas and other milks. Portion size estimated using household measures.	Energy Nutrients
Andersen et al (2004) [161]; Norway	24-mo, n=187 (53% boys)	Semi-quantitative FFQ	15	2wk	Self	Not specified (never/ <1/month to several times/day)	125 foods grouped into 15 questions based on the Norwegian meal pattern. Items include dairy (milk, yoghurt, cheese), bread, potatoes, vegetables, fruit, meat, fish, cake, chocolate, and soft drinks. Other questions on supplements, food habits, child nutrition information sources. Portion size estimated using a photographic booklet with four different sizes (small – large) or household units (e.g. slices, pieces, spoons).	Foods Energy Nutrients

Reference details, country	Age diet assessed, sample size (gender	Dietary intake measurement						Outcomes (food, energy and/or nutrient intakes)
		Type[1] and name (if provided) of tool	Number of *food* items	Tool reference period	Self- or interviewer administered [2]	Number response categories (Range)	Other tool details	
Andersen et al (2003) [164]; Norway	12 mo, n=64 (58% boys)	Semi-quantitative FFQ	18	2wk	Self	Not specified (never/ <1/month to several times/day)	140 foods grouped into 18 questions based on the Norwegian meal pattern. Items include dairy (milk, yoghurt, cheese), baby cereal, bread, potatoes, vegetables, fruit, meat, sweetened drinks and commercial baby foods. Other questions on dietary supplements food habits, child nutrition information sources. Portion size estimated using a photographic booklet with four different sized (small – large) or household units (e.g. slices, pieces, spoons).	Foods Energy Nutrients
Lartey et al (2000) [158]; Ghana	1–6 mo n=216 (53% girls)	Non-quantitative FFQ	28	1wk	NR	NR	Items include porridges, fruits, vegetables, soups, cereals, legumes, roots and tubers, animal products, cereal-legume mixtures, cereal-animal product mixtures. Other questions on breastfeeding frequency and daily number other milk feedings.	Foods
Preschoolers (2 - 5 years; 25 - 60 months)								
Pabayo et al (2012) [165]; Canada	4-5 y, n=2015 (51.5% boys)	Non-quantitative FFQ	20	Usual intake; NFS	Self	Report total number of daily or weekly	Items include: fruits, vegetables, grain products (bread, cereal, pasta, rice), milk and alternatives (white or flavoured, soy or rice beverages, cheese, yogurt), and	Foods

Reference details, country	Age diet assessed, sample size (gender	Dietary intake measurement						Outcomes (food, energy and/or nutrient intakes)
		Type[1] and name (if provided) of tool	Number of *food* items	Tool reference period	Self- or interviewer administered [2]	Number response categories (Range)	Other tool details	
						servings	meat and alternatives (meat, poultry, fish, peanut butter, nuts, tofu); chips, French fries, candy, chocolate, regular soft drinks, and cakes and cookies.	
Lanfer et al (2011) [166]; IDEFICS consortium; European countries[3]	2-9y (2-< 6y, 39.5%; 6- <10y, 60.5%), n=258 (44% boys)	Non-quantitative FFQ; Children's Eating Habits Questionnaire (CEHQ-FFQ)	43	4wk	Self	8 (never/ <1/week to ≥4/day and 'I have no idea')	Items include vegetables, potatoes, fruit, meat, fish, egg, cereals, bread, pasta, dairy (cheese, milk, yoghurt), sweetened beverages, spreads, sauces, take-away products, salty snacks, chocolate, candy, cake and ice-cream. Screening instrument investigating food consumption frequency and behaviours associated with child overweight, obesity and general health.	Foods
Ebeneger et al (2010) [167]; Switzerland	Mean 5y, n=44 (64% boys)	Non-quantitative FFQ	39	4wk	Self	7 (NR)	Items include fruit, vegetables, potato, meat, fish, dairy (yoghurt, cheese, dairy desserts), bread, cereal, sauces, sweets and snacks (e.g. chocolate), drinks (e.g. cola). Other questions on eating habits.	Foods
Kleiser et al (2009) [168]; Germany	3-17y, (3-6y, 7-10y, 11-17y), n=14105	Semi-quantitative FFQ	45	Previous "few wks"; NFS	Self	10 (never to >5/day)	Items include vegetables, fruit, fish, bread/cereal, rice/pasta/potatoes, milk/dairy products, eggs, meat, fats, sweets/fatty snacks/soft drinks, other	Foods Energy Nutrients

Reference details, country	Age diet assessed, sample size (gender	Dietary intake measurement						Outcomes (food, energy and/or nutrient intakes)
		Type[1] and name (if provided) of tool	Number of *food* items	Tool reference period	Self- or interviewer administered [2]	Number response categories (Range)	Other tool details	
	(51% boys)						beverages. Other questions on eating habits, supplement intake, fortified foods, light products, convenience food and probiotic products. Portion size estimated using illustrations or standard household measures.	
Huybrechts et al (2009) [131]; Belgium Huybrechts et al (2006) [171]; Belgium	2·5–6·5y, n=650 validity n=124 reproducibility (NR) 2·5–6·5y, mean 4.5y n=1052, (50% boys)	Semi-quantitative FFQ	47	12mo	Self	6 (every day to never or less than 1 day/month)	Items include beverages (water, juice, milk drinks), dairy (cheese, yoghurt), meat and meat alternatives (fish, eggs), bread, pasta, rice, vegetables, fruit, potatoes (including fried), meat/fish products, chocolate, sweet snacks, salty snacks, and desserts. Other questions on food habits of some product groups. Portion size estimated using examples of common standard measures.	Foods Energy Nutrients
Randall Simpson et al (2008) [169]; Canada	3-4y, n=269 validity n=140 reproducibility (94% girls)	Non-quantitative Screening Tool; NutriSTEP	6	Usual intake; NFS	Self	NR	Items include grains, milk, fruit, vegetables, meat, fast food. Other questions on nutrition risk constructs; physical growth, physical activity and sedentary behaviour, and factors affecting food intake.	Foods

Reference details, country	Age diet assessed, sample size (gender	Dietary intake measurement						Outcomes (food, energy and/or nutrient intakes)
		Type[1] and name (if provided) of tool	Number of *food* items	Tool reference period	Self- or interviewer administered[2]	Number response categories (Range)	Other tool details	
Romaguera et al (2008) [170]; Argentina	2-9y (mean boys=5.1; girls=5.2), n=360 (NR)	Semi-quantitative FFQ	46	NR	Interviewer	NR	Items include cereals/grains, potatoes/tubers, pulses, fish, meat/meat products, eggs, milk/dairy products, fruits and vegetables, fats, added oil, sugary drinks, herbal teas, added sugar and sweets, sweet and milky desserts. Portion sizes determined according to the observed amount usually consumed in population, measured prior to study.	Foods Energy Nutrients
Sullivan et al (2006) [172]; USA	<60mo, n=191 (59% boys)	Non-quantitative FFQ	47	2mo	Self	9 (1, 2, 3/day; 1, 2, 3/week; 0,1, 2/month)	Items include fruits, vegetables, legumes and nuts, dairy products, meat, fish, and poultry.	Foods

Abbreviations: FFQ, Food Frequency Questionnaire; IDEFICS, Identification and prevention of dietary- and lifestyle-induced health effects in children and infants; NFS, not further specified; mo, months; NR, Not Reported; USA, United States of America; UK, United Kingdom; y, years

[1]Tools were defined as quantitative (quantity of food consumed was estimated using weights, measures or food models), semi-quantitative (quantity of food consumed estimated using a standard portion size, serving or a predetermined amount and respondent asked about the number of portions consumed) or non-quantitative (quantity of food consumed not assessed)

[2]Self-administered (primary caregiver completed the dietary assessment without assistance); Interviewer-administered (a trained interviewer elicited the dietary assessment information from the primary care-giver in a one-on-one setting)

[3]Italy, Estonia, Cyprus, Belgium, Sweden, Germany, Hungary and Spain

Table 1-7 Summary of availability of validity and reproducibility data for each study according to energy and/or nutrient intake and food intake

Reference details	Validity		Reliability	
	Energy and/or nutrients	Foods	Energy and/or nutrients	Foods
Infants and toddlers (birth - 24 months)				
Smithers et al (2012) [162]	-	-	-	-
Ystrom et al (2009) [160]	-	-	-	-
Dee et al (2008) [163]	-	-	-	-
Marriott et al (2008) [159]	√	-	-	-
Andersen et al (2004) [161]	√	√	-	-
Andersen et al (2003) [164]	√	√	-	-
Lartey et al (2000) [158]	-	-	-	-
Preschoolers (2 - 5 years)				
Pabayo et al (2012) [165]	-	-	-	-
Lanfer et al (2011) [166]	-	-	-	√
Ebeneger et al (2010) [167]	-	-	-	√
Kleiser et al (2009) [168]	-	-	-	-
Huybrechts et al (2009) [131]	-	√	-	√
Huybrechts et al (2006) [171]	√	-	√	-
Randall Simpson (2008) [169]	-	-	-	√
Romaguera et al (2008) [170]	-	-	-	-
Sullivan et al (2006) [172]	-	-	-	-

Table 1-8 Short dietary assessment tool validity studies among infants and toddlers (birth - 24 months) and preschoolers (2 - 5 years)

Tests	Reference details; tool length; validation standard, reference period; sample size				
	Infants and toddlers (birth - 24 months)			Preschoolers (2 - 5 years)	
	Marriott et al (2008) [159]; 34-items; 4d WDR; 15 days; n=50	Andersen et al (2003) [164]; 18-items; 7d WDR; 1-2 weeks; n=64	Anderson et al (2004) [161]; 7d WDR; 15 items; 1-2 weeks; n=187	Huybrechts et al (2009) [131]; 47-items; 3d EDR; 1 week; n=650	Huybrechts et al (2006) [171]; 47-items; 3d EDR; 1 week; n=1052
Energy and nutrients					
Mean/median nutrient intakes)	All median intakes significant higher ($p<0.05$), except sodium	All median intakes significant higher ($p<0.05$), except Ca	All median intakes significant higher ($p<0.05$), except protein, Carb, SFA, Ca	-	Significantly lower mean Ca intake: 777mg/d v 838±305mg/d; difference 61±294mg/d ($p<0{\cdot}001$)
Mean/median nutrient densities	-	No significant differences except for protein, SFA, MUFA, Fibre, Vitamin A, Vitamin C, Calcium, Iron	No significant differences except for protein, SFA, MUFA, Fibre, Vitamin A, Vitamin C, Calcium, Iron	-	-
Pearson's correlation	-	-	-	-	$r = 0{\cdot}52$, corrected for intra-variability: $r = 0{\cdot}59$

Tests	Reference details; tool length; validation standard, reference period; sample size				
	Infants and toddlers (birth - 24 months)			Preschoolers (2 - 5 years)	
	Marriott et al (2008) [159]; 34-items; 4d WDR; 15 days; n=50	Andersen et al (2003) [164]; 18-items; 7d WDR; 1-2 weeks; n=64	Anderson et al (2004) [161]; 7d WDR; 15 items; 1-2 weeks; n=187	Huybrechts et al (2009) [131]; 47-items; 3d EDR; 1 week; n=650	Huybrechts et al (2006) [171]; 47-items; 3d EDR; 1 week; n=1052
Spearman's correlation (nutrients)	r = 0.63 (range 0.39 - 0.86) energy-adjusted: r = 0.55-0.89	r = 0.50 (range 0.18 – 0.72) *energy-adjusted* r = 0.50 (0.16 – 0.79)*:*	r = 0.38 (range 0.26 – 0.50) *energy-adjusted* r = 0.52 (range 0.46 – 0.66)	-	-
Spearman's correlation (foods)	-	*r* = 0.62 (range 0.28 - 0.83)	r = 0.48 (range 0.26 – 0.69)	r = 0.48 (range 0.23 - 0.62) *corrected:* r = 0.32 - 0.75	-
Specificity	-	-	-	-	77%
Sensitivity	-	-	-	-	62%
Bland Altman, mean bias	Mostly positive, all nutrients within range -12.5% to 12.5%, except vitamin B12 (-18.9%).	Systematic increase in difference with increasing intake, except Ca	Systematic increase in difference with increasing intake for most nutrients	-	Large differences, higher for greater mean intakes
Bland Altman, limits of agreement	-	Large for all nutrients	Large for all nutrients	-	-

Tests	Reference details; tool length; validation standard, reference period; sample size				
	Infants and toddlers (birth - 24 months)			Preschoolers (2 - 5 years)	
	Marriott et al (2008) [159]; 34-items; 4d WDR; 15 days; n=50	Andersen et al (2003) [164]; 18-items; 7d WDR; 1-2 weeks; n=64	Anderson et al (2004) [161]; 7d WDR; 15 items; 1-2 weeks; n=187	Huybrechts et al (2009) [131]; 47-items; 3d EDR; 1 week; n=650	Huybrechts et al (2006) [171]; 47-items; 3d EDR; 1 week; n=1052
Cross classification; nutrients	-	Same quartile, 38% (range 22% Fibre - 56% SFA); Opposite, 3%	Same quartile, 36% (range 29% fat - 44% vitamin A); Opposite, 5% Energy-adjusted Same, 42%; opposite, 4%	-	Same quartile, 42%; within one, 83%; opposite, 2.4%; difference between quartiles p<0.001
Foods					
Mean/median food group intakes	-	-	-	Mean differences within ±10% 6/13 food groups, 11-30% 6/13, >40% 1/13; Median differences within ±10% 5/13 food groups, 11-20% 1/13, >20% 6/13; 100% for 1/13	-
Wilcoxon signed rank test	-	Significantly higher intakes 11/17 food groups,	Significantly higher intakes 7/15 food groups, Significantly	Significantly different intake distribution for 6/13 (p<0.01) or 9/13 (p<0.05) food groups; higher	-

Tests	Reference details; tool length; validation standard, reference period; sample size				
	Infants and toddlers (birth - 24 months)			Preschoolers (2 - 5 years)	
	Marriott et al (2008) [159]; 34-items; 4d WDR; 15 days; n=50	Andersen et al (2003) [164]; 18-items; 7d WDR; 1-2 weeks; n=64	Anderson et al (2004) [161]; 7d WDR; 15 items; 1-2 weeks; n=187	Huybrechts et al (2009) [131]; 47-items; 3d EDR; 1 week; n=650	Huybrechts et al (2006) [171]; 47-items; 3d EDR; 1 week; n=1052
		NS differences 6/17	lower intakes 3/1, NS difference for 5/15	5/13, lower 4/13, NS difference 4/13	
Kappa statistic	-	-	-	<0.20 4/13 food groups, 0.20-0.40 4/13, 0.41-0.60 2/13, NR 3/13	0.38 (95% CI 0.34, 0.42)
Bland Altman, mean bias	-	-	-	Increasing bias with increasing intakes for “many foods” (*n* not reported)	-
Cross classification; foods	-	-	-	Same=NR, within one=67% – 88%, opposite <10% (2% fruit, fruit juices, milk products – 9% meat products)	-

Abbreviations: Ca, calcium; carb, carbohydrates; d, day; EDR, estimated dietary record; LOA, limits of agreement; MUFA, monounsaturated fatty acids; NR, not reported; NS, not significant; PUFA, polyunsaturated fatty acids; SFA, saturated fatty acids; WDR, weighed dietary record; %, percent

Table 1-9 Short dietary assessment tool reliability studies among preschoolers (2-5 years)

Tests	Reference details; tool length; re-administration period; sample size				
	Lanfer et al (2011) [166]; 43-items; 0-354 days, average 4 months; n=258	Ebenneger et al (2010) [167]; 39-items; within 4-weeks; n=44	Huybrechts et al (2009) [131]; 47-items; 5 weeks; n=124	Huybrechts et al (2006) [171]; 47-items; 5 weeks; n=124	Randall Simpson et al (2008) [169]; 5-items; 2-4 weeks; n=140
Mean/median differences (foods)	-	-	Mean intakes 12/13 food groups within ±10%, 1/13 >10% (11%). Intakes generally lower first administration. Median intakes 10/13 within ±10%, 3/13>20%	-	-
Paired t-test	-	-	-	p=0.26; 23.8 ± 161.2mg Ca/d (95% CI 17·8, 65·5; 774 ± 252 v 751 ± 255)	p<0.001
Pearson's Correlation	-	-	-	r = 0.80 for Ca	-
Spearman's Correlation (foods)	r = 0.59 (range 0.32 – 0.76); p<0.001 (r <0.50 for 8/43 foods, 0.51-0.69 for 26/43, r >0.70 for	r = 0.62 (r <0.50 for 8/39 (7 p<0.05 and 1 NS) ,0.50-0.70 for 22/39 (all p<0.01), >0.70 for 9/39	r = 0.64 (r=0.5-0.7 for 10/13,>0.7 for 3/13)	-	-

Tests	Reference details; tool length; re-administration period; sample size				
	Lanfer et al (2011) [166]; 43-items; 0-354 days, average 4 months; n=258	Ebenneger et al (2010) [167]; 39-items; within 4-weeks; n=44	Huybrechts et al (2009) [131]; 47-items; 5 weeks; n=124	Huybrechts et al (2006) [171]; 47-items; 5 weeks; n=124	Randall Simpson et al (2008) [169]; 5-items; 2-4 weeks; n=140
	9/43); re-administration >4 months (0.28-0.73), < 4 months (0.31-0.87)	(all p<0.01)			
ICC	-	0.59 (>0.50 28/39 foods)	0.59 (>0.50 13/13 foods)	-	-
Kappa Statistic	0.48 (0.23-0.68)	-	-	0.60 (95%CI 0.49 - 0.71)	0.54 (0.39 – 0.71)
Wilcoxon signed-rank test:	p<0.05 for 5/43 items, NS for 38/43 items	-	NS for 13/13 foods		
Cross Classification	-	-	-	grossly misclassified=0%, correctly classified=56.7%, adjacent quartile=36.7%	-

Abbreviations: Ca, calcium; NS, not significant

1.3.4.3.3 Dietary index applications

Dietary indices developed to characterise the diet quality of infants, toddlers or preschool-aged children are summarised in Table 1-10. Overall, data from six tools (n = 2, infants and toddlers [161, 164]; n = 4, preschoolers [131, 168, 170, 172]) can be applied to five measures of diet quality reviewed [168, 172-175], all developed for use in preschoolers (Table 1-10). Two have been tested for validity only [161, 164] and one for both validity and reliability [131]. Of these six short tools, two [168, 172], both for use in preschoolers, have previously been used in dietary index applications. The Healthy Nutrition Score for Kids and Youth (HuSKY) has been applied to the 54-item (45 food-item) semi-quantitative FFQ assessing intakes of three to six-year-old German children [168], whilst the 47-item non-quantitative FFQ has been used to assess dietary diversity in American children under five [172].

No other short tools were identified that provide dietary data to which a dietary index could be applied, because the level of detail provided by the tool was often too minimal for application of an index. This is particularly evident for those indices comprising food-group subcategories (for example, 'vitamin A rich vegetables') [176-181]. Additionally, use of several tools to derive an index score would require detailed analysis to determine nutrient (for example, total fat, cholesterol, iron) intakes [178, 179, 182-185]. Lastly, portion size quantification is required for the majority of dietary indices reviewed [168, 173-176, 178, 179, 181-187] and thus only quantitative or semi-quantitative tools provide data to which these indices could be applied.

1.3.4.3.4 Screening obesogenic behaviours

Of the 15 tools reviewed, 13 assess the intake of 'non-core' foods and/or beverages (n = 6, infant and toddlers [159-164]; n = 7 preschoolers [131, 165-171]). Three of these were specifically designed to screen obesity related behaviours [166, 167, 169] whilst five were identified (above) as being useful for application of a dietary index. Of the 19 indices reviewed [156], three (n = 1, infants and toddlers [23]; n = 4, preschoolers [168]) included food items associated with poor diet quality, such as intake of high fat or sugary foods and/or beverages. Two of these indices can be used with the short tools identified in this review [168, 174].

Table 1-10 Studies examining diet quality indices among infants and toddlers (birth - 24 months) and preschoolers (2 - 5 years), details of the content of the indices and their applicability to short dietary assessment tools identified in Table 1-6. Adapted from Smithers et al 2011 [156].

Index name, country; reference details; age of sample	Index properties	Applicability to short tools identified in Table 1-6					Can be applied to dietary data assessed by short tools reviewed (Table 1-6)
		Assesses			Requires		
	Number of components: component labels	Five 'core' food[1] groups	'Non-core' foods[2]	Assessment of food-group sub-categories	Detailed nutrient analysis	Portion size quantification[3]	
Infants and toddlers (birth-24 months)							
Mean Adequacy Ratio (MAR), USA; Hoerr et al 2006 [183]; 11-25m	Nutrients included in ratio score vary according to research interests. 8 key nutrients used in [46].	-	-	-	√	√	N
Dietary Diversity Score, Brazil, Ghana, India, Norway, Oman, USA; Dewey et al 2006 [177]; 1-2y	8 or 9 food groups: cereals, roots and tubers, vitamin A-rich fruit and vegetables, other fruit and vegetables, legumes and nuts , meat and alternatives, fats and oils, dairy, eggs, (fruits and vegetables separate for 9-food group DDS)	√	-	√	-	-	N
Healthy Eating Index-Canada (HEI-C), Canada; Glanville and McIntyre 2006 [182] ; 1-3y	9: grains, fruit and vegetables, milk, meat, other foods (high in fat, sodium and sat fat), total fat, saturated fat, cholesterol, variety	√	√	-	√	√	N
Food Variety Score (FVS), South Africa; Steyn et al 2006 [188]; 1-3y	1: Dietary diversity. One point for every food item consumed over 24-hour period from 45-item list[4].	-	-	-	-	-	N
Diet Quality Score 2 (DQS2), USA; Caliendo et	6: Vegetables, fruit, breads and cereals, meat and milk, citrus fruit, dark green, and yellow vegetables	√	-	√	-	√	N

Index name, country; reference details; age of sample	Index properties	Applicability to short tools identified in Table 1-6					Can be applied to dietary data assessed by short tools reviewed (Table 1-6)
		Assesses			Requires		
	Number of components: component labels	Five 'core' food[1] groups	'Non-core' foods[2]	Assessment of food-group sub-categories	Detailed nutrient analysis	Portion size quantification[3]	
al 1977 [176] ; 1-4y							
Child Feeding Index, Latin American countries; Ruel et al 2002 [189]; 1- 3y	7: breastfeeding, does not use bottle[5], dietary diversity, food frequency, (egg/fish/poultry), food frequency (meat), food, frequency (grains/tubers), meal frequency	-	-	-	-	-	N
Nutrient Adequacy Score, USA; Krebs-smith et al 1989 [181]; 1-3y	12: milk and milk products, whole grains, enriched grains, total grains, citrus fruit, other fruit and vegetables, total fruit, green and yellow vegetables, starchy vegetables, other vegetables, total vegetables, meat and alternatives	√	-	√	-	√	N
Preschoolers (2-5 years)							
Diet Score (DS), UK; Crombie et al 2009 [174]; 2y	5: bread, other cereals, or potatoes; fruit or vegetables; dairy products; meat, fish or alternatives; high-fat or high-sugar snacks	√	√	-	-	√	Y [131, 161, 164, 168, 170, 171]
Nutrient Quality Index (NQI), Germany; Libuda et al 2009 [185]; 2-4y	17 nutrients: Vitamins A, E, K, B6, B12, C, thiamine, riboflavin, niacin, pantothenic acid, folate; minerals calcium, magnesium, iron, phosphorus, potassium, zinc	-	-	-	√	√	N
Healthy Eating Index (HEI), USA; Manios et al 2009 [187]; 2-5y	10: Grains, vegetables, fruits, milk, meat, total fat (% calories), saturated fat (% calories), total , cholesterol, sodium, variety	√	-	-	√	√	N

Index name, country; reference details; age of sample	Index properties			Applicability to short tools identified in Table 1-6			Can be applied to dietary data assessed by short tools reviewed (Table 1-6)
		Assesses		Requires			
	Number of components: component labels	Five 'core' food[1] groups	'Non-core' foods[2]	Assessment of food-group sub-categories	Detailed nutrient analysis	Portion size quantification[3]	
Servings/day, USA; Kranz et al 2009 [175]; 2-5y	5: fruit, vegetables, grains, milk/dairy, meat/alternatives	√	-	-	-	√	Y [131, 161, 164, 168, 170, 171]
HEI-2005, USA; Fungwe et al 2009 [178] ;2-5y	12: whole fruit (not juice), total vegetables, dark green and orange vegetables and legumes, total grains, whole grains, milk and milk products, meat and alternatives and beans, food oils, Saturated fat, sodium, extra calories from solid fats (including fat in milk), added sugars	√	√	√	√	√	N
Healthy Nutrition score for Kids and Youth (HuSKY); Germany; Kleiser et al 2009 [168]; 3-6y	11: beverages, vegetables, fruit, fish, breads and cereals, other starchy foods (pasta, rice, potato), dairy products, eggs, meat and sausage, fats and oils (butter/margarine), sweets and fatty snacks and soft drinks	√	√	-	-	√	Y [168]
Revised Children's Diet Quality Index (RC-DQI), USA; Kranz et al 2008 [179] Kranz et al 2006 [180]; 2-5y	13: added sugar, total fat, fat quality – linoleic, fat quality – eicosapentaenoic, fat quality – docosahexaenoic, total grains, whole grains, vegetables, fruits, 100% fruit juice, dairy, iron intake, energy balance	-	√	√	√	√	N
Dietary Diversity Score, Malawi; Sullivan et al	Dietary diversity. 7: grains-roots-tubers, legumes and nuts, dairy, meat-poultry-fish-eggs, Vitamin A	√	-	√	-	-	Y [172]

Index name, country; reference details; age of sample	Index properties	Applicability to short tools identified in Table 1-6					Can be applied to dietary data assessed by short tools reviewed (Table 1-6)
		Assesses			Requires		
	Number of components: component labels	Five 'core' food[1] groups	'Non-core' foods[2]	Assessment of food-group sub-categories	Detailed nutrient analysis	Portion size quantification[3]	
2006 [172]; <5y	rich fruits and vegetables, other fruits and vegetables, foods cooked with fat or oil						
Diet Quality Index for Children, USA; Kranz et al 2004 [184]; 2-5y	8: % total energy as added sugars, total fat, saturated fat, number of servings of grains, fruit and vegetables, dairy, excessive juice, iron (mg/d)	-	-	-	√	√	N
Variety Index for toddlers (VIT), USA; Cox et al 1997 [173]; 2-3y	5:bread group, vegetable group, fruit group, dairy group, meat group	√	-	-	-	√	Y [131, 161, 164, 168, 170, 171]
Diet Quality Score 1 (DQS1), Canada; Campbell et al 1992 [186]; 2-4y	6: Milk, meat and alternatives, fruit and vegetables, breads and cereals, additional vegetables, vitamin A rich vegetables	√	-	√	-	√	N
Diversity Score (DS), USA; Caliendo et al 1977 [176]; 2-4y	1: dietary diversity using items consumed by 20% or more of the study samples. One point for every food item consumed from a list of 20 food items[4].	-	-	-	-	√	N

Abbreviations: Freq, frequency; FFQ, Food Frequency Questionnaire; N, no; Y, yes

[1]'Core' foods – foods recommended to be consumed daily e.g. fruit, vegetables, dairy, meat and alternatives, cereals [8, 94]

[2]'Non-core' foods – foods recommended to be consumed in minimal amounts e.g. high fat, salt and/or sugar foods [8, 94]

[3]If portion size-quantification required, index is only useful for data collected using semi-quantitative or quantitative methods

[4]Unlikely any short tool assess the same x-items

[5]No tool assess bottle use

1.3.4.4 Discussion

This review identified 16 papers reporting on 15 short dietary assessment tools that measure whole diets of children under five years (n = 7, infants and toddlers; n = 8, preschoolers). Tool reliability and validity, and applicability to dietary indices and for screening obesogenic dietary behaviours are highlighted. All but one tool was a FFQ, and approximately half (n = 7) of all tools were tested for either reliability or validity, and one tested for both. Six tools provide dietary intake data to which an index can be applied, five of which screen obesogenic dietary behaviours. Overall, testing of tool properties was limited and few tools are applicable to current dietary indices that screen obesogenic dietary behaviours of children birth to five years of age.

Of the 15 tools identified in this review, only seven were tested for validity and/or reliability at the food or food group level. In general, there was a lack of reliability testing to accompany validity testing with only one of four tools assessed for validity also assessed for reliability. As validity requires reliability [141], the remaining three tools cannot be considered as valid. Moreover, there was a high reliance on correlations which assess association only and thus should not be used alone but alongside agreement measures such as kappa statistic and Bland-Altman analysis [145, 146]. Further, although the reference period covered by the validation standard should correspond to that of the questionnaire [128], 3 or 7-day food records were commonly used in the reviewed studies to assess the validity of FFQ's covering two weeks [161, 164] or 12 months intake [131, 171]. For reliability studies, if re-administration periods are too close subjects may remember their previous responses, or if too far apart, lower reliability may reflect true variation in diet [128], particularly in young children at an age when dietary habits are rapidly changing [190]. This is evident as an average re-administration period of four months yielded weaker agreement [166] than studies with shorter re-administration periods. Despite these limitations in tool testing, and in considering the realistic estimates of measurement error between two dietary assessment methods [138] in conjunction with unstable dietary habits of young children, the reliability and validity results presented here can be considered reasonable. Thus, several short dietary assessment tools can be judged as useful for characterising whole diets of children under 5.

Given the increasing interest in assessing diet quality using an index, resulting from an increased understanding of the complexity in which individuals consume foods [191], determining those short tools that are useful for dietary index applications is of interest. For the current indices available for children under five years of age, summarised in this review, diet quality is assessed based on intake of particular foods or food groups, nutrients or a combination of both. Although most of the tools reviewed estimate whole-of-diet food intake making them potentially useful for food or food-group based index applications, few (n = 6 of 15) can be directly applied to current indices of diet quality [131, 161, 164, 168, 170, 172]. Further, these tools are limited by a lack of testing, with only one tested for reliability and validity [131, 171]. Thus the accuracy of the other five tools in assessing dietary intake, and diet quality when applied to an index, is questionable. Therefore, testing of tool properties is recommended prior to dietary index applications.

Several factors explain why other short tools reviewed are not useful for dietary index applications. First, as mentioned, many indices assess diet quality based on nutrient intakes or a combination of nutrient and food intakes. Applying an index of this type to a questionnaire-type tool requires linkage with appropriate food composition data to derive nutrient intakes. Alternatively, questionnaire-type tools are most useful for food-based indices. Further, several indices assess food-group subcategories, such as ‘vitamin A rich vegetables’ or ‘dark green vegetables’, which are not measured by the short tools reviewed. Also limiting applicability is that portion size quantification is required to apply dietary data to several indices. Although these factors limit the applicability of short tools to current indices, several tools that capture food groups of interest are ideal for development of a suitable index. For example, the 47-item FFQ by Huybrechts et al [131] is suitable as it assesses ‘core’ and ‘non-core’ food intake and was the one tool tested for both reliability and validity of food intake. Development of a dietary index based on food intake assessed using this short tool would be appropriate. Alternatively, future research to develop suitable short dietary assessment tools that measure whole diets to which a current index can be applied is ideal.

Moreover, in view of the high rates of overweight and obesity among children under five worldwide [74], indices are potentially a useful tool to evaluate early life dietary behaviours that contribute to obesity risk. Yet few current indices for children less than five years assess obesogenic dietary behaviours, with many evaluating 'core' food and/or nutrient intakes only. Thus, future indices based on 'core' and 'non-core' food intake are warranted. Additionally, considering that few short tools assess 'non-core' intakes and are useful for application of a dietary intake, there is a need for future development of short tools that are useful for both dietary index applications and screening obesogenic dietary behaviours in children under five, particularly in those less than two years of age.

Overall, this systematic review highlights the lack of high quality short dietary intake assessment tools for young children, particularly less than two years, to which a dietary index can be applied. Further, as the majority of those tools available for dietary index applications were developed and tested in European populations, restricting their generalisability outside the European context, there is a need for short dietary assessment tools developed for use in other populations of young children to which an index can be applied. Lastly, it is important to note that several rapid dietary assessment tools have been designed for use in young children, yet are not presented in this review as they focus on limited aspects of food intake, for example fruit and vegetables [95], beverages [62], and obesity-related food and beverages only [192], not total diet. Future rapid dietary assessment tools should be designed to comprehensively measure young children's whole-of-diet intake, including obesogenic dietary behaviours, and should be tested for reliability and validity of food intake.

1.3.4.5 Conclusion

A key finding of this review is that although several short dietary assessment tools were identified as useful for characterising whole diet of children 0 - 5 years, there is an overall lack of brief, valid and reliable dietary assessment tools available for use in this age group. This highlights a need for greater testing of existing short tools. A second key finding is that few short dietary assessment tools, particularly those developed for under 2's, are suitable for dietary index applications and for screening obesogenic dietary behaviours of young children. Due to the benefits of assessing diet quality using indices and of capturing dietary intake using less demanding, time-consuming and expensive dietary assessment methodologies, this review identifies opportunities for short tool development for use in children under five that are adequately reliable and valid for use, applicable to dietary indices, and that assess obesogenic dietary behaviours.

1.3.5 Summary – rapid, accurate assessment of toddlers' dietary risk

Dietary intake assessment is essential for identifying dietary behaviours that may increase risk for or confer protection against disease. Traditional dietary assessment methods, such as 24-hour recalls, food diaries and weighed food records, are associated with high respondent burden and high administration and analysis costs, whilst extracted data cannot be quickly compared to food-group based dietary guidelines. These limitations have led to an increased interest in alternative dietary assessment methods such as FFQ's that measure food or food-group based dietary intake. These questionnaire-style dietary assessment methods are advantageous over traditional dietary assessment methods as they are less time-intensive and burdensome and extracted data can easily be compared to food-group-based dietary guidelines. Nonetheless, increasing questionnaire length can result in reduced cooperation and completion and thus to collect dietary intake information from individuals to identify those at-risk requiring intervention, ideally a dietary intake assessment tool would be short and simple. Further, to assess dietary risk a dietary assessment tool must capture the foods or food groups representing total diet and must be reliable and valid to accurately assess dietary intake. Thus, an ideal dietary risk assessment tool would be short, valid and reliable, and assess whole diet.

To determine whether any such tools exist for use in toddlers, the evidence was reviewed. Detailed synthesis of the literature showed that there are few valid and reliable, brief dietary assessment tools that measure whole diets of children aged 0 - 5 years. More importantly, none were developed for and tested in Australian populations of young children. This gap in the literature highlights that the development of a short, reliable and valid dietary assessment tool that measures whole diets of Australian toddlers is warranted.

1.4 Developing a dietary risk assessment tool for toddlers

In recent decades whole-of-diet assessment has become a focus of nutrition epidemiology. That is, the interest has turned from investigating the impact of single dietary components, such as specific nutrients or foods, on nutritional and health outcomes, to describing overall diet. Whole-of-diet assessment provides a useful means for understanding the influence of diet, a complex exposure, on health, through examining the effect of combinations of foods and nutrients consumed together. This section describes the characterisation of whole diet and how this body of literature can be used to guide the development of a short dietary risk assessment tool for toddlers.

1.4.1 Characterising whole diet

Whole diet patterns are characterised through summarising multiple dietary components into an overall diet measure. There are two main methods (1) *a priori* assessment using score based approaches (for example, dietary indices), and (2) *a posteriori* assessment whereby variables are reduced through statistical manipulation into a small number of components and evaluated (for example, dietary pattern analysis) [154].

1.4.1.1 Characterising whole diet through dietary indices

Dietary indices evaluate diet by assessing intake against pre-determined criteria, termed index components. Components generally reflect current nutrition guidelines or recommendations [154]. On application to dietary intake, index components are quantified and summed to yield scores that indicate level of adherence to dietary guidelines [193, 194]. Resultant scores reflect a holistic assessment of diet and are easily understood and interpreted by health professionals, policy makers and the general public [193].

Dietary indices are constructed for a number of different purposes, and index and scoring characteristics will differ depending on the intended use. They are developed to (1) compare within and between individuals or groups of individuals to identify those with poorer dietary patterns who require dietary counselling [193], (2) determine how well individuals and/or populations comply with dietary guidelines and monitor compliance or changes over time [193, 194], (3) identify specific areas for improvement in the diets of individuals or populations based on adherence or not to individual index components, which can inform intervention development [193], (4) evaluate the effectiveness of these interventions [193], and (5) explore the relationship between diet quality and health outcomes [194]. Overall, dietary indices provide a holistic assessment of diet encompassed a simple summary score that reflects the level of compliance with dietary guidelines

1.4.1.2 Characterising whole diet through dietary patterns

In comparison to dietary indices that assess diet *a priori*, dietary pattern analyses are data-driven techniques that use correlations between food intakes to describe general patterns of consumption. These methods differ from dietary indices as they involve application of statistical methods to collected dietary data, for example, from 24-hour recalls, diet records or FFQ’s, and therefore do not depend on defining a healthy pattern or determining what components are included in an index *a priori* [154]. There are two approaches to derive dietary patterns; cluster and factor analysis.

Cluster analysis is a multivariate method that separates individuals into mutually exclusive groups based upon their consumption of similar types of foods [117, 156]. Individuals are aggregated into relatively homogeneous subgroups with similar diets based on consumption frequency, consumption quantity (in grams), percent energy contribution, nutrient intakes, or a combination of dietary and biochemical measures [116]. Factor analysis is a generic term that includes both principal components analysis (PCA) and common factor analysis (CFA) [191]. These multivariate analysis techniques describe the variation in intake in the population based on correlations between dietary items [117]. The underlying structure in the data matrix is identified by transforming a large set of correlated variables into smaller sets of non-correlated variables [195] that best represent the interrelationships among the set of variables [139], known as principal components or factors.

PCA is the most widely used factor analysis approach. In nutrition analysis, PCA identifies underlying ‘patterns’ of foods in a large number of variables by grouping foods that are commonly consumed together based on underlying linear dependencies among variables [116, 117, 162]. Through a strict algebraic procedure, PCA reveals similarities in people’s dietary habits whereby those foods with wide frequencies of consumption have a stronger influence on the pattern than those foods with narrow frequencies of consumption [196]. A qualitative and quantitative output are produced; loadings of variables on each component or pattern, and the factor scores for each factor–subject combination [197]. Principal components are named based on the foods which load most heavily on each pattern. A summary score is derived for each pattern and this can be used to examine the relationships between patterns and outcomes of interest, such as nutrient intake or health outcomes, via correlation or regression analysis [116, 197]. Overall, PCA summarises large complex dietary data into practical and meaningful information.

Table 1-11 Strengths and limitations of methods that characterise whole diet. Adapted from Moeller et al 2007 [117]

	Strengths	Limitations
Score based methods; *a priori*	• Characterise total diet • Intuitively appealing • Analytically simple to complete • Easily reproducible and comparable • Produce meaningful and interpretable results that are associated with health outcomes	• Dichotomous components (e.g. guidelines met v not met) do not consider the full range or amounts of foods consumed • Non-dichotomous components (those where components include a range of points) do consider variability in intake of foods but not extreme amounts • Dependent on the selected underlying dietary guidelines, which are generally not specific to one type of disease • Interpretation of the guidelines and construction of the scores is subjective • Equally weighted dietary component scores implies that each component is equally important
Data driven methods; *a posteriori*	• Characterise total diet • Account for biologic interactions between nutrients • Produce meaningful and interpretable results that are associated with health outcomes and show some reproducibility across populations	• Limited data on the reproducibility and validity of methods • Few rigorous statistical tests have been used to examine the validity of derived solutions • Procedure is highly subjective; grouping of dietary items, classification of input variables (e.g. grams, servings, percent energy), analytical choices and options (e.g. statistical algorithms, use of rotation), selecting a final pattern solution

1.4.2 Characterising whole diet to inform tool development

Dietary assessment questionnaires are commonly developed based on age- and population-specific dietary guidelines. Although this approach is sound, it can be difficult to identify what food or food-group items are most important to include in a short questionnaire of limited items that captures whole diet intake. A novel approach is to base tool items on current evidence; that is, age- and population-specific dietary intakes. This method is advantageous as it identifies the food items most relevant to the consumption patterns of the target population. Population-specific, evidence-based dietary patterns and dietary indices are therefore useful techniques that can inform the development of a short dietary risk assessment tool for Australian toddlers.

Developing a short dietary assessment tool based on dietary patterns is ideal. Dietary patterns measure overall diet, which is needed to determine dietary risk, and extracted patterns comprise food groups that represent the greatest variation in diet in a population group and which can therefore be used to distinguish between children of poor- and high-quality dietary patterns. Including the foods that load strongly on extracted dietary patterns in the tool will allow the variation between individuals' intake to be captured to determine those at greatest dietary risk. Therefore, characterising dietary patterns of Australian toddlers is important to provide age- and population-specific evidence-based information on foods to include in a short dietary assessment tool that identifies dietary risk of Australian toddlers. Dietary indices also encapsulate holistic diet, allowing for the evaluation of dietary intake against food-group based dietary recommendations to produce an overall rating of intake on a numerical scale. Thus, to assess toddlers' dietary risk, a dietary quality index, or similar, could be applied to dietary intake to derive dietary risk scores based on discrepancies between intake and dietary guidelines. Resultant scores can then be used by health professionals to rapidly identify 'at-risk' toddlers who require intervention to improve their dietary patterns.

1.4.3 Summary – development of a short dietary risk assessment tool for toddlers

Whole-of-diet analyses assess the combinations of foods and nutrients that represent overall diet. They have become increasingly widespread as a means of summarizing the multidimensional nature of dietary data and thus the complexity of individual food consumption. These methods include (1) dietary indices and (2) dietary pattern analysis. Dietary indices and dietary patterns are useful, novel methods for informing the development of a short tool that assesses whole diets of Australian toddlers and from which a measure of dietary risk can be derived. That is, to assess toddlers' dietary risk, a dietary index could be applied to overall intake measured using a short dietary assessment tool comprising items informed by current dietary patterns.

1.5 Thesis aims

1.5.1 Thesis general aim

Given the vulnerability of toddlers to poor diet, the importance of early 'dietary risk' identification, and the lack of tools that rapidly and accurately evaluate whole diets of Australian toddlers, the primary aim of this thesis is to develop and validate a short dietary assessment tool for measuring dietary risk in Australian toddlers aged 12 - 36 months. Further, as tool development based on dietary indices and dietary patterns is a novel and advantageous approach, dietary risk will be measured by the application of a scoring criterion to food intake data collected using a short tool that considers whole dietary patterns. It will be readily completed by parents, and easy to administer and score.

1.5.2 Thesis specific aims

The studies undertaken in this thesis aim to:

(1) Characterise whole-of-diet patterns of Australian toddlers using principal components analysis (PCA) to aid the selection of items to be included in the short tool (chapter two)

(2) Develop a short, simple food-group based dietary assessment questionnaire for Australian toddlers aged 12 - 36 months informed by dietary patterns, and from which a measure of overall diet, expressed as a dietary risk score, can be derived (chapter three)

(3) Determine the test-retest reliability and relative validity of questionnaire-derived dietary risk scores by examining variability of scores measured on two occasions and comparing scores to those derived from a validated food frequency questionnaire (chapter three)

(4) Determine the convergent validity of questionnaire-derived dietary risk scores by examining associations with nutrient intakes, demographic factors and a health outcome, namely toddler weight status (chapter four)

2 DIETARY PATTERNS OF AUSTRALIAN TODDLERS

2.1 Overview

This chapter describes the first step in the development of a short food-group based dietary assessment tool for measuring dietary risk in Australian toddlers (Figure 2-1). That is, dietary patterns of Australian toddlers aged 14 and 24 months are determined using principal components analysis (PCA), and validated, to identify food-group items that distinguish variation in dietary patterns and that can inform the selection of items to include in a new dietary assessment tool for Australian toddlers. The chapter begins with a critique of the dietary pattern literature, including validation of dietary patterns, before presentation of the paper "Dietary patterns of Australian children aged 14 and 24 months, and associations with socio-demographic factors and adiposity". This paper was published in the *European Journal of Clinical Nutrition*.

Step 1: specific thesis aim #1
Characterise dietary patterns of Australian toddlers to aid the selection of items to be included in the short tool

⇩

Step 2: specific thesis aim #2
Develop a short food-group based dietary risk assessment questionnaire for Australian toddlers

⇩

Step 3: specific thesis aim #3
Determine the test-retest reliability and relative validity of questionnaire-derived dietary risk scores

⇩

Step 4: specific thesis aim #4
Determine the convergent validity of questionnaire-derived dietary risk scores

Figure 2-1 Tool development and validation flow diagram; step 1 of 4

2.2 Dietary patterns in toddlers

To understand how dietary patterns are extracted using PCA, the literature on PCA-derived dietary patterns of toddlers from developed countries was critiqued. However, the usefulness of derived dietary patterns for research applications, such as tool development, remains uncertain without an understanding of their validity. This is because valid dietary patterns indicate that are they an accurate measure of dietary intake [154] and thus development of a tool based on valid dietary patterns is required to be certain that the tool provides useful information about diet. This can be achieved by determining whether patterns reflect underlying differences in food and nutrient intake, are associated with factors known to predict dietary intake, and/or are associated with health outcomes. The level of validation of dietary patterns against these three measures was examined.

2.2.1 Summary of studies

In recent years there has been an increase in the use of dietary pattern analysis in adult [118, 154] and child [156] populations. In children, similar PCA-derived dietary patterns have been observed across studies and populations. A review by Smithers et al [156] in 2011 identified 14 studies that characterised whole-of-diet patterns of children aged 1 - 5 years using PCA. Common patterns identified were a *'healthy'* pattern, characterised by fruit, vegetables, whole-grains and home prepared foods and an *'unhealthy'* pattern, characterised by EDNP items.

In toddlers, aged 1 - 3 years, PCA-derived dietary patterns have been investigated in ten studies [17, 160, 162, 198-204] from seven different cohorts, detailed in Table 2-1. Four publications were derived from the UK prospective birth cohort, the Avon Longitudinal Study of Parents and Children (ALSPAC) [162, 198, 200, 201]. Other cohorts were from the UK (Southampton Women's Survey (SWS) [199]), Norway (Norwegian Mother and Baby Cohort [160] and Norwegian National Dietary Survey [202]), Ukraine (European Longitudinal Study of Pregnancy and Childhood (ELSPAC) [17]), the Netherlands [204] and Australia (InFANT trial) [203]. The majority of studies (n = 8/10) were conducted in samples larger than 1000 (range, n = 398 - 27763) [160, 162, 198-202, 204]. Nearly all studies derived patterns from data collected using FFQ's, varying in number of items entered into the PCA (n = 21 [204] – 72 [200]), whilst one used 24-hour recall data [203].

2.2.2 Summary of extracted dietary patterns

The number of patterns extracted varied from two [160, 199, 204] to six [17], with a four-component solution most commonly extracted [162, 198, 200, 202] (Table 2-1). Patterns were similar between studies with common patterns emerging. For example, variations of "healthy" and "unhealthy" patterns were commonly observed.

Similar foods loaded strongly on the "unhealthy" patterns across studies. For example, the '*junk*' food pattern identified in UK three year olds [198], the '*discretionary*' foods pattern identified in UK 15 and 24 month olds [162, 200], and the '*unhealthy*' pattern identified in Norwegian 18 month olds [160] were all characterized by chocolate, sweets, and soft drinks. The '*junk*' [198] and '*discretionary*' [162, 200] patterns shared further similarities, both characterised by crisps/potato chips. The '*unhealthy*' pattern identified in two year old Norwegian children [202] was also similar to these patterns, particularly the '*junk*' pattern in three year old UK children [198], with both characterised by sweets, soft drinks, fried potato products, pizza and burgers/burger buns.

Similar foods loaded strongly on the "healthy" patterns across studies. The '*healthy*' [198, 202], '*wholesome*' [160] and '*health conscious*' [204] patterns included pasta, rice and fish whilst vegetables and legumes/beans/pulses loaded strongly on three [160, 202, 204] of these four patterns, and fruit [160, 202], cheese [160, 198] and potatoes [202, 204] loaded strongly on two of these four patterns. The '*bread and spread-based*' pattern identified in Norwegian two year olds [202] was similar to the '*vegemite and bread*' pattern extracted in Australian 18 month olds [203]. That is, bread, margarine and spreads loaded strongly on both patterns. '*Traditional'* patterns, characterised primarily by meat, vegetables, and potatoes were common in UK [162, 198, 200] and Norwegian [202] toddlers. Patterns characterised by convenience foods such as commercial baby foods [162, 202] or biscuits, bread, yoghurt, sweetened drinks [200] were also observed.

2.2.3 Validation of dietary patterns

Despite the widespread validation of dietary patterns in the adult literature [205] and some in children [156], few studies in toddlers (Table 2-1) have conducted further testing of patterns following extraction. This section examines studies that have validated extracted dietary patterns identified in toddlers, by investigating their association with nutrient intakes, socio-demographic factors and/or health outcomes.

2.2.3.1 Associations with nutrient intakes

Establishing the relationship between patterns and nutrient intake has been widely undertaken in studies of adults [118, 205-207], yet only three studies in toddlers have reported this relationship [204, 208, 209] (Table 2-1). Both the '*home-made contemporary'* (15 month old UK toddlers [204, 208]) and '*health conscious'* (14 month old Norwegian [204] and three year old UK toddlers [209]) patterns were negatively associated with total and saturated fat intakes, and positively associated with health-promoting nutrient intakes such as polyunsaturated fat [204], fibre [209] and/or several vitamins and minerals [208, 209]. Both the *'traditional'* patterns in 15 month old and three year old UK toddlers were positively correlated with protein and several micronutrients [208, 209]. Alternatively, the '*western-like'* [204] pattern in Norwegian 14 month olds and the *'processed'* pattern in three year old UK children were both positively associated with energy and total fat intake [204, 209] and negatively associated with protein intake [204] or energy-adjusted nutrient intakes of fibre, iron, zinc, magnesium and folate [209]. Similarly, the '*discretionary'* pattern in UK 15 month olds was associated with lower intakes of zinc, phosphorous and magnesium, and slightly higher intakes of sodium [208]. These studies highlight that toddlers' dietary patterns reflect underlying nutrient intakes in expected directions.

2.2.3.2 Associations with demographic factors

Consistent with the adult literature [118, 154], dietary pattern studies have shown "healthy" and "unhealthy" patterns in toddlerhood to be associated with various socio-demographic factors (n = 7/10) [17, 162, 198, 199, 201, 202, 204] (Table 2-1). Several studies (n = 6) reported a relationship between "healthier" dietary patterns in toddlers and higher maternal or paternal age and/or level of education [160, 162, 198, 199, 201, 202]. Additionally, "unhealthy" dietary patterns in toddlers have been shown to be associated with greater number of siblings [160, 198, 199, 204] and maternal smoking [160, 199, 202]. The association between white ethnicity and dietary patterns, however, was mixed. "Healthy" patterns were shown to be positively [198] and negatively [162] associated with white ethnicity, or positively associated with non-white ethnicity [201]. Evidently, toddlers' dietary patterns reflect variations in their socio-demographic characteristics.

2.2.3.3 Associations with health outcomes

Several studies in adults have investigated the effect of dietary patterns on health outcomes [118, 154, 205], yet, just over half of the studies characterising toddlers' dietary patterns have examined this relationship (n = 6/10) [17, 162, 198-200, 204] (Table 2-1). Outcomes were predominately adiposity-related and psychological measures, with varied results published across the papers. In 12 month old toddlers from the SWS cohort [199], no association was observed between "healthier" dietary patterns and weight, length or skinfolds cross-sectionally [210]. However, follow up at four years revealed a positive association between "healthier" patterns and lean mass [16] but not BMI [16], fat mass [16] or bone mass [211]. "Healthier" patterns at one year of age in this sample were positively associated with intelligence quotient

(IQ) at four years of age [10]. In the ALSPAC toddler sample, a weak negative association was found between the '*junk'* pattern at three years and level of school attainment [14]. "Healthier" dietary patterns at 15 and 24 months were positively associated with IQ at eight years of age, with the reverse seen for "unhealthy" patterns [162, 200]. In three year old Ukrainian children, consumption of meat-dominated patterns were associated with higher odds of being overweight [17]. In Norwegian two year olds, the '*health conscious'* pattern was negatively associated with constipation at 24 months [204], whilst the '*western-like'* pattern was positively associated with constipation at 36 and 48 months [212]. Dietary patterns of toddlers show associations with a range of health and development outcomes.

2.2.4 Summary – PCA-derived dietary patterns in toddlers

Dietary pattern analysis is a new, dynamic field in diet characterisation, with PCA-derived toddler dietary patterns characterised in predominately European populations. These patterns are not generalizable to Australian populations due to variations in food intake resulting from cultural and food supply differences. One study described dietary patterns of Australian 18 month olds [203], yet patterns were not assessed against nutrient intake, socio-demographic factors, or health outcomes, inhibiting their usefulness in informing tool items of a newly developed dietary risk assessment tool for Australian toddlers. Thus, the lack of knowledge of valid dietary patterns of Australian toddlers restricts development of a tool informed by age- and population-specific, evidence-based dietary patterns. Nonetheless, these studies demonstrate that dietary patterns can be described in toddlers, with similarities in patterns between studies and across populations, highlighting the usefulness of PCA to derive dietary patterns in populations of toddlers. Increasing our understanding of Australian toddlers' dietary patterns, and demonstrating their validity, will enable identification of foods that show the highest variation within the population. These foods will aid the selection of items to be included in the development of a short dietary risk assessment tool for Australian toddlers.

Table 2-1 Studies deriving dietary patterns of toddlers, aged 1 - 3 years, using principal components analysis (PCA) and testing of their properties. Adapted from Smithers et al 2011 [156]

First author, (year) reference	Study design, country/setting, cohort name, year diet assessed (if available)	Sample size (particip-ation rate), age diet assessed	Dietary intake tool, dietary data processing prior to pattern analysis, description of PCA patterns	Associations with child, family or socio-demographic factors	Associations with nutrient intakes: associations with health or development
Spence et al (2013) [203]	Intervention study, **Australia,** The Melbourne INFANT Program, (2008-2010)	n=398/480 (83%), 18mo	24-hour recall *Fruit* – fruit, legumes, meat meals with high veg content, and not sweet drinks, crisps and savoury snacks, potato with fat, red meat *Vegetables* – cooked, non-starchy veg, starchy veg other than potato, potato with no fat, red meat *Vegemite and bread* – vegemite, bread, margarine, water, confectionary, sweet snacks	-	-
Kristiansen et al (2012) [202]	Cross-sectional study, **Norway,** Norwegian	n=1373, 2y	131-item FFQ reduced to 46 food groups *Unhealthy* – Sweets,	*Unhealthy* – lower scores associated with girls (β -0.14 [-0.24, -0.04]), breastfed children at 12mo (β-0.17 [-	-

First author, (year) reference	Study design, country/setting, cohort name, year diet assessed (if available)	Sample size (particip-ation rate), age diet assessed	Dietary intake tool, dietary data processing prior to pattern analysis, description of PCA patterns	Associations with child, family or socio-demographic factors	Associations with nutrient intakes: associations with health or development
	National Dietary Survey **(1999)**		salty snacks, sugar-sweetened drinks, ice-cream and pudding, sausages, ketchup, cakes and biscuits, hamburger buns, sweet cereals, fried potatoes, pizza	0.28, -0.06]), higher maternal age (≤24y v ≥35y, β-0.48 [-0.72, -0.25]), higher maternal (e.g. school v university >4y, β-0.32 [-0.49, -0.14]) and paternal (β -0.33 [-0.49, -0.18]) education levels. Higher scores associated more than one child (e.g. 1 v ≥3, β0.27 [0.12, 0.42])	
			Healthy – veg, pasta, potatoes, fruits and berries, rice, fish, water, stew with meat, veg and potato, poultry	*Healthy* – lower scores associated with girls (β-0.15 [-0.26, -0.04])	
			Bread and spread-based – semi- and whole-grain bread, butter/margarine, meat, cheese, sweet spreads and NOT porridge and unsweetened cereals	*Bread and spread-based* – lower scores associated with girls (β-0.17 [-0.28, -0.07]) and higher maternal age (≤24y v ≥35y β-0.31 [-0.56, -0.07]); higher scores associated with ≥1 child (1 v 2, β0.18 [0.05, 0.31]), mothers working full-time (β-0.10 [-0.24, -0.04])	
			Low-fat milk, pancakes, fruits and berries – low-fat milk, pancakes, fruits and berries and NOT full-fat milk	*Low-fat milk, pancakes, fruits and berries* – lower scores associated with girls (β-0.14 [-0.24, -0.03]); higher scores associated with higher maternal (e.g. school v university >4y, β 0.26 [0.08, 0.44]) and paternal (β 0.20 [0.04, 0.36]) education levels and with >1child (e.g. 1 v ≥3, β0.35 [0.19, 0.51])	

First author, (year) reference	Study design, country/setting, cohort name, year diet assessed (if available)	Sample size (particip-ation rate), age diet assessed	Dietary intake tool, dietary data processing prior to pattern analysis, description of PCA patterns	Associations with child, family or socio-demographic factors	Associations with nutrient intakes: associations with health or development
Kristiansen et al (2012) [202]	Cross-sectional study, **Norway,** Norwegian National Dietary Survey **(2007)**	n=1472, 2y	151-item FFQ reduced to 47 food groups *Unhealthy* – Sweets, salty snacks, ice-cream and pudding, sweetened drinks, ketchup, fried potatoes, pizza, cakes/ biscuits, hamburger buns *Traditional* – meat, potatoes, fish, veg, butter/margarine, semi- and whole-grain bread, sauces, stew with meat, veg and potatoes, eggs *Healthy* – pasta, rice, pancakes, rice porridge, tomato soup/other soup, water, poultry, fish, veg, fruits and berries *Baby food* – porridge and unsweetened cereals, commercial baby food, sugar: NOT grain breads or cheese	*Unhealthy* – lower scores associated with girls (β-0.11 [-0.21, -0.01]), BF children at 12 mo (β-0.14 [-0.25, -0.04]), higher maternal age (β-0.27 [-0.51, -0.02]), and mothers on leave (β-0.24 [-0.41, -0.06]). Higher scores associated >1 child (β0.68 [0.53, 0.82]), smoking mothers (β0.16 [0.03, 0.30]). *Healthy* –higher scores associated with higher paternal education (e.g. school v university >4y β0.19 [0.05, 0.34]) *Baby food* – lower scores associated with mothers with more than one child (e.g. 1 v 2, β-0.19 [-0.31, -0.08]) and higher maternal education level (e.g. school v university >4y, β-0.21 [-0.36, -0.06]); higher scores associated with higher maternal age (≤24y v ≥35y, β0.33 [0.07, 0.58], and mothers on leave (full-time v leave, β0.48 [0.30, 0.66]) *Traditional* – lower scores associated with girls (β-0.15 [-0.25, -0.05]); higher scores associated with smoking mothers (no v yes, β0.25 [0.11, 0.39]	-

First author, (year) reference	Study design, country/setting, cohort name, year diet assessed (if available)	Sample size (particip-ation rate), age diet assessed	Dietary intake tool, dietary data processing prior to pattern analysis, description of PCA patterns	Associations with child, family or socio-demographic factors	Associations with nutrient intakes: associations with health or development
Kiefte de Jong et al (2012) [204]	Population-based, prospective birth-cohort study, Rotterdam, **The Netherlands**	n=5088/7893 (20%) **14mo**	211-item FFQ, reduced to 21 food groups *Health conscious* – pasta and rice, fruit, vegetables, potatoes, legumes, meat, fish *Western-like* – refined bread and breakfast cereals, soup and sauces, savoury snacks, animal fats, confectionary, sugar-containing beverages, meat.	*Health conscious* - positively associated with single parents (β0.30 [0.07, 0.52]), fully BF children to 4mo (β0.18 [-0.003, 0.36]); negatively with girls (β-0.11 [-0.20, -0.01]), maternal alcohol intake during pregnancy (β-0.10 [-0.20, -0.01]), maternal comorbidity (β-0.29 [-0.57, -0.01]) *Western-like* – positively associated with low paternal education (high v mid, β-0.16 [-0.07, 0.25; high v low β-0.41 [0.13, 0.70])]) and household income (β 0. 91 [0.07, 0.32]), paternal smoking (β0.12 [0.03, 0.21]), maternal smoking (β0.16 [0.04, 0.27]), high maternal BMI (β0.02 [0.01, 0.03]), multi-parity (β0.22 [0.16, 0.29]), high infant age (β0.10 [0.08, 0.12]); negatively with paternal (β-0.01 [-0.02, -0.003]) and maternal age (β-0.03 [-0.04, -0.01]), girls (-0.19 [-0.26, -0.11]), solids after 6 mo (β-0.14 [-0.22, -0.05]).	<u>Nutrient associations:</u> (In Kiefte de Jong et al 2012 [204]) *Health conscious* – positively correlated with energy (r=0.3), protein (0.10), polyunsaturated fat (0.10); negatively with total fat (-0.10) and saturated fat (-0.10) *Western-like* – positively associated with energy (0.5) and fat (total [0.10], saturated [0.11], monounsaturated [0.10], polyunsaturated [0.20]), and negatively with protein (-0.20) <u>Health/development associations:</u> (In Kiefte de Jong et al 2013 [212]) *Health conscious* – associated with a lower prevalence of constipation at 24mo (OR 0.65 [0.44, -0.96]), but not 36 or 48mo *Western-like* – no association with constipation at 24mo but positively associated with constipation at 36 (DNR) and 48mo (OR 1.39 [1.02, 1.87])

First author, (year) reference	Study design, country/setting, cohort name, year diet assessed (if available)	Sample size (particip-ation rate), age diet assessed	Dietary intake tool, dietary data processing prior to pattern analysis, description of PCA patterns	Associations with child, family or socio-demographic factors	Associations with nutrient intakes: associations with health or development
Smithers et al (2012) [162]	Prospective Cohort Study, **UK,** Avon Longitudinal Study of Parents and Children (1991-1992)	n=5610/14541 (39%) 15mo	70-item FFQ *Herbs, raw fruit and vegetable* (later termed *Home-made contemporary*) – herbs, spices, legumes, nuts, raw fruit, raw veg, raw carrot, other veg, cheese, fish, apple juice *Discretionary foods* – biscuits, chocolate, sweets, crisps, other savoury snacks, baked beans, sauces, fizzy drinks, added sugar *Ready-prepared baby foods* – Baby: milk pudding, fruit pudding, meat, fish, veg, rice cereal/other cereal/rusks *Reverse meat, vegetables and desserts* (*Home-made traditional*) – negative on meat, fish,	*Herbs, raw fruit and vegetables/home-made contemporary* - positively associated with maternal age (β 0.48 [0.30, 0.67]); negatively associated with being married (β-0.12 [0-0.20, -0.04]) and white ethnicity (β-0.37 [-0.53, -0.20]). *Discretionary foods* – positively associated with maternal BMI ≥30kg/m^2 (β0.43 [0.31, 0.55]) *Ready-prepared baby foods* – positively associated with older maternal age (β0.29 [0.10, 0.48]), not being married (β-0.12 [-0.20, -0.03]), and no siblings (none v 2+, -0.24 [-0.33, -0.15]). *Reverse meat, vegetables and dessert/Traditional* - negatively associated with mother being married (β-0.25[-0.33, -0.16])	Nutrient associations: (In Smithers et al (2012) [162]) *Home-made contemporary*- negatively associated with total fat (T1 v T3, 48.0 v 46.6g) and saturated fat (23.4 v 21.8g); positively with vitamin and minerals (e.g. Mg 146 v 158mg, folate 124 v 131ug) *Discretionary* – negatively associated with zinc (5.1 v 4.6mg), phosphorous (900 v 860mg) and Mg (157 v 144mg); positively with Na (1.38 v 1.42g) *Ready-prepared baby foods* –positively associated with sugar (71.7 v 76.7g), iron (4.8 v 5.1); negatively with Na (1.5 v 1.4g) *Traditional* –positively associated with protein (40.1 v 42.6g), saturated fat (21.8 v 22.8g), Ca (764 v 817mg), vitamin B12 (2.9 v 3.2ug), phosphorus (866 v 901mg); negatively with CHO (139 v 136g), vitamin D (1.2 v 1.1ug), vitamin E (4.4 v 3.9mg) Health/development associations: (In Smithers et al (2012) [200]) *Home-made contemporary* - associated

First author, (year) reference	Study design, country/setting, cohort name, year diet assessed (if available)	Sample size (particip-ation rate), age diet assessed	Dietary intake tool, dietary data processing prior to pattern analysis, description of PCA patterns	Associations with child, family or socio-demographic factors	Associations with nutrient intakes: associations with health or development
			yoghurt, pudding, potatoes, veg, sauces		with IQ at 8y (full scale IQ, β0.67 [0.07, 1.26]; verbal IQ β0.63 [0.004, 1.25]). *Discretionary foods* - weak negative association with IQ 8y (full scale, β-0.86 [-1.52, -0.20]; verbal β-1.20 [-1.90, -0.50]). *Ready-prepared pattern* – weak negative association with IQ at 8y (full scale, β-1.11 [-1.71, -0.50]; verbal β-1.18 [-1.78, -0.59]; performance β-0.71 [-1.34, -0.09]).
Smithers et al (2012) [200]	Prospective Cohort Study, **UK,** Avon Longitudinal Study of Parents and Children (1991-1992)	n=6366/14541 (44%) 24mo	72-item FFQ *Home-made traditional* – potatoes, other vegetables, meat products, gravy/soy sauce, green beans *Contemporary* – legumes, raw apple, other, raw fruit, herbs, cheese, apple juice, other fruit juice, egg *Discretionary* – crisps, sweets, fizzy drinks,	-	<u>Health/development associations:</u> (In Smithers et al (2012) [200]) *Home-made traditional* – weak negative association with IQ at 8y (full scale IQ, β-0.57 [-1.03, 0.01]) *Contemporary* – positive association with IQ at 8y (full scale IQ, β0.90 [0.13, 1.66]; verbal IQ β0.80 [0.08, 1.52]). *Discretionary* – weak negative association with IQ 8y (full scale, β-0.68 [-1.36, -0.01]) *Ready-to-eat foods* –positively associated with IQ 8y (full scale, β0.76 [0.23, 1.29]; verbal β0.90 [0.36, 1.44])

First author, (year) reference	Study design, country/setting, cohort name, year diet assessed (if available)	Sample size (particip-ation rate), age diet assessed	Dietary intake tool, dietary data processing prior to pattern analysis, description of PCA patterns	Associations with child, family or socio-demographic factors	Associations with nutrient intakes: associations with health or development
			chocolate, cola, tomato ketchup, savoury snacks, baked beans, biscuits *Ready-to-eat foods* – biscuits, bread/toast, breakfast cereal, cola, yoghurt, milk pudding		
Northstone and Emmett (2012) [201]	Prospective Cohort Study, **UK,** Avon Longitudinal Study of Parents and Children [213] (1991-1992))	n=10422/14 541 (72%) 24mo	53-item FFQ *Family foods* – bread, breakfast cereal, biscuits, milk-based and fruit-based puddings, meat, fish, cheese, potatoes, other vegetables, fresh fruit, yoghurts, squash/ cordial, cow's milk *Sweet and easy* – potatoes, baked beans, peas, soup, fizzy drinks, tea/coffee, flavoured milk, crisps, sweets, chocolate *Health conscious* –	*Family foods* - positively associated with maternal age (β0.19 [SE 0.06]) and education (β 0.50 [0.03]); negatively with children living in council/housing accommodation (β-0.27 [0.03]), non-white ethnicity (white v non-white, β-0.48 (0.06]) *Sweet and easy* - negatively associated with maternal age (β-0.56 [0.06]) and education (β-0.47 [0.03]); positively with living in council accommodation (β 0.20 [0.04]), parity (β0.17[0.33]), maternal unemployment (β0.11 [0.02]), financial difficulties (β0.09 [0.02]) *Health conscious* -positively associated with maternal age (β0.34 [0.06]),	-

First author, (year) reference	Study design, country/setting, cohort name, year diet assessed (if available)	Sample size (particip-ation rate), age diet assessed	Dietary intake tool, dietary data processing prior to pattern analysis, description of PCA patterns	Associations with child, family or socio-demographic factors	Associations with nutrient intakes: associations with health or development
			legumes, raw veg, other veg, fresh fruit, fish, eggs, cheese, fruit juice, fruit puddings, nuts	education (β0.06 [0.03]) non-white ethnicity (β0.42 [0.06]), maternal 'health conscious' dietary pattern (per 1SD increase, β1.25 [0.04]).	
Friedman et al (2009) [17]	Prospective cohort study, **Ukraine,** European Longitudinal Study of Pregnancy and Childhood (ELSPAC) (1992-1993)	n=883/4510 (20%) 3y	104-item FFQ reduced to 22 food items *Meat* *Staples* *Noodles and pasta* *Fruit and Vegetables* *Breakfast foods* *Snacks* (Food loadings not reported)	-	Health/development associations: Meat (unadjusted OR 1.37 [1.04, 1.81] p = 0.024; adjusted OR 1.62 [1.13, 2.33] p = 0.008), but not other patterns, associated with increased odds of BMI >85th percentile
Ystrom et al (2009) [160]	Survey, **Norway,** Norwegian Mother and Child Cohort Study (MoBa)	n=27763/28, 242 (98%), **1½y**	36-item FFQ *Unhealthy* – chocolate, sweets, soda, desserts, ice cream, juice, fruit drinks, cakes, cookies, waffles, bread and jam	*Unhealthy* – negatively associated with maternal age (β-0.03 [-0.04, -0.03]), education (β-0.02 [-0.02, -0.01]), and income (β-0.06 [-0.08, -0.04]); positively with smoking (β0.09 [0.15, 0.23]), BMI (β0.02 [0.02, 0.02]),	

First author, (year) reference	Study design, country/setting, cohort name, year diet assessed (if available)	Sample size (particip-ation rate), age diet assessed	Dietary intake tool, dietary data processing prior to pattern analysis, description of PCA patterns	Associations with child, family or socio-demographic factors	Associations with nutrient intakes: associations with health or development
	(1999-2008)		or honey, pancakes *Wholesome* – raw and boiled vegetables, fish, fruit, plain yoghurt, rice, peas, beans, bread with fish, cheese or meat products, soured milk, pasta and meat	several children (β0.37 [0.35, 0.39]) and maternal negative affectivity (β0.09 [0.07, 0.10]). *Wholesome* – negatively associated with maternal BMI (β-0.01 [-0.01, -0.01]), smoking (β-0.19 [-0.24, 0.15]), several children (β-0.10 [-0.12, -0.08]), boys (β-0.07 [-0.10, -0.04]); positively with maternal age (β0.02 [0.02, 0.03]), education (β0.08 [0.07, 0.08]).	
Robinson et al (2007) [199]	Prospective cohort study, **UK,** Southampton Women's Survey (1998-2001)	n=1434/1981 (72%), **12mo**	78-item FFQ reduced to 46 food groups *Infant guidelines* –home-prepared foods, cooked and salad veg, beans, meat, fish, egg, cheese, fresh fruit *Adult foods* –cow's milk, white bread, French fries, sweets, chips, processed meat, tinned veg, biscuit	*Infant guidelines* – associated with maternal education (β0.06 [0.02, -0.10]), prudent diet (β0.28, [0.22, 0.34]), lower birth order (β-0.14 [-0.21, -0.08]). *Adult foods* - negatively associated with maternal age (β-0.04 [-0.05, -0.03]), education (β-0.11 [-0.15, -0.07]), prudent diet (β-0.22 [-0.27, -0.16]); positively with maternal BMI (β0.01 [0.004, 0.02]), smoking (β0.07 [0.001, 0.14]), higher birth order (β0.29 [0.23, 0.34), earlier solid intro (β-0.22 [-0.28, -0.16]).	<u>Health/development associations:</u> *Infant guidelines/adult foods* - not associated with weight, length or skinfolds (Baird et al 2008 [210]) *Infant guidelines* - No association with bone mass 4y (Harvey et al 2009 [211]) *Infant guidelines* – positively associated with lean mass, but not fat mass or BMI at 4y (Robinson et al 2009 [16]) *Infant guidelines* - positively associated with IQ at 4y (Gale et al 2009 [10])

First author, (year) reference	Study design, country/setting, cohort name, year diet assessed (if available)	Sample size (particip-ation rate), age diet assessed	Dietary intake tool, dietary data processing prior to pattern analysis, description of PCA patterns	Associations with child, family or socio-demographic factors	Associations with nutrient intakes: associations with health or development
North and Emmett (2000) [198]	Prospective cohort study, **UK,** Avon Longitudinal Study of Parents and Children (ALSPAC) (1991-1992)	n=10139/14 541 (70%), **3y**	43-item FFQ *Junk* (later termed *processed*) – sweets, soft drinks, chocolate, fries, burgers, pies, chips, white bread, pizza, flavoured milk *Healthy* (later termed *health conscious* – pulses, vegetarian foods, rice, pasta, salad, fruit juice, fish, water, eggs, cheese *Traditional British* (later termed *traditional*) – meat, poultry, green and root veg, peas, sweet corn *Snacks* – puddings, biscuits, cakes/buns, squash, fruit	*Junk* – associated with younger (β-0.68 [0.80, -0.56]), less educated (β-0.73 [-0.81, -0.65]), unemployed (no v yes, β-0.09 [-0.14, -0.06]), smoking (β0.29 [0.19, 0.39]) mothers, older siblings (≥1 v 0, β0.22 [0.18, 0.26]) *Healthy* – associated with white ethnicity (β0.53 [0.42, 0.64]), maternal education (β0.57 [0.49, 0.65]), vegetarianism (β1.02 [0.93, 1.11]) *Traditional British* –associated with girls (boys v girls, β-0.11 [0.16, -0.07]), no siblings (≥1 v 0, β-0.15 [-0.19, 0.10]), smoking mothers (β0.16 [0.06, 0.27]) *Snacks* – associated with higher maternal education (β0.41 [0.33, 0.50]), older siblings (β0.17 [0.12, 0.21]), non-white ethnicity (white v non-white (β-0.38[-0.50, -0.27])	<u>Health/development associations:</u> (In Feinstein et al 2008 [14] –DNR) *Junk pattern* - negatively associated with level of school attainment (6-7y and 10-11y) - weak following adjustment *Health conscious* - associated with attainment at 10-11y <u>Nutrient associations:</u> (In Cribb et al 2013 [209]) *Processed* – positively correlated with energy (0.48), total fat (0.26), MUFA (0.41), SFA (0.14), sugar (0.15) *Health conscious* – negatively correlated with total fat (-0.15), MUFA (-0.21), SFA (-0.17), CHO (-0.01), sugar (-0.11) *Traditional* – negatively correlated with total fat (-0.06), MUFA (-0.06), PUFA (-0.06), SFA (-0.03), CHO (-0.23), sugar (-0.04), Na (-0.05)

Abbreviations: BF, breastfed; Ca, calcium; CHO, carbohydrate; DNR, data not reported; mo, months; Mg, magnesium; MUFA, monounsaturated fatty acids; Na, sodium; PUFA, polyunsaturated fatty acids; SFA, saturated fatty acids; T, tertile; veg, vegetables; y, years

2.3 Dietary patterns of Australian toddlers

The following section aims to describe, and validate, dietary patterns of Australian toddlers. It contains material from:

Bell L, Golley R, Daniels L, Magarey A (2013) Dietary patterns of Australian children aged 14 and 24 months and associations with socio-demographic factors and adiposity, *European Journal of Clinical Nutrition,* 67(6): 638-45

As this section is based on the above paper (presented in Appendix 1 - Papers, conference presentations and awards/prizes arising from this thesis), some repetition with previous sections might be encountered. Small alterations have been made to the published manuscript to provide further depth to this thesis, including additional tables, figures and discussion content. At the time of publication, no studies had described dietary of Australian toddlers. However, in 2013 Spence et al [203] published data on PCA-derived-dietary patterns of toddlers aged 18 months of age from the Melbourne Infant Feeding Activity and Nutrition Trial (InFANT) program. Details of this study have been incorporated into this section where applicable.

2.3.1 Introduction

Nutritional research has expanded to consider the effect of whole diets, in addition to individual nutrients and foods on health [116]. Summarising multiple dietary components into an overall diet measure takes into account correlations between dietary constituents by exploring the effect of food combinations [116, 117].

Whole diet measures can be based on food intake assessed against a pre-determined index, or empirically, whereby variables are reduced into a small number of components through statistical manipulation [116]. For example, factor analysis is used to derive a dietary pattern score reflecting foods that correlate with each other [162]. In adults, and less so in children [156], dietary patterns have been shown to be associated with health outcomes [118, 154, 156, 205] and socio-demographic factors [118, 156].

Although early life is a significant period when dietary preferences and habits are first established, laying the foundation of adult eating habits [28, 29, 44, 214] whole of diet patterns have rarely been characterised in children under two years [156]. As dietary patterns are likely to be age-specific, understanding early life dietary patterns, their determinants and their influence on later health is important for developing strategies to improve nutrition in early childhood. Principal components analysis (PCA) is a common type of factor analysis technique [117] that has shown "healthy" and "unhealthy" patterns in the first two years of life to be associated with adiposity measures [16], later IQ [16, 160], and maternal age and education level [160, 162, 199, 201]. However, these patterns have been characterised in predominantly European populations [160, 162, 199, 201, 204].

Given that dietary pattern analyses are data-dependent, and thus not generalisable to other populations, understanding Australian early life dietary patterns and their predictors is important. Further, as comparison of dietary pattern scores against nutrient intakes provides an important verification that pattern analysis can detect meaningful differences in nutrient intake [156], it is necessary to determine the underlying nutrient profiles of extracted patterns. Lastly, considering that in 2007 21% and 18% of Australian boys and girls, respectively, aged 2 - 3 years, were reported as being overweight [59], it is of interest to investigate whether early life dietary patterns predict adiposity. To our knowledge, only one study has described PCA-derived dietary intakes of Australian toddlers [203], yet patterns were not assessed against nutrient intakes, demographic factors or health outcomes.

We aimed to (1) describe dietary patterns of Australian children aged l4 and 24 months; (2) identify the socio-demographic determinants of observed dietary patterns; (3) investigate the underlying food, energy and nutrient profiles of dietary patterns; and (4) examine associations between dietary patterns and child adiposity.

2.3.2 Methods

2.3.2.1 Study design

A secondary analysis of dietary data collected for two Australian studies (described below) was conducted. Dietary patterns of Australian toddlers and socio-demographic predictors were determined using cross-sectional data collected at two points; when children were aged approximately 13 - 16 months and 22 - 25 months. The association between dietary patterns and child adiposity was assessed both cross-sectionally and longitudinally

2.3.2.2 Dataset

Data from the NOURISH [211] and South Australian Infant Dietary Intake (SAIDI) studies were used to determine dietary patterns of Australian toddlers. NOURISH was a multi-site (Brisbane and Adelaide, Australia) obesity prevention randomised controlled trial, comparing a feeding intervention with usual practice [215]. Data from control participants are used in the present study (Figure 2-4). SAIDI was a *concurrent* longitudinal study of infant and toddler dietary intake [216]. Common recruitment, assessment and dietary intake protocols were used for both studies.

Subjects were recruited between March 2008 - April 2009 (NOURISH) and September 2008 - March 2009 (SAIDI) in a two-stage process; mothers delivering healthy infants (≥37 weeks gestation, ≥2500g) were approached (stage one) for permission to be re-contacted approximately three months later for full enrolment in the study when written informed consent was obtained (stage two) (Figure 2-4).

NOURISH participants were first time mother-infant dyads recruited from post-natal wards of major maternity hospitals in metropolitan Adelaide (Flinders Medical Centre, Lyell McEwin and Children, Youth and Women's Health Service) and Brisbane (Royal Brisbane Women's Hospital, Logan Hospital and Mater Hospital). SAIDI participants were not necessarily first-time mothers and were recruited postnatally from hospitals in metropolitan Adelaide (as above) and regional South Australia **(**Murray Bridge Soldiers Memorial Hospital, Mt Barker Hospital, Mt Gambier and Districts Health Service, Whyalla Hospital, Port Lincoln Hospital). Inclusion and exclusion criteria for each study are detailed in Table 2-2. Ethics approval was obtained from Flinders Medical Centre, Queensland University of Technology and the ethics committees required to cover all recruitment sites.

Table 2-2 NOURISH and SAIDI study inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
Healthy term infants (≥37 weeks, ≥2500g)	Infants with a diagnosed congenital abnormality or chronic condition likely to influence normal development (including feeding behaviour)
Mothers delivering this infant as their first live infant (NOURISH only)	Mother with a documented history of domestic violence or intravenous substance abuse
Mothers at least 18 years of age	Mother with a self-reported eating, psychiatric disorder or mental health problem (measured by The Kessler Psychological Distress Scale (K10) [33].
Mothers willing and able to attend sessions at designated metropolitan child health clinics	
Mothers with facility with written and spoken English	

2.3.2.3 Data collection and entry

2.3.2.3.1 Dietary data

Primary caregivers were phone interviewed by a Dietitian trained in a standard protocol about their child's food and beverage intake using a multiple-pass 24-hour recall [217]. Caregivers recalled everything their child ate or drank in the previous 24 hours (pass one) and the amount consumed (pass two). Following that, the Dietitian repeated what and how much was consumed to confirm (pass three). Measuring spoons and a measuring sheet with life-size images of spoon, cup and bottle sizes were provided to assist with estimating serve sizes. Times not suitable to be called were previously identified to maximise successful contact. Unscheduled recalls aimed to avoid primary caregivers knowing when they would be called to ensure feeding on the day recalled was usual practice. For dishes prepared at home, recipes with ingredient quantities and the amount the child consumed were recalled. For breastfeeds, time (in minutes) the child spent suckling was recorded, and breast milk consumption quantified as 10g per minute to a maximum of 10 minutes per feed [218]**.** Post interview, primary caregivers were allocated two days on which to record their child's food and beverage intake in a food diary, thus providing three days of dietary intake (two weekdays and one weekend day).

Data were entered by Dietitians into FoodWorks Professional [219] version 9, using the AUSNUT 2007 food composition database from the 2007 National Children's Nutrition and Physical Activity Survey [220]. Additional commercial infant food and formula product data were sourced from websites, the companies or nutrient information panels**.** Foods entered into FoodWorks have an eight-digit code (available from Food Standards Australia New Zealand for all items in the AUSTNUT 2007 database [220]) which allows categorisation of foods into food groups at a number of levels; (i) the first two digits categorize foods into the broad food group such as cereal products and dishes, milk products and dishes, fruit, vegetables, non-alcoholic beverages etc.; (ii) the first three digits categorize foods into sub-groups within the broad food groups, for example, up to 11 vegetable sub-groups such as potatoes, carrot and similar root vegetables, peas and beans; (iii) the first five digits categorize foods further into sub-groups, for example, potato dishes and potato products (iv) the seven or eight digits represent the individual food, for example, mashed potato or potato chips. Additional new foods were assigned an appropriate code. Unclear coding decisions were discussed between study investigators and managed by a single dietitian. For recipes including items from several food groups, this code was based on the item that made the greatest contribution by weight while also reflecting that it was a mixed dish. Although macro- and micro-nutrient data are provided for all foods entered in the AUSNUT 2007 database, the complete nutrient profile was often not available for additional infant products. A data-cleaning protocol was applied and included assessing reasonability of food and beverage quantities, and checking for extreme energy and nutrient intakes. Data were exported from FoodWorks into Access, merged with the food code and exported into SPSS (SPSS Inc., Chicago, IL, USA).

2.3.2.3.2 Anthropometric data

Child weight (to the nearest 10g, 13 - 16 months, or 50g, 22 - 25 months) and length/height (to the nearest 0.5cm, 13 - 16 months, or 0.1cm, 22 - 25 months) were measured without clothing (13 - 16 months) or without shoes and heavy garments (22 - 25months) by trained study staff at an assessment appointment. If unable to attend an assessment appointment, children were weighed and measured at their local Child Health Clinic or General Practitioner (approximately 17%). Body Mass Index (BMI, kg/m^2) was calculated and converted to age- and sex- specific z-scores using a computer program containing World Health Organisation reference data [221].

2.3.2.3.3 Child and maternal socio-demographic data

At birth, child gender and maternal parity were collected from medical records. Maternal age, education, country of birth, marital status and self-report pre-pregnancy weight status were collected via questionnaire. Maternal education was reported as the highest completed level of six categories (Table 2-3) and collapsed into three: (1) school, (2) trade/TAFE, (3) university. Marital status was reported from five (Table 2-3) categories, and collapsed into two: (1) partnered, (2) not partnered. Maternal weight status was reported from five three categories (Table 2-3) and collapsed into two: (1) overweight, (2) not overweight.

At 13 - 16 and 22 - 25 months, maternal smoking status, age of introduction to solids, and breastfeeding status (yes/no), including age of breastfeeding cessation if applicable, were obtained via questionnaire (Table 2-3). Information from both times was combined to provide complete data. Breastfeeding data were categorised into four categories reflecting duration: (1) never breastfed, (2) up to 6 months, (3) 6 to 12 months, (4) longer than 12 months. Smoking status was reported from four categories (Table 2-3) and collapsed into three: (1) never smoked, (2) quit, (3) current smoker.

Child age at each time was calculated using date of birth and the respective recall date (Table 2-3). The Index of Relative Socio-Economic Advantage and Disadvantage, one of four Socio-Economic Index for Areas indices that rank geographic areas across Australia, was applied to postal code (Table 2-3). The Index of Relative Socio-Economic Advantage and Disadvantage scores areas on a continuum of disadvantage (lowest score, 1) to advantage (highest score, 10) [222], providing a Socio-Economic Index for Areas (SEIFA) decile.

Table 2-3 Summary of socio-demographic data collected at birth (stage 1 recruitment), 13 - 16 months and 22 - 25 months[1]

Birth (medical notes)	Birth/stage 1 Recruitment (questionnaire)	13 - 16 months (questionnaire)	22 – 25 months (questionnaire)
Child gender	Country of birth Australia (yes/no) If no, country of birth was specified	Smoking status • Do not smoke at all • Used to smoke, but no longer do • Less than once a day • At least once a day	Smoking status • Do not smoke at all • Used to smoke, but no longer do • Less than once a day • At least once a day
Maternal parity	Maternal age Calculated using maternal DOB and child's DOB	Breastfeeding duration Q: Are you currently breastfeeding your child? (yes/no) If no; Q: how old was your child when you stopped breastfeeding?	Breastfeeding duration Q: Are you currently breastfeeding your child? (yes/no) If no; Q: how old was your child when you stopped breastfeeding?
	Highest education level • Less than year 10 • Year 10/11 • Year 12 • Trade/apprenticeship • TAFE/college certificate • University	Age of introduction to solids Q: At what age was your child first given solid or semi-solid food regularly[2]?	Age of introduction to solids Q: At what age was your child first given solid or semi-solid food regularly[2]?
	Marital status • Single/never married • Married • Defacto • Divorced/separated • Widowed	Child age[3] Calculated using recall date and DOB	Child age[3] Calculated using recall date and DOB
	Self-reported pre-pregnancy weight status • underweight • normal weight • overweight		

Abbreviations: DOB, date of birth
[1]all factors are maternal characteristics, unless otherwise specified
[2]regularly = more than twice a week for several continuous weeks
[3]data not collected via questionnaire

2.3.2.4 Dietary pattern analysis

Dietary patterns were extracted using PCA. All dietary data (13 - 16 months/22 - 25 months; 1 day n = 136 (25%)/122 (25%), 2 days n = 7(2%)/7 (1.4%) and 3 days, n = 409 (74%)/364 (74%)) were kept in the analysis. Two and three days data were averaged and daily food (g), energy and nutrient intake determined per person.

2.3.2.4.1 Food grouping

The large number of foods and beverage items consumed (1621, 13 - 16 months; 1967, 22 - 25 months) were grouped into interpretable and meaningful categories to use as input variables for PCA. First, dietary supplements and cooking agents (for example, gelatin, wine) were eliminated as they do not represent children's usual intake. Second, foods were grouped into food groups of interest based on their nutrient profiles, recommendations for consumption according to the Australian Dietary Guidelines [8] and the accompanying Australian Guide to Healthy Eating [94], and the new Australian Food Modelling System categorisation [223]. Foods recommended to be consumed every day are described as 'core' foods, covering five 'core' food groups (fruit; vegetables/legumes; breads/cereals/rice/pasta/noodles; lean meat/fish/poultry/eggs/nuts/legumes; milk/yoghurt/cheese) [8, 94]. Foods not included in the 'core' food groups are described as 'non-core' (that is, energy-dense, low-nutrient) foods. Sixty-nine groups at 13 - 16 months and 73 groups at 22 - 25 months were created and included in the analysis (Table 2-4).

Table 2-4 Food groups and food group descriptions

Food group	Food group description
Infant meat-based dinners	Commercial infant egg-, fish-, meat-based dinners
Fruit: fresh	Raw or stewed fresh fruit (pome, berry, citrus, stone, tropical, other)
Infant fruit-based desserts	Commercial infant fruit and fruit-based desserts.
Flours and grains	Rice (brown/white), flour (wheat-based, gluten-free, cornflour), barley, quinoa, polenta, semolina, couscous, sago, food thickener, millet, tapioca
Formula	All infant and toddler formula
Bread: non-white	Rye, wholemeal, wholegrain breads and bread rolls
Infant vegetable-based dinners	Commercial infant vegetable and vegetable-based dinners
Infant milk-based desserts	Commercial infant custard or yoghurt
Vegetables: other	All other vegetables including mixtures of two or more vegetables
Cheese	Cheese, cream cheese, cream cheese dips
Butter	Butter, ghee
Eggs	Eggs (boiled, poached, fried, baked), mixed dishes where egg is the MC (e.g. scrambled eggs)
Oil	Oil (all types)
Nuts and seeds	Seeds, seed products (e.g. tahini), nuts, nut products (e.g. peanut paste, coconut milk/cream)
Infant cereal products	Commercial infant cereal (e.g. porridge, mixed grain cereal), commercial infant pasta and rice dishes
Poultry and feathered game	Chicken, duck, turkey
Vegetables: green and brassica	Broccoli, brussel sprouts, cabbage, cauliflower, lettuce, spinach, green peas, green beans
Pasta	Pasta (white/wholemeal-based; plain/filled) without sauce, noodles (rice/wheat-based)
Water	Water (still, carbonated, sports type, added to formula, added to drinks e.g. juice or cordial)
Potatoes: high fat	Potato fries, chips, gems/nuggets, wedges, hash browns (commercial, frozen-style, home-made)
Meat; muscle, game and organ	Beef, lamb, veal, pork, rabbit, kangaroo, lamb brains
Potatoes: low fat	Potatoes boiled, potatoes mashed (with/without milk/butter), potatoes scalloped/baked (with/without milk/butter/cheese)
Other beverages	Flavoured beverage bases, probiotic drink, sports drink powder
Chocolate and chocolate products	Chocolate and yoghurt-based confectionary

Vegetables: orange	Carrot, sweet potato, pumpkin
Dairy yoghurt: whole fat	Whole or high fat dairy yoghurt
Tea and coffee	Tea (regular, herbal), coffee
Custard	Dairy custard
Flavourings	Salt, pepper, herbs, spices, seasonings, stock, essences
Vegetables: home-style MD	Mixed dishes where vegetables are the MC (e.g. vegetable pasta sauce, vegetable mash)
Soup	Homemade, prepared/ready to eat soup, canned condensed soup, dry soup mix
Fish and seafood: packaged	Canned fish (e.g. tuna, salmon, anchovy)
Bread: white	White flour breads and bread rolls (including high fibre white)
Dairy milk: whole fat	Whole or high fat milk (cow, sheep and goat), evaporated milk, condensed milk, milk powder
Margarine and table spreads	Margarine and table spreads
Fruit and vegetable juice	Fruit and/or vegetable juice (regular, no added sugar, added vitamin c)
Vegemite-type spreads	Vegemite, promite, marmite
Breast milk	Human breast milk
Fish and seafood: fresh	Fresh fish, crustacea and molluscs, fish roe
Frozen milk products	Ice cream, frozen yoghurt
Breakfast cereal: cold type	Breakfast cereals typically consumed cold (e.g. wheat-based, multigrain, puffed rice, flakes, muesli)
Processed meat	Sausage, bacon, ham, corned beef, frankfurt/cheerios/saveloy, devon/fritz, kabana/cabanossi, mortadella, salami, chicken/turkey roll, mixed dishes where pork/bacon/ham are the MC
Sugar and sugar products	Sugar, honey, syrup (golden, maple), jams and sweet spreads, sweet sauces, toppings, sugar-based desserts
Savoury sauces and condiments	Gravies and savoury sauces (including pasta and simmer sauces), pickles, chutneys and relishes, salad dressings
Pastries	Pie, sausage roll, pasty, quiche, spring roll, dim sim, croissant, savoury scroll, pastry sweets (e.g. éclair, custard tart)
Breakfast cereal: hot type	Breakfast cereals typically consumed hot (e.g. oats, porridge, semolina)
Cordial and soft drink	Cordial (<25% fruit juice, cordial concentrate) and soft drink
Cereal: home-style MD	Sandwiches and filled rolls, taco's, savoury pasta/noodle and sauce dishes (e.g. lasagne, stir-fry noodles), savoury rice-based dishes (e.g. sushi, risotto, fried rice, rice porridge) (homemade or commercial)
Infant drinks	Commercial infant fruit juice
Cereal, fruit and nut bars	Muesli bar (chocolate/non-chocolate coated), fruit bar, cake-based bar, fruit-based confectionary (e.g. apricot delight)
Legumes and pulses	Beans (cannellini, mixed, red kidney, chickpea, soy) and lentils

Sweet biscuits and cakes	Sweet biscuits, cakes, cake-type desserts (buns, muffins, scones) and other batter-based products
Bread: other	English-style muffins, flat breads, savoury filled or topped breads and bread rolls, sweet breads
Other dairy products	Dairy desserts (e.g. mousse), cream, flavoured milk
Confectionary	Lollies and other confectionary, liquorice, hundreds and thousands, marshmallow
Meat: home-style MD	Home-style mixed dishes where meat (beef/veal/lamb) is the MC (e.g. beef bolognaise, lamb stew)
Snack products	Crisps (potato-, corn-, soy-, vegetable-based), popcorn, pretzels, extruded cheese/non-cheese flavoured snack, savoury crackers with cheese dip
Poultry: home-style MD	Home style mixed dishes where poultry (chicken/duck/turkey) is the MC (e.g. chicken stew/curry/stir fry)
Cereal: take away-style MD[2]	Pizza, hamburgers, savoury dumplings (chain-style, frozen-style, homemade),
Poultry: high fat MD[2]	High fat mixed dishes where poultry (chicken/duck/turkey) is the MC (e.g. chicken patties, crumbed/topped/filled chicken, battered duck)
Fruit: dried[2]	Dried and preserved fruit, dried fruit and nut mix
Fish and seafood: home-style MD[2]	Mixed dishes where fish or seafood is the MC (e.g. tuna mornay, fish casserole)
Legume and pulse MD	Baked beans, hummus, pappadams, beans, lentils, tofu, falafel, vegetarian sausage, mixed dishes where legumes and pulses are the MC (e.g. lentil/legume curry)
Infant gels	Commercial infant fruit-flavoured gels
Fish and seafood: high fat	Crumbed or battered fish (including fish fingers), crumbed or battered crustacea and molluscs
Savoury biscuits	Savoury biscuits, rice/corn crackers and cakes (flavoured/unflavoured)
Infant desserts: other	Commercial infant rusks, breadsticks, biscuits, muesli, rice bars, cakes
Dairy milk: reduced fat	Reduced, skim or non-fat milk (cow, sheep and goat)
Dairy yoghurt: reduced fat	Reduced, low or no fat dairy yoghurt
Dairy alternatives	Rice/soy milk, soy-cheese, soy-based ice confection, soy-based yoghurt
Dairy blends	Dairy blend spreads
Fruit: home-style MD[1]	Mixed dishes where fruit is the MC (e.g. fruit with cereal)
Fruit: packaged	Canned/tubs fruit (pome, berry, citrus, stone, tropical, other)
Meat: high fat MD[2]	High fat mixed dishes where meat (beef/lamb/veal/pork) is the MC (e.g. meat patties, crumbed/topped meat)

Abbreviation: MC, major component; MD, mixed dishes
[1]Food group at 13-16 months only
[2]Food group at 22-25 months only

2.3.2.4.2 Principal components analysis (PCA)

To determine whether a meaningful PCA could be performed several factors (correlation matrix, Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy, Bartlett's test of sphericity, communalities) were inspected [224]. The correlation matrix demonstrates the strength of the relationship among food groups [225]. It should include several sizeable correlations, with at least some exceeding >0.30 [225]. This was true for both 13 - 16 month and 22 - 25 month correlation matrixes (data not shown). The KMO [226] is a ratio of the sum of squared correlations to the sum of squared correlations plus the sum of squared partial correlations [225]. It also represents the strength of the relationship among variables. A KMO >0.5 indicates sampling adequacy [225]. At 14 and 24 months respectively, the KMO was 0.47 (0.5 rounded) and 0.48 (0.5 rounded), indicating a satisfactory PCA could be performed. Bartlett's test of sphericity [227] tests the hypothesis that the correlations in a correlation matrix are zero. At 13 - 16 and 22 - 25 months, the Bartlett's test of sphericity was statistically significant at $p<0.001$, indicating that the factor analysis was appropriate [227]. Lastly, communalities measure the percent of variance in a variable explained by all the extracted dietary patterns jointly [228]. They indicate whether the variables are a reliable indicator of dietary intake [228]. Those with low values (that is, <0.1) are said to contribute minimally to extracted dietary patterns. At 13 - 16 and 22 - 25 months all communalities were >0.1 and thus appeared to be contributors to the extracted dietary patterns (Table 2-5). As all criteria were sufficient, indicating all variables contributed to extracted dietary patterns, no variables (that is, food groups) were eliminated for subsequent analysis.

Prior to extraction of dietary patterns, factors were 'rotated' to aid interpretability of the pattern loadings. 'Rotation' is a process by which the pattern of loadings is presented in a more interpretable manner without changing the underlying mathematical solution [139]. By doing so, the variance within components is maximised, making them more distinguishable. There are two main approaches to rotation, both of which produce similar solutions [225]. Orthogonal rotation gives solutions that are easier to interpret, describe and report, yet require the researcher to assume that the underlying constructs are independent (that is, not correlated) [225].

Varimax rotation is the most commonly used orthogonal approach, in which high loadings are made higher following rotation and lower ones made lower [225]. By emphasising the differences in loadings, and thus making it clear the variables that correlate with each factor, interpretation is made easier. Conversely, oblique approaches allow for the factors to be correlated, with conceptual advantages, but practical disadvantages in terms of interpretation, describing and reporting of results [225]. For this study Orthogonal (Varimax) rotation was applied.

The number of dietary patterns identified was based on eigenvalues >1.0, identification of a break point in the scree plot and interpretability [139, 162]. Eigenvalues represent the total variance explained by that factor. Components with an eigenvalue less than 1 are not as important from a variance perspective, and thus, only factors with an eigenvalue of more than 1.0 are retained for further investigation [139]. Table 2-6 and Table 2-7 show that the first 31 (at 13 - 16 months) and 32 (at 22 - 25 months) components had eigenvalues greater than 1.0, explaining 65.2% and 64.3% of the variance, respectively. The scree plot is a visual representation of the eigenvalues [229]. Usually the scree plot is negatively decreasing, that is, the eigenvalue is highest for the first factor and decreases for the next few factors [225]. The plot was inspected to determine a point at which the shape of the curve changes direction. It is recommended that all factors above the first elbow or break in the plot are retained as these explain the most variance in the dataset [229]. Figure 2-2 (13 - 16 months) and Figure 2-3 (22 - 25 months) show that the there is a bend in the plot at the third component and thus the two components above the break were retained. These components explain 7.3% and 6.6% of the variance at 13 - 16 months (Table 2-6), and 22 - 25 months (Table 2-7), respectively.

Potential PCA solutions (two at 13 - 16 months; two at 22 - 25 months) were assessed for strength of loadings of food items on and across components to determine interpretability. Easily interpretable factors are those with which several variables correlate highly with it (that is, factor loadings ≥ 0.25) and do not correlate with other factors. That is, each factor is characterised by several strongly loading variables, each of which loads strongly on only one component. If few variables load highly on a factor, interpretation is difficult and thus the factor is not a true ‘pattern’ of intake. There were few loadings of foods across dietary patterns at both 13 - 16 months (n = 1; formula loaded negatively on both patterns) and 22 - 25 months (n = 0) (Table 2-10). Thus, the numerous strong loadings on each dietary pattern and minimal cross-loadings indicated two true ‘patterns’ of consumption obtained from Varimax rotation at 13 - 16 and 22 - 25 months of age (Table 2-10).

For every participant, a dietary pattern score for each identified pattern was determined by summing the product of standardised grams of each item consumed by its factor loading. Patterns were approximately normally distributed (mean 0, standard deviation (SD) 1). To simplify the appearance of the PCA matrix and to assist with interpretability and naming of the extracted patterns, strong loadings (≥ 0.25) were highlighted. Doing so did not change the dietary pattern scores. Patterns were named based on those foods loading ≥ 0.25,

Table 2-5 Communalities for foods included in PCA at 13 – 16 and 22 - 25 months

Foods	13 - 16 months	22 -25 months
Infant meat-based dinners	0.619	0.636
Fruit: fresh	0.664	0.573
Infant fruit-based desserts	0.517	0.591
Flours and grains	0.666	0.670
Formula	0.730	0.590
Bread: non-white	0.732	0.764
Infant vegetable-based dinners	0.647	0.615
Infant milk-based desserts	0.719	0.682
Vegetables: other	0.605	0.621
Cheese	0.592	0.650
Butter	0.700	0.599
Eggs	0.602	0.563
Oil	0.585	0.673
Nuts and seeds	0.589	0.709
Infant cereal products	0.535	0.655
Poultry and feathered game	0.612	0.631
Vegetables: green and brassica	0.524	0.660
Pasta	0.700	0.655
Water	0.657	0.627
Potatoes: high fat	0.587	0.637
Meat: muscle, game and organ	0.593	0.732
Potatoes: low fat	0.665	0.723
Other beverages	0.719	0.615
Chocolate and chocolate products	0.674	0.492
Vegetables: orange	0.630	0.674
Dairy yoghurt: whole fat	0.714	0.649
Tea	0.614	0.544
Custard	0.679	0.633
Flavourings	0.604	0.614
Vegetables: home-style MD	0.648	0.655
Soup	0.626	0.741
Fish and seafood: packaged	0.568	0.617
Bread: white	0.714	0.766
Dairy milk: whole fat	0.792	0.772
Margarine and table spreads	0.702	0.661
Fruit and vegetable juice	0.546	0.501
Vegemite-type spreads	0.745	0.734
Breast milk	0.750	0.696
Fish and seafood: fresh	0.647	0.900

Frozen milk products	0.702	0.492
Breakfast cereal: cold type	0.646	0.666
Processed meat	0.666	0.634
Sugar and sugar products	0.582	0.612
Savoury sauces and condiments	0.676	0.650
Pastries	0.648	0.556
Breakfast cereal: hot type	0.875	0.593
Cordial and soft drink	0.627	0.515
Cereal: home-style MD	0.651	0.601
Infant drinks	0.625	0.573
Cereal, fruit and nut bars	0.684	0.601
Legumes and pulses	0.634	0.609
Sweet biscuits and cakes	0.642	0.691
Bread: other	0.891	0.686
Other dairy	0.645	0.528
Confectionary	0.584	0.700
Legume and pulse MD	0.637	0.774
Infant gels	0.616	0.621
Fish and seafood: high fat	0.623	0.634
Savoury biscuits	0.644	0.542
Infant desserts: other	0.640	0.677
Dairy milk: reduced fat	0.588	0.68
Dairy yoghurt: reduced fat	0.604	0.622
Dairy alternatives	0.728	0.678
Dairy blends	0.749	0.731
Fruit: home-style MD	0.678	-
Fruit: packaged	0.696	0.687
Meat: home-style MD	0.481	0.617
Snack products	0.607	0.522
Poultry: home-style MD	0.708	0.660
Cereal: take away-style MD[g]	-	0.564
Poultry: high fat MD[g]	-	0.577
Fruit: dried[g]	-	0.588
Fish and seafood: home-style MD[g]	-	0.879
Meat: high fat MD[g]	-	0.640

Abbreviations: MD, mixed dishes

Table 2-6 Total variance explained by each of the 69 components at 13 - 16 months

Component	Initial Eigenvalues		
	Total	% of Variance	Cumulative %
Tea	2.635	3.818	3.818
Fruit and vegetable juice	2.376	3.444	7.262
Cordial and soft drink	2.064	2.991	10.253
Water	1.927	2.793	13.045
Other beverages	1.790	2.594	15.639
Flours and grains	1.769	2.564	18.203
Bread: white	1.654	2.397	20.600
Bread: non-white	1.628	2.360	22.960
Bread: other	1.595	2.311	25.271
Pasta	1.568	2.273	27.544
Breakfast cereal: hot type	1.529	2.215	29.759
Breakfast cereal: cold type	1.467	2.126	31.885
Sweet biscuits and cakes	1.448	2.098	33.983
Savoury biscuits	1.383	2.005	35.987
Pastries	1.367	1.981	37.969
Cereal: home-style MD	1.346	1.951	39.920
Butter	1.332	1.930	41.850
Dairy blends	1.296	1.879	43.729
Margarine and table spreads	1.247	1.807	45.536
Oil	1.242	1.800	47.336
Fish and seafood: fresh	1.226	1.776	49.112
Fish and seafood: packaged	1.204	1.745	50.857
Fish and seafood: high fat	1.187	1.720	52.578
Fruit: fresh	1.161	1.682	54.260
Fruit: packaged	1.143	1.657	55.917
Fruit: home-style MD	1.137	1.648	57.565
Eggs	1.126	1.632	59.197
Meat: muscle, game and organ	1.075	1.559	60.755
Meat: home-style MD	1.045	1.515	62.270
Poultry and feathered game	1.021	1.479	63.749
Poultry: home-style MD	1.002	1.453	65.202
Processed meat	0.980	1.420	66.622
Dairy milk: whole fat	0.957	1.387	68.009
Dairy milk: reduced fat	0.945	1.370	69.379
Dairy yoghurt: whole fat	0.916	1.328	70.707
Dairy yoghurt: reduced fat	0.892	1.292	71.999
Cheese	0.868	1.257	73.256

Custard	0.839	1.216	74.472
Frozen milk products	0.832	1.206	75.678
Other dairy	0.820	1.189	76.867
Dairy alternatives	0.804	1.165	78.032
Soup	0.799	1.158	79.190
Nuts and seeds	0.771	1.117	80.307
Savoury sauces and condiments	0.763	1.105	81.412
Potatoes: low fat	0.751	1.088	82.500
Potatoes: high fat	0.721	1.045	83.546
Vegetables: green and brassica	0.711	1.031	84.577
Vegetables: orange	0.703	1.019	85.595
Vegetables: other	0.674	0.977	86.573
Vegetables: home-style MD	0.650	0.942	87.515
Legumes and pulses	0.629	0.912	88.427
Legume and pulse MD	0.609	0.882	89.309
Snack products	0.594	0.861	90.170
Sugar and sugar products	0.576	0.835	91.005
Chocolate and chocolate	0.571	0.827	91.832
Cereal, fruit and nut bars	0.553	0.801	92.633
Confectionary	0.541	0.784	93.417
Vegemite-type spreads	0.511	0.740	94.157
Flavourings	0.490	0.711	94.868
Formula	0.489	0.708	95.576
Breast milk	0.460	0.667	96.243
Infant cereal products	0.432	0.626	96.869
Infant fruit-based desserts	0.413	0.599	97.468
Infant vegetable-based dinners	0.382	0.554	98.022
Infant meat-based dinners	0.370	0.536	98.559
Infant milk-based desserts	0.350	0.508	99.066
Infant gels	0.297	0.431	99.497
Infant desserts: other	0.200	0.289	99.786
Infant drinks	0.147	0.214	100.000

Table 2-7 Total variance explained by each of the 73 components at 22 - 25 months

Component	Initial Eigenvalues		
	Total	% of Variance	Cumulative %
Tea	2.557	3.503	3.503
Fruit and vegetable juice	2.260	3.096	6.598
Cordial and soft drink	2.114	2.896	9.494
Water	2.014	2.759	12.253
Other beverages	1.903	2.607	14.861
Flours and grains	1.846	2.528	17.389
Bread: white	1.755	2.405	19.794
Bread: non-white	1.710	2.342	22.136
Bread: other	1.675	2.294	24.430
Pasta	1.629	2.231	26.662
Breakfast cereal: hot type	1.527	2.092	28.754
Breakfast cereal: cold type	1.487	2.037	30.791
Sweet biscuits and cakes	1.454	1.992	32.784
Savoury biscuits	1.449	1.985	34.768
Pastries	1.428	1.955	36.724
Cereal: take away-style MD[g]	1.389	1.903	38.626
Cereal: home-style MD	1.362	1.865	40.492
Butter	1.312	1.797	42.289
Dairy blends	1.282	1.756	44.045
Margarine and table spreads	1.252	1.715	45.760
Oil	1.231	1.686	47.446
Fish and seafood: fresh	1.216	1.666	49.111
Fish and seafood: packaged	1.201	1.645	50.756
Fish and seafood: high fat	1.168	1.601	52.357
Fish and seafood: home-style	1.163	1.593	53.950
Fruit: fresh	1.142	1.564	55.514
Fruit: packaged	1.110	1.521	57.035
Fruit: home-style MD	1.090	1.493	58.528
Eggs	1.079	1.478	60.006
Meat: muscle, game and organ	1.058	1.449	61.455
Poultry and feathered game	1.044	1.430	62.884
Meat: high fat MD[g]	1.012	1.386	64.271
Meat: home-style MD	0.975	1.336	65.606
Poultry: high fat MD[g]	0.961	1.317	66.923
Poultry: home-style MD	0.946	1.296	68.219
Processed meat	0.937	1.284	69.503
Dairy milk: whole fat	0.930	1.274	70.777

Dairy milk: reduced fat	0.913	1.251	72.028
Dairy yoghurt: whole fat	0.892	1.222	73.250
Dairy yoghurt: reduced fat	0.862	1.181	74.431
Cheese	0.857	1.174	75.606
Frozen milk products	0.832	1.139	76.745
Custard	0.806	1.105	77.849
Other dairy	0.793	1.087	78.936
Dairy alternatives	0.778	1.066	80.002
Nuts and seeds	0.775	1.061	81.063
Soup	0.740	1.014	82.077
Savoury sauces and	0.730	1.000	83.077
Potatoes: low fat	0.721	0.988	84.065
Potatoes: high fat	0.709	0.971	85.035
Vegetables: orange	0.676	0.926	85.962
Vegetables: green and brassica	0.664	0.909	86.871
Vegetables: other	0.638	0.874	87.745
Vegetables: home-style MD	0.606	0.830	88.575
Legumes and pulses	0.592	0.811	89.385
Legume and pulse MD	0.588	0.805	90.191
Snack products	0.576	0.788	90.979
Sugar and sugar products	0.547	0.749	91.728
Chocolate and chocolate	0.537	0.735	92.463
Cereal, fruit and nut bars	0.522	0.715	93.178
Confectionary	0.492	0.673	93.851
Vegemite-type spreads	0.486	0.666	94.517
Flavourings	0.481	0.659	95.176
Formula	0.473	0.648	95.824
Breast milk	0.438	0.600	96.424
Infant cereal products	0.414	0.567	96.991
Infant fruit-based desserts	0.401	0.549	97.540
Infant vegetable-based dinners	0.376	0.515	98.055
Infant meat-based dinners	0.364	0.498	98.553
Infant milk-based desserts	0.344	0.472	99.025
Infant gels	0.311	0.425	99.450
Infant desserts: other	0.262	0.359	99.810
Infant drinks	0.139	0.190	100.000

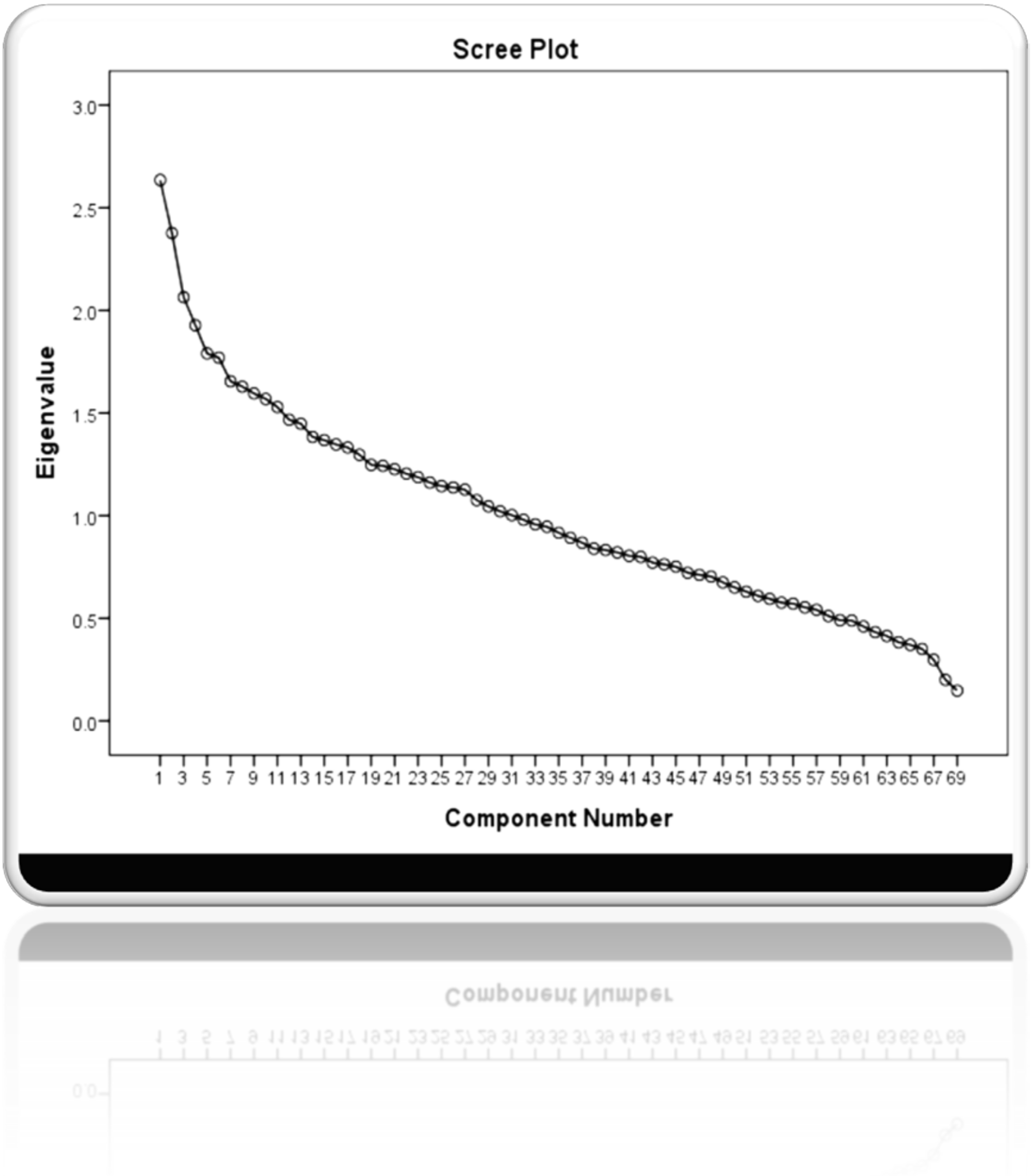


Figure 2-2 Scree-plot for the PCA at 13 - 16 months

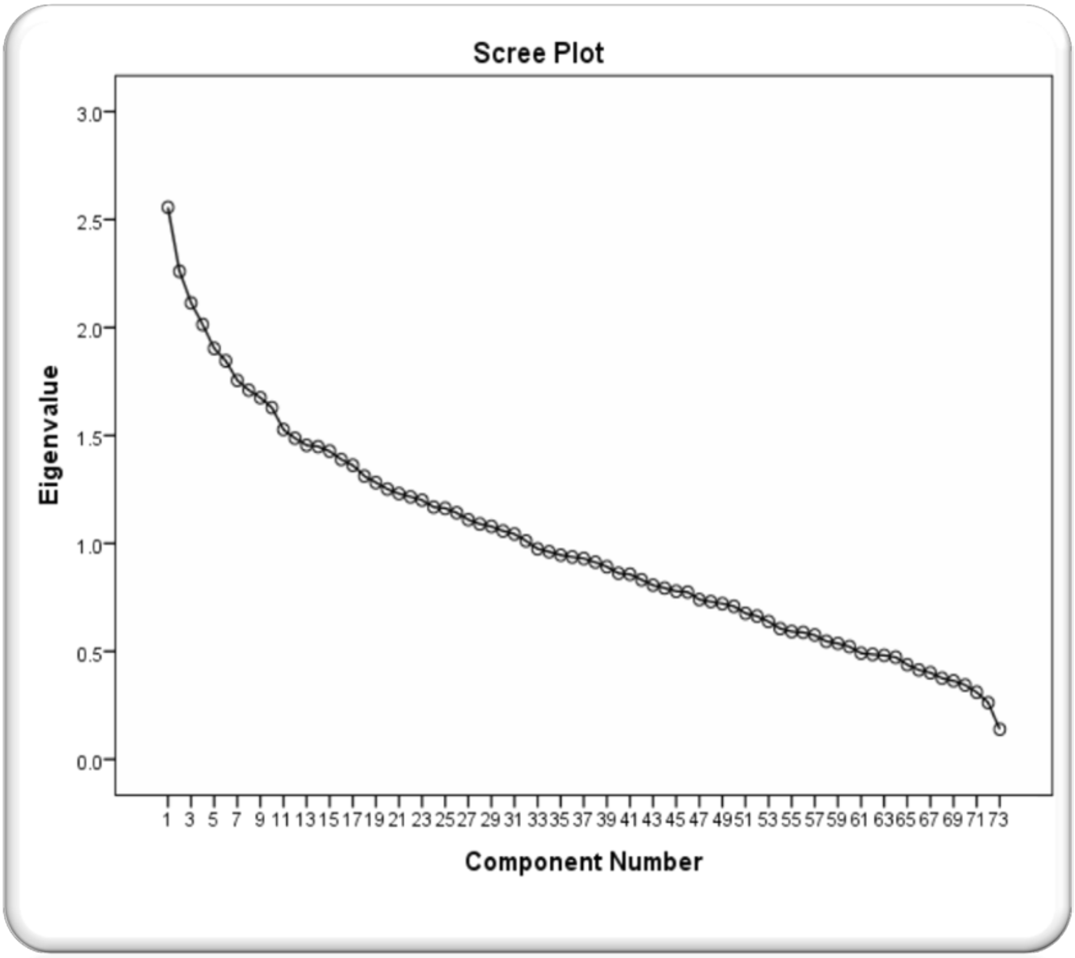


Figure 2-3 Scree plot for the PCA at 22 - 25 months

2.3.2.5 Statistical analysis

Statistical analyses were conducted using SPSS version 19.0 (SPSS Inc.). All continuous data were assessed for normality using mean (SD) and visually using frequency histograms. Data are presented as means (SD) where normally distributed, and parametric statistics employed, or as medians (interquartile range, IQR), and non-parametric statistics employed, where not. Dietary patterns scores were divided into quartiles; quartile 1 has the lowest and quartile 4 has the highest scores on each dietary pattern. Validity of dietary patterns was investigated by comparing food, energy and energy-adjusted nutrient intakes across quartiles of dietary pattern scores using Kruskal-Wallis test for non-parametric data. Analyses were conducted on all available data and a significance level of $p<0.05$ was set.

Pearson correlations between dietary patterns at 13 - 16 month and 22 - 25 months were determined to explore the similarities in patterns across time. Standard linear regression was employed to investigate the relationship of dietary patterns with socio-demographic characteristics and BMI z-score. For each time, two regression models were used which included (1) socio-demographic covariates and respective dietary pattern scores, and (2) dietary patterns scores and respective BMI z-scores, adjusting for covariates. The final regression model included 13 - 16 month dietary pattern scores and 22 - 25 month BMI z-scores, adjusting for covariates. For each model, univariate and multivariate associations were explored. Regression assumptions were tested by checking the normality, linearity and variance (homoscedasticity) of residuals [139]. Regression coefficients (β) and 95% confidence intervals were used to evaluate the strength and precision of associations. The level of significance was set at $p<0.05$.

2.3.3 Results

Dietary intake data were provided for 552 and 493 children (54% girls at both times) at 14 (10 – 17) months and 24 (22 – 28) months, respectively (Figure 2-4). At both 14 (552:69 = 8:1) and 24 (493:73 = ~7:1) months, the cases to food variable ratio was appropriate, being greater than a 5:1 ratio [225]. Participant characteristics are reported in Table 2-8. Mothers were mostly university educated, partnered, not overweight, born in Australia, primiparous and had never smoked.

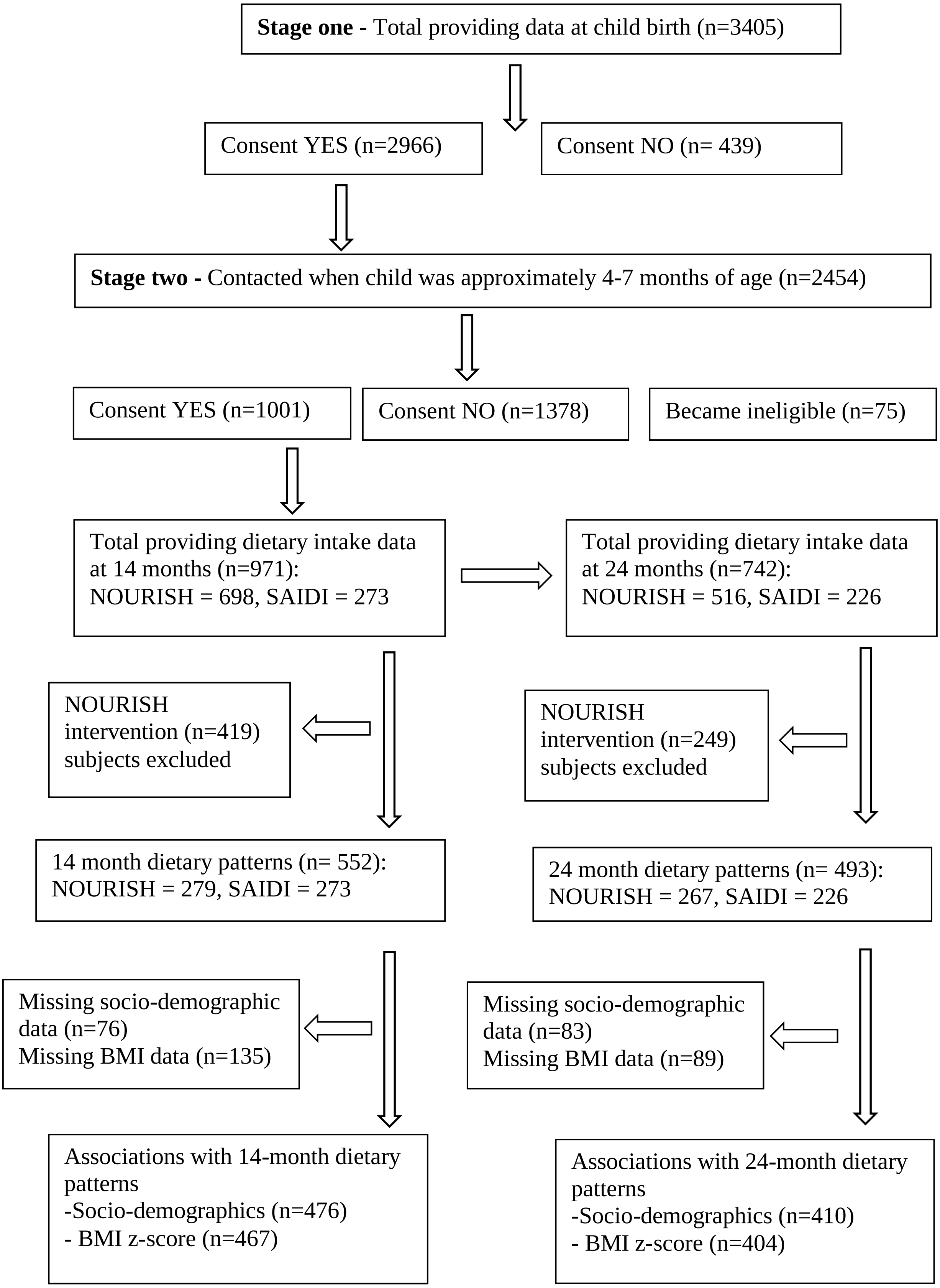


Figure 2-4 Two-phase recruit process for the NOURISH and SAIDI studies and derivation of participants for PCA of dietary intake data

Table 2-8 Characteristics of mother-child dyads included in PCA at 14 and 24 months

	14 months (n=552)	24 months (n=493)
Maternal characteristics		
Age at child's birth (years)[1]	31.2 (5.1)	31.3 (5.0)
Highest education level[2]		
School	126 (23)	104 (21)
Trade/TAFE	153 (28)	128 (26)
University	273 (49)	261 (53)
Smoking status[3]		
Never smoked	417 (75)	366 (74)
Quit	37 (7)	25 (5)
Current smoker	32 (6)	31 (6)
Not recorded/missing	66 (12)	71 (14)
Marital status[4]		
Not partnered	23 (4)	16 (3)
Partnered	527 (96)	476 (97)
Not recorded/missing	2 (0)	1 (0)
Weight status[5]		
Not overweight	438 (79)	386 (78)
Overweight	111 (20)	104 (21)
Not recorded/missing	3 (1)	3 (1)
Parity		
Primiparous	364 (66)	331 (67)
Multiparous	184 (33)	158 (32)
Not recorded/missing	4 (1)	4 (1)
SEIFA decile[16]	6.3 (2.8)	6.3 (2.8)
Born in Australia		
Yes	473 (86)	417 (85)
No	77 (14)	74 (15)
Not recorded/missing	2 (0)	2 (0)
Study		
NOURISH	286 (52)	267 (54)
SAIDI	266 (48)	226 (46)
Child characteristics		
Gender		
Boys	254 (46)	227 (46)
Age (months)[1]	13.7 (1.2)	23.6 (1.1)
Age of introduction to solids (weeks)[1, 7]	20.9 (5.1)	20.8 (5.1)
Breastfeeding duration		
Never breastfed	18 (3)	14 (3)
Up to 6 months	187 (34)	164 (33)
6 to 12 months	158 (29)	147 (30)
Longer than 12 months	158 (29)	151 (31)
Not recorded/missing	31 (6)	17 (3)

Abbreviations: TAFE, Technical and Further Education; SEIFA, Socio Economic Index for Areas
[1]values are presented as mean (SD). All other values are presented as number (%). [2]Reported at consent and categorised as: (1) school (less than year 10, year 10/11, year 12), (2) trade/TAFE (trade/apprenticeship, TAFE/college certificate), (3) university (university degree). [3]Reported at each time and categorised as: (1) never smoked (do not smoke at all), (2) quit (used to smoke but no longer do so), (3) current smoker (less than once/day, at least once/day). [4]Reported at consent and categorised as: (1) not partnered (single/never married, separated/divorced, widowed), (2) partnered (de facto, married). [5]Reported at consent and categorised as: (1) not overweight (underweight, normal weight), (2) overweight (overweight). [6]SEIFA categorised by applying the Index of Relative Socio-Economic Advantage and Disadvantage (IRSAD) to postal code [222], reported at consent. [7]missing/not reported=12

2.3.3.1 Food consumption and dietary patterns

At 14 months, foods consumed in greatest amounts (median grams (≥10g), IQR) were whole fat dairy milk (470g, 197 - 637g), water (311g, 198 - 503g), fresh fruit (101g, 54 - 150g), white bread (23g, 2 - 44g), cold breakfast cereals (15g, 5 - 24g) and cheese (11g, 2 - 20g) (Table 2-9) (data not published).. Two distinct patterns were extracted at this age (Table 2-10). The first pattern was termed *'14-month core foods'* as fruit, grains, non-white bread, vegetables, cheese, eggs, and nuts and seeds loaded positively. Six commercial baby foods loaded negatively on this pattern. The second pattern included basic 'core' (white bread, milk) and 'non-core' (spreads, juice, and frozen milk products, for example, ice-cream) foods and beverages, with no fruit or vegetables, and was therefore termed *'basic combination'*.

Similarly, foods consumed in greatest amounts (median grams (≥10g), IQR) at 24 months were water (398g, 265 - 600g), whole fat dairy milk (288g, 123 - 485g), fresh fruit (102g, 19 - 175g), cold breakfast cereals (16g, 3 - 27g), other vegetables (15g, 0 - 46g), cheese (11g, 2 - 21g) and sweet biscuits and cakes (10g, 0 - 23g) (Table 2-9) (data not published).. Two distinct patterns were also extracted at 24 months (Table 2-10). The first pattern was similar to that at 14 months, with several foods covering all 'core' food groups, in addition to water, loading positively, and was therefore named *'24-month core foods'*. The second pattern was labelled *'non-core foods'*, as it included sweetened beverages, spreads, high-fat potatoes, snack products, chocolate and processed meat.

As there were similarities between the two dietary patterns at 14 and 24 months we examined the relationship between 'core' food-based patterns and 'non-core' food-based patterns. Pattern scores were moderately correlated (r = 0.35 *'14-month core foods'* and *'24-month core foods'*, r = 0.40 'basic combination' and *'non-core foods'*; both $p < 0.001$).

Table 2-9 Median (IQR) of food group intake in 14 and 24 month old toddlers (n=552)

Foods	14 months (n=552)		24 months (n=493)	
	Median	IQR	Median	IQR
Infant meat-based dinners[1]	0	0 - 0	0	0 - 0
Fruit: fresh[1, 3]	101	53.8 – 150.2	101.6	19.4 – 174.7
Infant fruit-based desserts[1]	0	0 - 0	0	0 - 0
Flours and grains[1, 4]	0	0 - 0	0	0 – 19.6
Formula[1]	0	0 - 0	0	0 - 0
Bread: non-white[1, 3]	0	0 - 17	9.3	0 – 32.3
Infant vegetable-based dinners[1]	0	0 - 0	0	0 - 0
Infant milk-based desserts[1]	0	0 - 0	0	0 - 30
Vegetables: other[1, 3]	5.6	0 – 28.1	15	0 – 46.1
Cheese[1]	10.8	1.5 – 20.3	11.1	2.3 – 21.1
Butter[1]	0	0 -1.3	0	0 – 1.2
Eggs[1]	0	0 - 0	0	0 – 2.6
Oil[1]	0	0 - 0	0	0 - 0
Nuts and seeds[1, 3]	0	0 - 0	0	0 – 0.4
Infant cereal products[1]	0	0 - 0	0	0 - 0
Poultry and feathered game	0	0 -5.8	0	0 – 10.8
Vegetables: green[3]	0	0 -16.1	0.6	0 - 10
Pasta	0	0 – 32.1	0	0 - 28.8
Water[3]	310.6	198.1 -503.3	397.5	265 -600
Potatoes: high fat[4]	0	0 – 7.6	0	0 – 5.9
Meat: muscle, game and organ[3]	0	0 – 13.8	0	0 – 11.3
Potatoes: low fat[3]	0.3	0 – 29.3	0	0 -16.3
Other beverages	0	0 - 0	0	0 - 0
Chocolate and chocolate products[4]	0	0 - 0	0	0 - 0
Vegetables: orange[3]	3.3	0 -17.9	0.8	0 - 12.8
Dairy yoghurt: whole fat[3]	0	0 -65.4	0	0 – 26.9
Tea	0	0 - 0	0	0 - 0
Custard[3]	0	0 - 0	0	0 - 0
Flavourings	0	0 - 0	0	0 – 0.1
Vegetables: home-style MD[4]	0	0 - 0	0	0 - 11.7
Soup	0	0 - 0	0	0 - 0
Fish and seafood: packaged	0	0 - 0	0	0 - 0
Bread: white[2, 4]	22.5	1.9 - 44	5	0 - 25
Dairy milk: whole fat[2]	470.1	196.7 – 637.3	288.4	112.9 – 484.5
Margarine and table spreads[2, 4]	0.6	0 - 3.6	0	0 – 3.2
Fruit and vegetable juice[2, 4]	0	0 – 24.7	0	0 – 70.3
Vegemite-type spreads[2, 4]	1.5	0 – 4.1	0	0 – 2.4
Breast milk[2]	0	0 - 0	0	0 - 0

Fish and seafood: fresh[2]	0	0 - 0	0	0 - 0
Frozen milk products[2]	0	0 - 0	0	0 – 1.5
Breakfast cereal: cold type[4]	14.8	4.5 - 23.7	15.5	3.3 – 26.3
Processed meat[4]	3.3	0 - 21	7	0 - 22
Sugar and sugar products	0	0 – 3.5	1.1	0 – 6.2
Savoury sauces and condiments	0	0 – 4.5	0.6	0 - 7
Pastries	0	0 - 0	0	0 - 0
Breakfast cereal: hot type	0	0 - 0	0	0 - 0
Cordial and soft drink[4]	0	0 - 0	0	0 - 0
Cereal: home-style MD	0	0 - 26.4	0	0 – 23.4
Infant drinks	0	0 - 0	0	0 - 0
Cereal, fruit and nut bars	0	0 - 0	0	0 - 0
Legumes and pulses	0	0 - 0	0	0 - 0
Sweet biscuits and cakes	6.7	0 – 16.3	10	0 – 23.2
Bread: other	0	0 - 0	0	0 – 4.7
Other dairy	0	0 - 0	0	0 - 0
Confectionary	0	0 - 0	0	0 - 0
Legume and pulse MD	0	0 - 0	0	0 - 0
Infant gels	0	0 - 0	0	0 - 0
Fish and seafood: high fat	0	0 - 0	0	0 - 0
Savoury biscuits	0.6	0 - 0	3	0 - 0
Infant desserts: other	0	0 - 0	0	0 - 0
Dairy milk: reduced fat	0	0 - 0	0	0 - 0
Dairy yoghurt: reduced fat	0	0 - 0	0	0 - 0
Dairy alternatives	0	0 - 0	0	0 - 0
Dairy blends	0	0 - 0	0	0 - 0
Fruit: home-style MD[5]	0	0 - 0	-	-
Fruit: packaged	0	0 - 0	0	0 - 0
Meat: home-style MD	0	0 - 0	0	0 - 0
Snack products[4]	0	0 - 0	0	0 - 0
Poultry: home-style MD	0	0 - 0	0	0 - 0
Cereal: take away-style MD[6]	-	-	0	0 - 0
Poultry: high fat MD[6]	-	-	0	0 - 0
Fruit: dried[6]	-	-	0	0 – 11.3
Fish and seafood: home-style MD[6]	-	-	0	0 - 0
Meat: high fat MD[6]	-	-	0	0 - 0

Abbreviation: MD, mixed dishes
[1]Foods loading strongly (≥ 0.25) on the *'14-month core foods'* pattern
[2]Foods loading strongly (≥ 0.25) on the *'basic combination'* pattern at 14 months
[3]Foods loading strongly (≥ 0.25) on the *'24-month core foods'* pattern
[4]Foods loading strongly (≥ 0.25) on the *'non-core foods'* pattern at 24 months
[5]Food group at 14 months only
[6]Food group at 24 months only

Table 2-10 Varimax-rotated food group loadings on each of the two dietary patterns extracted by principal components analysis at 14 and 24 months

	14 months[1] (n=552)			24 months[2] (n=493)		
		Dietary patterns[5]			Dietary patterns[5]	
Foods[3]	n (%)[4]	*14-month core foods*	*Basic combin-ation*	n (%)[4]	*24-month core foods*	*Non-core foods*
Infant meat-based dinners	126 (23)	**-0.50**	-0.19	15 (3)	0.02	-0.02
Fruit: fresh	506 (92)	**0.48**	-0.05	453 (92)	**0.47**	-0.01
Infant fruit-based desserts	135 (24)	**-0.47**	-0.25	46 (9)	-0.11	-0.03
Flours and grains	226 (41)	**0.47**	**-0.36**	220 (45)	0.04	**-0.37**
Formula	188 (34)	**-0.35**	**-0.26**	56 (11)	-0.08	-0.11
Bread: non-white	291 (53)	**0.35**	-0.03	287 (58)	**0.32**	-0.16
Infant vegetable-based dinners	41 (7)	**-0.33**	-0.15	5 (1)	-0.06	-0.03
Infant milk-based desserts	163 (30)	**-0.32**	-0.15	159 (32)	-0.21	-0.03
Vegetables: other	387 (70)	**0.30**	-0.15	356 (72)	**0.41**	-0.16
Cheese	394 (71)	**0.30**	0.12	390 (79)	0.20	-0.07
Butter	194 (35)	**0.29**	-0.06	156 (32)	0.10	-0.11
Eggs	166 (30)	**0.29**	-0.15	157 (32)	0.00	0.07
Oil	95 (17)	**0.29**	-0.21	91 (18)	-0.09	0.02
Nuts and seeds	72 (13)	**0.26**	-0.19	126 (26)	**0.37**	-0.17
Infant cereal products	87 (16)	**-0.26**	-0.13	12 (2)	-0.01	-0.16
Poultry and feathered game	175 (32)	0.23	0.03	161 (33)	0.19	0.07
Vegetables: green and brassica	299 (54)	0.22	-0.03	254 (52)	**0.45**	0.10
Pasta	211 (38)	0.20	0.18	212 (43)	-0.10	0.02
Water	534 (97)	0.20	0.15	481 (98)	**0.32**	0.24
Potatoes: high fat	102 (18)	-0.20	0.17	137 (28)	-0.21	**0.30**
Meat: muscle, game and organ	211 (38)	0.20	0.13	177 (36)	**0.30**	0.08
Potatoes: low fat	267 (48)	0.18	0.07	188 (38)	**0.31**	0.06
Other beverages	16 (3)	-0.17	0.01	52 (11)	0.24	0.13
Chocolate and chocolate products	34 (6)	0.16	0.05	92 (19)	-0.11	**0.29**
Vegetables: orange	352 (64)	0.15	0.02	258 (52)	**0.51**	0.04
Dairy yoghurt: whole fat	269 (49)	0.15	0.00	160 (32)	**0.30**	-0.16
Tea and coffee	7 (1)	0.15	-0.01	23 (5)	-0.07	-0.05
Custard	64 (12)	-0.11	0.04	47 (10)	**0.31**	-0.08
Flavourings	135 (24)	0.09	-0.08	149 (30)	-0.01	-0.07
Vegetables: home-style MD	149 (27)	0.09	-0.02	153 (31)	-0.08	**-0.26**
Soup	45 (8)	0.06	-0.03	48 (10)	-0.07	-0.15
Fish and seafood: packaged	57 (10)	0.05	-0.03	38 (8)	0.17	-0.03
Bread: white	272 (49)	-0.03	**0.48**	273 (55)	0.01	**0.60**
Dairy milk: whole fat	445 (81)	0.07	**0.43**	430 (87)	-0.10	-0.16
Margarine and table spreads	174 (32)	0.07	**0.43**	223 (45)	0.18	**0.46**
Fruit and vegetable juice	109 (20)	-0.02	**0.38**	224 (45)	-0.14	**0.41**

Vegemite-type spreads	280 (51)	0.09	**0.38**	247 (50)	0.15	**0.37**
Breast milk	132 (24)	0.12	**-0.32**	35 (7)	-0.04	-0.02
Fish and seafood: fresh	71 (13)	0.24	**-0.27**	56 (11)	0.18	-0.03
Frozen milk products	57 (10)	0.00	**0.25**	133 (27)	-0.01	0.05
Breakfast cereal: cold type	384 (70)	0.10	**0.25**	384 (78)	0.19	**-0.31**
Processed meat	231 (42)	0.08	0.23	286 (58)	0.04	**0.28**
Sugar and sugar products	183 (33)	0.03	0.23	272 (55)	0.20	0.13
Savoury sauces and condiments	161 (29)	0.08	0.22	253 (51)	0.07	0.17
Pastries	67 (12)	-0.04	0.21	108 (22)	-0.10	-0.04
Breakfast cereal: hot type	29 (5)	0.10	-0.20	23 (5)	0.04	-0.13
Cordial and soft drink	22 (4)	-0.10	0.20	71 (14)	-0.07	**0.48**
Cereal: home-style MD	152 (28)	0.03	0.19	160 (32)	0.06	0.15
Infant drinks	19 (3)	0.02	0.19	12 (2)	-0.03	-0.06
Cereal, fruit and nut bars	74 (13)	0.00	0.18	109 (22)	-0.12	0.11
Legumes and pulses	29 (5)	0.15	-0.17	11 (2)	0.05	-0.13
Sweet biscuits and cakes	326 (59)	0.05	0.17	345 (70)	-0.07	0.03
Bread: other	141 (26)	0.10	-0.16	138 (28)	-0.09	-0.14
Other dairy products	40 (7)	0.06	0.16	84 (17)	-0.18	0.17
Confectionary	13 (2)	-0.08	0.14	82 (17)	-0.02	0.24
Legume and pulse MD	80 (14)	0.11	0.13	78 (16)	0.15	0.01
Infant gels	13 (2)	-0.11	0.12	4 (1)	0.00	-0.00
Fish and seafood: high fat	29 (5)	-0.04	0.11	53 911)	0.09	-0.02
Savoury biscuits	286 (52)	0.01	0.11	297 (60)	0.00	0.07
Infant desserts: other	152 (28)	-0.07	-0.09	36 (7)	-0.14	-0.05
Dairy milk: reduced fat	39 (7)	0.01	-0.09	84 (17)	0.14	0.02
Dairy yoghurt: reduced fat	79 (14)	-0.01	0.08	91 (18)	0.12	-0.02
Dairy alternatives	27 (5)	0.01	-0.07	27 (5)	0.01	-0.04
Dairy blends	42 (42)	-0.00	0.05	75 (15)	-0.04	0.07
Fruit: home-style MD[6]	2 (<1)	0.01	-0.05	-	-	-
Fruit: packaged	125 (23)	0.0	0.04	85 (17)	-0.02	-0.02
Meat: home-style MD	78 (14)	0.02	0.03	81 (16)	0.02	-0.17
Meat: home-style MD	78 (14)	0.02	0.03	81 (16)	0.02	-0.17
Snack products	38 (7)	-0.02	0.03	109 (22)	-0.06	**0.29**
Poultry: home-style MD	88 (16)	-0.01	0.02	50 (10)	-0.14	-0.15
Cereal: take away-style MD[7]	-	-	-	39 (8)	-0.21	0.02
Poultry: high fat MD[7]	-	-	-	89 (18)	-0.19	0.18
Fruit: dried[7]	-	-	-	215 (44)	0.16	-0.10
Fish and seafood: home-style MD[7]	-	-	-	15 (15)	0.15	-0.02
Meat: high-fat MD				16 (3)	-0.04	0.00

Abbreviation: MD, mixed dishes
[1]Total number of food groups included in the PCA; 69. [2]Total number of food groups included in the PCA; 74. [3]Food variables entered into PCA as g/day. [4]of respondents who consumed food. [5]Loadings ≥0.25 in **bold** to aid labelling of dietary patterns. [6]Food group at 14 months only. [7]Food group at 24 months only

2.3.3.2 Construct validity of dietary patterns

To assess the validity of identified dietary patterns, their underlying food, energy and nutrient profiles were examined. At 14 (Table 2-11) and 24 months (Table 2-12), respectively, foods loading positively on patterns have an increasing gradient (median grams) across quartiles of dietary pattern scores, whilst foods loading negatively decrease across quartiles. Foods consumed in small quantities (for example, tea, confectionary) do not load on any pattern as there is little variation in intake and minimal gradient across quartiles. Consistent associations with energy and nutrients were seen across ages. The *'14-month core foods'* (Table 2-13) and *'24-month core foods'* (Table 2-14) patterns were positively associated with the intake of energy, protein, dietary fibre and several micronutrients. Conversely, the '*basic combination'* and *'non-core foods'* patterns at 14 and 24 months, respectively, were positively associated with energy and sodium intake, and negatively associated with iron intake. In addition, the *'24-month core foods'* pattern was positively associated with iron and negatively associated with fat intake, whereas the *'non-core foods'* pattern was negatively associated with dietary fibre intake.

Table 2-11 Median (IQR) of food group[1] intake across quartiles of PCA-derived dietary pattern scores in 14 month old toddlers (n=552)

	Quartiles of dietary pattern score								
	Q1		Q2		Q3		Q4		
	median	IQR	median	IQR	median	IQR	median	IQR	p
n									
14-month core foods									
Infant meat-based dinners[2]	34.3	0.0 - 113.3	0.0	0.0 – 0.0	0.0	0.0 – 0.0	0.0	0.0 – 0.0	<0.001
Fruit: fresh	44.2	7.9 - 84.9	69.9	33.4 - 127.1	109.2	59.8 – 165.8	157.5	90.7 – 221.7	<0.001
Infant fruit-based desserts[2]	7.1	0.0 - 63.3	0.0	0.0 – 0.0	0.0	0.0 – 0.0	0.0	0.0 – 0.0	<0.001
Flours and grains	0.0	0.0 – 0.0	0.0	0.0 - 6.6	0.0	0.0 - 12.8	6.4	0.0 – 36.0	<0.001
Formula[2]	100.5	0.0 - 464.8	0.0	0.0 - 132.2	0.0	0.0 – 4.4	0.0	0.0 – 0.0	<0.001
Bread: non white	0.0	0.0 - 11.3	0.0	0.0 - 13.8	8.5	0.0 - 23.0	20.4	0.0 – 43.0	<0.001
Infant vegetable-based dinners[2]	0.0	0.0 – 0.00	0.0	0.0 – 0.0	0.0	0.0 – 0.0	0.0	0.0 – 0.0	<0.001
Infant milk-based desserts[2]	0.0	0.0 - 62.6	0.0	0.0 - 40.0	0.0	0.0 – 0.0	0.0	0.0 – 0.0	<0.001
Vegetables: other	0.0	0.0 - 14.2	8.7	0.0 - 23.2	17.2	3.8 – 37.0	28.6	9.7 – 26.4	<0.001
Cheese	0.5	0.0 - 8.4	5.1	0.0 - 15.0	13.5	3.4 – 21.1	13.2	4.9 – 21.8	<0.001
Butter	0.0	0.0 – 0.0	0.0	0.0 - 1.1	0.0	0.0 – 1.6	0.0	0.0 – 3.0	<0.001
Eggs	0.0	0.0 – 0.0	0.0	0.0 - 0.6	0.0	0.0 – 8.9	0.0	0.0 – 16.3	<0.001

Oil	0.0	0.0 – 0.0	0.0	0.0 – 0.0	0.0	0.0 – 0.0	0.0	0.0 – 0.3	<0.001
Nuts and seeds	0.0	0.0 – 0.0	0.0	0.0 – 0.0	0.0	0.0 – 0.0	0.0	0.0 – 0.0	0.001
Infant cereal products[2]	0.0	0.0 - 3.7	0.0	0.0 – 0.0	0.0	0.0 – 0.0	0.0	0.0 – 0.0	<0.001
Basic combination									
Bread: white	0.0	0.0 - 5.0	0.0	0.0 – 8.3	0.0	0.0 – 16.1	22.5	1.9 – 44.0	<0.001
Dairy milk: whole fat	30.5	0.0 - 129.0	116.5	13.6 - 426.8	408.5	126.1 – 619.3	470.1	196.7 – 637.3	<0.001
Margarine and table spreads	0.0	0.0 – 0.0	0.0	0.0 - 0.4	0.0	0.0 – 1.6	0.6	0.0 – 3.6	<0.001
Fruit and vegetable juice	0.0	0.0 – 0.0	0.0	0.0 – 0.0	0.0	0.0 – 0.2	0.0	0.0 – 24.7	<0.001
Vegemite-type spreads	0.0	0.0 - 0.7	0.0	0.0 - 1.0	0.6	0.0 – 1.8	1.5	0.0 - 4.1	<0.001
Flours and grains[2]	3.8	0.0 -23.2	0.0	0.0 – 14.5	0.0	0.0 – 8.6	0.0	0.0 – 0.0	<0.001
Breast milk[2]	0.0	0.0 - 218.3	0.0	0.0 - 2.6	0.0	0.0 – 0.0	0.0	0.0 – 0.0	<0.001
Formula[2]	0.0	0.0 - 378.7	0.0	0.0 - 290.3	0.0	0.0 – 20.8	0.0	0.0 – 0.0	<0.001
Fish and seafood: fresh[2]	0.0	0.0 – 0.0	0.0	0.0 – 0.0	0.0	0.0 – 0.0	0.0	0.0 – 0.0	<0.001
Frozen milk products	0.0	0.0 – 0.0	0.0	0.0 – 0.0	0.0	0.0 – 0.0	0.0	0.0 – 0.0	<0.001

Abbreviation: Q, quartile
[1]Only food groups loading strongly (≥0.25) on identified patterns are presented
[2]Foods loading negatively on the pattern. All other foods load positively on the pattern.

Table 2-12 Median (IQR) of food group[1] intake across quartiles of PCA-derived dietary pattern scores in 24 month old toddlers (n=493)

	Quartiles of dietary pattern score								
	Q1		Q2		Q3		Q4		
	median	IQR	median	IQR	median	IQR	median	IQR	p
n	123		123		124		123		
24-month core foods									
Fruit: fresh	45.0	4.0 – 99.8	99.0	47.1 – 137.0	120.6	75.8 – 186.9	155.3	93.2 – 252.0	<0.001
Bread: non white	0.0	0.0 – 10.0	7.8	0.0 – 25.7	16.3	0.0 – 33.4	26.6	0.0 – 45.2	<0.001
Vegetables: other	1.1	0.0 – 8.7	12.2	0.0 – 32.7	26.5	5.8 – 57.4	45.6	11.3 – 92.1	<0.001
Nuts and seeds	0.0	0.0 – 0.0	0.0	0.0 – 0.5	0.0	0.0 – 0.7	0.0	0.0 – 2.5	0.051
Vegetables: green	0.0	0.0 – 0.6	0.3	0.0 – 7.3	2.1	0.0 – 9.6	9.8	0.0 – 27.6	<0.001
Water	333.5	238.3 – 500.0	370.2	249.2 – 500.0	380.8	257.1 – 597.5	520.8	397.2 – 791.7	<0.001
Meat: muscle, game and organ	0.0	0.0 – 0.0	0.0	0.0 – 9.2	0.0	0.0 – 13.2	0.0	0.0 – 25.0	<0.001
Potatoes: low fat	0.0	0.0 – 0.0	0.0	0.0 – 8.8	0.0	0.0 – 19.2	6.7	0.0 – 44.2	<0.001
Vegetables: orange	0.0	0.0 – 1.2	0.8	0.0 – 7.5	3.0	0.0 – 13.1	9.3	0.0 – 27.5	<0.001
Dairy yoghurt: whole fat	0.0	0.0 – 0.0	0.0	0.0 – 6.9	0.0	0.0 – 36.6	0.0	0.0 – 62.4	<0.001
Custard	0.0	0.0 – 0.0	0.0	0.0 – 0.0	0.0	0.0 – 0.0	0.0	0.0 – 0.0	0.048

Non-core foods									
Flours and grains[2]	17.4	0.0 – 42.4	0.1	0.0 – 18.8	0.0	0.0 – 10.5	0.0	0.0 – 0.0	<0.001
Potatoes: high fat	0.0	0.0 – 0.0	0.0	0.0 – 0.0	0.0	0.0 – 7.6	0.0	0.0 – 26.7	<0.001
Chocolate and chocolate products	0.0	0.0 – 0.0	0.0	0.0 – 0.0	0.0	0.0 – 1.0	0.0	0.0 – 3.3	<0.001
Vegetables: home-style MD[2]	0.0	0.0 – 43.0	0.0	0.0 – 13.4	0.0	0.0 – 8.2	0.0	0.0 – 0.0	<0.001
Bread: white	0.0	0.0 – 8.3	0.0	0.0 – 10.8	8.5	0.0 – 24.3	30.0	6.3 – 49.7	<0.001
Margarine and table spreads	0.0	0.0 – 0.0	0.0	0.0 - 2.2	0.8	0.0 – 3.9	2.2	0.0 – 6.7	<0.001
Fruit and vegetable juice	0.0	0.0 – 0.0	0.0	0.0 – 43.8	0.0	0.0 – 66.5	85.8	0.0 – 159.0	<0.001
Vegemite-type spreads	0.0	0.0 – 1.0	0.0	0.0 -2.0	0.9	0.0 – 3.3	1.2	0.0 – 3.0	<0.001
Breakfast cereal: cold type[2]	25.3	12.1 – 35.0	17.5	4.3 – 26.3	11.7	3.2 – 19.0	10.0	0.0 – 17.5	<0.001
Processed meat	0.0	0.0 – 9.1	6.8	0.0 – 21.0	11.7	0.0 – 26.9	17.5	0.0 – 38.0	<0.001
Cordial and soft drink	0.0	0.0 – 0.0	0.0	0.0 – 0.0	0.0	0.0 – 0.0	0.0	0.0 – 7.3	<0.001
Snack products	0.0	0.0 – 0.0	0.0	0.0 – 0.0	0.0	0.0 – 0.3	0.0	0.0 – 6.7	<0.001

Abbreviation: MD, Mixed Dishes; Q, quartile
[1]Only food groups loading strongly (≥0.25) on identified patterns are presented
[2]Foods loading negatively on pattern. All other foods load positively on pattern.

Table 2-13 Median (IQR) of energy-adjusted nutrient intakes across quartiles of PCA-derived dietary pattern scores in 14 month old toddlers (n=552)

	Quartiles of dietary pattern score								
	Q1		Q2		Q3		Q4		
Nutrient	median	IQR	median	IQR	median	IQR	median	IQR	P[1]
n	138		138		138		138		
14-month core foods									
Total Energy Intake (kJ)	3787	3319- 4352	3833	3365 - 4383	4209	3694 - 4770	4653	4069 - 5201	<0.001
Protein (%E)	15.7	14.1- 17.8	17.4	15.5 - 19.3	18.3	16.2 - 20.1	17.8	16.1 - 20.3	<0.001
Fat (%E)	31.7	28.6 - 35.7	32.2	29.9 - 35.4	33.4	30.2 - 36.9	31.6	28.2 - 35.2	0.101
CHO (%E)	48.2	43.9 - 52.0	46.6	43.2 - 49.6	44.6	41.6 - 47.5	45.4	41.5 - 48.3	<0.001
Fibre (g/MJ)	2.0	1.5 - 2.5	2.2	1.7 - 2.8	2.4	2.1 - 3.0	2.9	2.3 - 3.5	<0.001
Fe (mg/MJ)	1.8	1 - 2.7	1.5	1.0 - 2.2	1.3	1.0 - 1.9	1.4	1.1 - 1.8	0.001
Ca (mg/MJ)	184	140 - 219	187	149 - 223	175	137 - 210	153	130 - 192	<0.001
Na (mg/MJ)	178	150 - 223	222	177 - 259	133	195 - 274	217	173 - 276	<0.001
Vitamin C (mg/MJ)	12.4	6.6 - 19.7	11.1	5.2 - 17.3	10.2	6.0 - 14.4	11.6	8.5 - 17.2	0.028
Vitamin A (RE/MJ)	124	98 - 166	129	99 - 169	134	108 - 166	142	111 - 191	0.033
Thiamin (mg/MJ)	0.2	0.1 - 0.3	0.2	0.2 - 0.3	0.2	0.2 - 0.3	0.2	0.2 - 0.3	0.295
Riboflavin (mg/MJ)	0.4	0.3 - 0.5	0.5	0.4 - 0.6	0.5	0.3 - 0.6	0.4	0.3 - 0.5	0.059
Total Folate (ug/MJ)	42.7	33.2 - 57.8	51.0	41.6 - 62.0	49.4	39.4 - 68.7	51.8	463 - 66	<0.001
Potassium (mg/MJ)	371	310 - 420	403	349 - 444	411	349 - 457	420	362 - 485	<0.001

Basic combination									
Total Energy Intake (kJ)	3833	3331 - 4440	3899	3377 - 4526	4031	3548 – 4570	4588	4133 - 5413	<0.001
Protein (%E)	15.6	13.8 - 17.8	16.9	14.8 - 19.6	17.9	16.2 - 19.4	18.1	16.7 - 20.1	<0.001
Fat (%E)	31.5	27.9 - 36.1	33.0	29.0 - 36.3	32.1	29.5 - 35.7	32.2	30.1 - 35.4	0.455
CHO (%E)	47.8	44.0 - 51.7	45.9	42.2 - 49.8	45.9	42.6 - 48.9	45.5	41.6 - 48.8	0.002
Fibre (g/MJ)	2.5	1.9 - 3.3	2.4	1.9 - 3.0	2.3	1.8 - 2.9	2.4	1.9 - 3.0	0.405
Fe (mg/MJ)	1.7	1.1 - 2.4	1.6	1.2 - 2.4	1.3	0.9 - 1.9	1.3	1.0 - 1.6	<0.001
Ca (mg/MJ)	150	117 - 199	182	139 - 212	193	150 - 229	167	141 - 199	<0.001
Na (mg/MJ)	175	143 - 220	195	167 - 238	222	180 - 259	254	219 - 299	<0.001
Vitamin C (mg/MJ)	13.9	9.8 - 20.1	13.1	8.4 - 19.7	9.6	5.2 - 15.0	7.9	4.7 - 13.8	<0.001
Vitamin A (RE/MJ)	125	102 - 170	134	108 - 180	140	108 - 175	127	99 - 160	0.197
Thiamin (mg/MJ)	0.2	0.1 - 0.3	0.2	0.2 - 0.3	0.2	0.2 - 0.2	0.3	0.2 - 0.4	0.001
Riboflavin (mg/MJ)	0.3	0.3 - 0.4	0.4	0.3 - 0.5	0.5	0.4 - 0.6	0.5	0.4 - 0.6	<0.001
Total Folate (ug/MJ)	42.3	35.2 - 53.5	45.7	36.2 - 55.5	51.2	41.9 - 65.9	59.8	45.9 - 82.8	<0.001
Potassium (mg/MJ)	382	314 - 444	396	348 -459	413	350 - 458	403	355 - 465	0.025

Abbreviations: MJ, megajoule; Q, quartile; RE, retinol equivalents; %E, percent energy
[1]Kruskal-Wallis test used to compare differences in energy-adjusted nutrient intakes across quartiles of dietary pattern score

Table 2-14 Median (IQR) of energy-adjusted nutrient intakes across quartiles of PCA-derived dietary pattern scores in 24 month old toddlers (n=493)

	Quartiles of dietary pattern score								
	Q1		Q2		Q3		Q4		
Nutrient	median	IQR	median	IQR	median	IQR	median	IQR	P[1]
n	123		124		123		124		
24-month core foods									
Total Energy Intake (kJ)	4616	3981 - 5103	4415	3805 - 5108	4848	4280 - 5460	5287	4650 - 6315	<0.001
Protein (%E)	16.4	14.9 - 18.5	17.1	15.2 - 18.8	17.3	16.0 - 19.2	18.2	16.1 - 20.0	<0.001
Fat (%E)	34.1	31.0 - 37.9	31.9	29.0 - 35.2	32.9	29.1 - 36.2	31.2	27.5 - 34.1	<0.001
CHO (%E)	45.3	42.0 - 49.4	47.0	42.8 - 50.0	45.1	41.7 - 49.7	46.1	42.8 - 49.5	0.249
Fibre (g/MJ)	1.9	1.6 - 2.4	2.4	2.0 - 2.8	2.5	2.1 - 3.2	2.9	2.4 - 3.5	<0.001
Fe (mg/MJ)	1.1	0.8 - 1.4	1.3	1.0 - 1.6	1.3	1.0 - 1.6	1.4	1.1 - 1.7	<0.001
Ca (mg/MJ)	148	118 - 186	156.5	130 - 186	160	130 - 186	148	125 - 181	0.427
Na (mg/MJ)	264	229 - 329	261.8	222 - 302	270	229 - 319	253	208 - 293	0.090
Vitamin C (mg/MJ)	8.1	3.5 - 14.1	8.7	5.1 - 14.4	9.8	6.6 - 15.8	12.1	8.0 - 17.4	<0.001
Vitamin A (RE/MJ)	104	81 - 124	106	82 - 131	116	95 - 139	125	102 - 151	<0.001
Thiamin (mg/MJ)	0.2	0.1 - 0.3	0.2	0.2 - 0.3	0.2	0.2 - 0.3	0.2	0.2 - 0.3	<0.001
Riboflavin (mg/MJ)	0.4	0.3 - 0.5	0.4	0.3 - 0.5	0.4	0.4 - 0.5	0.4	0.3 - 0.5	0.740
Total Folate (ug/MJ)	44.5	33.9 - 58.8	49.9	38.1 - 64.3	53.6	42.7 - 74.5	53.0	44.5 - 72.3	<0.001
Potassium (mg/MJ)	345	301 - 387	379	326 - 418	395	349 - 447	427	388 - 472	<0.001

Non-core foods									
Total Energy Intake (kJ)	4815	4301 - 5590	4494	3945 - 5171	4616	4078 - 5389	4939	4483 - 5920	<0.001
Protein (%E)	17.9	15.8 - 19.6	16.8	15.2 - 18.8	17.7	15.9 - 19.3	16.8	14.9 - 18.6	0.030
Fat (%E)	32.1	29.1 -35.2	32.5	29.1 - 36.0	32.4	29.1 - 36.5	32.7	28.7 - 36.8	0.717
CHO (%E)	45.6	42.0 - 49.5	45.5	42.8 - 49.2	45.6	41.9 - 49.1	46.6	42.4 - 51.5	0.419
Fibre (g/MJ)	2.7	2.1 - 3.3	2.6	2.2 - 3.1	2.3	1.9 - 2.8	2.3	1.8 - 2.8	<0.001
Fe (mg/MJ)	1.3	1.1 - 1.7	1.3	1.0 -1.6	1.2	0.9 - 1.6	1.2	0.9 - 1.4	0.003
Ca (mg/MJ)	170	144 - 199	154	128 - 179	157	132 - 190	131	108 - 164	<0.001
Na (mg/MJ)	237	195 - 283	254	224 - 292	269	232 - 324	289	242 - 337	<0.001
Vitamin C (mg/MJ)	8.0	4.5 - 13.5	10.2	6.6 - 16.4	9.6	6.0 - 15.2	11.0	5.9 - 17.7	0.007
Vitamin A (RE/MJ)	117	93 - 141	113.2	93.0 - 140.0	117.3	87.4 - 136.8	104.0	77.5 - 128.8	0.024
Thiamin (mg/MJ)	0.2	0.1 - 0.3	0.2	0.2 - 0.3	0.2	0.1 - 0.3	0.2	0.2 - 0.3	0.406
Riboflavin (mg/MJ)	0.4	0.3 -0.5	0.4	0.3 - 0.5	0.4	0.4 - 0.6	0.4	0.3 - 0.5	0.009
Total Folate (ug/MJ)	46.0	37.4 - 57.1	49.8	39.8 - 64.3	53.7	42.3 - 72.6	53.0	39.6 - 78.7	0.004
Potassium (mg/MJ)	405	358 - 449	374	328 - 427	390	331 - 440	374	326 - 421	0.005

Abbreviation: MJ, megajoule; Q, quartile; RE, retinol equivalents; %E, percent energy

[1]Kruskal-Wallis test used to compare differences in energy-adjusted nutrient intakes across quartiles of dietary pattern score

2.3.3.3 Dietary patterns and socio-demographic characteristics

To assess the validity of dietary patterns, their association with socio-demographic predictors was assessed. Table 2-15 presents the unadjusted estimates for dietary pattern scores at 14- and 24- months according to socio-demographic characteristics. Higher scores on the *'basic combination'* pattern were seen for children of younger, Australian-born overweight, smoking, multiparous mothers from a lower SEIFA area, whilst higher scores were associated with older children at assessment, earlier introduction to solids, and earlier breastfeeding cessation. Alternatively, higher scores on the *'14-month core foods'* pattern were seen in older children of partnered, Australian-born and not overweight mothers from a higher SEIFA decile area, who were breastfed for longer. Higher scores on the *'24-month core foods'* pattern were associated with Australian-born, partnered mothers. Scores on the *'non-core foods'* pattern were positively associated with Australian-born, overweight mothers and negatively with maternal age, SEIFA decile, partnered mothers, older children at assessment, longer breastfeeding duration, and being a NOURISH study participant.

After adjustment for covariates several maternal (age, education, smoking status, country of birth, study) and child (age, breastfeeding duration, age of introduction to solids) factors were independently associated with 14- and/or 24-month pattern scores (Table 2-16). For example, a maternal university education was associated with a 0.16 (95% confidence interval 0.04, 0.28) higher *'14-month core foods'* pattern score than a maternal school-level education. Higher scores on this pattern at 14 months were also associated with longer breastfeeding duration and older children at assessment whilst higher scores on the *'24-month core foods'* pattern were associated with later solid introduction and Australian-born mothers. Conversely, *'basic combination'* pattern scores at 14 months were positively associated with younger mothers, smoking mothers, SAIDI participants, older children at assessment, and earlier solid introduction and breastfeeding cessation. Younger mothers and earlier breastfeeding cessation also predicted higher scores on the *'non-core foods'* pattern at 24 months.

Table 2-15 Unadjusted associations between dietary patterns and maternal and child characteristics, at 14 and 24 months[1]

	Dietary patterns at 14 months (n=476)						Dietary patterns at 24 months (n=410)					
	14-month core foods			*Basic combination*			*24-month core foods*			*Non-core foods*		
	beta	95% CI	p	beta	95% CI	p	beta	95% CI	p	beta	95% CI	p
Maternal characteristics												
Age at child’s birth	0.015	-0.003, 0.033	0.108	-0.026	-0.042, -0.009	0.002	0.010	-0.006, 0.026	0.233	-0.021	-0.037, -0.005	0.010
Highest education level	0.271	0.159, 0.384	<0.001	-0.261	-0.364, -0.158	<0.001	0.172	0.069, 0.275	0.001	-0.0112	-0.870, 0.100	0.119
SEIFA	0.052	0.021, 0.084	0.001	-0.088	-0.116, -0.060	<0.001	0.029	-0.001, 0.059	0.055	-0.069	-0.098, -0.040	<0.001
Smoking	-0.138	-0.308, 0.032	0.112	0.317	0.163, 0.471	<0.001	-0.133	-0.283, 0.017	0.083	0.075	-0.074, 0.224	0.324
Marital												
	Referent = not partnered											
Partnered	0.205	-0.296, 0.706	0.422	0.031	-0.430, 0.491	0.896	0.487	-0.003, 0.976	0.051	-0.385	-0.215, -0.009	0.032
Weight												
	Referent = not overweight											
Overweight	0.385	-0.610, -0.159	0.001	0.273	0.066, 0.481	0.010	-0.137	-0.347, 0.073	0.199	0.360	0.156, 0.565	0.001
Parity												
	Referent = primiparous											
Multiparous	0.101	-0.295, 0.093	0.307	0.504	0.332, 0.677	<0.001	-0.067	-0.246, 0.113	0.465	0.333	0.159, 0.507	<0.001

Born in Australia												
	Referent = no											
Yes	0.258	-0.511, -0.006	0.045	0.371	0.141, 0.602	0.002	0.243	0.008, 0.478	0.042	0.279	0.047, 0.511	0.019
Study												
	Referent = SAIDI											
NOURISH	0.048	-0.012, 0.109	0.117	-0.205	-0.257, -0.152	<0.001	0.040	-0.016, 0.096	0.160	-0.129	-0.183, -0.075	<0.001
Child characteristics												
Gender												
	Referent = male											
Female	-0.011	-0.192, 0.170	0.906	-0.043	-0.209, 0.123	0.614	-0.143	-0.309, 0.023	0.091	0.057	-0.107, 0.222	0.493
Age	0.023	0.005, 0.042	0.015	0.027	0.010, 0.044	0.002	0.013	-0.006, 0.032	0.171	-0.033	-0.052, -0.015	<0.001
Age of solid introduction	0.011	-0.007, 0.029	0.227	0.024	0.008, 0.040	0.004	0.012	-0.004, 0.029	0.136	0.015	-0.001, 0.031	0.072
Breastfeed-ing duration	0.314	0.216, 0.412	<0.001	-0.221	-0.313, -0.129	<0.001	0.088	-0.006, 0.183	0.066	-0.161	-0.253, -0.068	0.001

[1]Results were obtained from standard linear regression models with BMI z-score for each age as the dependent variable and all respective dietary pattern scores and covariates as independent predictors. Data are presented as regression model *beta* coefficients, 95% confidence intervals (95% CIs) and p value of significance.
[2]Maternal (age, education level, smoking status, marital status, weight status, parity, SEIFA decile, study) and child (age, gender, age of introduction to solids, breastfeeding duration) covariates adjusted for in all analyses.

Table 2-16 Associations between dietary patterns and maternal and child characteristics after adjustment for covariates[1]

	Dietary patterns 14 months (n=476)						Dietary patterns 24 months (n=410)					
	14-month core foods			*Basic combination*			*24-month core foods*			*Non-core foods*		
	beta	95% CI	p	beta	95% CI	p	beta	95% CI	p	beta	95% CI	p
Maternal characteristics												
Age at child's birth (years)	0.004	-0.014, 0.023	0.654	-0.028	-0.043, -0.012	0.001	0.006	-0.011, 0.023	0.504	-0.026	-0.042, -0.009	0.003
Highest education level	0.156	0.035, 0.278	0.012	-0.057	-0.161, 0.047	0.279	0.109	-0.003, 0.221	0.058	0.030	-0.078, 0.138	0.584
SEIFA decile[2]	0.028	-0.010, 0.065	0.146	-0.015	-0.047, 0.017	0.371	0.006	-0.031, 0.042	0.753	-0.027	-0.063, 0.008	0.124
Smoking status	0.006	-0.163, 0.175	0.944	0.198	0.054, 0.343	0.007	-0.095	-0.248, 0.057	0.220	-0.004	-0.150, 0.143	0.959
Marital status	Referent = Not Partnered											
Partnered	0.024	-0.467, 0.516	0.922	0.320	-0.100, 0.740	0.135	0.395	-0.105, 0.895	0.121	-0.141	-0.622, 0.340	0.565
Weight status	Referent = Not Overweight											
Overweight	-0.181	-0.411, 0.049	0.123	0.084	-0.112, 0.280	0.400	-0.017	-0.238, 0.205	0.881	0.208	-0.005, 0.421	0.056
Parity	Referent = Primiparous											
Multiparous	-0.115	-0.414, 0.185	0.453	0.222	-0.034, 0.478	0.088	0.016	-0.276, 0.308	0.914	0.199	-0.081, 0.480	0.164

Born in Australia						Referent = No						
Yes	-0.125	-0.372, 0.121	0.318	0.155	-0.055, 0.366	0.148	0.342	0.101, 0.582	0.005	0.096	-0.135, 0.327	0.413
Study						Referent = SAIDI						
NOURISH	-0.022	-.0133, 0.090	0.703	-0.186	-0.281, -0.090	<0.001	0.072	-0.053, 0.197	0.258	-0.078	-0.198, 0.042	0.204
Child characteristics												
Gender						Referent = Male						
Female	-0.017	-0.191, 0.158	0.851	-0.079	-0.228, 0.070	0.297	-0.150	-0.316, 0.016	0.077	0.017	-0.142, 0.177	0.830
Age (months)	0.023	0.004, 0.042	0.020	0.034	0.018, 0.051	<0.001	0.007	-0.021, 0.034	0.625	0.002	-0.024, 0.029	0.857
Age of solids introduction (weeks)	0.003	-0.020, 0.026	0.784	-0.021	-0.041, -0.001	0.036	0.022	0.001, 0.043	0.041	-0.005	-0.025, 0.016	0.659
Breastfeeding duration	0.263	0.160,0.366	<0.001	-0.157	-0.245, -0.070	<0.001	0.039	-0.058, 0.137	0.429	-0.119	-0.213, -0.025	0.013

[1]Results were obtained from standard linear regression models with diet pattern score for each age as the dependent variable and all respective covariables as independent predictors. Data are presented as regression model *b* coefficients, their 95% confidence intervals (95% CIs) and their p value of significance. For definitions of maternal and infant predictor terms, see Table 2-8.
[2]SEIFA decile categorised by applying the Index of Relative Socio-Economic Advantage and Disadvantage (IRSAD) to postal code [222]

2.3.3.4 Dietary patterns and adiposity

The association between toddlers' dietary patterns and adiposity was also investigated. Median BMI z-scores at 14 and 24 months were 0.41 (interquartile range -0.24, 1.03) and 0.78 (interquartile range 0.05, 1.51), respectively. Table 2-17 and Table 2-18 present the unadjusted and adjusted estimates, respectively, for BMI z-score according to 14- and 24-month dietary pattern scores. Adjustment for covariates did not alter the findings; dietary pattern scores at both ages were not significantly associated with concurrent or subsequent BMI z-scores.

Table 2-17 Unadjusted associations between BMI z-score and dietary patterns, at 14 and 24 months[1]

	BMI z-score 14 months (n=467)			BMI z-score 24 months (n=404)		
	beta	95% CI	p	beta	95% CI	p
Dietary patterns at 14 months						
14-month core foods	0.003	-0.081, 0.087	0.948	0.078	-0.052, 0.209	0.239
Basic combination	0.064	-0.028, 0.156	0.174	-0.031	-0.164, 0.101	0.642
Dietary patterns at 24 months						
24-month core foods	-	-	-	-0.045	-0.156, 0.065	0.420
Non-core foods	-	-	-	0.089	-0.035, 0.213	0.160

[1]Results were obtained from standard linear regression models with BMI z-score for each age as the dependent variable and all respective dietary pattern scores and covariates as independent predictors. Data are presented as regression model *beta* coefficients, 95% confidence intervals (95% CIs) and p value of significance.
[2]Association between dietary patterns at 14 months and BMI z-score at 24 months, n=417

Table 2-18 Associations between BMI z-score and dietary patterns, at 14 and 24 months, after adjustment for covariates[a]

	BMI z-score 14 months (n=467)			BMI z-score 24 months (n=404)		
	beta	95% CI	p	beta	95% CI	p
Dietary patterns at 14 months[b]						
14-month core foods	0.029	-0.060, 0.118	0.521	-0.007	-0.128, 0.113	0.906
Basic combination	-0.002	-0.107, 0.103	0.968	0.038	-0.104, 0.180	0.603
Dietary patterns at 24 months						
24-month core foods	-	-	-	0.078	-0.034, 0.236	0.144
Non-core foods	-	-	-	-0.032	-0.248, 0.033	0.132

[a]Results were obtained from standard linear regression models with BMI z-score for each age as the dependent variable and all respective dietary pattern scores and covariates as independent predictors. Data are presented as regression model *beta* coefficients, 95% confidence intervals (95% CIs) and p value of significance. Maternal (age, education level, smoking status, marital status, weight status, parity, SEIFA decile, study) and child (age, gender, age of introduction to solids, breastfeeding duration) covariates adjusted for in all analyses.
[b]Association between dietary patterns at 14 months and BMI z-score at 24 months, n=417

2.3.4 Discussion

This study enhances the small body of literature on dietary patterns in early life, describing the dietary patterns of Australian toddlers aged 14 and 24 months, and their association with socio-demographic factors and child adiposity.

2.3.4.1 Dietary patterns, 14 and 24 months

Two dietary patterns were identified in 14- and 24-month-old children representing 'core' (rich in fruits, vegetables and grains) and 'non-core' (low-fibre, fatty and sugary foods and beverages) intake. Each pattern shares similarities with identified patterns in other equivalent aged populations. The *'14-month core foods' pattern* is similar to the *'infant guidelines'* pattern extracted in the 12-month Southampton Women's Study (SWS) cohort [199] and comparable to the *'herbs, raw fruit and vegetables'* (Avon Longitudinal Study of Parents and Children (ALSPAC) sample, 15 months [162]), *'wholesome'* (Norwegian Mother and Baby Cohort, 18 months [160]) and *'health conscious' (*Generation R Study, 14 months [204]) patterns. Likewise, the *'basic combination'* pattern at 14 months is consistent with the Generation R Study [204] *'western-like'* , the Norwegian Mother and Baby Cohort [160] *'unhealthy'*, and the Melbourne Infant Feeding Activity and Nutrition Trial (InFANT) *'vegemite and bread'* pattern [203]. At 24 months, the *'24-month core foods'* and *'non-core foods'* patterns are similar to the ALSPAC [201] 24-month *'health-conscious'* and *'sweet and easy'* patterns, respectively. Thus, our findings suggest that similar dietary patterns are evident in similar aged populations of European and Australian toddlers.

Compared with other similar studies, the variance in food groups explained by the derived patterns, 7.3% and 6.6% at 14 and 24 months respectively, was low. For example, derived from 12-month infants in the Southampton Women's Study (SWS) cohort [199] explained 13.4% of the variance, whilst patterns derived for infants aged 14 months in the Generation R Study [204] explained 24.5% of the variance.

The proportion of variance explained by a set of components (i.e. patterns) is dependent on the number of variables (i.e. food groups) entered into the PCA and the number retained [199]. In both these published studies, a smaller number of food groups (n=56 [199]; n=21 [204]) were included in the PCA than that entered in our study (n=69 14 months; 74 24 months). The larger number of food groups employed in this study allowed for greater discrimination between types of foods, yet may have resulted in the relatively small amount of variance explained by the patterns [230].

As diet continually and rapidly changes, assessing toddlers' dietary patterns over time can enhance the understanding of the stability of early life dietary patterns. In adults, dietary patterns have shown reasonable stability over time [231]. Although dietary patterns are likely to vary more substantially across early life [119], previous studies have demonstrated tracking of dietary patterns between six and 12 months [199], and three, four and seven years of age [231, 232]. Similarly, our study identified patterns at 14 and 24 months that were moderately correlated (*'14-month core foods'* and *'24-month core foods'* patterns; *'basic combination'* and *'non-core foods'* patterns), indicating tracking of dietary patterns over the second year of life. Beyond 12 months of age, children begin to exert independence in food choices and develop fussy eating behaviours, contributing to rapidly changing day-to-day dietary habits [38]. However, our findings suggest dietary patterns are relatively stable longer-term, supporting the persistence of food preferences and eating habits over time [28, 44] and raising concerns for those with poor dietary patterns in early life.

2.3.4.2 Construct validity of dietary patterns

We described the construct validity of extracted dietary patterns in terms of food, energy and nutrient intakes across quartiles of pattern scores, which confirmed that dietary patterns reflect meaningful differences in underlying combinations of food and nutrient intake. Few studies have reported this relationship in the first years of life. In children aged six and 15 months, protective micronutrients (for example, calcium and iron) were associated with healthier dietary patterns and nutrients linked to disease risk (for example, sodium, saturated fat) with less healthy patterns [208]. At 14 months, macronutrient (protein, polysaccharide, saturated fat) intakes were associated with '*health-conscious*' and '*western-like*' pattern scores in expected directions [204]. At three years, the '*processed*' pattern was found to be energy-dense and nutrient-poor, whilst the '*health conscious*' and '*traditional*' patterns were associated with a more healthy nutrient profile. Comparing our findings, consistency is evident as healthier patterns were related to better nutrient intakes, including fibre, iron, vitamin A and vitamin C, compared with less healthy patterns. Overall, these relationships can contribute to resolving the controversy around whether data-reduction techniques measure true differences in nutrient density or reflect greater food consumption [156].

2.3.4.3 Dietary patterns and socio-demographic characteristics

Understanding the characteristics of toddlers with less optimal diets is crucial for developing targeted and effective interventions to improve dietary intake. In accordance with other studies, poorer quality dietary patterns were seen in children of younger mothers [162, 199, 201] and those breastfeed for shorter durations [199, 204] (at both ages), and in children with smoking mothers [160, 199] and those introduced to solids earlier [103, 199] (at 14 months only). Conversely, higher-quality dietary patterns were associated with highly educated mothers (at 14 months) [160, 162, 199, 201]. Associations between maternal factors and health behaviours such as diet, are well documented, reflecting the influence of socio-economic disadvantage on health. At 14 months, poorer-quality dietary patterns were further associated with SAIDI participants, likely reflecting the multi-parity of SAIDI mothers and thus the influence of siblings on diet quality, reported elsewhere [162].

Our findings of associations between dietary patterns and toddler feeding practices (breastfeeding duration and introduction to solids) are similar to previous studies. In the present study, longer breastfeeding duration was associated with an overall healthier eating pattern in toddlerhood. Similarly, in a sample of Australian children aged 2 - 8 years, breastfeeding duration was positively associated with diet quality [233], whilst in UK children higher scores on the healthy transition diet between six and 24 months of age were positively associated with breastfeeding at six months [234]. Furthermore, the association between earlier solid introduction and poorer dietary quality found in this study has been reported previously [103, 199]. For example, higher scores on the *'adult foods'* pattern was positively associated with earlier introduction to solids in 12 month old toddlers in the SWS [199].

Overall, these associations of earlier and later breastfeeding cessation and introduction to solids with poorer- and higher-quality dietary patterns, respectively, suggest that maternal feeding practices translate between breastfeeding, weaning and eating patterns. Beyond this, however, these associations may be partially explained by the effect of early feeding experiences on later food and taste acceptance [34, 235]. For example, previous research found that earlier solid introduction was associated with liking a greater proportion of 'non-core' foods [47] and early solid introduction (before 17 weeks of age) predicted introduction of 'non-core' foods by 52 weeks [103]. These findings suggest that mothers who introduce solids early may also introduce 'non-core' foods early, thus escalating the innate preference for and acceptance of sweet and salty foods [235]. Furthermore, earlier breastfeeding cessation has previously been associated with liking a greater proportion of 'non-core' foods [47] whilst longer breastfeeding duration positively influences children's taste preferences [236] and vegetable intake [34]. This is likely explained by evidence that breastfeeding provides ongoing exposure to a variety of flavours not experienced by formula-fed infants and results in improved later flavour acceptance [237]. Overall, the association between early feeding practices and dietary patterns may be influenced by maternal choices or by the effect of early dietary exposures on children's food acceptance. Either way, targeting young mothers of potential disadvantage prior to commencement of early feeding practices may improve their child's eating habits.

The association between diet quality and maternal education level found in this study has previously been reported in populations of 12 [199], 18 [160, 162, 199, 201] and 24 month old toddlers [201] in expected directions. This relationship is likely explained by their ability (that is, their education level) to understand and apply dietary recommendations for practical use [238]. However, this simple interpretation doesn't take into consideration the multi-factorial components of the issue. For example, there is literature to suggest that income and food prices affect food habits and diet quality [239, 240]. As income was not measured in this study, which may reflect maternal education status, income may be a likely explanation for the association observed between maternal education level and toddler diet quality.

Our findings of an association between dietary patterns and smoking mothers, parent ethnicity and child age have also been reported elsewhere, suggesting agreement across studies. Our findings showed that maternal smoking was a risk factor for poor diet quality at 14 months. Previous studies reported that maternal smoking was negatively associated with a *'wholesome'* diet [160] and positively associated with an *'unhealthy'* [160] or '*adult foods'* [199] pattern. Higher scores on "healthy" patterns have been associated with ethnicity in several studies [162, 198, 201, 232], yet associations have been bi-directional; "healthy" and "unhealthy" patterns associated with white ethnicity. Further, we found that a poorer-quality diet was more common in older children at 14 months. This has been reported elsewhere, where older infants were more likely to adhere to a '*western-like'* diet pattern consisting of high-fat and -sugar foods and beverages [204]. Together these findings suggest that dietary interventions should begin early in life and target smoking mothers.

2.3.4.4 Dietary patterns and adiposity

Despite the increase in median BMI z-scores from 14 and 24 months, we did not show an association between dietary patterns and BMI z-scores. Inconsistent results have previously been reported between early life dietary patterns and measures of adiposity [17, 18]. For example, in 12 month old children dietary patterns were associated with lean mass but not with other adiposity measures, including BMI [16]. Although weight status is not only influenced by diet, but by genetic, behavioural (for example, activity levels) and environmental factors (for example, parent-child interaction), [75] a possible explanation for our findings is that each pattern at both ages was positively associated with total energy intake. This supports evidence that children can respond to the energy density of foods consumed and regulate their daily energy intake [241]. Further, it may be too early to detect the influence of diet on weight status as previous research has shown that weight gain from birth - 2 years is largely influenced by intrauterine factors [242], with the effect of environmental factors not manifesting until 2 -5 years [242, 243], and that weight gain between 2-11 years may be a more important predictor of obesity risk than BMI at two years [244]. Therefore, continuation of a non-nutritious dietary pattern beyond two years may lead to a clear distinction in weight status across the population later, and thus investigating this association longitudinally is warranted.

2.3.4.5 Study strengths and limitations

A limitation of the present study is our highly educated sample of mothers who may have greater knowledge of dietary recommendations and thus may have reported more favourable dietary intakes [245]. Additionally, associations of dietary patterns with socio-demographic variables and BMI z-score may be influenced by missing data or by evaluating associations in different time periods (for example, maternal weight status reported post-birth and diet reported at 14 and 24 months). Another consideration is that approximately one-fifth of child anthropometric data were collected by general practitioners or child health nurses, not by study staff, and thus accuracy is questionable. In terms of dietary reporting by mothers, social desirability bias, a phenomenon that occurs when subjects report what they believe to be acceptable, cannot be ignored. Further, PCA has its own inherent limitations that must be acknowledged. The multi-step process of PCA is highly subjective as it involves several decisions to be made by the researcher throughout the analytical process: (1) if and how data (for example, foods) are grouped, (2) how input variables should be treated (for example, rotation), (3) how many patterns should be retained in the final solution, and (4) how the patterns should be named [154]. These decisions may influence the composition of extracted dietary patterns.

Nevertheless, our study is strengthened by investigation of dietary patterns at two different ages in one sample, including tracking over time. Identified patterns were clearly distinguishable by the type of foods loading on them, defined by very few cross-loadings and several foods loading strongly on each pattern. The derivation of patterns from recall and record data, compared with food frequency questionnaires (FFQ's) [160, 162, 199, 201, 204] that often lack portion sizes and information on brands and food type, is a study strength as the former methods provide comprehensive energy and nutrient data from which construct validity can be assessed. Additionally, FFQ's may not cover the full range of foods consumed by individuals. The use of 24-hour recalls was strengthened by the implementation of a standardised protocol for interviewers to ensure consistent delivery of recalls across sites and interviewers, and provision of instructions and equipment to parents to enable consistent detail to be gathered between the recall and diet record, and between participants. Together this minimised the risk of measurement bias [138].

2.3.5 Conclusion

In conclusion, dietary patterns reflecting 'core' and 'non-core' food intake can be described in Australian toddlers and are influenced by maternal age, breastfeeding duration and age of introduction to solids in expected directions. Healthier dietary patterns were associated with a more positive food and nutrient profile than less healthy patterns. Although we did not find an association between children's dietary patterns and adiposity, it is of concern that dietary patterns characterised by non-nutritious foods were identified at this young age. These findings support the need to intervene early with parents to promote healthy eating in children and establish positive life-long eating behaviours. Further longitudinal studies are warranted to provide evidence of associations of dietary patterns with adiposity beyond two years, and with a broader range of health outcomes.

2.4 Chapter summary

This chapter aimed to describe and validate dietary patterns of Australian toddlers to inform the development of a food-group based dietary risk assessment tool. Dietary patterns reflecting 'core' (nutrient-rich) and 'non-core' (EDNP) food intake were characterised in Australian toddlers aged 14 and 24 months. The validity of patterns was established by demonstrating that underlying food, energy and nutrient profiles differ across quartiles of dietary patterns scores in expected directions. That is, healthier patterns were associated with better nutrient intakes and unhealthier patterns with poorer nutrient intakes. Additionally, their validity was demonstrated by showing that patterns are influenced by several maternal and child socio-demographic predictors. No association was found between patterns and toddler BMI z-score, cross-sectionally.

At both ages fresh fruit, vegetables, non-white bread, amongst others, loaded strongly on both the high quality dietary patterns, whilst white bread, margarine and table spreads, juice and vegemite-type spreads loaded strongly on both the poor-quality dietary patterns. As PCA is a multivariate statistical data reduction technique that identifies groups of foods accounting for the largest variation in diet between individuals, these foods can be used to distinguish between children of high- and poor-quality dietary patterns and thus can be used as food-group items in a short questionnaire that distinguishes children's dietary risk. This is a novel approach to questionnaire item selection and is advantageous as it identifies the food items most relevant to the consumption patterns of the target population. Therefore, a newly developed dietary assessment tool will be based on these foods.

3 DEVELOPMENT AND TESTING OF A NEW TODDLER DIETARY QUESTIONNAIRE (TDQ)

3.1 Overview

This chapter addresses the second and third specific aims of the thesis (Figure 3-1), namely the development of a short, food-group based dietary risk assessment tool for Australian toddlers aged 12 - 36 months and testing of its reliability and validity. The chapter begins by presenting the key considerations for tool development and testing and discussing how dietary indices can be used to derive a measure of dietary risk. This is followed by presentation of the paper titled “Development, reliability and relative validity of a simple tool assessing Australian toddlers’ dietary risk” published in the *British Journal of Nutrition*.

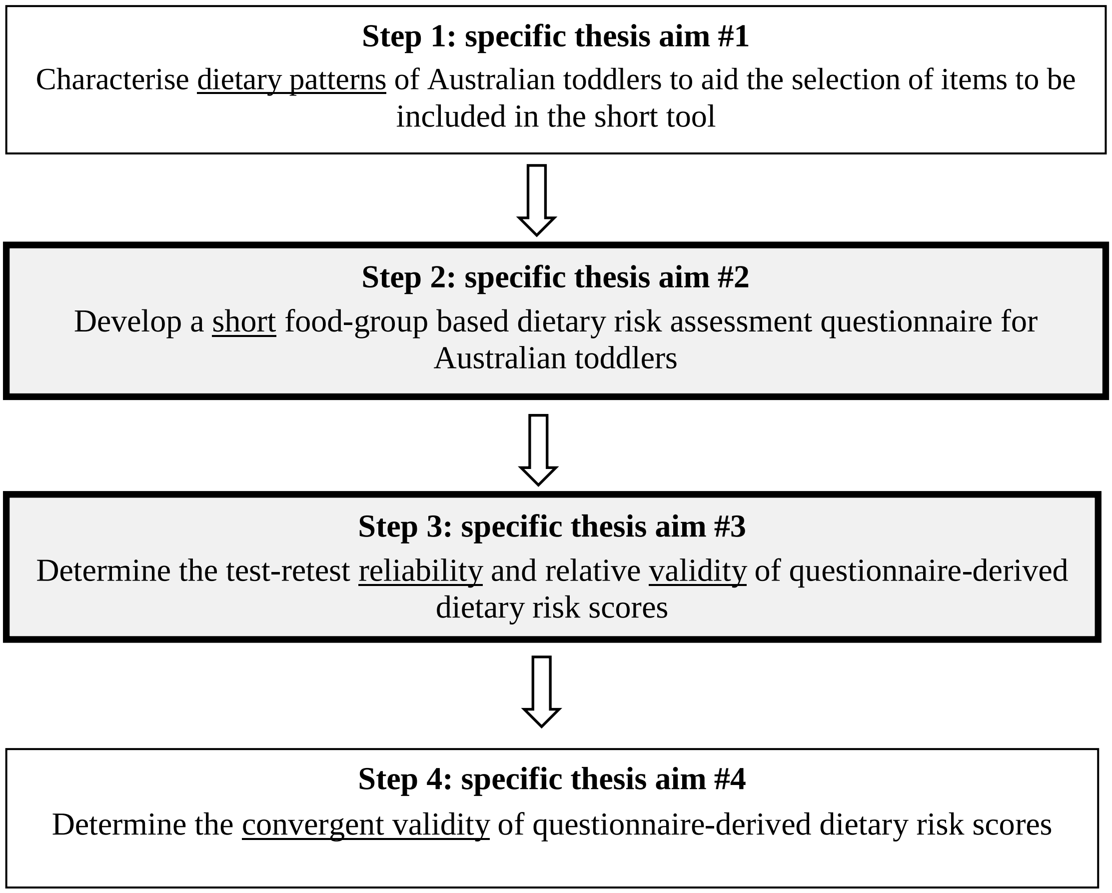


Figure 3-1 Tool development and validation flow diagram; step 2 and 3 of 4

3.2 Considerations for developing a short dietary risk assessment tool for Australian toddlers

3.2.1 Selection of tool items using age- and population-specific dietary patterns

Whole-of-diet patterns of Australian toddlers characterised in chapter two revealed similarities in the foods loading strongly on patterns across ages (14 and 24 months). That is, the "healthy" patterns at both ages were characterised by fresh fruit, vegetables, and non-white bread and the "unhealthy" patterns were characterised by white bread, margarine and table spreads, vegemite-type spreads, and juice. These two patterns reflect intake in line or not in line with dietary guidelines, respectively. Further, the foods loading on these patterns represent those for which there is the greatest variation in intake between individuals. The consistency in dietary patterns from the beginning of the second year of life to that of the third year of life represents consistency in foods that distinguish toddlers of good- and poor-quality dietary patterns. Given this, these food-groups are ideal to inform the items of a new short dietary assessment tool that measures whole diets of Australian toddlers and that aims to distinguish variation in intake across the population enabling identification of those toddlers at greatest dietary risk. Thus, items in the new short dietary assessment tool that assesses toddlers' dietary risk will be based on PCA-derived dietary patterns identified in Australian toddlers aged 14 and 24 months.

3.2.2 Dietary assessment period of a new short tool

A design consideration for any dietary assessment instrument is the time frame for which intake is assessed. Asking subjects to recall their dietary intake retrospectively can be associated with recall bias as it relies on memory [246]. As recall errors increase with time [247], the chance of recall bias is greater if the recall period is months or years compared to recall covering only the previous few weeks. Further, for questionnaires assessing several months' intake, the season in which it is administered can influence reporting during the entire year [126]. Compared to the minimum requirement of two days of intake data for assessing the relationship between usual diet and health outcomes at the group level, the clinical assessment of an individual’s diet generally requires seven or more days of intake data to represent usual intake [126]. Therefore, to assess dietary risk, the tool will cover dietary intake over seven or more days.

3.2.3 Should a new short tool be self- or interviewer-administered?

Another key consideration is the mode of questionnaire delivery. Questionnaires may be interviewer-administered, either in person or via phone, or self-administered. In certain situations an interviewer may be advantageous as they can immediately check improbable responses with the respondent [127]. Yet, interviewer-administered questionnaires are burdened by the cost of employing an interviewer, who requires standardised training and whose presence may increase the probability of social desirability bias (the inaccurate reporting of behaviours to appear more favourable [248]) in subjects’ responses [125, 127]. Therefore, most FFQ’s are designed to be self-administered as they are less costly, do not rely on trained interviewers, and are generally subject to less social desirability bias [126]. In light of these advantageous, the new dietary risk assessment tool for Australian toddlers will be designed to be self-administered by the parent or caregiver.

3.2.4 Should a new short tool include portion size estimation?

A major consideration in the development of a dietary assessment tool is whether to query portion size of dietary intake. Although consumption amount is considered important in estimating dietary intakes, whether or not portion size questions should be included in FFQ’s is highly debated [126]. Compared with weighing food to determine intake, portion size estimation is appealing as it is associated with much lower respondent burden. Portion size can be estimated in three ways; asking respondents to (1) estimate portion size in an open-ended manner, (2) indicate the portion size consumed from a set of categorical portion size responses, or (3) indicate how many portions of food, using a standard portion size, were consumed [126].

Either way portion size estimation can be difficult as it requires perception, conceptualisation and memory, and can therefore lead to sources of error and invalidity [125]. Wide variation has been shown in individuals' ability to estimate food portions, with quantification of portions consumed possibly the largest source of measurement error in most dietary assessment methods [249]. Nonetheless, whilst some studies have found frequency to be a greater contributor to variance in intake than serving size, others have found that reporting a usual serving size generates improvements [126].

Ultimately the inclusion of portion size questions is dependent upon the study objectives [126]. Given the objective of this study is to measure dietary risk, a concept that reflects overall dietary patterns and which is largely influenced by the amount consumed, simply estimating whether a particular food was/is consumed or not is insufficient. Further, given that toddlers show great variation in intakes from day-to-day and meal-to-meal [43], contributing to variation in intakes within a population, capturing this variation requires assessment of amount consumed. Therefore, the new dietary risk assessment tool for Australian toddlers will be designed to assess portion size of food intake.

3.2.5 Applying a dietary index scoring system to derive a measure of dietary risk

With items in the new short toddler dietary risk assessment tool to be based on PCA-derived dietary patterns of Australian toddlers, and design characteristics of the tool decided upon, the next step is to determine how a measure of overall diet, expressed as a dietary risk score, will be derived. Dietary indices are scoring systems that enable multiple components of diet to be expressed in a single number, often reflecting degree of adherence to a package of dietary guideline recommendations. They provide a holistic assessment of diet by capturing the multi-dimensional nature of people's diets [191, 250] and the cumulative impact of dietary components [251]. By assessing dietary intake against pre-determined index components to derive a summary score, a dietary index can be used to describe dietary risk, through the calculation of a dietary risk score.

Several decisions must be made regarding the design of the dietary risk scoring criterion. First, index components can be defined either quantitatively or qualitatively. Qualitative index scores may be those where a point is assigned for every food consumed from a defined list reflecting dietary guidelines, to determine, for example, dietary diversity [116]. These indices are appropriate for tools that assess frequency but not quantity of intake. Alternatively, quantitative index scores involve calculating the number of serves consumed and comparing that to the number of serves recommended by the guidelines. This approach requires knowledge of portion size intake. As the new dietary risk assessment tool for Australian toddlers will be designed to assess portion size intake, a quantitative index will be applied to derive a dietary risk score.

Second, the method for applying a quantitative scoring system to a food-based index must be decided upon. The most common approach is to use a cut-off for each component and award "points" [251]. Often a score of zero is applied if consumption is lower (or higher if an unfavourable component is assessed) than the cut-off value and a score of one if consumption is higher (or lower) than the cut-point [191]. Other approaches include using the group median intake of each variable as a cut-off value or scoring items proportionally based on the extent to which dietary guidelines are met [191]. An example of the latter is provided by Healthy Eating Index (HEI) scores, whereby if, for example, the daily requirement of grains is six serves but a person consumes three, then a score of 5 (range 0 - 10) would be given [252]. This approach is appealing as scores better represent the degree to which the individuals meet the recommendations [191] and thus are a better reflection of degree of guideline adherence. Therefore, this approach will be taken to determine dietary risk scores derived from the new toddler dietary risk assessment tool.

The third consideration is the relative contribution of index components to the total dietary index score [191, 194]. Index components are most commonly weighted equally [191]. However, some components may have a greater influence on health outcomes than others. Thus, it may be appropriate to weight subscales [194], whereby those components known to have a greater impact on health are weighted to make a higher relative contribution to the final index score [251]. As the food-group items to be included in the new short dietary risk assessment tool are informed by PCA-derived dietary patterns that include 'core' and 'non-core' items, with varied influence on health relative to consumption amount, it is likely that it will be more appropriate to weight food group intake to determine dietary risk scores.

In summary, intake assessed by the newly developed tool can be compared to dietary guidelines and a score that represents dietary risk be established to serve as a measure of disease risk prediction. That is, by determining whether food-group consumption does not meet, meets or exceeds recommendations, and by what degree, will allow for calculation of a dietary risk score for each component, which will be aggregated to derive a total index, or dietary risk, score. Ideally this score should be calculated directly from the assessment tool, through a simple addition or awarding of points, rather than requiring additional, complex analysis before a final score can be derived [144]. This is due to the benefits of lower participant and researcher burden and provision of immediate feedback to clients or participants [144].

3.2.6 Summary – developing a short dietary risk assessment tool for Australian toddlers

Development of a short dietary risk assessment tool for Australian toddlers will be based on current age- and population-specific evidence on Australian toddlers' PCA-derived dietary patterns and a dietary index will be applied to derive index scores that represent level of dietary risk. The tool will be self-administered by the child's parent or caregiver, cover a dietary assessment period of seven or more days and capture portion size of food intake.

3.3 Testing the reliability and validity of a new short dietary risk assessment tool for Australian toddlers

Nutrition research and practice relies on accurate assessment of dietary intake. Unreliable or invalid measures will yield unreliable and/or invalid results [142]. It is therefore important that any new dietary assessment method is tested for reliability and is validated against more established methods [126].

To determine the reliability of a newly developed short dietary risk assessment tool for toddlers, test-retest reliability can be used to establish the tools' repeatability. This involves completion of the same measurement two or more times to yield repeated values, where the similarity in values reflects the test-retest reliability of the measure [142]. Importantly, to truly indicate the test–retest reliability of a measure, the results of the retest should not be influenced by the results of the initial test [142]. Re-administration periods must be carefully considered because if they are too close it may result in subjects remembering their previous responses, whilst if too long a lower reliability may reflect true changes in dietary intake [121]. Thus, accurate assessment of test-retest reliability requires careful planning of administration times.

Determining the validity of a new short toddler dietary risk assessment tool requires comparison to a reference method. Although doubly labelled water is considered the 'gold standard' for determining energy intake [121], being accurate to 1% [125], it is associated with high costs, is invasive and is impractical for use in large populations or non-clinical settings [125, 142]. Importantly, this method only validates energy intake, and is therefore not appropriate for validating food-group intake captured by a food-group based dietary risk assessment tool. Thus, to determine the validity of such a tool, comparison to a reference method believed to be superior to establish relative validity is required.

Relative validation standards in nutrition research include respondent-based methods such as weighed or estimated food records, 24-hour recalls or FFQ's. Common to all methods are social desirability bias, social approval bias, and recall bias. Social desirability bias is misreporting on sensitive or embarrassing behaviours to appear more favourable or to be consistent with social norms or beliefs [248]. In nutrition, this refers to reporting, either consciously or subconsciously, consumption of foods and beverages different from actual consumption [125]. Similarly, social approval bias refers to responding in a way that makes the respondent appear favourable to the researchers [125], That is, in nutrition research, reporting intake that is closer in line with what is believed to be the recommendations. Respondents may also simplify their diet to make recording easier [124], due to the time required and level of difficulty associated with recording. Reporting also relies on memory, which is subject to error [246, 247], increasing recall bias. Nonetheless, mere participation in a study can result in biased reporting of intake, known as the Hawthorn effect [125]. Yet this effect is likely to be consistent across a sample [248].

Further to these common limitations of respondent-based dietary assessment methods is the limitations of each individual method (highlighted earlier in Table 1-5). Food diaries, particularly weighed records are expensive and labour intensive for participants and researchers, requiring highly motivated and cooperative respondents [125]. Although options of two-, three- or seven-day food diaries can be chosen, these are often too burdensome for population based studies. Recording periods of more than four consecutive days result in respondent fatigue and thus inaccurate reported intakes or incomplete records [126]. Twenty-four hour recalls on the other hand are limited by reliance on memory, often resulting in recall bias. The cognitive process of recalling past intake is more difficult for populations with lower literacy skills, lower concentration skills, limited memory, limited knowledge of food and food preparation methods, and a lack of familiarity with recipe components [125]. Further, there are high expenses associated with requiring trained interviewers to deliver 24-hour recall assessments [125, 126] Reporting methods that are less-burdensome on researchers and respondents, and less costly and time-intensive in terms of administration and analysis, such as FFQ's, may result in more accurate information. These methods measure diet retrospectively so do not result in changes in eating habits. Yet they do rely on memory of past dietary intake. As each method is associated with limitations, choosing a validation standard requires weighing up their advantages and disadvantages. When choosing a validation method, usually a compromise between data accuracy and participant burden is required [121].

Above and beyond these limitations, there are two key design factors that need to be considered when choosing a validation method. First, both the test method and reference method must measure intake over the same time period [142]. That is, the reference method should cover a sufficient number of days to represent the interval of time corresponding to the questionnaire [128]. A large difference in referent periods may yield differences in results due to true variation in diet. Second, errors in the validation standard should be independent of those in the dietary assessment method [142]. If errors are not independent then you cannot be certain that the resultant correlations are because both the test and reference method accurately measure the underlying concept, as it may be because they are both measured with the same type of error [142]. For example, errors in observer-recorded measures are independent of those in respondent-based measures, whereas respondent-based methods are subject to similar types of errors and thus their comparison will lead to artificially inflated correlations [137]. Thirdly, the outcome and context, for example, the timeframe and resources, also play a role in the choice of reference method. For example, conducting 24-hour recalls is more time-consuming for researchers than a participant-completed questionnaire. The former may simply not be possible within the researchers' time-frame. Additionally, 24-hour recalls are much more resource intensive than the latter, for which the research budget may not allow for. Thus, ideally both measures should measure intake over the same period of time, should be subject to independent errors and should be feasible within the study constraints.

Overall, the validity and reliability of a newly developed tool must be established to be certain it provides accurate evidence on what toddlers are consuming. Test-retest reliability and relative validity are the most appropriate tests. Yet, determining what validation standard to use is complicated, with decisions regarding which method to use usually a compromise between limitations and feasibility. Ideally, it is important to select a validation measure that (1) is reliable and valid (that is, more superior), (2) is easy and inexpensive to administer and analyse and non-burdensome for respondents to complete, (3) has a short reporting period to reduce recall bias and which covers the dietary intake period of the primary dietary assessment tool, (4) is subject to errors that are independent to those of the test measure, and (5) which is appropriate for the study design and within the study constraints.

3.4 Development and testing of the TDQ

The following section aims to develop, and validate, a short, food-group based dietary risk assessment tool for Australian toddlers aged 12 - 36 months. It contains material from:

Bell L, Golley R, Daniels L, Magarey A (2014) A short food-group-based dietary questionnaire is reliable and valid for assessing toddlers' dietary risk in relatively advantaged samples, *British Journal of Nutrition,* 112(4): 627-37

As this section is based on the above paper (presented in Appendix 1 - Papers, conference presentations and awards/prizes arising from this thesis), some repetition with previous sections might be encountered. Small alterations have been made to the published manuscript.

3.4.1 Introduction

'Dietary risk' is a term used to describe 'any inappropriate dietary pattern' that may impair health [115]. Toddlers are vulnerable to dietary risk as they begin to exert their independence in food choices and demonstrate fussy eating behaviours [38, 46]. As dietary risk habits may persist over time [86, 112] and influence short and long-term health [7, 113], early risk identification is important.

The current dietary intakes of toddlers are inadequate suggesting many are at dietary risk. In general, intakes of nutrient-rich foods are below the national dietary guideline recommendations and consumption of energy-dense, nutrient-poor (EDNP) foods is common. For example, the 2008 - 2009 UK National Diet and Nutrition Survey showed that approximately 50% of 1.5 - 3 year olds consumed EDNP items such as meat products, fried potato products, confectionary and sweetened beverages over the four day food diary period [111]. Nutrient-rich foods such as fish, raw vegetables, and eggs were consumed by less than half the sample [111]. Similarly, a recent Australian study demonstrated that 11 - 15% of 12 - 36 months consumed no fruit or vegetables, respectively, less than one-quarter consumed eggs (24%), fish (11%) and legumes (17%), and nearly all (89%) consumed EDNP item/s in the previous 24 hours [52]. Similar trends are observed in other countries including the US [107, 109]. These data highlight that toddlers' dietary patterns are not consistent with dietary guidelines and may place them at risk of nutrient (for example, iron and folate [23, 36]) deficiencies and chronic diseases, including excess weight [6, 86] and cardiovascular disease [19]. Therefore, the need to screen toddler's dietary intakes against current dietary guidelines to identify those at-risk is evident.

Timely, accurate and cost effective assessment of dietary intake is important. Traditional dietary assessment methods, such as recalls and records, are time-intensive, costly and burdensome [125]. Further, it can be difficult to easily extract food intake data from these methods for meaningful comparison with food-group based dietary guidelines [120]. Conversely, less costly, time-consuming and laborious methods such as food frequency questionnaires [128] quickly measure food or food-group intake, allowing easy comparison with food-group based dietary guidelines [120]. Nonetheless, increasing questionnaire length is associated with increasing burden, likely resulting in reduced cooperation and completion [134]. Therefore, an ideal screening questionnaire that identifies toddlers at dietary risk would be short and simple while providing food or food-group data that can easily be compared with dietary guidelines.

Dietary risk identification requires the assessment of whole diets. In comparison with that of individual dietary components, the assessment of whole diets refers to capturing intake of all five 'core' food groups (that is, foods recommended to be consumed every day including fruits; vegetables; grains [for example, bread, rice, pasta, noodles]; meat and alternatives [for example, fish, eggs, nuts]; dairy) and 'non-core' (EDNP) items [62, 95]. However, current short food or food-group based questionnaires generally aim to measure a specific aspect of diet (for example, fat intake [253]) or a limited number of food groups (for example, fruit and vegetables only [192]). Supporting this, our recent review [1] (in section 0) highlighted the lack of short tools (≤50 items) assessing the whole diets of children aged under five.

Due to the lack of population-specific, age-appropriate, short tools that characterise the whole diets of Australian toddlers, the present study aimed to develop a short, simple food-group-based dietary risk assessment tool for toddlers aged 12 - 36 months and determine its reliability and validity.

3.4.2 Methods

The Toddler Dietary Questionnaire (TDQ) is a 19-item, parent-completed, semi-quantitative tool that assesses food-group intake over the previous seven days (Appendix 3 - Study data collection forms). The intake of ‘core’ (for example, fruit, vegetables, dairy) and ‘non-core’ (for example, high-fat, -sugar and/or -salt foods, sweetened beverages) food-groups is then evaluated against a dietary risk criterion. The TDQ risk scores range from 0 to 100, with a higher score representing higher dietary risk (that is, poorer dietary intake).

3.4.2.1 Development of the TDQ

The development of the TDQ was informed by dietary patterns observed in recent dietary intake data of Australian toddlers [2], the Australia Dietary Guidelines Modelling System [223], and the Australian Dietary Guidelines [8, 94]. Questionnaire drafts were pilot tested for readability, understanding and timing with three parent-toddler dyads (university researchers, n = 2, researcher family member, n = 1) and changes made to the questionnaire format.

The TDQ items were informed primarily by dietary patterns of Australian children [2] (Table 3-1), derived using principal components analysis (PCA). PCA is a common type of factor analysis technique [191] that identifies underlying 'patterns' of intake from a large number of variables by grouping foods commonly consumed together. PCA was applied to the average of 24-hour recall and record data collected over three days from 14-month-old (n = 552) and 24-month-old (n = 493) children. Data were derived from two Australian studies, the control arm of NOURISH [215], an obesity prevention randomised controlled trial, and the South Australian Infant Dietary Intake (SAIDI) study [216], a longitudinal study of infants' and toddlers' dietary intake. The foods that represent extracted patterns account for the greatest variation in diet between individuals [196]. At both ages, two patterns were identified representing (1) 'core' (for example, fruit, vegetables, grains, dairy products, meat and water), and (2) 'non-core' (for example, high-fat, high-sugar and/or high-salt products and sweetened beverages) intake [2] (Table 3-1). Based on these patterns and the Australian Dietary Guidelines [8, 223], a 19-item questionnaire comprising three sections was developed. Section one assesses 'core' intake (*eight items*; fruit, vegetables [green, orange, other], dairy products, grains, lean red meat, and fish), section two 'non-core' intake (*eight items*; spreadable fats, vegemite-type spreads, snack products, hot potato products, meat products, sweet biscuits and cakes, chocolate, ice-cream) and section three 'usual' intake (*three items*; bread type, milk beverages and non-milk beverages, for example, fruit juice, soft drink, cordial [a fruit flavoured concentrate that is usually mixed with water]).

As only few items loaded strongly on patterns at both ages (fresh fruit, vegetables, non-white bread, white bread, margarine and table spreads, juice and vegemite-type spreads), the use of PCA-derived items in the tool was widened to include those loading strongly on a pattern at either age. Table 3-1 highlights the items loading strongly on a pattern at either 14 or 24 months that were used as food-group items in the TDQ. *Sweet biscuits and cakes* was included in section two of the TDQ, despite not loading strongly on a pattern age either age, to ensure both section one and section two comprised equal number of items and as *sweet biscuits and cakes* are a commonly consumed 'non-core' item (shown in Table 2-9) by toddlers.

Sections one and two comprise questions asking respondents to report *how often* and *how much* their child ate of each food group over the previous week. Based on the appropriateness of categories for a one-week period of intake, four consumption frequency categories (nil, once, 2-4 times and ≥5 times) were developed. In addition, three consumption quantity categories (representing ‘small’ [e.g. <50g], ‘medium’ [e.g. 50g-100g], ‘large’ [e.g. >100g] portions) were developed. For section one, portion-size categories were informed by the average serving sizes and weekly number of servings recommended for 13 – 23 month olds and 2 – 3 year olds outlined in the Australia Dietary Guidelines Modelling System [223]. For TDQ food groups not directly comparable to those in the modelling system, a proportion of the recommended intake was used. For example, for the TDQ food group ‘yoghurt/custard’, portion sizes were informed by applying 25% to the recommended intake of ‘dairy foods (milks, yoghurts, cheese)’. For section two, portion-size categories were informed by tertiles of consumption of 24 month old NOURISH and SAIDI children (n = 742). Food labels that reflect each portion-size category (‘small’, ‘medium’, ‘large’) were added for each food-group item. For example, a ‘small’ portion of ‘other vegetables’ was labelled ‘*less than 1 cup of raw salad vegetables OR less than ½ cup cooked vegetables’*, representing <75g of vegetables.

Section three comprises the following three questions: (1) What proportion of white: non-white bread (for example, some white: mostly non-white) does your child usually consume? (2) What milk drinks (breast, plain, flavoured, formula) does your child usually consume? (3) What non-milk drinks (water, diluted juice, juice, cordial/soft drink) does your child usually consume? The final questionnaire is given in Appendix 3 - Study data collection forms.

Table 3-1 Foods loading strongly (≥0.25) on each dietary pattern of 14-(n=552) and 24-month-old (n=493) Australian toddlers

14 months				24 months			
14-month core foods		*Basic combination*		*24-month core foods*		*Non-core foods*	
Food	Loading	Food	Loading	Food	Loading	Food	Loading
Fruit: fresh[1]	0.483	Bread: white[1]	0.483	Vegetables: orange[1]	0.507	Bread: white[1]	0.597
Flours and grains[1]	0.467	Dairy milk: whole fat[1]	0.430	Fruit: fresh[1]	0.467	Cordial and soft drink[1]	0.479
Bread: non white[1]	0.351	Margarine and table spreads[1]	0.427	Vegetables: green and brassica[1]	0.454	Margarine and table spreads[1]	0.456
Vegetables: other[1]	0.300	Fruit and vegetable juice[1]	0.381	Vegetables: other[1]	0.407	Fruit and vegetable juice[1]	0.407
		Vegemite-type spreads[1]	0.380	Nuts and seeds	0.367	Vegemite-type spreads[1]	0.367
Cheese	0.297	Frozen milk products[1]		Water[1]	0.320	Potatoes: high fat[1]	0.297
Butters[1]	0.292			Bread: non white[1]	0.318	Snack products[1]	0.294
Eggs	0.291			Custard[1]	0.314	Chocolate and chocolate	0.287
Oil	0.287			Potatoes: low fat	0.305	Processed meat[1]	0.281
Nuts and sseds	0.264			Meat; muscle, game and organ[1]	0.304		
				Dairy yoghurt: whole fat[1]	0.303		
Infant meat-based dinners	-0.504	Flours and Grains[1]	-0.357			Flours and grains[1]	-0.372
Infant fruit-based desserts	-0.469	Breast Milk[1]	-0.319			Breakfast cereal: cold type	-0.313
Formula[1]	-0.354	Fish and Seafood; Fresh[1]	-0.269			Vegetables: home-style MD	-0.255
Infant vegetable-based dinners	-0.327	Formula[1]	-0.259				
Infant milk-based desserts	-0.317						
Infant cereal products	-0.263						

Abbreviations: MD, mixed dishes

[1]Foods or food-groups included in the Toddler Dietary Questionnaire

3.4.2.2 Scoring of the TDQ

The dietary risk score is derived by evaluating food group intake against a scoring criterion (Table 3-3). For sections one and two of the TDQ, food-group intake per week in grams was calculated by multiplying the frequency response (zero [nil], one [once], three [2-4 times] and seven [≥5 times] times per week) with the median quantity response (e.g. small = <50g, 25g; medium = 50 - 100g, 75g). For example, if the median of the 'small category' is 25g, then a response of '2-4 times' and 'small' is 75g (3 x 25g). As the median of the 'large' (e.g. >100g) category could not be established based on the TDQ categories, an upper limit of consumption of 24 month old NOURISH and SAIDI children was used (e.g. 300g) and the median determined (e.g. 200g). Intake is then compared against recommendations (see Table 3-2) [223]. That is, a scale of 0 (lowest score = lowest risk) to 18 (highest score = highest risk) is applied per question, with '0' reflecting consumption closest in line with the recommendations and '18' reflecting intake furthest from the recommendations (Table 3-3). For section one, a response of '2-4 times' and 'medium' amount reflects intake most closely in line with the recommendations and is therefore scored a '0'. Lower and higher intakes are scored between 2 and 18 according to the percentage of deviation from recommendations. Under-consumption is scored slightly more severely than over-consumption due to greater severity of health risks. For example, under-consumption of 'core' foods may result in nutrient deficiencies leading to suboptimal growth and development and/or chronic diseases such as CVD and cancer [62]. Further, insufficient 'core' intake may lead to over-consumption of 'non-core' items and thus an increased risk of overweight and obesity [62]. Alternatively, over-consumption of 'core' foods may also contribute to overweight through establishment of a positive energy balance [71] and may displace the intake of other 'core' foods from the diet, thus decreasing variety [62]. Conversely, for section two, scores increase proportionally from zero with increasing consumption frequency and quantity, as consumption of 'non-core' foods should be limited [8, 62, 95] and increasing exposure and familiarity increase preference for these foods [34].

Each question in section three is scored on a scale of 0 (ideal intake, for example, none white: all non-white, breast milk or plain milk, and water) to 12 (non-ideal intake, for example, all white: none non-white, no milk drinks consumed, and soft drink or cordial) (Table 3-3). For question 2 and 3, a proportionally increasing scale of 0, 4, 8 12, is applied, with multiple responses accepted. However, for question one, a scale of 0, 3, 9, 12 is applied, as the proportions 25%: 75% and 75%: 25% are used to represent the responses some white: mostly non-white and mostly white: some non-white, respectively.

Dietary risk scores are created for each section, tallied to give a score out of 336, which is converted to a total dietary risk score (range 0 - 100; higher score=higher risk). Total risk scores are categorised into four levels of dietary risk: (1) low (0 - 24); (2) moderate (25 - 49); (3) high (50 - 74); (4) very high (75 - 100).

Table 3-2 Modelled serves per week of *Omnivore Foundation Diet* food groups for toddlers aged 13-23 months and 2-3 years used to inform portion-size categories of the TDQ. Adapted from the Dietary Guidelines Modelling System [223]

Composite food group	Serve size	13 - 23 mo	2 - 3 y
Starchy vegetables	75g	2.5	2.5
Green and brassica vegetables	75g	3.5	3.5
Orange vegetables	75g	3.5	3.5
Legumes	75g	1	2
Other vegetables	75g	7	7
Fruit	150g	3.5	7
Wholegrain or higher fibre cereals/grains	Equiv 40g bread	16	19
Refined or lower fibre cereals/grains[1]	Equiv 40g bread	8.5	9
Meat and alts minus red	Equiv 65g red meats	3.5	3.5
Red meats (beef, lamb, veal, pork)	65g	3.5	3.5
Dairy foods (milks, yoghurts, cheeses)[2]	Equiv 250g milk	8	10.5

Abbreviations: equiv, equivalent; g, grams; mo, months; y, years
[1]Refined or lower fibre cereals were included as a group for cultural reasons; wholegrain or higher fibre can replace these if preferred.
[2]Should be mostly low fat

Table 3-3 Scoring template for the Toddler Dietary Questionnaire (TDQ)

Section	Question	Response			Score		Maximum score per question	Possible section score range
1 and 2	Each question (16 items) scored according to the combination of frequency and quantity categorical response	Frequency[1]	and	Quantity	Section 1	Section 2		0 - 144
		Nil		Nil	18	0	18	
		Once		Small	14	2		
		Once		Medium	11	4		
		Once		Large	8	6		
		2-4 times		Small	6	8		
		2-4 times		Medium	0	10		
		2-4 times		Large	4	12		
		≥5 times		Small	2	14		
		≥5 times		Medium	6	16		
		≥5 times		Large	12	18		
3	What proportion of white: non-white bread does your child usually[2] consume? (tick one only)	None white : All non-white			0		12	0 - 48
		Some white: Mostly non-white			3			
		Mostly white: Some non-white			9			
		All white: None non-white			12			
	What milk drinks does your child usually[2] consume? (tick all that apply)	Breast milk or plain milk (dairy or non-dairy)			0		12[3]	
		Formula			4			
		Flavoured milk (dairy or non-dairy)			8			
		None of the above i.e. no milk drinks			12			
	What non-milk drinks does your child usually[2] consume? (tick all that apply)	Water			0		24	
		Diluted juice (fruit and/or vegetable)			4			
		Un-diluted juice (fruit and/or vegetable)			8			
		Cordial or soft drink			12			
Total								0 – 336 (converted to out of 100)

[1]Frequency of intake per week. [2]Usually=on most days. [3]Despite the option to tick all that apply, if a response of ‘*none of the above i.e. no milk drinks’* is provided, no other responses are possible. Therefore, any combination of the first three responses are possible providing a maximum score of 12, or ‘*none of the above i.e. no milk drinks’* only (score = 12).

3.4.2.3 Reliability and validity of the TDQ

3.4.2.3.1 Study design

A validation study was conducted between October 2012 and February 2013 to determine the reliability and relative validity of the TDQ. Ethics approval was granted by the Flinders University Southern Behavioural Research Ethics Committee (SBREC) (Appendix 4 - Ethics approval letter)

3.4.2.3.2 Study sample

The participants were primary caregivers of toddlers aged 12–36 months recruited for the Toddler Dietary Intake study via (1) flyers distributed at South Australian private child care centres, (2) advertisements in Flinders University newsletters and on noticeboards, (3) a study-specific Facebook page, and (4) parents enrolled in the SAIDI study who had another eligible child. Recruitment materials are available in Appendix 5 - Recruitment materials. Children with a food allergy or intolerance or a diagnosed medical condition affecting their dietary intake were excluded. Parents with two eligible children chose one child to participate in the study to prevent a clustering effect. Parental consent was obtained. Participants received feedback on their child’s diet and the CSIRO kids wellbeing diet book for completing the study (Appendix 6 - Participant incentives).

3.4.2.3.3 Data collection

Data collection occurred in two stages. In stage one, participants completed a demographic questionnaire and the TDQ (that is, the TDQ1). In stage two, participants were mailed a second TDQ (that is, the TDQ2) and a validated semi-quantitative Food Frequency Questionnaire (FFQ) [131, 171] to be completed on the same day approximately 2 - 4 weeks after the completion of TDQ1.

Demographic questionnaire

Child (age, sex, country of birth, and parent-reported weight and height), parent (age, country of birth, marital status, education level, and employment status) and family (postal code and household numbers) demographic characteristics were assessed via questionnaire (Appendix 3 - Study data collection forms). As a measure of socio-economic status, the Index of Relative Socio-Economic Advantage and Disadvantage (ISRAD), one of the four Socio-Economic Index for Areas (SEIFA) indices that rank geographic areas across Australia on a continuum of disadvantage (lowest score, 1) to advantage (highest score, 10), was applied to the postal code [222].

Food Frequency Questionnaire (FFQ)

To determine the validity of the TDQ, a dietary assessment tool that allowed collected data to be translated into the TDQ and dietary risk calculated was necessary. A recently developed 17-item FFQ for Australian 2 – 5 year olds [254] was not suitable as the validation tool due to the lack of assessment of dairy product and grain food intakes, preventing the calculation of a dietary risk score. Furthermore, alternative measures, such as 24-hour recalls and two- or three-day records, do not provide collected over sufficient number of days to cover that of the TDQ, while seven-day records are associated with high participant burden [121, 125] and respondent fatigue [126]. Therefore, a FFQ developed and validated in Belgian 2.5 - 6.5 year olds [131, 171] was chosen as the validation reference tool (Appendix 3 - Study data collection forms). This FFQ was identified in a recent review as the only short dietary assessment tool for children aged 0 – 5 years tested for reliability and validity [1] and from which a TDQ score could be calculated. Food-group items are mostly compatible to those in the TDQ and the one-month assessment period of the FFQ covers the one-week assessment period of the TDQ. Small adaptations were made to the FFQ to reflect culturally appropriate foods and terminology (for example, *sugared milk* replaced with *flavoured milk*), and to capture intake over the past month rather than that over the past year.

Comparative validity was assessed to evaluate dietary risk scores determined using the 19-item TDQ relative to those determined using the 54-item (47-food-item) FFQ. The final FFQ included six frequency categories (never, 1-3d/month, 1d/week, 2-4d/week, 5-6d/week, and every day) and three quantity categories (representing ‘small’ [e.g. ≤40g], ‘medium’ [e.g. 40g-120g], ‘large’ [e.g. ≥120g] portions). FFQ data were converted to a third dietary risk score using a standardised format based on comparative quantity and frequency categories and the risk score was calculated. That is, responses ‘never’ and ‘1-3 d/month’ were translated to ‘nil’ in the TDQ, ‘1d/wk’ to ‘once’, ‘2-4 d/wk’ to ‘2-4 times’, and ‘5-6d/wk’ and ‘everyday’ to ‘≥5 times’. Quantity responses were translated to the most appropriate TDQ quantity category (‘small’, ‘medium’, or ‘large’) based on gram amount.

3.4.2.4 Statistical analysis

Data were analysed using SPSS stastisical software package for windows version 19.0 (SPSS Inc., Chicago, IL, USA). The level of significance was set at $p<0.05$.

3.4.2.4.1 Individual TDQ item agreement; repeatability

The proportion of parents reporting their child’s intake within the same response category (product of frequency and quantity; data not shown) between each administration of the TDQ (TDQ1 and TDQ2) was determined and the percentage of agreeement calculated. The percentage of agreement between the administrations beyond that expected by chance [148] was determined by calculating weighted kappa (K_w) (for ordinal data) using MedCalc statistical software version 12.7.7.0. K_w values were defined as poor (< 0.20), fair (0.21 - 0.40), moderate (0.41 - 0.60), good (0.61 - 0.80) and very good (0.81 - 1.00) [153, 255].

3.4.2.4.2 Reliability and validity of dietary risk scores

Risk scores were evaluated for test-retest reliability and relative validity of section and total scores. Reliability was assessed by comparing scores obtained during the first administration (TDQ1) and second administration (TDQ2) of the TDQ and relative validity by evaluating average scores (termed 'TDQave') derived from two administrations of the TDQ [(TDQ1 + TDQ2)/2] against FFQ risk scores. Average risk scores were used in the validity analyses instead of TDQ1 or TDQ2 scores as these cover a two-week period of intake, more in line with the four-week assessment period of the FFQ, and are thus a better representation of 'usual' intake and risk. As the majority of scores were normally distributed, parametric tests were used in all analyses for consistency.

To assess reliability and relative validity at the individual level, intra-class correlations (ICC) and Pearson's correlations, defined as low $\leq$ 0.50, moderate 0.51-0.69, and high $\geq$ 0.70 [139], were used. At the group level, paired-t-tests were used for both analyses. A Bland Altman plot was constructed to assess the strength of agreement between the two tools by plotting the mean bias, that is, the difference between the TDQave and FFQ risk scores, against the mean of the tools. The plot was assessed visually and linear regression analysis performed to test for any systematic bias. Agreement at the individual level is defined as the limits of agreement (LOA, ±2SD) of the mean bias, and that at the group level by the mean bias and slope of the mean bias line [120].

3.4.2.4.3 Cross classification into dietary risk categories (low – very high)

Classification analysis was conducted to determine if participants were classified into the same dietary risk category (low, moderate, high, and very high) during each TDQ administration, and by TDQave scores compared with the FFQ scores.

3.4.3 Results

3.4.3.1 Sample Characteristics

Consent was provided for 138 parent-toddler dyads, of which 117 completed stage one measures. One-hundred and eleven parents (100% biological mother) completed all study measures (stage one and two). Mothers (mean age 34 (SD 4) years) were mostly partnered (94%), Australian born (95%), in paid employment (74%) with a university education (67%), and predominately in the top five SEIFA deciles (range 5-10, n = 85/111, 77%). Children (54% girls) were, on average, 23.0 (SD 6.9) months of age, primarily Australian born (95%), and lived in a household of four (SD 1) members (Table 3-4).

3.4.3.2 Reliability and validity

The duration between the repeat administrations of the TDQ ranged from 1.0 to 11.9 weeks (average 3.2 (SD 1.8) weeks). The average dietary risk scores ranged from 30.2±8.6 for TDQ1 to 31.4±8.1 for the TDQ derived from the FFQ **(**Table 3-5). Over two-thirds of children were classified as moderate risk and less than one-third as low risk.

3.4.3.2.1 Test-retest reliability

The percent agreement and K_w for each TDQ item are shown in Table 3-6. The percentage of agreement ranged from 32% for vegemite-type spreads to 85% for non-milk drinks. K_w values ranged from 0.40 to 0.78, indicating fair (grains), moderate (fruit, vegetables [orange, green, other], red meat, fish, vegemite-type spreads, snack products, hot potato products, meat products, sweet biscuits and cakes, chocolate and ice-creams),and good (yoghurt, spreadable fats, bread, milk drinks, and non-milk drinks) agreement.

The results of the test-retest analysis of dietary risk scores are given in Table 3-7. The total risk scores calculated from each TDQ administration were highly correlated (ICC = 0.90, $p<0.001$) and not statistically different (30.2±8.6 v 30.9±8.9; $p = 0.14$). For section risk scores, all ICC's were good (0.88 - 0.91). Risk scores for section three (6.2±6.4 v 7.1±7.3; $p = 0.017$), but not section one ($p = 0.55$) or 2 ($p = 0.45$), were significantly different between each administration. Mean bias ranged from -0.88 for section three to -0.71 for section one (TDQ1 scores were lower than the TDQ2 scores). All children were classified into the same (n = 83, 75%) or adjacent (n = 28, 25%) dietary risk category during each administration (Table 3-8).

3.4.3.2.2 Relative validity

The total and section dietary risk scores derived from the TDQave and those derived from the FFQ were highly correlated (all r = 0.71 or greater, $p<0.001$; Table 3-7). Risk scores were significantly different for section one (TDQave 56.3±17.7, FFQ 61.0±18.1; $p<0.001$) and section three (TDQave 6.6±6.6, FFQ 5.3±5.9; $p = 0.005$) but not for section two ($p = 0.69$), and total risk scores were not significantly different (TDQave 30.5±8.4, FFQ 31.4±8.1; $p = 0.05$). Mean bias between TDQave and FFQ risk scores ranged from -4.68 (section one; TDQave scores were lower than the FFQ scores) to 1.31 (section two; TDQave scores were greater than the FFQ scores).

The Bland Altman plot (

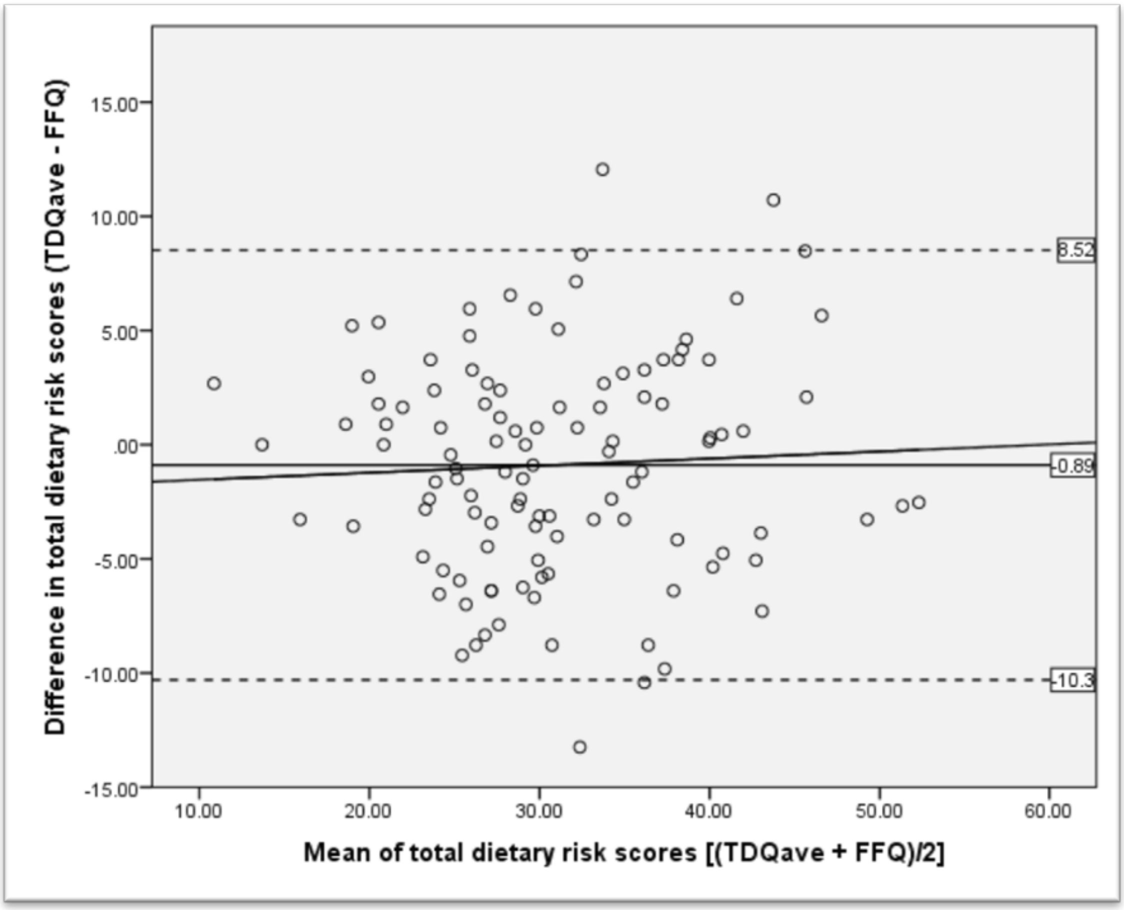


Figure 3-5) revealed a small negative mean difference between the TDQave and FFQ risk scores; that is, the TDQave tends to provide a lower estimate of risk than the FFQ (mean bias -0.89 [-1.79, 0.02]). However, most measurements fell within the 95% LOA and there was no significant linear trend for the fitted regression line (β 0.51, 95 % CI -0.08, 0.15; p = 0.60), that is, no systematic bias between the two tools. Classification analysis between the TDQave and FFQ revealed all the participants were classified into the same (n = 88, 79%) or adjacent (n = 23, 21%) dietary risk category (Table 3-8).

Table 3-4 Characteristics of parent-toddler dyads included in the reliability and relative validity analyses (n=111)

Characteristic		n (%)
Respondent characteristics		
Age, years		34.3 (4.0)[1]
Relationship to child		
	Biological mother or father	111 (100)
	Step mother or father	0 (0)
	Other	0 (0)
Highest education level[2]		
	School	8 (7)
	Trade or TAFE	29 (26)
	University	74 (67)
Marital status[3]		
	Not partnered	7 (6)
	Partnered	104 (94)
In paid employment		
	yes	83 (75)
	no	28 (5)
Born in Australia		
	yes	86 (78)
	no	25 (23)
Aboriginal or Torres Strait Islander		
	yes	0 (0)
	no	111 (100)
Number of people living in household		
	3 or less	57 (51)
	4 or more	54 (49)
SEIFA decile[4]		6.8 (2.6)[1]
Child characteristics		
Age, years		1.9 (0.6)[1]
Age, months		23.0 (6.9)[1]
Gender		
	female	60 (54)
Born in Australia		
	yes	105 (95)
	no	6 (5)

Abbreviations: SEIFA, Socio Economic Index for Areas; TAFE, Technical and Further Education

[1]Values are presented as mean (standard deviation, s.d.)

[2]categorised as: (1) school (less than year 10, year 10/11, year 12), (2) trade/TAFE (trade/apprenticeship, TAFE/college certificate), (3) university (university degree)

[3]categorised as: (1) not partnered (single/never married, separated/divorced, widowed), (2) partnered (de facto, married)

[d]SEIFA decile categorised by applying the Index of Relative Socio-Economic Advantage and Disadvantage (IRSAD) to postal code [222]

Table 3-5 Section and total dietary risk scores for each administration of the TDQ (TDQ1, TDQ2), average TDQ and FFQ, and classification into dietary risk categories (n=111)

Dietary risk measures	Possible score range	Test-retest reliability		Relative validity	
		TDQ1	TDQ2	TDQave[1]	FFQ
		mean (SD)	mean (SD)	mean (SD)	mean (SD)
Dietary risk score, mean (SD)					
Section 1	0 - 144	56.0 (18.0)	56.7 (19.5)	56.3 (17.7)	61.0 (18.1)
Section 2	0 - 144	39.3 (18.6)	40.1 (19.1)	39.7 (17.8)	39.3 (19.3)
Section 3	0 - 48	6.2 (6.4)	7.1 (7.3)	6.6 (6.6)	5.3 (5.9)
Total	0 - 100	30.2 (8.6)	30.9 (8.9)	30.5 (8.4)	31.4 (8.1)
Dietary risk score category, n (%)					
Low	(0.0 - 24.9)	31 (27.9)	33 (29.7)	33 (29.7)	21 (18.9)
Moderate	(25.0 - 49.9)	76 (68.5)	74 (66.7)	76 (68.5)	87 (78.4)
High	(50.0 -74.9)	4 (3.6)	4 (3.6)	2 (1.8)	3 (2.7)
Very high	(75.0 - 99.9)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)

Abbreviations: FFQ, Food Frequency Questionnaire; TDQ, Toddler Dietary Questionnaire
[1]TDQave = [(TDQ1 risk scores + TDQ2 risk scores)/2]

Table 3-6 Agreement of Toddler Dietary Questionnaire items (product of frequency and quantity categories, categorical) between each administration among Australian children aged 12-36 months (n=111)

Section	TDQ items	TDQ1, TDQ2	
		% agreement[1]	Kw[2]
1	Fruit	64	0.48
	Green vegetables	51	0.52
	Orange vegetables	48	0.51
	Other vegetables	52	0.50
	Yoghurt or custard	54	0.61
	Grains	40	0.40
	Red meat	55	0.46
	Fish	57	0.55
2	Spreadable fats	51	0.64
	Vegemite-type spreads	32	0.51
	Snack products	56	0.46
	Hot potato products	48	0.53
	Meat products	42	0.51
	Sweet biscuits or cakes	41	0.46
	Chocolate	65	0.60
	Ice-cream or frozen yoghurt	56	0.52
3	Bread type	80	0.78
	Milk drinks	89	0.67
	Non-milk drinks	85	0.74

[1]percentage within the same category response i.e. combination of frequency and quantity categories for sections 1 and 2 (n=10). For section 3 question 1 on b*read type*, one response was allowed and five responses were provided; (1) none white: all non-white; (2) some white: mostly non-white; (3) mostly white: some non-white; (4) all white: none non-white; (5) does not eat bread. For section 3 question 2 on *milk drinks*, multiple responses were allowed with eight responses provided: (1) breast milk or plain milk only; (2) formula only; (3) flavoured milk only; (4) no milk drinks; (5) breast milk/plain milk and formula; (6) breast milk/plain milk and flavoured milk; (7) breast milk/plain milk and formula milk and flavoured milk (8) formula and flavoured milk. For section 3 question 3 on *non-milk drinks*, multiple responses were allowed with eight responses provided: (1) water; (2) diluted juice only; (3) water and diluted juice; (4) water and un-diluted juice; (5) water and cordial/soft drink; (6) water and diluted juice and cordial/soft drink; (7) water and diluted juice and undiluted juice; (8) water and undiluted juice and cordial/soft drink.

[2]Weighted k (kw) calculated for categorised data, as described above in [1].

Table 3-7 Test-retest reliability of TDQ risk scores and relative validity of average TDQ and FFQ risk scores, for each section and total risk scores(n=111)

(Correlations, 95% confidence intervals and 95% limits of agreement (LOA))

Dietary risk scores	Test-retest reliability (TDQ1 and TDQ2)			Relative validity (TDQave[1] and FFQ)				
	ICC[2]	Mean bias (95% CI)	P value[3]	Pearson correlation[2]	Mean bias (95% CI)	P value[3]	95% LOA	Slope of the mean bias line (p value)[4]
Section one	0.88	-0.71 (-3.06, 1.64)	0.55	0.71	-4.68 (-7.24, -2.12)	<0.001	-31.32, 21.96	-0.03 (0.74)
Section two	0.89	-0.86 (-3.15, 1.42)	0.45	0.84	0.40 (-1.57, 2.37)	0.69	-20.12, 20.91	-0.08 (0.13)
Section three	0.91	-0.88 (-1.61, -0.16)	0.017	0.71	1.31 (0.40, 2.22)	0.005	-8.16, 10.78	0.12 (0.13)
Total	0.90	-0.73 (-1.72, 0.25)	0.14	0.83	-0.89 (-1.79, 0.02)	0.05	-10.30, 8.52	0.03 (0.59)

Abbreviations: ICC, intra-class correlation
[1]TDQave = [(TDQ1 risk scores + TDQ2 risk scores)/2]
[2]For all correlations p<0.001
[3]Paired t-test was used to compare differences in risk scores
[4]Linear regression analysis of difference in risk scores (TDQave - FFQ) and the mean of difference of risk scores [(TDQave – FFQ)/2]. Agreement at the individual level is defined as the LOA (±2 SD) of the mean bias and that at the group level by the mean bias and slope of the mean bias line

Table 3-8 Cross classification of participants into dietary risk categories (low, moderate, high, very high) between the administrations of the Toddler Dietary Questionnaire (TDQ) and average TDQ (TDQave) and FFQ (n=111)[1]

(Number of participants and percentages)

	Test-retest reliability (TDQ1, TDQ2)				Relative validity (TDQave[2], FFQ)		
		TDQ2				FFQ	
	Low	Moderate	High		Low	Moderate	High
TDQ1				TDQave			
Low	20 (18)	11 (10)	-	Low	16 (14)	17 (15)	-
Moderate	13 (12)	61 (55)	2 (2)	Moderate	5 (5)	70 (63)	1 (1)
High	-	2 (2)	2 (2)	High	-	-	2 (2)

Abbreviations: TDQ, Toddler Dietary Questionnaire; FFQ, Food Frequency Questionnaire

[1]values presented as n (%). No subjects classified as 'very high risk' by the TDQ1, TDQ2, TDQave or FFQ.

[2]TDQave = [(TDQ1 risk scores + TDQ2 risk scores)/2]

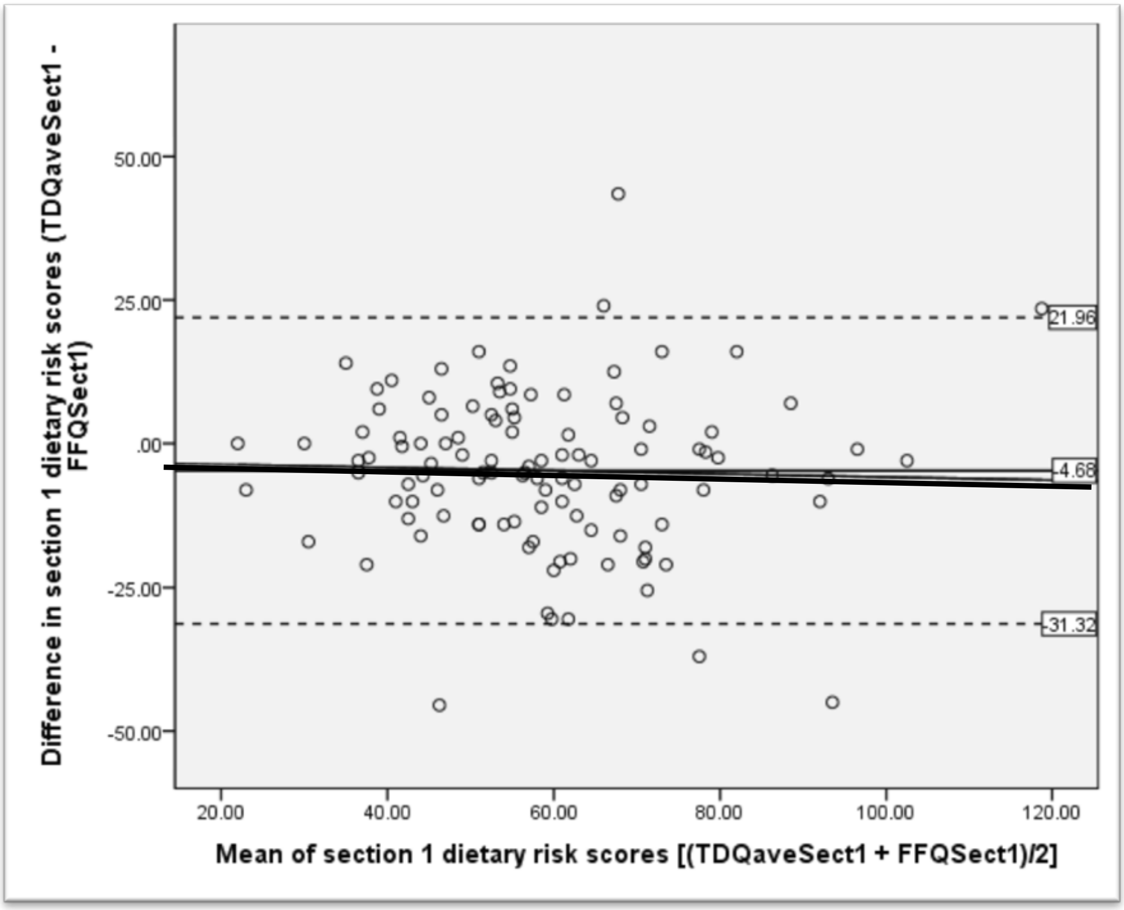


Figure 3-2 Bland Altman plot assessing the validity of average <u>section 1</u> dietary risk scores TDQave versus the FFQ among Australian children (n=111) aged 12-36 months. Plot shows the mean difference (mean diff.; ——), the 95% limits of agreement (LOA; - - - - - -) and the fitted regression line (▬▬) for section 1 dietary risk scores (p for linear trend = 0.742)

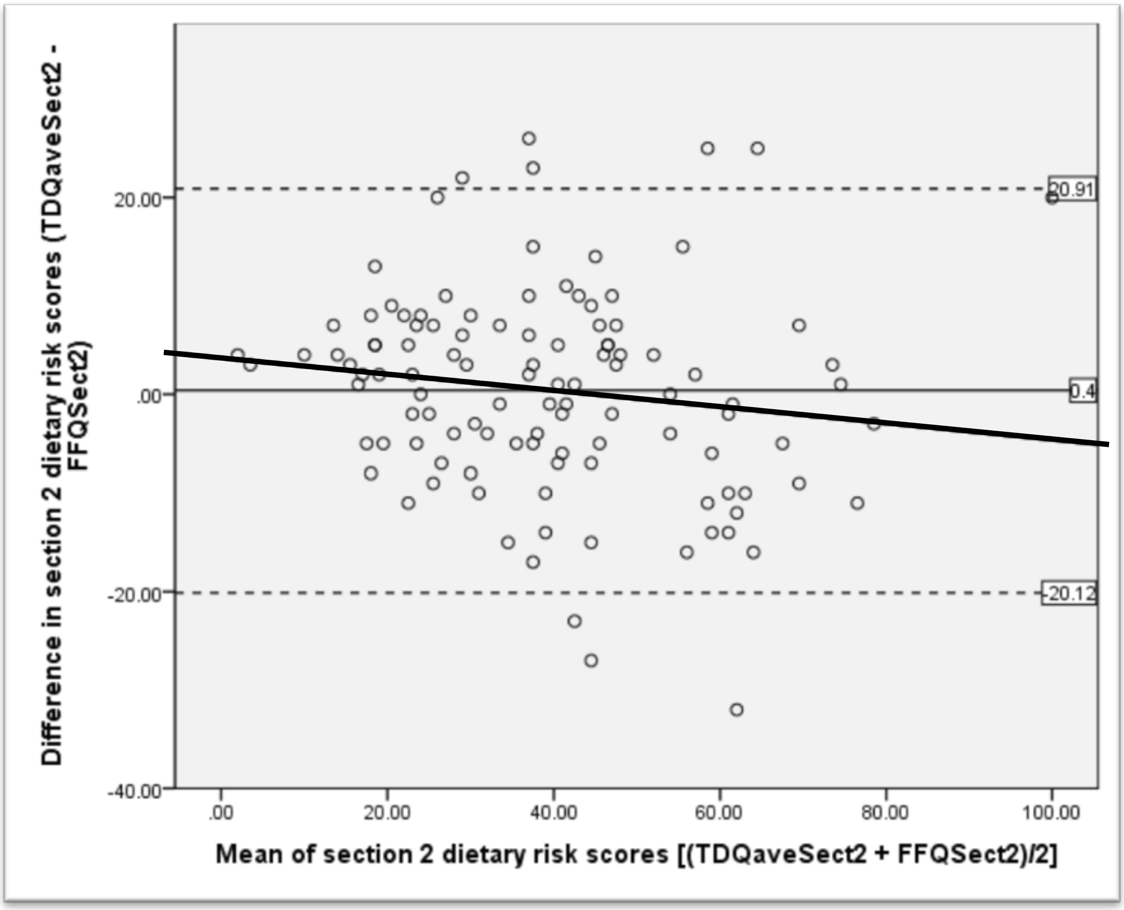


Figure 3-3 Bland Altman plot assessing the validity of average <u>section 2</u> dietary risk scores TDQave versus the FFQ among Australian children (n=111) aged 12-36 months. Plot shows the mean difference (mean diff.; ——), the 95% limits of agreement (LOA; - - - - - -) and the fitted regression line (▬▬) for section 2 dietary risk scores (P for linear trend=136)

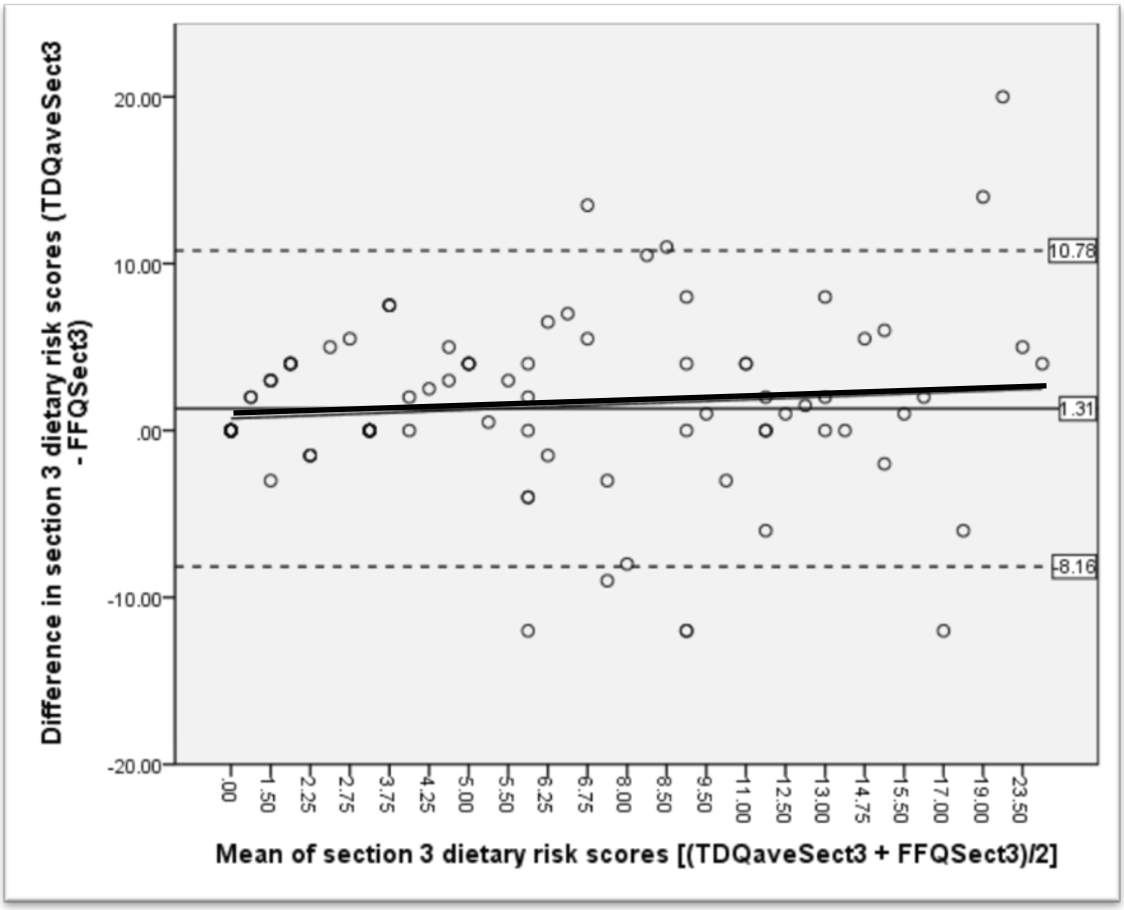


Figure 3-4 Bland Altman plot assessing the validity of average section 3 dietary risk scores from the TDQave versus the FFQ among Australian children (n=111) aged 12-36 months. Plot shows the mean difference (mean diff.; ——), the 95% limits of agreement (LOA; - - - - - -) and the fitted regression line (━━) for section 3 dietary risk scores (P for linear trend=0.133)

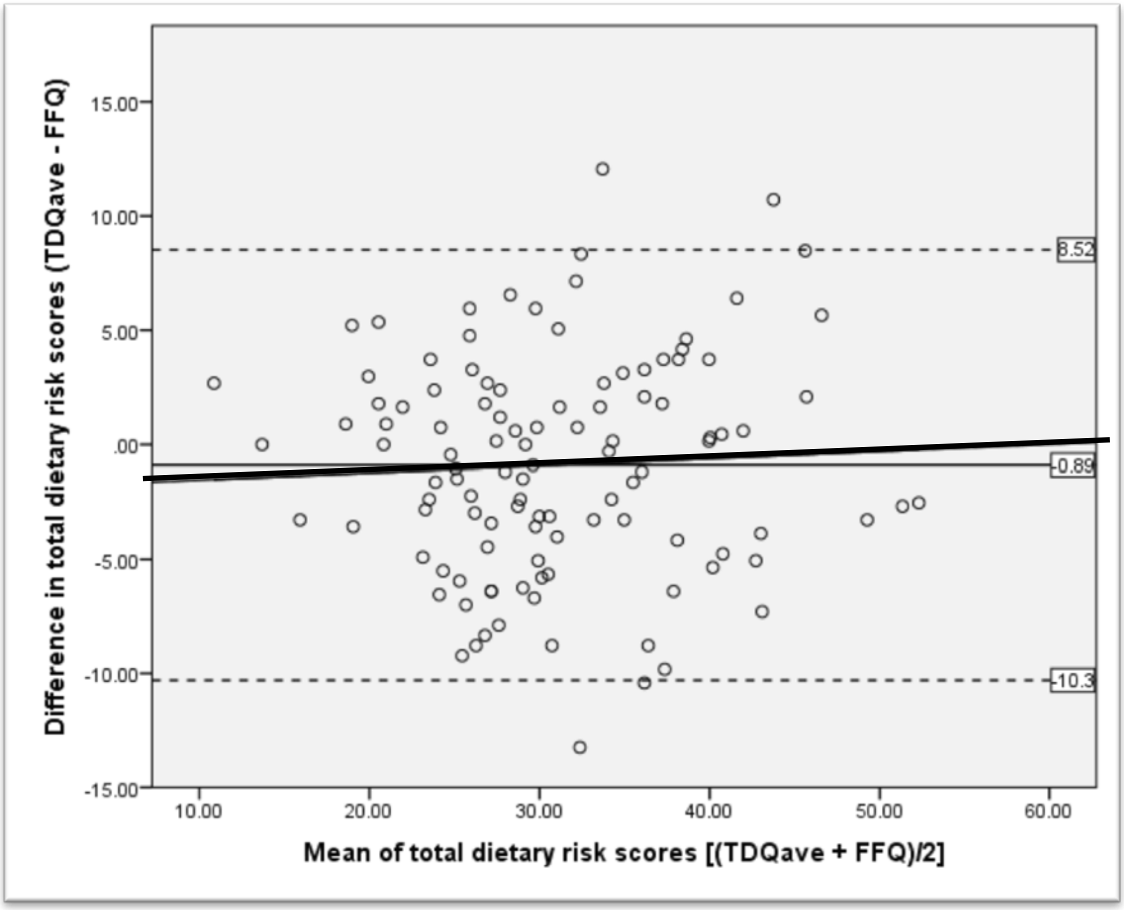


Figure 3-5 Bland Altman plot assessing the validity of <u>total dietary risk scores</u> derived from the average Toddler Dietary Questionnaire (TDQave) versus those derived from the FFQ among Australian children (n=111) aged 12-36 months. The plot shows the mean difference (——), the 95% limits of agreement (- - - - - -) and the fitted regression line (▬▬) for total dietary risk scores (P for linear trend=0.595).

3.4.4 Discussion

In the present article, the development and testing of a 19-item TDQ that assesses dietary risk of children aged 12 - 36 months are described. Our findings revealed that the TDQ-derived dietary risk scores of toddlers in the study sample were highly correlated and not significantly different between the two administrations or on comparison with scores derived from a 54-item FFQ. The TDQ is a reliable and valid screening tool for assessing dietary risk of Australian toddlers from relatively advantaged backgrounds and categorising them into dietary risk categories. The reliability and validity of the TDQ in relatively disadvantaged samples is not yet known.

3.4.4.1 Reliability of the TDQ

The TDQ performed well in terms of reliability. Repeatability analysis of individual questionnaire items revealed predominately moderate agreement. The percentage of agreement (32 - 86%; n = 19 items) was slightly lower than that reported for a FFQ tested on Australian 2 – 5 year olds (53 - 97%; n = 16 items) [254]. Yet K_w values derived from the FFQ (K_w, 0.37 [red meat] - 0.85 [take-away foods]) and those derived from the TDQ used in the present study (K_w, 0.40 [grains] - 0.78 [bread]) were similar; the reproducibility of the TDQ was predominately 'moderate' (n = 13/19 items) or 'good' (n = 5/19 items). Test-retest analysis of dietary risk scores revealed that the TDQ is reliable for assessing individuals' dietary risk. At the group level, total risk scores were not significantly different, with less than one risk score point being observed between mean scores during each administration. The mean bias was greatest for section three, with risk scores statistically, but not meaningfully different (0.9 points out of 48; 1.9%), between the administrations. Classification analysis revealed three-quarters of the children to be in the same dietary risk category during each TDQ administration. Overall, these results suggest that the TDQ is reliable for assessing dietary risk in this population, an important finding considering that the validity of a tool requires reliability [141].

3.4.4.2 Validity of the TDQ

The TDQ performed well in terms of validity. The 19-item TDQ accurately derives dietary risk scores and assigns toddlers to risk categories in comparison with a longer 54-item FFQ. The total dietary risk scores between derived from the TDQave and those derived from the FFQ were highly correlated and not significantly different. The Bland-Altman plot for total dietary risk scores showed narrow limits of agreement, indicating that the TDQ can accurately distinguish dietary risk at the individual level [146]. As the slope of the mean bias line indicated no overall bias, the TDQ is acceptable for measuring the dietary risk of toddlers at the group level [120]. Classification analysis revealed promising results with the majority of children (approximately three-quarters) classified into the same dietary risk category by the TDQave and FFQ. Thus, the TDQ is a valid toddler dietary risk assessment tool suitable for this population in a clinical (individual) or community (group) setting.

The 54-item FFQ developed by Huybrechts et al [131, 171] was chosen as the reference tool to assess validity. In the absence of a gold standard to measure dietary intake, this FFQ was determined to be the best available validation tool. It has been shown to be reliable and valid in terms of food [131] and nutrient [171] intake assessment compared with estimated diet records and provides a reasonable measure when compared with the TDQ, capturing the intake data of key foods of interest over a similar time period. Despite this, minor changes were made to the FFQ primarily to reflect cultural differences, possibly altering the reliability and validity of the tool. Ideally, the tool would have been retested in the Australian population; however, this was not feasible within the study constraints. Additionally, translation of items from the FFQ into the TDQ was challenged by incompatible portion-size categories for some items (for example, fish, snack products, chocolates and ice-cream/frozen yoghurt). That is, a ‘small’ response in the FFQ was translated to ‘medium’ in the TDQ, whilst both ‘medium’ and ‘large’ FFQ responses were translated to ‘large’ in the TDQ. Nonetheless, this FFQ was the most compatible tool that allowed derivation of dietary risk scores, could be completed in the participant’s own time, and was considered least burdensome for the participants.

3.4.4.3 Novelty of the TDQ

The novelty of the TDQ is demonstrated by the innovative approach to the selection of food items, through the use of PCA-derived dietary patterns, and the formation of portion-size categories, based on the Australian Dietary Guidelines and toddlers' intakes. Due to its novel nature there are few similar tools evaluating an overall score of diet quality in young children with which it can be compared. In a Canadian study of 3 – 5 year old preschool children, a 17-item NutriSTEP (Nutritional Screening Tool for Every Preschooler) questionnaire, which derives a nutrition risk score from five food-group questions and 12 questions on other nutrition risk constructs, was reliable between administrations (ICC = 0.89) and valid (r = 0.48) on comparison with a dietitian rating [169]. The total dietary risk scores (reliability, ICC=0.90; validity, r=0.83) obtained in the present study were comparatively better.

3.4.4.4 Dietary risk of Australian toddlers

Besides the reliability and validity results of the TDQ, the present study provides information on the dietary risk of Australian toddlers. Scores derived from the TDQ categorised approximately one-third of the study sample as 'low' risk and two-thirds as 'moderate' risk. Few toddlers were categorised as 'high' risk and none as 'very high' risk. This is likely explained by our homogeneous sample, whereby the majority were highly-educated, in paid employment, and of a high socio-economic status. Additionally, enrolment in the present study was voluntary and thus the participants were probably highly motivated parents. The assessment of dietary risk in a more representative sample of toddlers may yield higher proportions at 'high' or 'very high' risk.

3.4.4.5 Potential uses of the TDQ

There are several potential uses of the TDQ. In the clinical setting, it could be used by health professionals to rapidly screen dietary intakes of toddlers from relatively advantaged backgrounds, accurately identify those at risk, and facilitate referral to a dietitian for detailed assessment and intervention to improve dietary patterns. Once tested in a more generalisable sample, the TDQ could be applied in this manner to low-socio-economic status populations. This is important considering that diet quality is socially patterned, whereby a less healthy diet is seen in socio-economically disadvantaged populations [256, 257]. Furthermore, it could potentially be useful in the research setting, for population health monitoring of toddlers' dietary risk, for exploring the socio-demographic predictors of dietary risk, and for furthering our understanding of the relationship between dietary risk and health outcomes. Additionally, as contemporary interventions commonly focus on food-based dietary guidelines, the food-group-based TDQ is particularly useful for developing relevant interventions that aim to improve toddlers' dietary patterns and for determining the effectiveness of these interventions. Thus, further testing of the TDQ is warranted to ensure wider applicability.

3.4.4.6 Study strengths and limitations

The study findings should be interpreted within the context of the strengths and limitations. The TDQ is a novel tool developed based on population-specific evidence and age-appropriate public health dietary recommendations. It is easy and inexpensive to administer and calculates an overall dietary risk score. It does not rely heavily on memory, particularly in comparison with other short tools [131, 166, 167, 171]. Additionally, the high participation rate in the present study suggests that completion of the TDQ is not burdensome for the respondent. Reliability and validity testing were undertaken in a sample size consistent with that recommended for validation studies (>100 [146, 150]) and the sample size was comparatively larger than that used in similar studies [159, 164, 254]. Furthermore, we investigated the repeatability of individual questionnaire items in addition to the reliability and validity of dietary risk scores. Nonetheless, our findings may not be representative of those in the general population due to the highly educated and motivated study sample, although social desirability bias is possible given the self-reporting nature of dietary intake [258]. Moreover, while attempts were made to ensure stage two questionnaires were completed approximately 2 - 4 weeks after the completion of stage one questionnaires, this could not be standardised. Consequently, participants completing each stage within 1 - 2 weeks (n = 15) may have remembered their previous responses, while true changes in diet may have occurred for those completing each stage over five weeks apart (n = 7). To overcome this, however, average risk scores from each TDQ administration were used in the validity analysis. Lastly, despite its limitations [151, 259], we used K_w as a measure of agreement as it is frequently used for ordinal food frequency data [166, 254] and chose linear analysis over quadratic analysis due to its lower sensitivity to increasing number of categories [149].

3.4.5 Conclusion

In conclusion, the TDQ is a short assessment tool that provides information on toddlers' dietary risk, allowing identification of those requiring intervention. The present study showed that the TDQ is reliable and valid and accurately categorises toddlers from relatively advantaged backgrounds into dietary risk categories. The TDQ may be useful in the clinical setting, enabling screening of toddlers to identify those at-risk requiring intervention, and potentially in the research setting for the development and evaluation of interventions. Overall, the TDQ is a multi-purpose tool ideal for preventative nutrition promotion efforts.

3.5 Chapter summary

The purpose of this chapter was to (1) develop a short dietary assessment tool for Australian toddlers, aged 12 - 36 months, from which an overall measure of dietary risk could be derived, and (2) determine the test-retest reliability and relative validity of the tool. The newly developed food-group based Toddler Dietary Questionnaire (TDQ) was informed by dietary patterns identified in chapter two, and a dietary index was applied to score intake against current dietary guidelines to derive index scores that represent level of dietary risk. It was designed to be parent-administered, and to assess frequency and portion size of food intake over the previous seven days. The 19-item TDQ was shown to be reliable and valid for assessing dietary risk of Australian toddlers from relatively advantaged backgrounds.

Although the reliability and relative validity of the TDQ has been demonstrated, there are several other important types of validity that can be established to strengthen these findings. For example, determining the convergent validity, defined as “the extent to which two measures that theoretically should be related, are in fact related” [140, 143], of the dietary risk construct, will enable determination of whether dietary risk scores actually measure ‘inappropriate dietary patterns’ that may impair health [115]. This can be achieved by investigating whether the dietary risk score accurately ranks dietary patterns according to potential risk for negative health consequences. Further, as health outcomes are influenced by the combination of foods and associated energy and nutrient content, determining whether higher dietary risk scores derived from the food-group based TDQ are related to poorer nutrient intakes, and vice versa, is important. Lastly, determining whether dietary risk scores identify those toddlers who are most vulnerable to dietary risk, by establishing whether variation in risk scores is evident across the toddler population, is important. Therefore, the psychometric properties of TDQ-derived dietary risk scores will continue to be explored by examining their convergent validity against a health outcome, nutrient intakes, and demographic factors.

4 TESTING THE CONVERGENT VALIDITY OF THE TDQ

4.1 Overview

This chapter builds on the findings of chapter three and addresses the fourth specific aim of this thesis (Figure 4-1), namely the convergent validity of the dietary risk construct. This can be established by determining whether variation in nutrient exposure is seen across TDQ-derived risk scores, whether demographic characteristics predict risk scores and whether risk scores are related to health outcomes. This chapter begins with a critique of the dietary index literature, with a focus on testing their convergent validity against nutrient intakes, socio-demographic factors and health outcomes. This leads to the paper titled "Dietary risk scores of Australian toddlers are associated with nutrient intakes and socio-demographic factors, but not adiposity", which has been accepted for publication in *Nutrition & Dietetics.*

Step 1: specific thesis aim #1
Characterise dietary patterns of Australian toddlers to aid the selection of items to be included in the short tool

⇩

Step 2: specific thesis aim #2
Develop a short food-group based dietary risk assessment questionnaire for Australian toddlers

⇩

Step 3: specific thesis aim #3
Determine the test-retest reliability and relative validity of questionnaire-derived dietary risk scores

⇩

Step 4: specific thesis aim #4
Determine the convergent validity of questionnaire-derived dietary risk scores

Figure 4-1 Tool development and validation flow diagram; step 4 of 4

4.2 Dietary indices in toddlers

To understand how dietary indices are associated with underlying nutrient intakes, health outcomes and demographic factors, the literature on dietary indices applied to samples of toddlers from developed countries was critiqued. Included studies were those that captured the age range of 1 - 3 years. This critique will assist in placing the convergent validity of the dietary risk construct in context.

4.2.1 Summary of studies

The 23 studies that have utilised a dietary index (n = 22) in samples of toddlers from developed countries are described in Table 4-1. Studies were predominately conducted in samples of toddlers from the USA (n = 11) [173, 175, 176, 178-181, 183, 184] and Europe (n = 4) [174, 185, 187, 250]. Three indices, described in two studies [203, 260], were developed for Australian populations. Seven studies were conducted in samples over 1000 [179, 180, 184, 187, 189, 250, 260]. The most commonly used indices were the Healthy Eating Index (HEI, n = 4) (HEI [187, 261], HEI-C [182], HEI-2005 [178]), the Children's Diet Quality Index (DQI, n = 3) (C-DQI [184], RC-DQI [179, 180]), the Diet Quality Score (DQS, n = 2) (DQS1 [186], DQS2 [176]) and the Dietary Diversity Score (DDS, n = 2) [177, 188]. The majority of indices were applied to dietary data collected by 24-hour recalls [175, 176, 178-180, 182, 183, 188, 203, 260, 261], diet diaries [186], weighed food intake methods [185] or a combination of methods [173, 177, 181, 184, 187, 189, 250], with only one using an alternative method; a structured questionnaire [174].

4.2.2 Summary of dietary index properties

The indices vary in what aspects of diet are assessed (that is, index components) and scoring system. The majority assess foods or food groups [173-177, 186, 188, 189, 203, 260, 261] and a few use nutrient intakes [181, 183, 185, 188] or a combination of food groups and nutrients [178-180, 182, 184, 187, 250]. More recent indices include food-group subcategories, such as dark green vegetables or whole-grains

[176-181, 186, 188], which reflect the evolution of dietary guideline recommendations [156] following an increase in knowledge regarding their positive association with health. Several studies extrapolated adult-based guidelines to toddlers (for example, the HEI) [173, 179-181, 183, 185, 189], likely due to the lack of quantitative guidelines for children less than two years of age at the time [156]. Others used guidelines specific to young children (for example, the C-DQI [184]).

4.2.3 Validation of dietary indices

Consistent with the adult literature [118, 191, 262-264], the majority of toddler indices described in Table 4-1 have been validated against nutrient intake, health outcomes or demographics.

4.2.3.1 Associations nutrient intake

Eight studies assessed whether index scores were related to nutrient intake [180, 184, 185, 187, 203, 250], or a measure of nutrient adequacy [173, 188]. Studies assessed either the average ratio of estimated intake to recommended intake for various nutrients (that is, mean adequacy ratio, MAR) [188], correlations between index scores and individual nutrients [173, 185, 203], or nutrient intakes across categories of index score [180, 184, 187, 250].

Findings showed that index scores were associated with nutrient intakes in expected directions. Higher scores (= healthier diet) were generally associated with intakes of healthful nutrients such as protein, fibre, iron and calcium; lower risk of vitamin deficiency; and lower intakes of risk-promoting nutrients, such as saturated fat and sodium. For example, in Greek toddlers aged 2 – 3 years, HEI scores were positively moderately correlated with energy ($r = 0.56$, $p < 0.001$), fibre ($r = 0.60$, $p<0.001$) and micronutrient (for example, folate, vitamin C, magnesium) intake [187]. In a similar sample of children, Preschooler Diet-Lifestyle Index (PDL-index) scores were positively associated with unsaturated fat (tertile 1 v 3, 1.60 v 2.10 tbsp/d) intake [250]. In Australian toddlers aged 18 months, Obesity Protective Dietary Index scores were positively ($p<0.01$) moderately correlated with energy-adjusted fibre ($r = 055$), β-carotene ($r = 0.51$) and vitamin C ($r = 0.40$) intake and negatively ($p < 0.05$) with saturated fat ($r = -0.19$) and sodium ($r = -0.11$) intake [203]. Thus, higher toddler dietary index scores are related to better nutrient intakes, and vice versa, demonstrating the convergent validity of indices again nutrient intakes.

4.2.3.2 Associations with health outcomes

Few studies have examined whether toddlers' index scores predict health or development. Specifically, only the association between index scores and cross-sectional anthropometry has been examined (Table 4-1). Five studies [175, 179, 187, 188, 250] investigated this relationship, with inconsistent findings. Higher dietary quality, measured by the revised Children's Diet Quality Index (RC-DQI) [179] and PDL-index [250] was associated with lower risk of obesity (quartile 1 v 4, ~14% v ~9%, $p < 0.05$ [179]; tertile 3 v 1, OR 0.66 [0.42, 1.00] [250]), whilst no association was found between HEI scores and weight status (normal weight v overweight, 58.8 v 58.8) [187]. Food Variety Scores and Diet Diversity Scores were not associated with weight-for-height z-scores ($r = 0.01$, $r = -0.01$) in 1 - 3 year olds [188]. The percentage of children meeting all five daily food group serve recommendations was lower for overweight (>85th percentile, 6-7%) than normal weight (<85th percentile, 12%) children [175]. The mixed association between diet indices and cross-sectional weight status demonstrates that further investigation is warranted to determine whether indices are good measures for predicting impaired health.

4.2.3.3 Associations with socio-demographics

Ten studies [174, 176, 177, 179, 185-187, 189, 260, 261] reporting on 11 indices, have examined the influence of demographic factors, such as parental age, ethnicity, education and employment status, on toddlers' dietary index scores (Table 4-1). Maternal education was positively associated with Core Food Variety Score (CFVS) (β 0.47, $p < 0.001$) [260], Fruit and Vegetable Variety Score (FVVS) (β 0.19, $p = 0.043$) [260], HEI (<9 v >12 years, β 1.45, $p=0.029$) [187], and Diet Quality Scores (DQS2) [176]. Maternal employment negatively affected children's diet index scores in one study [176], yet the opposite was found in a nationally representative cohort from Greece (unemployed v employed, β 2.12, $p < 0.001$) [187]. Index scores were also shown to be positively associated with child gender (boys [185], girls [176]), older children [189] (and younger [179]), fewer number of siblings or children in the household [189, 260], white ethnicity [179, 261] and higher family income [179, 186] in several studies. Overall, findings show that in general toddler dietary indices have the ability to show convergent validity with demographic factors in predominately expected directions.

4.2.4 Summary – dietary indices in toddlers

The development and use of dietary indices in toddler populations is rapidly growing. Several indices developed for toddlers in developed countries have been evaluated for their association with nutrient intakes, health outcomes and socio-demographic factors. Results show that index scores can distinguish variation in underlying nutrient exposure, can predict cross-sectional weight status (although results are mixed), and are influenced by child and maternal demographic factors, highlighting the ability of dietary indices to demonstrate convergent validity. Evaluating whether TDQ-derived dietary risk scores are associated with nutrient intakes, health outcomes and demographic factors is crucial for understanding the convergent validity of the TDQ.

Table 4-1 Studies examining indices of diet quality among toddlers, aged 1 - 3 years, from developed countries. Adapted from Smithers et al 2013 [156] and Marshall et al 2014 [144]

First author, (year), reference; Index name	Sample size, age diet assessed, country, data collection method	Index components and score	Association with nutrient intake	Associations with child, family or socio-demographic factors	Associations with health or development
Spence et al (2013) [203]; Obesity Protective Dietary Index (OPDI)	*n* =395, 18mo, Australia 24-hour recall	3 food groups (fruits; vegetables; non-core foods), scored 0-30, unspecified scoring method	OPDI scores positively (p<0.01) correlated with energy (r=0.18), fibre (r=0.55), β-carotene (r=0.51), and vitamin C (r=0.40), but not with saturated fat (r=-0.02) or sodium (r=003) (significant (p<0.05) when adjusted for energy; saturated fat r=-0.19, sodium r=- 0.11)	-	
Scott et al (2012) [260]; Core Food Variety Score (CFVS)	*n* = 1905, 2y, Australia 24-hour recall	6 food groups (dairy; grains; fruit; vegetables, meat and alternatives; 'non-core' foods), scored 0-34, points awarded and summed	-	CFVS positively associated with maternal age (β 0.06 [0.04, 0.09]) and education (0.47 [0.23, 0.72]), and BF duration (β 0.05 [0.03, 0.06]), and inversely with the presence of older siblings (β -0.37 [-0.62, -0.12]).	
Scott et al (2012) [260]; Fruit and Vegetable Variety Score (FVVS)	*n* = 1905, 2y, Australia 24-hour recall	6 food groups (dairy, grains, fruit, vegetables, meat and alternatives, non-core foods), scored 0-16, points awarded and summed	-	FVVS positively associated with maternal age (β 0.03 [0.02, 0.05]) and education (β 0.19 [0.01, 0.37]), and BF duration (β 0.029 [0.02 , 0.04]), and inversely with the presence of older siblings (β -0.31[-0.50, -0.13])	

First author, (year), reference; Index name	Sample size, age diet assessed, country, data collection method	Index components and score	Association with nutrient intake	Associations with child, family or socio-demographic factors	Associations with health or development
Manios et al (2010) [250]; Preschool Diet-Lifestyle Index (PDL-Index)	*n* = 2287, 2 – 5y, Greece 24-hour recall and food diary	11 components (fruit; vegetables; sweets; dairy, grains; white meat/legumes, red meat; fish/seafood, unsaturated fats; TV viewing; MVPA), scored 0-44, points awarded and summed	PDL-Index scores positively associated with unsaturated fats (T1 v T3; 1.60 v 2.10 tbsp/d), protein (16.9 v 17.2%E), carbohydrate (45.1 v 45.7%E) and lower proportion *not* meeting the EAR for several nutrients (e.g. calcium T1 15.7 v T3 8.9%). PDL-Index scores negatively associated with total (T1 v T3; 40.6 v 39.9%E) and saturated fat (14.8 v 14.2%E) intake	-	Participants in third tertile of the PDL-Index were less likely to be obese or overweight/obese compared to those in the first tertile (OR 0.66 [0.42, 1.00]).
Crombie et al (2009) [174]; Diet Score (DS)	*n* = 300, 2y, Scotland Structured questionnaire	5 food groups (bread, other cereals, or potatoes; fruit or vegetables; dairy products; meat, fish or alternatives; high-fat or high-sugar snacks), dichotomous scoring awarded for each component and summed	-	Poorer diet associated with mothers who do not limit sweets (OR 21.63 [2.70, 173.30), have difficulty providing fruit (2.94 [1.09, 7.95]), concern for child’s intake (healthy diet will help child eat more, 0.28 [0.11 , 0.74]; concern that child does not eat enough, 2.37 [1.09, 5.16]), and do not provide breakfast (0.22 [0.05, 0.99])	

First author, (year), reference; Index name	Sample size, age diet assessed, country, data collection method	Index components and score	Association with nutrient intake	Associations with child, family or socio-demographic factors	Associations with health or development
Libuda et al (2009) [185]; Nutrient Quality Index (NQI)	*n* = 851, 2 – 4y, Germany 3 days WFR	17 nutrients: Vitamins A, E, K, B6, B12, C, and thiamine, riboflavin, niacin, pantothenic acid, folate; minerals calcium, magnesium, iron, phosphorus, potassium, zinc. Scores range 0-100	NQI more strongly associated with nutrient density than nutrient intake.	Mean NQI score higher for boys (83.2 ± 10.0) than girls (81.6 ± 10.0)	
Manios et al (2009) [187]; Healthy Eating Index (HEI)	*n* = 2,287, 2 – 3y, Greece WFR + 24-hour recall or food diary	10 components (grains; vegetables; fruits; milk; meat; total fat (%E); saturated fat (%E); total cholesterol; sodium; variety), scored 0-100, points awarded and summed	Intake of energy (Q1 v Q4, 1192 v 1597 kal/d), fibre (8 v 14g/d), CHO (45.3 v 45.9%E), protein (17.2 v 16.9%E), folate (115 v 198ug/d), iron (9.3 v 11.4mg/d), vitamin C (46 v 106mg/d), magnesium (153 v 219mg/d), phosphorus (1032 v 1247mg/d), zinc (7.4 v 9.2mg/d), calcium (970 v 1028mg/d) increased across quartiles of HEI scores. HEI score was correlated with nutrients: energy (r=0.56), fibre (r=0.60), carbohydrate (r=0.30), protein (r=-0.05), folate (r=0.56), iron (r=0.25), vitamin C (r=0.52), magnesium (r=0.55), phosphorus (r=0.27), zinc (r=0.28), calcium (r=0.09)	HEI scores were 1–2 points higher for boys (boys v girls, 59.2±8.3 v 58.2±8.1), rural locality (large urban/urban v rural/small town, 58.5±8.3 v 59.4±7.7), maternal education (<9 v >12y, 57.7±8.0 v 59.4±8.1), and maternal employment (unemployed v employed, 57.2±8.9 v 59.3±7.9)	HEI scores were not different by BMI-for-age: <85th (normal weight 58.8±8.2), 85^{th}–94^{th}, (overweight 58.9 ±8.0), and ≥95^{th} (obese 58.8±7.9) percentiles

First author, (year), reference; Index name	Sample size, age diet assessed, country, data collection method	Index components and score	Association with nutrient intake	Associations with child, family or socio-demographic factors	Associations with health or development
Kranz et al (2009) [175]; Servings/day	*n* = 104, 2 – 5y (48 plausible reporters), USA 3 x 24-hour recall	5 food groups (fruit,; vegetables; grains; milk/dairy; meat/alternatives), servings/day	-	-	Percentage of children meeting none (<85th 0%; 85th-94th 0%; ≥95th 3%) and all (<85th, 12%; 85th- 94th, 7%; ≥95th, 6%) recommendations varied across weight status
Fungwe et al (2009) [178]; HEI-2005	*n* = 763, 2 – 5y, USA 24-hour recall	12 components (fruit; total vegetables; dark green and orange vegetables and legumes; total grains; whole grains; milk/milk products; meat and alternatives and beans; food oils; saturated fat; sodium; extra calories from solid fats; added sugars), scored 0-10, points awarded and summed	-	-	-
Kranz et al (2008) [179]; Revised Children's Diet Quality Index (RC-DQI)	*n* = 1,521, 2 – 5y, USA 24-hour recall	13 components (added sugar; total fat; fat quality – linoleic; fat quality –EPA; fat quality – DHA; total grains; whole grains; vegetables; fruits; 100% fruit juice; dairy; iron intake; energy balance), scored 0–95, calculated by nutrient analysis and servings	-	RC-DQI scores positively associated with younger child age (β -2.38 [-3.10, -1.61]), family income (1.22 [0.74, 1.70]) and Mexican-American compared with non-white Hispanic ethnicity (2.18 [0.19 , 4.18]	Quartiles of RC-DQI scores negatively associated with proportion of overweight/obese children (Q1 v Q4, ~14% v ~9%)

First author, (year), reference; Index name	Sample size, age diet assessed, country, data collection method	Index components and score	Association with nutrient intake	Associations with child, family or socio-demographic factors	Associations with health or development
Kranz et al (2006) [180]; Revised Children's Diet Quality Index (RC-DQI)	*n* = 5,437, 2 – 5y, USA 2 x 24-hour recalls	13 components (added sugar; total fat; fat quality – linoleic; fat quality – EPA; fat quality – DHA;, total grains; whole grains; vegetables; fruits; 100% fruit juice; dairy; iron intake; energy balance), scored 0–95, calculated by nutrient analysis and servings	Subcomponent scores increased across quartiles of RC-DQI for energy (Q1 v Q4; 1416.2 v 1612.1 kcal/d), CHO (200.8 v 212.3g), saturated fat (18.8 v 226g), protein (46.4 v 61.6g), fibre (7.9 v 13.1g), calcium (673.4 v 930.1) intake. Quartiles of RC-DQI scores negatively associated with proportion of children with vitamin and mineral intakes below the EAR (e.g. vitamin A;Q1 49% v Q4 12%)	-	-
Hoerr et al (2006) [183]; Mean Adequacy Ratio (MAR)	*n* = 100, 11 – 25mo, USA 2 x 24-hour recalls	8 nutrients (vary according to research interests), percentage of RDA consumed calculated. <u>MAR</u>= sum of NAR (ratio of nutrient intake to EAR, truncated at 100%)/number of nutrients considered. Scores range 0-100, >85 considered adequate	-	-	-
Dewey et al (2006) [177]; Dietary Diversity Score (DDS)	*n* = 903, 1 – 2y, Brazil, Ghana, India, Norway, Oman, and USA	9 food groups (cereals, roots and tubers; vitamin A-rich fruit; vitamin A-rich vegetables; other fruit and vegetables; legumes and nuts; meat and alternatives; fats	-	DDS were lowest in children from Brazil (12m, 18m, 24m; 3.5, 4.3, 4.3) and highest in Ghana (12m, 18m, 24m; 5.3, 6.2, 6.3)	

First author, (year), reference; Index name	Sample size, age diet assessed, country, data collection method	Index components and score	Association with nutrient intake	Associations with child, family or socio-demographic factors	Associations with health or development
	FFQ + 24-hour recall	and oils; dairy; eggs), scored 0-9, points awarded and summed			
Glanville and McIntyre (2006) [182]; Healthy Eating Index-Canada (HEI-C)	*n* =82, 1 – 3y, Canada 4 x 24 recalls	9 components (grains; fruit and veg; milk; meat, other high-fat, -salt, -saturated fat foods; total fat; saturated fat; cholesterol; variety), scored 0-100, calculated by nutrient analysis and servings	-	-	
Steyn et al (2006) [188]; Food Variety Score (FVS), Dietary Diversity Score (DDS)	*n* = 795, 1 – 3y, South Africa 24-hour recall	<u>FVS:</u> No components specified, scored 0-45 (1 point for every food item consumed over 24-hrs from 45-item list) and summed <u>DDS:</u> 9 components (cereals, roots and tubers; vitamin-A-rich fruits and vegetables; other fruit; other vegetables; legumes and nuts; meat, poultry and fish; fats and oils; dairy; eggs) scored 0-9 points, awarded and summed <u>MAR</u>= sum of NAR (ratio of nutrient intake to EAR, truncated at 100%)/number of nutrients considered.	FVS (r=0.65) and DDS (r=0.62) positively correlated with MAR	-	FVS and DDS did not correlate with WHZ

First author, (year), reference; Index name	Sample size, age diet assessed, country, data collection method	Index components and score	Association with nutrient intake	Associations with child, family or socio-demographic factors	Associations with health or development
Kranz et al (2004) [184]; Diet Quality Index for Children (C-DQI)	*n* = 8,628, 2 – 5y, USA 1 x 24-hour recall + 2 day food diary	8 components (% total E as added sugars; total fat; saturated fat; number of servings of grains; fruit and vegetables; dairy; excessive juice; iron), scored 0-70, calculated by nutrient analysis and servings	C-DQI scores positively associated with intake of iron (lowest v highest tertile; NFCS77 8.3 v 11.3mg; CSII94, 10.4 v 13.9mg), total fat (37.3 v 35.5%E; 33.2 v 31.3%E) and energy (1265 v1498 kcal/d; 1476 v 1632)	-	
Knol et al. (2004) [261]; Healthy Eating Index (HEI) variety score	*n* = 1,242, 2 – 3y, USA 2 x 24-hour recall	Calculated based on number of foods consumed contributing >half a serving according to the US Food Guide Pyramid serving sizes, scored 0-10, points awarded and summed	-	HEI variety score not associated with food sufficiency but positively associated with WIC program involvement (β 1.40, t 2.92) and ethnicity (non-Hispanic white v Hispanic, β 1.53, t 2.64)	
Ruel et al (2002) [189]; Child Feeding Index (CFI)	*n* = 15,423, 1 – 3y, 7 datasets from 5 Latin American countries 24h recall + FFQ; 24h recall; 7d recall	5 components (breastfeeding; does not use bottle; dietary diversity [grains, tubers, milk, eggs/fish/poultry, meat , other]; food frequency [milk, meat, egg/fish/ poultry]; meal frequency), scored 0–12, points awarded and summed	-	CFI scores positively associated with child age (4/7 datasets), higher maternal education (6/7), higher SES (6/7), fewer children <5years (7/7), and rural residence (6/7)	-

First author, (year), reference; Index name	Sample size, age diet assessed, country, data collection method	Index components and score	Association with nutrient intake	Associations with child, family or socio-demographic factors	Associations with health or development
Cox et al (1997) [173]; Variety Index for toddlers (VIT)	*n* = 124, 2 – 3y, USA 2 day food diary + 24-hour recall	5 food groups (bread; vegetables; fruit; dairy; meat), scored 0-1.00, food items summed and truncated at 33%	VIT correlated with total energy (r = 0.54 to 0.66) but not percent energy from fat	-	
Campbell et al (1992) [186]; Diet Diversity (DD) and Diet Quality Score 1 (DQS1)	*n* = 160, 2 – 4y, Canada 3 day food diary	6 food groups (milk; meat and alternatives; fruit and vegetables; breads and cereals; additional vegetables; vitamin A rich vegetables) DD: number of different foods consumed DQS1: scored 0-18, points awarded and summed	-	DD scores positively associated with licensed childcare (β 0.33), income (β 0.31), and less negative child feeding practices (e.g. not using food to reward or pacify child) (β -0.19) DQS1 scores positively associated with less job strain (β -0.13), less child care satisfaction (β -0.19), less work schedule control (β -0.13), older children (β 0.13), higher DD (β 0.45)	
Krebs-smith et al (1989) [181]; Nutrient Adequacy Score (NAS)	*n* = 151, 1 – 3y, USA 24-hour recall + 2 day food diary	12 components (milk and milk products; whole grains; enriched grains; total grains; citrus fruit; other fruit and veg;, total fruit; green and yellow veg; starchy veg; other veg; total veg;	-		

First author, (year), reference; Index name	Sample size, age diet assessed, country, data collection method	Index components and score	Association with nutrient intake	Associations with child, family or socio-demographic factors	Associations with health or development
		meat/alternatives), 1 point per food within each component, points summed. NAS=average daily nutrient intake/age- and sex-specific RDA for nutrient, scores truncated at 1.00 MAR= sum of NAS/number of nutrients considered.			
Caliendo et al (1977) [176]; Diversity score (DS) and Diet Quality Score 2 (DQS2)	*n* = 113, 2 – 4y, USA 24-hour recall	DS: 1 point for every food item consumed from a list of 20 food items DQS2: 6 food groups (vegetables; fruit; breads and cereals; meat and milk; citrus fruit; dark green and yellow vegetables), scored 0-6, points awarded and summed	-	DSQ2 scores positively associated with diet diversity, girls, ordinal position in family, higher maternal education and homemaker attitude	

Abbreviations: BMI, body mass index; C-DQI, Children’s Diet Quality Index; CFI, Child Feeding Index; CHO, carbohydrate; CSFII94, Continuing Survey of Food Intake in Individuals for 1994 – 1996 and 1998; DDS; Dietary Diversity Score; DHA; docosahexaenoic; DQS, diet quality score; EAR, estimated average requirement; EPA, eicosapentaenoic; FFQ, Food Frequency Questionnaire; FVVS, Fruit and Vegetable Variety Score; HAZ, height-for-age z-score ; HEI, Healthy Eating Index; HuSKY, Healthy Nutrition Score for Kids and Youth; MAR; mean adequacy ratio; MVPA, moderate-to-vigorous physical activity; NAS, nutrient adequacy score; NCFS77, National Food Consumption Survey for 1977 – 1979; NQI, Nutrient Quality Index; NR, not reported; OPDI, Obesity Protective Dietary Index; PDL-Index, PDL-Index, Preschool Diet-Lifestyle Index; Q, quartile; RC-DQI, Revised children’s Diet Quality Index; RDA, Recommended Dietary Allowances; SES, socio-economic status; T, tertile; veg, vegetables; VIT, variety index for toddlers; QAZ, weight-for-age z-score; WAZ, weight-for-age z-score; WFR, weighed food record; WHZ, weight-for-height z-score; WIC, Special Supplemental Nutrition Program for Women, Infants and Children; y, years; %E, percent energy

4.3 Testing the convergent validity of the TDQ

The following section aims to determine the convergent validate of the TDQ. It contains material from:

Bell L, Golley R, Daniels L, Magarey A (2013) Dietary risk scores of Australian toddlers are associated with nutrient intakes and socio-demographic factors, but not adiposity, *accepted 8th March 2015 Nutrition & Dietetics*

As this section is based on the above paper (presented in Appendix 1 - Papers, conference presentations and awards/prizes arising from this thesis), some repetition with previous sections might be encountered. Small alterations have been made to the published manuscript.

4.3.1 Introduction

Toddlers' diets are generally low in fruit and vegetables and high in energy-dense, nutrient-poor foods [52, 59, 109, 265]. Inappropriate dietary intakes in toddlerhood are known to track into child- and adult-hood [37, 86] and contribute to the development of chronic disease [6]. Current dietary patterns of toddlers therefore place them at 'dietary risk', a term used to describe 'any inappropriate dietary pattern' that may impair health [115].

As food consumption is a modifiable behaviour, identifying toddlers with poor intakes can assist intervention efforts that aim to improve dietary patterns and reduce negative health consequences [6]. Due to the benefits of short, simple dietary assessment tools compared to detailed methods such as recalls and records [1, 126], a short Toddler Dietary Questionnaire (TDQ) that assesses toddlers' dietary risk was developed [3]. The 19-item TDQ assesses 'core' and 'non-core' [8, 62, 95] food-group intake which is evaluated against a dietary risk criteria. Component scores are aggregated to derive a total dietary risk score (0-100; higher score = higher risk). Previous evaluation of the TDQ psychometric properties [3] showed that risk scores were highly correlated and not significantly different between administrations

(TDQ1 v TDQ2; ICC = 0.90, mean bias = -0.73 [-1.72, 0.25], p = 0.143) or compared with a FFQ (average TDQ [(TDQ1+TDQ2)/2] v FFQ; r = 0.83, mean bias = -0.89 [-1.79,0.02], p = 0.054). The TDQ has good reliability and comparative validity as a short toddler dietary assessment tool.

To determine whether the TDQ captures variation in toddler dietary risk it is important to understand its convergent validity [140, 143]. Convergent validity is a subtype of relative validity and is established when two similar constructs agree with each other in a way that is expected [140, 142]. This can be achieved by exploring the association between TDQ dietary risk score, energy or nutrient intakes, health outcomes and sociodemographic factors, as previously undertaken in studies of diet quality [203, 251]. First, as health outcomes are influenced by the combination of foods and associated energy and nutrient content [62], higher TDQ scores may be related to poorer nutrient intakes, and vice versa. Second, childhood overweight is a major public health issue world-wide, with 27% of English [266] and approximately one-fifth of Australian 2-3 year olds categorised as overweight or obese[59]. As these children experience negative health consequences [267], including tracking of adiposity into adulthood [268], preventing childhood overweight is a global priority [269, 270]. Determining whether TDQ-derived dietary risk scores are associated with adiposity is crucial for establishing the usefulness of the TDQ in obesity interventions. Third, sociodemographic factors have commonly been linked to young children's diet quality [271]. For example, maternal age, breastfeeding duration and age of introduction to solids were key predictors of PCA-derived dietary patterns of Australian toddlers [2]. Determining whether dietary risk scores identify those toddlers who are most vulnerable to dietary risk, by establishing whether variation in risk scores is evident across the toddler population, is important.

This study aimed determine the convergent validity of TDQ-derived dietary risk by examining associations between risk scores and (1) underlying nutrient intake, (2) toddler adiposity, and (3) maternal and child sociodemographic factors.

4.3.2 Methods

4.3.2.1 Study population

Data collection for this cross-sectional validation study have been described in detail previously (3.4.2.3) [3]. Briefly, between October - November 2012 primary caregivers of toddlers aged 12 – 36 months were recruited through advertisements at Flinders University, on a study-specific Facebook page, at South Australian private child care centres, and via participants enrolled in the South Australian Infant Dietary Intake (SAIDI) study [216] who agreed to further contact. Children were ineligible if they had a food allergy or intolerance or a diagnosed medical condition affecting their dietary intake. Ethics approval was provided by the Social and Behavioural Research Ethics Committee (SBREC) (Appendix 4 - Ethics approval letter**)** and written caregiver consent was obtained (Appendix 3 - Study data collection forms).

4.3.2.2 Measures

Data for this study were collected at stage one of the Toddler Dietary Intake study (described in chapter four). That is, eligible participants completed a demographic questionnaire and the Toddler Dietary Questionnaire (TDQ).

4.3.2.2.1 Toddler Dietary Questionnaire (TDQ)

Participants completed the 19-item TDQ that assesses food-group intake over the previous seven days of toddlers aged 12 - 36 months. Three sections capture (1) ‘core’ intake (*eight items*; fruit, vegetables [green, orange, other], yoghurt/custard, grains such as rice and couscous, red meat, fish), (2) ‘non-core’ intake (*eight items*; spreadable fats, vegemite-type spreads, salty snack products, hot potato products, meat products, sweet biscuits and cakes, chocolate, ice-cream/frozen yoghurt), and (3) ‘usual’ intake (*three items*; bread, milk beverages, non-milk beverages). Sections one and two ask respondents to report *how often* and *how much* their child ate of each food-group item over the previous week. Four categories (nil, once, 2-4 times,

≥5 times per week) assess consumption frequency and three (representing small e.g. <50g, medium e.g. 50 - 100g, and large e.g. >100g) assess portion size. Section three asks respondents to select the most appropriate categorical response to three questions: (1) what proportion of white: non-white bread (e.g. some white: mostly non-white), (2) what milk drinks (breast, plain, flavoured, formula) and 3) what non-milk drinks (water, diluted juice, undiluted juice, cordial/soft drink), does your child usually consume? Portion size is not reported for section three. A dietary risk score (0-100; higher score = higher risk) is derived by evaluating food-group intake against scoring criteria (described previously; Table 3-3). Risk scores are categorised into four levels of dietary risk: (1) low (0 - 24), (2) moderate (25 - 49), (3) high (50 - 74) and (4) very high risk (75 - 100). Further details of the TDQ and its development are provided chapter four [3].

4.3.2.2.2 Demographic Questionnaire

Participants completed a demographic questionnaire assessing child (age, gender, country of birth, caregiver-reported weight and height), caregiver (age, country of birth, marital status, education level, employment status) and family (postal code, household numbers) characteristics (Appendix 3 - Study data collection forms**)**. Child and maternal age were calculated from date of birth and date of completion of the TDQ. Marital status was reported from five categories and collapsed into two (partnered, not partnered). Education level was reported as the highest completed level of six categories and categorised into three (school, trade/TAFE [Technical and Further Education], university).

Caregivers were provided with an instruction sheet to assist with measuring their child’s weight and height. Measures were encouraged as they are more accurate than parental judgements [272, 273]. Measures were converted to Body Mass Index (BMI, kg/m^2) and age- and sex- specific z-scores using World Health Organisation (WHO) reference data [221]. As a measure of socio-economic status, The Index of Relative Socio-Economic Advantage and Disadvantage (IRSAD), one of four Socio-Economic Index for Areas (SEIFA) indices that scores geographical areas on a continuum of disadvantage (lowest score, 1) to advantage (highest score, 10) [222], was applied to postal code.

4.3.2.3 Nutrient intakes

To determine whether TDQ-derived risk scores are associated with nutrient intakes (Table 4-2), two steps were conducted to establish nutrient intakes of the sample according to TDQ food-group intake.

First, nutrient profiles per 100g of each TDQ food-group item were created. Nutrient profiles of section one items (‘core’ foods; fruit, vegetables [green, orange, other], yoghurt/custard, grains, red meat, fish) were informed by composite nutrient profiles developed based on dietary intake data of 2 - 3 year olds (data not available for under two’s) from the 2007 Australian National Children’s Nutrition and Physical Activity Survey [59]. These profiles informed the development of Foundation Diets for 12 - 23 month olds and 2 - 3 year olds [223] on which the newly revised Australian Dietary Guidelines were developed [62, 95]. At times, nutrient profiles for food items were collapsed to form whole food-group items that were comparable to TDQ items. For example, the nutrient profiles of ‘low-’, ‘medium-’ and ‘high-omega fish’ were combined to develop a nutrient profile for the TDQ item ‘fish’. Each nutrient profile was added as a “new food” to FoodWorks Professional version 7 [219].

Nutrient profiles of section two (‘non-core’ foods) and three (‘usual’ intake) items were informed by composite nutrient profiles developed based on dietary intake data of 24 month old children from the NOURISH [215] and SAIDI [216] studies. Items included spreadable fats, vegemite-type spreads, salty snack products, hot potato products, meat products, sweet biscuits and cakes, chocolate, ice-cream/frozen yoghurt, white bread, brown bread, breast milk, plain milk, formula, flavoured milk, water, diluted juice, juice and cordial/soft drink. For each item the types and proportions of foods consumed informed the composite nutrient profile. For example, as 95% of vegemite-type spreads consumed was vegemite, 3% was promite, 1.5% was compressed yeast and 0.5% was marmite, the 100g TDQ nutrient profile for ‘vegemite-type spreads’ was based on 95g vegemite, 3g promite, 1.5g compressed yeast and 0.5g marmite. Grams of each food for each TDQ food-group item were entered into FoodWorks professional version 7 [219] as a “new recipe” and an overall nutrient profile created per food-group.

Second, the amount of each TDQ food-group item consumed per subject per week was determined. For sections one and two, food-group intake in grams was calculated by multiplying the frequency response (zero [nil], one [once], three [2-4 times] and seven [≥5 times] times per week) by the median quantity response (e.g. small = <50g, 25g; medium = 50 - 100g, 75g). For example, if the median of a ‘small’ category representing <50g is 25g, then a response of ‘2-4 times’ and ‘small’ is 75g (3 x 25g). As the median of the ‘large’ (e.g. >100g) category could not be established based on the TDQ categories, an upper limit of consumption of 24 month old NOURISH and SAIDI children was used (e.g. 300g) and the median determined (e.g. 200g).

To determine a nutrient profile for section three items, an estimate of amount was derived from 24 month old NOURISH and SAIDI intake data. Median daily intake of all breads (33g), milk beverages (174g) and non-milk beverages (328g) was multiplied by seven to derive weekly intakes (231g, 1216g, 2296g, respectively). For question one on bread consumption nutrient profiles were applied to response options in the following manner: (1) *none white: all non-white* (0% [0g]: 100% [231g]), (2) *some white: mostly non-white* (25% [46.2g]: 75%, [173.3g]), (3) *mostly white: some non-white* (75% [173.3g]: 25%, [46.2g]), (4) *all white: none non-white* (100% [231g]: 0% [0g]). For questions two and three on beverage consumption multiple responses were allowed. Thus, if two responses (for example, formula and flavoured milk) were provided a proportion of 50% of gram intake was applied to each; if three responses (for example, water, diluted juice and undiluted juice) were provided 33%

of gram intake was applied to each; and if four responses (for example, water, diluted juice, undiluted juice, and cordial/soft drink) were provided 25% of gram intake was applied to each.

The amount (in grams) of each TDQ food-group item consumed per subject per week was entered into FoodWorks professional version 7 and the composite nutrient profiles were used to generate a complete nutrient profile per person per week. Data were exported from FoodWorks into SPSS for windows version 19.0 (SPSS Inc., Chicago, IL, USA) via Microsoft Access.

4.3.2.4 Data analysis

All analyses were conducted in SPSS for windows version 19.0. The level of significance was set at $p<0.05$.

4.3.2.4.1 Associations with nutrient intake

Convergent validity of dietary risk scores was investigated by comparing weekly energy and energy-adjusted nutrient intakes (nutrient densities) across quartiles of dietary risk score using one-way ANOVA and post-hoc test of linear trend analysis**.** Quartiles of dietary risk scores were treated as continuous variables with quartile 1 (Q1) representing lowest risk and quartile 4 (Q4) highest risk. As energy and nutrient distributions were normally distributed parametric statistics were employed. Values are presented as means and standard deviations (SD).

4.3.2.4.2 Associations with socio-demographics and measures of adiposity

The relationship between dietary risk scores and socio-demographic characteristics and BMI z-score by investigated using standard linear regression. Univariate and multivariate models explored associations between: (1) socio-demographic covariates and dietary risk scores and (2) dietary risk scores and BMI z-scores, adjusting for covariates (child age, gender and country of birth, parent age, marital status, education level, employment status and country of birth, household numbers and SEIFA decile). The normality, linearity and variance (homoscedasticity) of residuals were checked to verify that the regression assumptions were met [139]. The strength and precision of associations were evaluated using regression coefficients (β) and 95% confidence intervals.

4.3.3 Results

4.3.3.1 Sample characteristics

Overall 138 parent-toddler dyads consented to participate in the study and 117 (85%) completed all study measures. All participants were mothers (mean age 34±4 years) and most were university educated (68%), partnered (94%), born in Australia (79%), and in paid employment (75%) (Table 4-2). Children (56% girls, 10% overweight) were on average 23±7 months old with an average dietary risk score of 30±9 out of 100, classified as 'moderate' risk. Children's BMI z-score according to dietary risk category was 0.75±1.29 ('low risk', n=34), 0.47±1.35 ('moderate' risk, n=78) and 0.49±0.76 ('high' risk, n=4). Ten percent (n=12) of children were overweight (BMI z-score ≥2, corresponding to the 97.7th percentile[274]); six categorised as 'low' risk and six as 'moderate' risk.

4.3.3.2 Associations with nutrient intakes

Toddlers' energy and energy-adjusted nutrient intakes according to quartiles of dietary risk scores are shown in Table 4-3. Average toddler risk score doubled between Q1 (20.0±2.7; low risk) and Q4 (41.6±5.6; moderate risk). Linear trend analysis showed that dietary risk scores were positively associated with energy, total fat, saturated fat, sugar and sodium intakes and negatively associated with intakes of protein, fibre, iron, magnesium and phosphorus (all $p<0.05$). The difference between Q1 and Q4 was greatest for energy, total fat, saturated fat, sodium, protein and fibre. Dietary risk score was not significantly associated with amount (in grams) consumed, percent energy from carbohydrate or intake of calcium, Vitamin A, Vitamin C, riboflavin, thiamin, folate or potassium intake.

4.3.3.3 Associations with socio-demographic factors

In the univariate model, household numbers and child age predicted dietary risk scores (Table 4-4). After adjustment for covariates, dietary risk scores remained significantly positively associated with household numbers (β = 2.26 [0.13, 4.38] p = 0.037) and child age (β = 4.03 [1.10, 6.96], p = 0.008) (Table 4-5). That is, increasing toddler age and number of people in the household were associated with higher scores (= greater risk). These factors described 12.6% of the variance.

4.3.3.4 Associations with adiposity

The average BMI z-score of toddlers was 0.54±1.34 (n = 116). In the univariate model, dietary risk score (n = 114) was not associated with BMI z-score (β = 0.06 [-0.04, 0.02], p = 0.550). This association remained non-significant after adjustment for covariates (Table 4-5).

Table 4-2 Characteristics of parent-toddler dyads included in the convergent validity analysis (n=117)

Characteristics		n (%)
Respondent characteristics		
Age, years[1]		34.2 (3.9)
Marital status[2]		
	Partnered	110 (94.0)
Highest education level[3]		
	School	8 (6.8)
	Trade/TAFE	29 (24.8)
	university	80 (68.4)
In paid employment[4]		
	Full time	18 (15.7)
	Part time	67 (58.3)
	None	30 (26.1)
Born in Australia		
	Yes	92 (78.6)
Household numbers		3.59 (0.83)
SEIFA decile[1,3]		6.7 (2.6)
Child characteristics		
Age, months[1]		22.8 (6.9)
Gender		
	Female	65 (55.6)
Born in Australia		
	Yes	111 (94.9)
Dietary risk score[1]		29.9 (8.6)
Dietary risk score category[6]		
	Low	34 (29.1)
	Moderate	79 (67.5)
	High	4 (3.4)
BMI z-score[1,7,8]		0.54 (1.3)
Classified as overweight[7,8]		12 (10.3)

Abbreviations: TAFE, Technical and Further Education; SEIFA, Socio Economic Index for Areas

[1]Values are presented as mean (s.d.).

[2]categorised as: (1) not partnered (single/never married, separated/divorced, widowed), (2) partnered (de facto, married)

[3]categorised as: (1) school (less than year 10, year 10/11, year 12), (2) trade/TAFE (trade/apprenticeship, TAFE/college certificate), (3) university (university degree)

[4]missing, n=2

[5]SEIFA categorised by applying the Index of Relative Socio-Economic Advantage and Disadvantage (IRSAD) to postal code [222]

[6]No subjects were classified as 'very high' risk by the TDQ

[7]missing, n=1

[8]WHO BMI z-score [221]

[9]BMI z-score ≥2, corresponding to the 97.7th percentile [274]

Table 4-3 Mean (SD) of energy-adjusted nutrient intakes across quartiles of dietary risk scores in 12 - 36 month children (n=117)

	Quartiles of dietary risk score[1]				Linear trend p[2]
	Q1	Q2	Q3	Q4	
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	
n	30	30	28	29	
Dietary risk score	20.0 ± 2.7	26.2 ±1.4	32.1 ± 1.8	41.6 ± 5.6	-
Intake[3]					
Weight (g)[4]	6219 ± 1170	6370 ± 1228	6800 ± 1690	6385 ± 1279	0.405
Total Weekly Energy (MJ)	14.5 ± 3.8	15.9 ± 4.5	17.0 ± 5.2	17.2 ± 4.7	0.016
CHO (%E)	46.2 ± 3.6	45.6 ± 2.7	46.5 ± 3.0	47.4 ± 3.4	0.090
Fat (%E)	29.1 ± 3.0	30.3 ± 2.1	30.8 ± 2.0	32.3 ± 3.3	<0.001
Protein (%E)	22.2 ± 3.0	22.0 ± 2.5	20.6 ± 2.7	18.0 ± 2.6	<0.001
Saturated fat (g/MJ)	3.1 ± 0.4	3.0 ± 0.6	3.3 ± 0.4	3.4 ± 0.6	0.005
Sugar (g/MJ)	18.8 ± 2.9	20.2 ± 3.9	20.5 ± 2.9	20.7 ± 4.0	0.037
Dietary fibre (g/MJ)	4.2 ± 0.9	4.0 ± 1.2	4.0 ± 1.3	3.5 ± 1.3	0.037
Iron (mg/MJ)	1.4 ± 0.3	1.5 ± 0.4	1.2 ± 0.3	1.2 ± 0.3	0.002
Calcium (mg/MJ)	136 ± 29.8	138 ± 28.4	143 ± 24.7	138 ± 38.7	0.625
Sodium (mg/MJ)	188 ± 41.1	202 ± 54.2	200 ± 36.0	230 ± 66.4	0.004
Vitamin C (mg/MJ)	26.9 ± 10.6	27.6 ± 12.6	27.7 ± 12.1	23.8 ± 11.3	0.336
Vitamin A (µg/MJ)	218 ± 99	217 ± 109	257 ± 146	203 ± 127	0.961
Riboflavin (mg/MJ)	0.3 ± 0.1	0.4 ± 0.1	0.4 ± 0.1	0.4 ± 0.1	0.069
Thiamin (mg/MJ)	0.2 ± 0.1	0.2 ± 0.1	0.3 ± 0.1	0.2 ± 0.1	0.119
Total folate (µg/MJ)	64.0 ± 16.9	67.6 ± 17.7	74.0 ± 29.0	68.8 ± 22.1	0.245
Potassium (mg/MJ)	516 ± 62.4	507 ± 88.1	514 ± 94.6	470 ± 101	0.072
Magnesium (mg/MJ)	46.7 ± 4.2	44.7 ± 5.6	43.7 ± 5.6	40.0 ± 6.4	<0.001
Phosphorus (mg/MJ)	244 ± 32.4	237 ± 34.6	225 ± 41.6	208 ± 43.4	<0.001

Abbreviation: MJ, megajoule; Q, quartile; %E, percent energy
[1]Quartiles range from 1 (lowest) to 4 (highest) dietary risk scores
[2]ANOVA test used to compare differences in total weekly energy intake and energy-adjusted nutrient intakes across quartiles of dietary risk score. Data is interpreted using linear trend across quartiles of dietary risk score
[3]Nutrient intakes calculated per week (seven days) of TDQ assessment
[4]Weight (food and beverages) consumed

Table 4-4 Unadjusted associations between participant characteristics and dietary risk scores[1]

	Dietary risk scores[2] (n=115)		
Characteristics	β	95% CI	p-value
Maternal characteristics			
Age, years	-0.27	-0.68, 0.14	0.190
Marital status			
Partnered	-0.48	-11.49, 1.86	0.155
Highest education level	-2.30	-4.98, 0.38	0.092
In paid employment	-0.66	-3.20, 1.89	0.609
Born in Australia			
Yes	0.08	-3.83, 3.98	0.970
Household numbers	2.07	0.17, 3.96	0.033
SEIFA decile	-0.53	-1.16, 0.09	0.093
Child characteristics			
Age, months	0.35	0.12, 0.57	0.003
Gender			
Female	-0.35	-3.60, 2.90	0.833
Born in Australia			
Yes	3.93	-3.93, 11.79	0.324

[1]Data are presented as regression model *beta* coefficients, 95% confidence intervals (95% CIs) and p value of significance. For definitions and categorisation of maternal and child predictor terms, see Table 4-2.
[2]Results were obtained from standard linear regression models with dietary risk scores as the dependent variable and all respective covariates as independent predictors.

Table 4-5 Associations between maternal and child characteristics (n=117) and toddler dietary risk scores (n=115), and between toddler dietary risk scores and toddler BMI z-scores (n=114), after adjustment for covariates[1]

	Dietary risk scores[2](n=115)			BMI z-score[3](n=114)		
Characteristics	β	95% CI	p-value	β	95% CI	p-value
Maternal characteristics						
Age, years	-0.28	-0.69, 0.13	0.184	0.05	-0.02, 0.12	0.141
Marital status			Referent = Not Partnered			
Partnered	-5.69	-13.02, 1.63	0.126	-0.50	-1.69 , 0.69	0.408
Highest education level	-1.76	-4.39, 0.87	0.188	-0.22	-0.66, 0.21	0.313
In paid employment	-1.62	-4.31, 1.01	0.236	0.43	-0.01, 0.86	0.053
Born in Australia			Referent = No			
Yes	-0.83	-4.72, 3.06	0.674	0.00	-0.63, 0.63	0.991
Household numbers	2.26	0.13, 4.38	0.037	0.05	-0.30, 0.40	0.792
SEIFA decile	-0.59	-1.26, 0.08	0.082	-0.03	-0.14, 0.08	0.542
Child characteristics						
Age, months	4.03	1.10, 6.96	0.008	-0.04	-0.08, 0.00	0.049
Gender				-0.24	-0.75, 0.28	0.363
Female	1.37	-1.83, 4.56	0.397			
Born in Australia			Referent = No			
Yes	-0.27	-7.64, 7.09	0.941	0.36	-0.90, 10.63	0.571
Dietary risk score	-	-	-	-0.00	-0.04, 0.03	0.845

[1]Data are presented as regression model *beta* coefficients, 95% confidence intervals (95% CIs) and p value of significance. For definitions and categorisation of maternal and child predictor terms, see Table 4-2.[2]Results were obtained from standard linear regression models with dietary risk scores as the dependent variable and all respective covariates as independent predictors. [3]Results were obtained from standard linear regression models with BMI z-scores as the dependent variable and all respective covariates as independent predictors

4.3.4 Discussion

The purpose of this study was to determine the convergent validity of dietary risk, measured by a newly developed Toddler Dietary Questionnaire (TDQ) for Australian toddlers aged 12 - 36 months, by examining whether dietary risk scores are associated with nutrient intakes, child adiposity and socio-demographic characteristics.

4.3.4.1 Associations with nutrient intakes

A higher dietary risk score (= greater risk) was positively associated with energy, macronutrients (total fat, saturated fat, sugar) and sodium intakes, likely reflecting significantly higher intakes of ‘non-core’ foods, captured in section two of the TDQ. Protein, dietary fibre, iron, magnesium and phosphorus were inversely associated with dietary risk scores which may reflect poorer intakes of ‘core’ foods captured in section one, and/or bread consumption captured in section three of the TDQ. The association of higher TDQ scores with poorer nutrient intakes supports its validity as a measure of dietary risk with implications for negative health consequences. Of note is the lack of association between risk scores and calcium intake, a key nutrient in young children’s diets [275]. This could be explained by the limited variation in dairy food intake in our sample in which the majority of children (n = 94, 80%) were reported to usually consume breast milk or plain milk, with few (n = 6, 5%) non-consumers. Associations between dietary risk scores and other vitamins (A, C riboflavin, thiamin, folate) or minerals (calcium or potassium) were not observed, which was not unexpected as intakes of these nutrients are generally adequate in toddlers [276, 277]. In contrast, large variations in intakes across risk scores were seen for several key nutrients; sodium, saturated fat, energy, protein, fibre and iron. Importantly amount of food consumed did not vary across risk score quartiles, suggesting that children can respond to the weight of foods but not necessarily the energy density of the food. This does not support some previous work [241] which found that children were able to compensate for energy-dense meals in experimental situations. Overall, our findings of lower and higher dietary risk scores being associated with protective (protein, dietary fibre, iron, magnesium, phosphorus) and harmful (saturated fat, sugar, sodium) nutrients [62] respectively are consistent with previous studies that have investigated the association between measures of overall diet quality and selected nutrient intakes [2, 187, 203, 251, 278]. Our findings show that TDQ-derived dietary risk scores meaningfully reflect differences in energy and selected nutrient intakes, demonstrating the convergent validity of the TDQ. Nonetheless, these findings must be interpreted with caution as analyses were performed using nutrient densities and not nutrient intakes adjusted for energy intake using the residual method [279]. Several subjective decisions were also made to determine TDQ food-group nutrient profiles. While energy and nutrient associations are likely only reflective of the limited food types included in this short questionnaire, their estimation was appropriate for the trend analysis conducted. Although the association of higher TDQ scores with poorer nutrient intakes supports the TDQ as a measure of dietary risk with implications for negative health consequences, further investigation is required to determine whether TDQ-derived dietary risk scores adequately assess inappropriate dietary patterns that may impair health.

4.3.4.2 Associations with adiposity

Despite the positive association between dietary risk scores and energy intakes, risk scores were not associated with BMI z-scores in this cross-sectional analysis. This finding is consistent with previous work assessing the influence of Australian toddlers' (14 (n=467) and 24 (n=404) month olds [2]) and young children's (8-11 years (n=846) [278]) diet quality (assessed via 24h dietary recalls) on weight status. There are several possible explanations for our finding. First, although energy intake across quartiles of risk scores were statistically different, the difference (2.7MJ/wk or 385kJ/day) between Q1 and Q4 risk scores may not be sufficient to produce observable differences in weight status. Second, the influence of poor diet on weight status may not yet have manifested [242-244]. Third, dietary risk scores do not capture the full scope of obesity-promoting foods, including takeaway foods, as included items were based on toddlers' dietary patterns [2]. Fourth, anthropometric data were parent reported not researcher measured. However, to overcome potential error we provided instructions and requested the mother to measure her child rather than rely on an estimation. Lastly, BMI, a measure of excess weight relative to height [280], may not be the best measure of adiposity for examining diet-body composition associations. Previous studies reported associations between diet and percent body fat but not BMI, suggesting that total body fatness may have a stronger association with diet quality [281]. Including other adiposity indicators, such as waist circumference, may reveal an association with dietary risk scores.

4.3.4.3 Associations with socio-demographic factors

As health inequalities exist across all populations we explored how toddlers' dietary risk varies by socio-demographic factors. Our findings were consistent with similar studies investigating the influence of demographic factors on a measure of diet quality. In UK children, the impact of more siblings on poorer diet quality has been documented [162, 232]. Similarly, in Australian children, negative associations between number of siblings [2] or children in the household [278] and diet quality have been reported. The present study found that higher dietary risk scores (= greater risk) were associated with higher household numbers, likely a proxy for number of siblings. Together these findings suggest that mothers of multiple children are a promising avenue in which to intervene. Further, we found that risk scores were strongly positively associated with toddler age. This is not unexpected. As a child progresses through toddlerhood, stronger food preferences and habits are formed and fussy eating behaviours become more common [39], resulting in undesirable eating patterns. Nonetheless, it does highlight the essentiality of providing adequate support to parents, prior to and during this period of their toddler's development, to ensure they are well-equipped with appropriate feeding strategies to deal with fussy eating behaviours and subsequent poor eating patterns. The lack of further associations between dietary risk scores and demographic variables may reflect the small variation in risk scores (most children were classified as 'low' or 'moderate' risk), or our homogenous sample (most mothers were partnered, born in Australia, university educated and in paid employment).

4.3.4.4 Comparison of study findings to other similar studies

Dietary risk is a concept not commonly investigated. One study examined the properties of a 17-item questionnaire that assesses nutrition risk of Canadian 3 – 5 year olds [169], but associations between risk scores and nutrient intakes were not explored. Diet quality is a similar concept that assesses adherence to a certain dietary pattern or dietary guidelines [116]. Previous diet quality index studies have used validation approaches similar to that used in this study. For example, associations between scores on the Dietary Guideline Index for Children and Adolescents were associated with lower energy, fat and sugar intake, higher fibre and micronutrient intake, socio-demographic characteristics such as household income and education, and weakly with adiposity measures [278]. Further, the Complementary Feeding Utility Index (CFUI), which measures infant diet quality, demonstrated convergent validity, showing associations with food and nutrient intakes, maternal predictors of infant diet, and infant dietary patterns [251]. Similarly, in Australian 18 month olds, scores on the Obesity Protective Dietary Index (OPDI) were positively correlated with energy, dietary fibre, β-carotene and vitamin C intakes [203]. Our findings of associations between higher risk scores and poorer nutrient intakes, and socio-demographic factors, are comparable and demonstrate the convergent validity of TDQ-derived dietary risk.

4.3.4.5 Study strengths and limitations

Our highly educated sample of mothers is a limitation of the present study. These mothers may have reported more positive dietary intakes due to greater knowledge of dietary recommendations or may provide healthier options for their children than less educated mothers [2]. It is therefore not surprising that few toddlers were classified as ‘high’ risk and none as ‘very high’ risk, and that only 10% of children in our sample were overweight, half of what is estimated nationally for children aged 2-3 years (20%) [59]. A second limitation, discussed earlier, is that children’s height and weight were parent reported and thus the associations found with BMI z-score should be treated with caution. A third limitation is the complex method used of applying a range of foods and portions to categorical responses to determine nutrient intakes for each food-group item of the TDQ, in which several assumptions were made. As part of this, several subjective decisions were made during the determination of TDQ food-group nutrient profiles. For example, we used seven times/week to represent the midpoint of the “≥5 times” frequency category. However this choice is contentious. The cross-sectional analyses and relatively small sample size in comparison to other similar studies (n = 6065 [251], n = 3146 [278]) are other limitations of this study and possible reasons for the lack of association between dietary risk scores and adiposity. Nonetheless, the strengths of this study include the high participation rate and the ability of the short, simple food-group based TDQ to associate with selected nutrient intakes and respondent characteristics.

4.3.4.6 Future directions of the TDQ

Overall the findings of this study enhance the usefulness of the TDQ by demonstrating its ability to measure energy and nutrient intakes in expected directions and be influenced by respondent characteristics. These findings highlight the convergent validity of the TDQ and demonstrate that variation in dietary risk represents variation in nutrient intake in expected directions. This provides support that TDQ-derived dietary risk scores adequately assess inappropriate dietary patterns that may impair health. The influence of household numbers and toddler age on dietary risk scores highlights the potential for education programs targeting families with these characteristics. Yet with no association demonstrated between risk scores and BMI z-scores, the TDQ is not currently valuable in an obesity context and therefore should be used as a screening instrument for overall dietary risk. Nonetheless, future research could improve the usefulness of the TDQ. Investigation of the association of weight status and demographic factors with dietary risk scores in a more diverse and thus generalisable population is warranted. Likewise, investigation of the effect of toddlers’ dietary risk on weight status longitudinally is appealing as it could potentially show significant associations and thus highlight intervention points to prevent childhood overweight. The relationship between dietary risk and other health-related outcomes could also be examined.

4.3.5 Conclusion

In conclusion, a newly developed 19-item Toddler Dietary Questionnaire (TDQ) that assesses dietary risk adequately measures energy and selected nutrient intakes in expected directions (i.e. lower and higher risk scores reflect better and poorer nutrient intakes, respectively) and is influenced by respondent characteristics. Risk scores were not shown to influence weight status, highlighting that the TDQ is currently not valuable in an obesity context. Longitudinal investigation of this association, in a more diverse and generalisable population, is warranted. Associations between dietary risk and other health outcomes could also be examined. The study findings enhance the usefulness of the TDQ and provide some support for its use as a dietary risk screening tool for use by health professionals in early childhood preventative health efforts.

4.4 Chapter summary

The purpose of this study was to determine whether dietary risk scores derived from the TDQ, a newly developed short food-group based dietary risk assessment tool for Australian toddlers, demonstrate convergent validity against nutrient intakes, socio-demographic factors and a health outcome, namely toddler weight status. Findings indicate that the TDQ measures nutrient intakes in expected directions, can be influenced by child (age) and family (household numbers) demographic characteristics but cross-sectionally does not predict toddler weight status. This is consistent with the toddler dietary index literature; supporting evidence that indices accurately reflect underlying nutrient intakes and are influenced by demographics but do not consistently predict cross-sectional adiposity. The present study findings demonstrate that the TDQ has convergent validity in assessing inappropriate dietary patterns (and their underlying nutrient intakes) that may predict impaired health.

5 DISCUSSION AND CONCLUSION

5.1 Overview

In light of the vulnerability of toddlers to poor diet and health outcomes; the importance of assessing toddlers' whole diets to identify those at dietary risk; the limitations of laborious, costly and time-intensive traditional dietary assessment methods; and the gap in the literature on short (<50 items) dietary assessment tools that assess whole diets of Australian toddlers: the overall aim of this thesis was to develop and validate a short food-group based dietary assessment questionnaire for measuring dietary risk in Australian toddlers aged 12 - 36 months. The specific aims of this thesis were to characterise whole-of-diet patterns of Australian toddlers to inform the items of a short, food-group based dietary questionnaire from which a dietary risk score could be derived, and to determine the test-retest reliability, relative validity and convergent validity of the dietary risk score. This final chapter reiterates the main findings of this thesis before synthesising the thesis strengths and limitations. Conclusions on the potential usefulness of the short tool in practice are drawn before discussion of future research directions.

5.2 Summary - methodology and key findings

Due to the importance of valid dietary assessment and the benefits of capturing dietary intake using short, efficient assessment methodologies to aid monitoring of Australian toddlers' dietary risk, a literature review was conducted (chapter one; published in the *Journal of Obesity* [1]) to identify, critique and learn from the literature on short, valid tools that assess whole diets of children aged 0 - 5 years. Findings highlighted the lack of valid and reliable, brief dietary assessment tools that measure whole diet, not merely components of diet, of young children. Only one of 16 tools reviewed was tested for both validity and reliability. No tools were developed for populations of Australian young children. Thus, the literature review confirmed a gap and need to develop a short dietary assessment tool that assesses dietary risk of Australian toddlers.

To aid the selection of items to be included in the short tool, dietary patterns of Australian toddlers were characterised by applying the common factor analysis technique of principal components analysis (PCA) to dietary data from two contemporary Australian studies (chapter two; published in *European Journal of Clinical Nutrition* [2]). Extracted patterns were similar at the two ages examined, 14 and 24 months, representing ‘core’ (fresh fruit, vegetables and non-white bread) and ‘non-core’ (white bread, margarine, juice and salty-spreads) type dietary patterns. The validity of the ‘core’ and ‘non-core’ patterns was established by demonstrating that ‘core’ patterns were related to better nutrient intakes compared with ‘non-core’ patterns. Although no association was found between toddler dietary patterns and concurrent or longitudinal weight status, associations were found between dietary patterns and maternal and child socio-demographic predictors. Thus, extracted dietary patterns demonstrate validity with underlying nutrient intakes and socio-demographic factors but not with toddler adiposity.

As PCA identifies foods accounting for the largest variation in diet between individuals, these foods can be used to distinguish good- and poor-quality dietary patterns in toddlers. Thus, foods loading strongly on extracted dietary patterns of Australian toddlers were used to select the items for the Toddler Dietary Questionnaire (TDQ) (chapter three; published in the *British Journal of Nutrition* [3]). Age-appropriate servings per week, recommended by the revised 2013 Australian Dietary Guidelines [223], were used to inform portion-size categories. The 19-item TDQ assesses intake over the previous seven days of ‘core’ (for example, fruit, vegetables, dairy) and ‘non-core’ (for example, high-fat, high-sugar and/or high-salt foods, sweetened beverages) items. Dietary risk is expressed as a single summary score, by scoring food group intake against a dietary risk score criterion (0 - 100; higher score = higher risk), which is classified into one of four risk categories (low, moderate, high, very high). This criterion was developed based on how closely intake (frequency x median quantity response) aligns with the Australian Dietary Guideline recommendations for toddlers [223].

To investigate the reliability and various aspects of validity of the TDQ a sample of mother-toddler dyads were recruited**.** The test-retest reliability and relative validity of the dietary risk score was determined by examining variability of scores measured on two occasions and comparing scores to those derived from a validated FFQ (chapter three). Results showed that risk scores were highly correlated and not significantly different between administrations or compared with a FFQ and that all participants were classified into the same or adjacent risk category (low - very high). The convergent validity of the questionnaire-derived dietary risk score was tested by examining associations with nutrient intakes, demographic factors and the health outcome of toddler weight status (chapter four; *accepted Nutrition & Dietetics).* Results showed that higher toddler risk scores were associated with higher energy, total fat, saturated fat, sugar and sodium intake, and lower protein, fibre, iron, magnesium and phosphorus intake. That is, higher risk scores were associated with disease-promoting nutrients and lower risk scores with health-promoting nutrients. This demonstrates the convergent validity of the dietary risk construct, highlighting that dietary risk scores measure intake that may impair health. Further, dietary risk scores were influenced by socio-demographic characteristics but were not associated with toddler weight status, highlighting that the TDQ measures variation in dietary risk across populations but cannot specifically assess obesity risk. Overall, the findings of this study, summarised in Table 5-1, demonstrate that the TDQ is a valid and reliable screening tool for identifying at-risk toddlers requiring intervention in relatively advantaged samples of Australian toddlers.

Overall, studies undertaken in this thesis led to the development and validation of a short Toddler Dietary Questionnaire that assesses ‘core’ and ‘non-core’ food group intake of Australian toddlers aged 12 - 36 months from which a dietary risk score can be derived. Scores demonstrated high test-retest reliability, relative validity and convergent validity in a relatively advantaged sample of Australian toddlers. These findings highlight the potential usefulness of the TDQ as a dietary assessment tool for screening toddlers’ intakes to identify those at nutritional risk with potential for diet-related health consequences.

Table 5-1 Summary of the findings of the reliability and validity properties of the TDQ derived from a sample of parent-toddler dyads

	Reliability and relative validity (n = 117; chapter 3)		Convergent validity (n = 111; chapter 4)				
			Nutrients[1]		Socio-demographic[2]		
	Test-retest reliability (TDQ1, TDQ2)	Relative validity (TDQave, FFQ)	Positive association with.	Negative association with	Positive association with	Negative association with	BMI z-score[2]
Dietary risk scores	ICC = 0.90 Paired t-test: 30.2±8.6 v 30.9±8.9 (p=0.143) Cross classification analysis: same = 75% adjacent = 25%	r = 0.83 Paired t-test: 30.5±8.4 v 31.4±8.1 (p=0.054) Linear regression: β 0.51, p=0.595 Cross classification analysis: same = 79% adjacent = 21%	Energy Total fat Saturated fat Sodium Sugar	Protein Dietary Fibre Iron Magnesium Phosphorus	Household numbers Toddler age	-	Not associated with cross-sectional BMI z-score

Abbreviations: ICC, Intraclass correlation; TDQ, Toddler Dietary Questionnaire
[1]Determined by comparing weekly energy and energy-adjusted nutrient intakes across quartiles of dietary risk score using one-way ANOVA and post-hoc test of linear trend analysis
[2]Determined using standard linear regression, adjusting for covariates

5.3 Thesis limitations and strengths

Each of the studies presented in this thesis are not without limitations, which have been discussed in the respective chapters. However, there are some limitations to the thesis as a whole which are discussed here, followed by the thesis strengths.

5.3.1 Thesis limitations

The first limitation of this thesis is associated with the development of the TDQ. The TDQ asks respondents to report the amount their child consumed of 16 food-group items over the previous week. Portion-size categories were included because the amount consumed is an important variable in level of toddlers' dietary risk. Dietary risk is defined as poor adherence to dietary guidelines, and thus to assess how well intake aligns with food group serving recommendations, portion size information is needed. Further, given that toddler intake varies greatly from day-to-day and meal-to-meal [43], capturing this variation requires portion size assessment. Yet the inclusion of portion size estimation may be considered a limitation as there is evidence that suggests that untrained individuals have difficulty in estimating portion sizes of foods, with small portion sizes often over-estimated and large portion sizes under-estimated [126]. Further, the large variation in toddlers' intake between meals and days increases the difficulty for respondents to estimate the average portion size consumed for the previous week. Thus, although portion size estimation is essential for determining dietary risk, and was therefore included in the TDQ, it is important to be mindful of its associated limitations.

Second is the use of a FFQ as the validation standard. This method was chosen because it was the only dietary assessment tool that allowed collected data to be translated into the TDQ and a dietary risk score calculated. Nonetheless, a limitation to its use is that the TDQ and FFQ are both respondent-based methods that are subject to the same errors. When errors in the validation standard are not independent of those in the test method then it will be uncertain if the correlations between the methods are due to both accurately measuring the underlying concept, or because both were measured with the same type of error [142]. Respondent-based methods, such as the FFQ and TDQ, are subject to similar types of errors and thus their comparison may lead to artificially inflated correlations [137]. This may have contributed to the strong validation results observed in the present thesis. Alternatively, errors in observer-recorded measures are independent of those in respondent-based measures and thus if an observer-recorded measure were used then the results would likely not have been as strong. However, the only truly independent method is direct observation of an individual's usual intake which may affect dietary intake behaviour, whilst covert observation of intake is not logistically or ethically feasible [282]**.** Nonetheless, to place the highest level of confidence in the study results, ideally a validation standard with errors independent to that of the TDQ would have been used.

Other methods, such as 24-hour recalls or weighed food records, were considered as the validation standard as they are not questionnaire-based methods and are therefore subject to different errors to those of the TDQ. Thus, the results of validation testing using one of these methods would be stronger than those derived from the studies undertaken in this thesis. However, to be translatable into the TDQ, derived intake data needed to cover the seven day period of the TDQ and thus a 7-day food record or 7 x 24-hour recalls would have been required. These were considered to be not feasible for a number of reasons. First, they are associated with substantial researcher and/or participant burden, particularly in terms of administration time and data analysis, and subsequently it would be difficult to recruit a sufficient number of participants in a reasonable time frame for a study in which participants were required to complete the TDQ and record seven days of dietary intake. Second, research suggests that with increasing number of days recalled or recorded, particularly more than four consecutive days, the number of incomplete records significantly increases and the validity of collection data decreases [126, 283]. The limitations associated with each dietary assessment method demonstrate the challenges of validity testing and why the choice of a validation standard usually requires a compromise between limitations and feasibility. Overall, a FFQ was determined to be the best available tool for testing the reliability and validity of the TDQ considering study time constraints, participant burden and the need for outcome data from the tool to be translatable into the TDQ. Despite the limitations associated with the use of the FFQ as the validation tool, the validation results are still useful for understanding the psychometric properties of the TDQ.

The third limitation of this thesis is that the reliability and validity of the TDQ was tested in a relatively advantaged population, and thus applicability of the TDQ to toddlers from relatively disadvantaged populations is not known. This has implications on the generalisability of the TDQ, restricting its use in the wider population and in both the clinical and research settings. The recruitment of families from high socio-economic status (SES) populations, however, is not new. Several other studies relying on volunteer recruitment of similar samples of young children resulted in relatively advantaged samples. In particular, there is often a selection bias towards more educated mothers regardless of the sample size [284]. For example, an analysis of the NOURISH RCT data (n = 698) found that those who declined to participate in the study were younger and less likely to have a university education [285]. The barriers to participation in research by less advantaged mothers of young children are not entirely clear [284] but the level of literacy required for participation in research is one. Engaging low SES samples in research remains a high priority, yet a large challenge, to ensure study outcomes are broadly generalisable.

The fact that the sample for the reliability and validity study was not representative of all SES groups is not surprising. The recruitment methods used and the literacy level required to complete the questionnaires may have affected participation of lower SES groups. One of the major methods of recruitment was advertising at private child care centres. Community child care centres were not approached due to the additional ethics approval required from the South Australian Department for Education and Child Development, which is considered to be a lengthy process. Thus, due to time-constraints of the study, recruitment was limited to private child care centres as only approval from the centre director was required in addition to the original ethics obtained for the study from the SBREC at Flinders University. Other recruitment means, such as through Flinders University and Facebook, were also used in an attempt to yield a more heterogeneous sample. However, these methods may have also contributed to our relatively advantaged sample, as those responding to advertisements at Flinders University were predominately staff, not students, whilst those responding to the Facebook advertisement were potentially high SES, non-working mothers who had the time to use Facebook, respond to the study advertisement, and participate in the study. Given the implication of testing the reliability and validity of the TDQ in a relatively advantaged sample on the generalisability of the TDQ, ideally participants would have been recruited from both private and public child care centres to yield a more generalisable sample.

The fourth limitation of this thesis is that investigation of the association between toddlers' dietary risk scores and BMI z-scores failed to show a significant relationship cross-sectionally. There are several possible explanations for this: (1) the association was tested cross-sectionally in 12 – 36 month olds and therefore the influence of poor diet on weight status may not yet have manifested, (2) the dietary risk score does not capture the full scope of obesity-promoting foods, including takeaway foods, as included items were based on toddlers' dietary patterns, and (3) anthropometric data were parent measured and reported, not researcher measured, and thus accuracy is questionable. Yet this finding is consistent with previous work assessing the influence of diet quality on toddler adiposity (discussed in 2.2.3.3 and 4.2.3.2). Risk scores were, however, positively associated with energy intakes, suggesting that an association between toddler risk scores and adiposity may be observed if tested longitudinally. The present findings of no relationship between toddler dietary risk scores and cross-sectional adiposity have implications for use of the TDQ. It cannot specifically assess obesity risk and therefore should be used as a screening instrument for overall dietary risk.

5.3.2 Thesis strengths

A thesis strength is the robust approach used for tool development. The TDQ is a novel tool based on population-specific empirical evidence; that is, using data driven PCA-derived dietary patterns of Australian toddlers to guide selection of the TDQ items, and the Australian Dietary Guidelines which informed portion-size categories. This is in contrast to most tools which are developed solely based on dietary guidelines. Yet to base a short tool that captures whole diet intake in limited items solely on dietary guidelines, requires determining which dietary guideline items to include or not include. Basing items on toddlers' dietary patterns is a novel approach to tool development that ensured included food-group items were relevant to the contemporary consumption patterns of the target population and were selected in an unbiased manner. Importantly, best practice in PCA was undertaken, whereby patterns were validated, increasing the level of confidence that can be placed in them, and the subsequent TDQ, to distinguish intake amongst Australian toddlers.

A robust approach was also taken in developing the dietary risk score criterion, with scores developed according to age-appropriate dietary guideline recommendations [223]. Given that moderation in food intake is important, in which over-consumption of 'core' items, for example fruit or milk, can have implications for health like that of over-consumption of 'non-core' items, intake of section one items is not scored in a linear manner relative to consumption frequency and quantity. Over-consumption, as well as under-consumption, of these items is awarded a higher risk score than consumption in line with recommendations. Conversely, scores for intake of 'non-core' food items are linear, with scores increasing proportionally from zero with increasing consumption frequency and quantity, based on the recommendation that consumption of 'non-core' foods should be avoided or limited [64]. The meticulous, detailed approach to development of the scoring system is a strength of this thesis and of the TDQ.

Further, the rigorous testing of the reliability and validity of the TDQ also contributes to the thesis strengths. TDQ-derived dietary risk scores were tested for test-retest reliability and relative validity. While increasingly these properties are being tested in newly developed tools, the testing of convergent validity is far less common and an important addition to validity testing. The convergent validity results that show risk scores are associated with nutrient intakes in expected directions and positively associated with socio-demographic factors, strengthen the validity of the TDQ and its applicability in the wider context. Some other strengths include: (1) the TDQ is short and inexpensive to administer, (2) the TDQ does not rely heavily on long-term memory, assessing intake over only the past week, (3) the high participation rate, suggesting that completion of the TDQ is not burdensome on the respondent, (4) that all testing was conducted in a large sample size consistent with that recommended for validation studies (>100 [146, 150]).

5.4 Implications for practice and future directions

The key learning outcome of this thesis is that the TDQ-derived dietary risk scores appear to be a reasonably accurate measure of whole-of-diet patterns that may have implications for health. Promising findings were seen for the relationship between dietary risk scores and nutrient intakes, with higher risk characterised by poorer nutrient intakes compared to lower risk. The differences in nutrient intake across dietary risk scores indicate that the dietary risk construct assesses variation in risk of diet-related health consequences. This is in addition to the high reliability and relative validity of the TDQ. As a result there are several potential uses of the TDQ in both the clinical and research settings, discussed below.

5.4.1 Implications for practice

5.4.1.1 The use of the TDQ in the clinical setting

The findings of this thesis demonstrate that the TDQ may be a useful tool to guide nutrition counselling in the clinical setting. It could be suitable for use by dietetic and non-dietetic health professionals such as general practitioners (GP's) and child health nurses to rapidly screen toddlers' dietary intakes to determine dietary risk; that is, those at risk of impaired health. As it is quick to complete, the TDQ could be completed by parents as they wait to see their health professional. However, the time required for health professionals to calculate the dietary risk score, and the reliability in doing so, is currently not known and would therefore need to be tested, as discussed later.

As a screening tool, the TDQ allows for identification of toddlers who require further detailed dietary assessment and possible intervention through nutrition counselling to improve toddlers' dietary patterns and reduce risk-related dietary behaviours. Thus, GP's or child health nurses could refer high-risk toddlers to a Dietitian for further assessment and intervention. Any dietary education that is required to improve dietary risk patterns would naturally be targeted at the toddlers' parent or caregiver, as they provide the food environment for their child. Intervening with parents of at-risk toddlers is crucial as the toddler period is an important stage when eating behaviours and food preferences are established, informing life-long food behaviours and health. Importantly, however, the TDQ is currently only suitable for use with toddlers from relatively advantaged samples.

5.4.1.2 The use of the TDQ in the research setting

Dietary assessment is particularly important in research, as it can aid the understanding of characteristics of populations with less optimal diets, which is crucial for developing targeted and effective interventions to improve dietary intake. The TDQ could therefore be used in the research setting for the development, implementation, and evaluation of early life interventions that aim to improve dietary patterns. As contemporary interventions commonly focus on food-based dietary guidelines, the food-group based TDQ is particularly useful. Further, it could be used for population health monitoring of toddler's dietary risk; that is, assessing the stability of eating behaviours across time, and for investigating the link between diet risk and health outcomes, such as the development of childhood overweight. Yet, as the TDQ has only been validated in relatively advantaged samples, it is currently only appropriate for research with these populations.

5.4.2 Future directions

Although the TDQ has applications in both the clinical and research setting, its use is currently restricted by the thesis limitations discussed earlier. This section discusses future directions for the TDQ to ensure wider applicability in the clinical and research settings and possibilities for modifying the TDQ to enhance its usefulness.

5.4.2.1 Widening the applicability of the TDQ

5.4.2.1.1 Testing the reliability and validity of the TDQ in a generalisable sample

Given that the TDQ was validated in a population of parent-toddler dyads from a relatively advantaged population, testing the reliability and validity of the tool in a relatively disadvantaged population is important for determining its generalisability and thus its wider applicability in both the clinical and research settings. Ensuring the TDQ is applicable to lower SES populations is crucial as social disparities are evident in health and nutrition [256, 257], whereby lower SES populations generally have poorer diets than higher SES populations [286, 287]. Further, use of the TDQ in relatively disadvantaged populations would allow for more equitable disease prevention efforts. However, as lower SES populations may be harder to engage in research [288, 289], greater effort needs to be placed in recruiting participants from these populations. Financial incentives may help [290], yet are not significantly motivating for all participants [291]. Additionally, low literacy and culturally and linguistically diverse populations may find it difficult to complete the TDQ and thus its reliability and validity in these populations could be tested using a researcher-assisted administration. Overall, support for the TDQ as an important public health tool could potentially be provided by demonstrating its reliability and validity in a sample of toddlers from relatively disadvantaged backgrounds.

5.4.2.1.2 Investigating further whether dietary risk scores predict impaired health

As dietary risk is a measure of dietary patterns that may impair health [275], it is important to understand whether dietary risk scores measure variation in health outcomes. In this thesis, the association between dietary risk scores and weight status was investigated to determine whether risk scores can be used to predict obesity. While the association was only determined cross-sectionally, with no significant relationship observed, risk scores were positively associated with energy intakes, suggesting an association with adiposity at some point is possible. Thus, investigation of this association longitudinally is warranted. A reasonable follow-up time is required to ensure that the effect of diet on weight status has adequate time to manifest. A more representative sample may display greater variability in risk scores and a higher prevalence of ‘high’ or ‘very high’ risk toddlers, which in turn may show a greater difference in energy intakes across quartiles of dietary risk score and possibly an association with toddler adiposity. Determining whether questionnaire-derived dietary risk scores are associated with adiposity longitudinally is crucial for establishing the usefulness of the TDQ in obesity interventions. This is important given that childhood overweight is a major public health issue world-wide, with high rates observed in Australian toddlers.

Furthermore, as dietary risk not only encompasses the risk of adiposity, research is required to investigate the association between dietary risk scores and other health outcomes. In general, few studies have evaluated the relationship between paediatric diet quality indices and health outcomes, and of those that have, only the association with anthropometrics has been investigated (reported in 4.2.3.2). Yet, as dietary risk encompasses a range of health implications, such as impaired growth and development, including mental and psychomotor development, and chronic diseases, such as obesity, heart disease, and diabetes, the influence of dietary risk on disease markers such as blood pressure, serum cholesterol, blood glucose or child IQ longitudinally should be investigated. Change in diet and associated dietary risk scores should be considered in such investigations given that poor dietary patterns over time have greater influence on later health outcomes than poor diet at one time point. For example, Brazionis et al [19, 234] investigated the association between types of transition diets from 6 - 24 months of age and blood pressure at seven years of age. Results of investigations into the association between dietary risk scores across the early life period and longitudinal health outcomes would assist in determining whether the TDQ is a useful tool for child preventative health efforts. Overall, further testing of the association between dietary risk scores and health outcomes, including longitudinal weight status, is warranted to more comprehensively understand whether the TDQ can be used to detect dietary patterns that impair health.

5.4.2.1.3 Validating the calculation of dietary risk scores using the scoring criterion

For this thesis, dietary risk scores were calculated in SPSS based on questionnaire responses. Yet, as calculation of dietary risk scores in the clinical-setting involves the application of a scoring criterion to dietary data, knowledge and skills are required. Accuracy of dietary risk score calculation by two different health professionals is not yet known. This refers to inter-rater reliability; the agreement between values of a measure determined by more than one individual [142]. The intra-rater reliability of scores, that is, the agreement among multiple repetitions by the same health professional that represents change over time [292], and the time taken for health professionals to calculate dietary risk are also not yet known. Therefore, determining the inter-rater and intra-rater reliability of dietary risk score calculation, and time required to do so, is warranted.

5.4.2.2 Opportunities for modification of the TDQ

5.4.2.2.1 An online version of the TDQ

With increases in the popularity of the internet and the cost advantages of web-administered questionnaires [126], translating the TDQ into an online version would be ideal. It would allow greater accessibility of health professionals to the TDQ and consequently greater screening of toddlers' intakes and education to their families. Online questionnaires are easy for responders to complete and only require initial set-up with minimal on-going responsibilities. The limitations of complex scoring processes can also be addressed with automated scoring. Several questionnaires and indices have been developed for online administration. For example, in Australia, the online Healthy Eating Quiz for adults assesses intake and generates an overall healthy eating score, including personalised feedback, based on compliance with the Australian Dietary Guidelines [293]. Given the FFQ-style nature of the TDQ, translation into an online version is feasible. A suggestion would be to include food pictures that depict commonly consumed portion sizes to assist in portion size estimation and thus reduce associated error. Further, after completion of the questionnaire and calculation of a dietary risk score, feedback and guidance could be provided to assist parents in their efforts to improve their child's score. Nonetheless, it will be important to examine how an online version of the TDQ compares with the hard-copy version in terms of reliability and validity.

5.4.2.2.2 Inclusion of other key foods in toddlers' diets

As discussed in section 1.3.2, the goal of the TDQ was to ensure it was a short tool. An unavoidable consequence of short dietary assessment tools is that not all aspects of diet can be assessed. Thus, necessary decisions must be made regarding what items to, and not to, include. As items included in the TDQ were primarily based on

PCA derived dietary patterns, this limited inclusion of some food groups relevant to toddlers' diets. For example, consumption of pre-sweetened versus non pre-sweetened breakfast cereals or the quantity of milk consumed (rather than simply the milk type) may be important aspects to assess in this age group. If the later was included in the TDQ, calcium, amongst other nutrients, may have subsequently been associated with the risk scores. Yet, as items included in the TDQ are those that distinguish between different diets, those foods commonly consumed by children (for example, any milk) are not quantified. Additionally, calcium is infrequently an issue in toddlers [59], unlike in older populations [59, 294]. Of greatest concern in this age group is over-consumption of milk, which can displace intake of other nutritious foods and lead to iron deficiency [58, 60, 61]. Future modification of the TDQ could incorporate an item to assess this, in addition to other items such as type of breakfast cereal consumed, in attempt to capture the range of food items that are indicative of dietary risk.

5.4.2.2.3 A shorter version of the TDQ

As this thesis was developed based on the premise that short dietary assessment tools are more advantageous than traditional methods such as recalls and records and longer questionnaire-style tools, it is not unreasonable to ask whether a measure of toddlers dietary risk could be established using a shorter (<19 items) tool. That is, could a 5- or 10-item TDQ accurately assess toddlers' dietary risk compared with that of the 19-item TDQ. A shorter TDQ that is both reliable and valid would be less burdensome on respondents and could therefore potentially result in greater screening of toddlers' intakes to identify those at-risk requiring intervention. A shorter version of the TDQ could be designed to focus on particular aspects of dietary risk, for example, iron deficiency or failure to thrive, informed by the practice context.

5.4.2.2.4 Developing an Infant Dietary Questionnaire and/or Preschooler Dietary Questionnaire

Infants and preschoolers, like toddlers, are vulnerable to poor nutrition, which can have negative life-long health consequences. Dietary patterns of infants (birth – 12 months) change rapidly as they transition from a diet based solely on milk in the first six months of life to one consisting of a complex mixture of complementary foods. The rapid change in diet experienced in the first year of life increases their vulnerability to nutrient deficiencies [114]. Preschoolers, aged 3 - 5 years, are also vulnerable to nutrition-related consequences, as fussy eating behaviours established in toddlerhood may persist into the preschool years [295]. As no short dietary assessment tools exist that assesses whole diets of Australian infants or preschoolers (0), the development of a similar tool to that of the TDQ for use with infants and preschoolers would be ideal.

5.4.2.2.5 Practical aspects of determining foods to include in a dietary assessment tool – considerations for future research

The use of PCA-derived dietary patterns in determining which foods to include in the TDQ is a novel approach. Items loading strongly on extracted patterns were prioritised in terms of importance in toddlers' diets and those of highest priority were included in the tool. However, this approach may not always be practical. If PCA does not yield clear dietary patterns that are distinguishable by the items loading strongly, defined by very few cross-loadings and several foods loading strongly on each pattern, the use of the dietary patterns to inform tool development would be questionable. Thus, future tool development across all age groups should be based on PCA-derived dietary patterns that are clearly distinguishable by the type of foods loading on them. Additionally, it is suggested that items included in future tools are not restricted to those loading strongly on dietary patterns, and that further consideration is given to foods commonly contributing to the target population's food consumption. This would help to ensure that dietary assessment tools capture the range of foods consumed by the relevant population, thus providing a more comprehensive assessment of diet and/or dietary risk.

5.5 Conclusion

In conclusion, the newly developed Toddler Dietary Questionnaire is a short, simple food-group based dietary assessment tool for measuring dietary risk in Australian toddlers aged 12 - 36 months. Results of this thesis suggest that the TDQ provides a reliable and valid measure of Australian toddlers' dietary risk in relatively advantaged samples, allowing monitoring and identification of those requiring intervention. The strengths of this study lie in the robust approach to tool development, being based on evidence-based dietary patterns of Australian toddlers and age-appropriate Australian Dietary Guidelines, and the rigorous tool testing, which included examining the tool's test-retest reliability, relative validity and convergent validity. Further research is required to evaluate the reliability and validity of the TDQ in a more generalisable sample. Investigation of the association between TDQ-derived dietary risk scores and health outcomes other than weight status is also warranted. At present, the TDQ could be a useful tool for health professionals in the clinical setting, enabling screening of relatively advantaged toddlers to identify those at-risk and requiring intervention to improve their dietary patterns, and in the research setting, for the development, implementation and evaluation of relevant interventions.

6 REFERENCES

1. Bell LK, Golley RK & Magarey AM (2013) Short tools to assess young children's dietary intake: a systematic review focusing on application to dietary index research. *J Obes* **709626**, Epublication 26 September 2013.
2. Bell LK, Golley RK, Daniels L *et al.* (2013) Dietary patterns of Australian children aged 14 and 24 months, and associations with socio-demographic factors and adiposity. *Eur J Clin Nutr* **67**, 638-45.
3. Bell LK, Golley RK & Magarey AM (2014) A short food-group based dietary questionnaire is reliable and valid for assessing toddlers' dietary risk in relatively advantaged samples. *Br J Nutr* **112**, 627-37.
4. Bell LK, Golley RK & Magarey AM (2015) Dietary risk scores of toddlers are associated with nutrient intakes and socio-demographic factors, but not weight status. *Nutr Diet*, accepted 8th March 2015.
5. World Health Organization (2000) Nutrition for Health and Development; A global agenda for combating malnutrition. Geneva: WHO.
6. World Health Organization (2003) *Diet, nutrition and the prevention of chronic diseases: report of a joint WHO/FAO expert consultation. WHO Technical Report Series 916*. Geneva: WHO.
7. Wu TC & Chen PH (2009) Health consequences of nutrition in childhood and early infancy. *Pediatr Neonatol* **50**, 135-142.
8. National Health and Medical Research Council (2003) Dietary Guidelines for Children and Adolescents in Australia Incorporating the Infant Feeding Guidelines for Health Workers. Canberra: Commonwealth of Australia.
9. de Onis M, Onyango AW, Borghi E *et al.* (2006) Comparison of the World Health Organization (WHO) Child Growth Standards and the National Center for Health Statistics/WHO international growth reference: implications for child health programmes. *Public Health Nutr* **9**, 942-7.
10. Gale CR, Martyn CN, Marriott LD *et al.* (2009) Dietary patterns in infancy and cognitive and neuropsychological function in childhood. *J Child Psychol Psychiatry* **50**, 816-23.
11. Gökçay G (2010) Breastfeeding and child cognitive development. *Child Care Health Dev* **36**, 591.
12. Kramer MS, Aboud F, Mironova E *et al.* (2008) Breastfeeding and child cognitive development: new evidence from a large randomized trial. *Arch Gen Psychiatry* **65**, 578-84.
13. Morgan J, Taylor A & Fewtrell M (2004) Meat consumption is positively associated with psychomotor outcome in children up to 24 months of age. *J Pediatr Gastroenterol Nutr* **39**, 493-8.
14. Feinstein L, Sabates R, Sorhaindo A *et al.* (2008) Dietary patterns related to attainment in school: the importance of early eating patterns. *J Epidemiol Community Health* **62**, 734-9.
15. Wiles NJ, Northstone K, Emmett P *et al.* (2009) 'Junk food' diet and childhood behavioural problems: results from the ALSPAC cohort. *Eur J Clin Nutr* **63**, 491-8.
16. Robinson SM, Marriott LD, Crozier SR *et al.* (2009) Variations in infant feeding practice are associated with body composition in childhood: a prospective cohort study. *J Clin Endocrinol Metab* **94**, 2799-8050.

17. Friedman LS, Lukyanova EM, Serdiuk A *et al.* (2009) Social-environmental factors associated with elevated body mass index in a Ukrainian cohort of children. *Int J Pediatr Obes* **4**, 81-90.
18. Shin KO, Oh SY & Park HS (2007) Empirically derived major dietary patterns and their associations with overweight in Korean preschool children. *Br J Nutr* **98**, 416-21.
19. Brazionis L, Golley RK, Mittinty MN *et al.* (2013) Diet spanning infancy and toddlerhood is associated with child blood pressure at age 7.5 y. *Am J Clin Nutr* **97**, 1375-86.
20. Reilly JJ, Methven E, McDowell ZC *et al.* (2003) Health consequences of obesity. *Arch Dis Child* **88**, 748-752.
21. Geleijnse JM, Hofman A, Witteman JC *et al.* (1997) Long-term effects of neonatal sodium restriction on blood pressure. *Hypertension* **29**, 913-7.
22. Pan American Health Organization (PAHO)/World Health Organization (WHO) (2003) Guiding principles for complementary feeding of the breastfed child. Washington DC: PAHO/WHO.
23. Morgan J (2005) Nutrition for toddlers: the foundation for good health--1. Toddlers' nutritional needs: what are they and are they being met? *J Fam Health Care* **15**, 56-9.
24. Hetherington MM, Cecil JE, Jackson DM *et al.* (2011) Feeding infants and young children. From guidelines to practice. *Appetite* **57**, 791-5.
25. Carruth BR & Skinner JD (2002) Feeding behaviors and other motor development in healthy children (2-24 months). *J Am Coll Nutr* **21**, 88-96.
26. Carruth BR, Ziegler PJ, Gordon A *et al.* (2004) Developmental milestones and self-feeding behaviors in infants and toddlers. *J Am Diet Assoc* **104**, S51-6.
27. Birch LL (1998) Development of food acceptance patterns in the first years of life. *Proc Nutr Soc* **57**, 617-624.
28. Birch LL (1999) Development of food preferences. *Annu Rev Nutr* **19**, 41-62.
29. Drewnowski A (1997) Taste preferences and food intake. *Annu Rev Nutr* **17**, 237-53.
30. Schwartz C, Scholtens PA, Lalanne A *et al.* (2011) Development of healthy eating habits early in life. Review of recent evidence and selected guidelines. *Appetite* **57**, 796-807.
31. Wardle J & Cooke L (2008) Genetic and environmental determinants of children's food preferences. *Br J Nutr* **99**, S15-21.
32. Scaglioni S, Arrizza C, Vecchi F *et al.* (2011) Determinants of children's eating behavior. *Am J Clin Nutr* **94**, S2006-2011.
33. Birch LL (1979) Dimensions of preschool children’s food preferences. *J Nutr Educ Behav* **11**, 77-80.
34. Cooke L (2007) The importance of exposure for healthy eating in childhood: a review. *J Hum Nutr Diet* **20**, 294-301.
35. Skinner JD, Carruth BR, Wendy B *et al.* (2002) Children's food preferences: a longitudinal analysis. *J Am Diet Assoc* **102**, 1638-47.
36. Lioret S, McNaughton SA, Spence AC *et al.* (2013) Tracking of dietary intakes in early childhood: the Melbourne InFANT Program. *Eur J Clin Nutr* **67**, 275-81.
37. Mikkilä V, Räsänen L, Raitakari OT *et al.* (2005) Consistent dietary patterns identified from childhood to adulthood: the cardiovascular risk in Young Finns Study. *Br J Nutr* **93**, 923-31.
38. Cowbrough K (2010) Feeding the toddler: 12 months to 3 years--challenges and opportunities. *J Fam Health Care* **20**, 49-52.

39. Morgan J (2005) Nutrition for toddlers: the foundation for good health--2. Current problems and ways to overcome them. *J Fam Health Care* **15**, 85-8.
40. Wright CM, Parkinson KN, Shipton D *et al.* (2007) How do toddler eating problems relate to their eating behavior, food preferences, and growth? *Pediatrics* **120**, e1069-75.
41. Needlman RD (2000) *Growth and development*. 16th ed. Philadelphia: WB Saunders.
42. Leung AK & Robson WL (1994) The toddler who does not eat. *Am Fam Physician* **49**, 1789-92, 1799-800.
43. Schwartz S & Benuck I (2013) Strategies and suggestions for a healthy toddler diet. *Pediatr Ann* **42**, 181-3.
44. Birch LL, Savage JS & Ventura A (2007) Influences on the development of children's eating behaviours: from infancy to adolescence. *Can J Diet Pract Res* **68**, S1-56.
45. Cathey M & Gaylord N (2004) Picky eating: a toddler's continuing approach to mealtime. *Pediatr Nurs* **30**, 101-7.
46. Dovey TM, Staples PA & Gibson EL (2008) Food neophobia and 'picky/fussy' eating in children: a review. *Appetite* **50**, 181-93.
47. Howard AJ, Mallan KM, Byrne R *et al.* (2012) Toddlers' food preferences. The impact of novel food exposure, maternal preferences and food neophobia. *Appetite* **59**, 818-825.
48. Sullivan SA & Birch LL (1994) Infant dietary experience and acceptance of solid foods. *Pediatrics* **93**, 271-7.
49. Maier A, Chabanet C, Schaal B *et al.* (2007) Effects of repeated exposure on acceptance of initially disliked vegetables in 7-month old infants. *Food Qual Pref* **18**, 1023-1032.
50. Birch LL & Marlin DW (1982) I don't like it; I never tried it: effects of exposure on two-year-old children's food preferences. *Appetite* **3**, 353-60.
51. Carruth BR, Ziegler PJ, Gordon A *et al.* (2004) Prevalence of picky eaters among infants and toddlers and their caregivers' decisions about offering a new food. *J Am Diet Assoc* **104**, S57-64.
52. Chan L, Magarey AM & Daniels LA (2011) Maternal feeding practices and feeding behaviors of Australian children aged 12-36 months. *Matern Child Health* **15**, 1363-71.
53. Leung AK, Marchand V, Sauve RS *et al.* (2012) The 'picky eater': The toddler or preschooler who does not eat. *Paediatr Child Health* **17**, 455-60.
54. Satter E (1995) Feeding dynamics: helping children to eat well. *J Pediatr Health Care* **9**, 178-84.
55. Carruth BR, Skinner J, Houck K *et al.* (1998) The phenomenon of "picky eater": a behavioral marker in eating patterns of toddlers. *J Am Coll Nutr* **17**, 180-6.
56. Gregory JE, Paxton SJ & Brozovic AM (2010) Maternal feeding practices, child eating behaviour and body mass index in preschool-aged children: a prospective analysis. *Int J Behav Nutr Phys Act* **7**, 55.
57. Hoddinott P, Tappin D & Wright C (2008) Breast feeding. *BMJ* **336**, 881-7.
58. Thane CW, Walmsley CM, Bates CJ *et al.* (2000) Risk factors for poor iron status in British toddlers: further analysis of data from the National Diet and Nutrition Survey of children aged 1.5-4.5 years. *Public Health Nutr* **3**, 433-40.
59. Department of Health and Ageing (2008) 2007 Australian National Children's Nutrition and Physical Activity Survey: Main Findings. Canberra: Commonwealth of Australia.

60. Nguyen ND, Allen JR, Peat JK *et al.* (2004) Iron status of young Vietnamese children in Australia. *J Paediatr Child Health* **40**, 424-9.
61. Ziegler EE (2011) Consumption of cow's milk as a cause of iron deficiency in infants and toddlers. *Nutr Rev* **69** S37-42.
62. National Health and Medical Research Council (2013) Australian Dietary Guidelines. Canberra: Commonwealth of Australia.
63. Baird DL, Syrette J, Hendrie GA *et al.* (2012) Dairy food intake of Australian children and adolescents 2-16 years of age: 2007 Australian National Children's Nutrition and Physical Activity Survey. *Public Health Nutr* **15**, 2060-73.
64. National Health and Medical Research Council (2013) Educator Guide. Canberra: Commonwealth of Australia.
65. Oti-Boateng P, Seshadri R, Petrick S *et al.* (1998) Iron status and dietary iron intake of 6-24-month-old children in Adelaide. *J Paediatr Child Health* **34**, 250-3.
66. Pasricha SR, Flecknoe-Brown SC, Allen KJ *et al.* (2010) Diagnosis and management of iron deficiency anaemia: a clinical update. *Med J Aust* **193**, 525-32.
67. National Health and Medical Research Council, Australian Government Department Health and Ageing & New Zealand Ministry of Health (2006) Nutrient reference values for Australia and New Zealand including recommended dietary intakes. Canberra: Commonwealth of Australia.
68. Black MM (2003) Micronutrient deficiencies and cognitive functioning. *J Nutr* **133**, S3927-3931.
69. Lozoff B, Brittenham GM, Wolf AW *et al.* (1987) Iron deficiency anemia and iron therapy effects on infant developmental test performance. *Pediatrics* **79**, 981-95.
70. Eden AN & Mir MA (1997) Iron deficiency in 1- to 3-year-old children. A pediatric failure? *Arch Pediatr Adolesc Med* **151**, 986-8.
71. World Health Organization (2000) *Obesity: preventing and managing the global epidemic. Report of a WHO consultation. WHO Technical Report Series* no. 894. Geneva: WHO.
72. Popkin BM (2001) The nutrition transition and obesity in the developing world. *J Nutr* **131**, S871-873.
73. Australian Bureau of Statistics (2012) *Australian Health Survey: Physical Activity, 2011-12* Canberra: ABS.
74. World Health Organization (2011) Obesity and overweight. http://www.thehealthwell.info/node/82914 (accessed September 2012)
75. Karnik S & Kanekar A (2012) Childhood obesity: a global public health crisis. *Int J Prev Med* **3**, 1-7.
76. Olds TS, Tomkinson GR, Ferrar KE *et al.* (2010) Trends in the prevalence of childhood overweight and obesity in Australia between 1985 and 2008. *Int J Obes* **34**, 57-66.
77. Peneau S, Salanave B, Maillard-Teyssier L *et al.* (2009) Prevalence of overweight in 6- to 15-year-old children in central/western France from 1996 to 2006: trends toward stabilization. *Int J Obes* **33**, 401-7.
78. Ogden CL, Carroll MD & Flegal KM (2008) High body mass index for age among US children and adolescents, 2003-2006. *JAMA* **299**, 2401-5.
79. Sjöberg A, Lissner L, Albertsson-Wikland K *et al.* (2008) Recent anthropometric trends among Swedish school children: evidence for decreasing prevalence of overweight in girls. *Acta Paediatrica* **97**, 118-23.
80. Ministry of Health (2008) A Portrait of Health - Key Results of the 2006/07 New Zealand Health Survey. Wellington: Ministry of Health.

81. Ogden CL, Carroll MD, Kit BK *et al.* (2012) Prevalence of obesity and trends in body mass index among US children and adolescents, 1999-2010. *J Am Diet Assoc* **307**, 483-90.
82. National Health and Medical Research Council (2013) Clinical practice guidelines for the management of overweight and obesity in adults, adolescents and children. Melbourne: NHMRC.
83. Gatineau M & Dent M (2011) *Obesity and Mental Health*. Oxford: National Obesity Observatory.
84. Reilly JJ & Kelly J (2011) Long-term impact of overweight and obesity in childhood and adolescence on morbidity and premature mortality in adulthood: systematic review. *Int J Obes* **35**, 891-8.
85. Dietz WH (1998) Health consequences of obesity in youth: childhood predictors of adult disease. *Pediatrics* **101**, 518-25.
86. Craigie AM, Lake AA, Kelly SA *et al.* (2011) Tracking of obesity-related behaviours from childhood to adulthood: a systematic review. *Maturitas* **70**, 266-284.
87. Singh AS, Mulder C, Twisk JW *et al.* (2008) Tracking of childhood overweight into adulthood: a systematic review of the literature. *Obes Rev* **9**, 474-88.
88. Bayer O, Kruger H, von Kries R *et al.* (2011) Factors associated with tracking of BMI: a meta-regression analysis on BMI tracking. *Obesity (Silver Spring)* **19**, 1069-76.
89. Kelsey MM, Zaepfel A, Bjornstad P *et al.* (2014) Age-related consequences of childhood obesity. *Gerontology* **60**, 222-8.
90. Australian Institute of Health and Welfare (2010) *Australia's Health 2010*. *Australia's health series* no. 12. Canberra: AIHW.
91. Baker JL, Olsen LW & Sorensen TI (2007) Childhood body-mass index and the risk of coronary heart disease in adulthood. *N Engl J Med* **357**, 2329-37.
92. Kitahara CM, Gamborg M, Berrington de Gonzalez A *et al.* (2014) Childhood height and body mass index were associated with risk of adult thyroid cancer in a large cohort study. *Cancer Res* **74**, 235-42.
93. Barker DJ, Osmond C, Forsen TJ *et al.* (2005) Trajectories of growth among children who have coronary events as adults. *N Engl J Med* **353**, 1802-9.
94. Kellet L, Smith A & Schmerlaib Y (1998) Australian Guide to Healthy Eating (AGHE). Canberra: Commonwealth Department of Health and Family Services.
95. National Health and Medical Research Council (2013) Australian Guide to Healthy Eating (AGHE). Canberra: Commonwealth of Australia.
96. National Health and Medical Research Council (2013) Healthy Eating for Children. Canberra: Department of Health and Ageing.
97. United States Department of Agriculture & United States Department of Health and Human Services (2010) Dietary Guidelines for Americans, 2010. Washington DC: US Government.
98. Pac S, McMahon K, Ripple M *et al.* (2004) Development of the Start Healthy Feeding Guidelines for Infants and Toddlers. *J Am Diet Assoc* **104**, 455-67.
99. Butte N, Cobb K, Dwyer J *et al.* (2004) The Start Healthy Feeding Guidelines for Infants and Toddlers. *J Am Diet Assoc* **104**, 442-54.
100. Public Health England (2014) The eatwell plate: how to use it in promotional material. www.gov.uk/government/publications/the-eatwell-plate-how-to-use-it-in-promotional-material (accessed May 2014)
101. Food Standards Agency (2001) The Balance of Good Health: Information for educators and communicators. Middlesex: Department of Health.

102. Public Health England (2013) Your guide to the eatwell plate: helping you eat a healthier diet. www.gov.uk/government/uploads/system/uploads/attachment_data/file/237282/Eatwell_plate_booklet.pdf (accessed May 2014)
103. Koh GA, Scott JA, Oddy WH *et al.* (2010) Exposure to non-core foods and beverages in the first year of life: results from a cohort study. *Aus J Nutr Diet* **67**, 137-142.
104. Webb KL, Lahti-Koski M, Rutishauser I *et al.* (2006) Consumption of 'extra' foods (energy-dense, nutrient-poor) among children aged 16-24 months from western Sydney, Australia. *Public Health Nutr* **9**, 1035-44.
105. Rangan AM, Randall D, Hector DJ *et al.* (2008) Consumption of 'extra' foods by Australian children: types, quantities and contribution to energy and nutrient intakes. *Eur J Clin Nutr* **62**, 356-64.
106. Bell AC, Kremer PJ, Magarey AM *et al.* (2005) Contribution of 'noncore' foods and beverages to the energy intake and weight status of Australian children. *Eur J Clin Nutr* **59**, 639-45.
107. Siega-Riz AM, Kinlaw A, Deming DM *et al.* (2011) New findings from the Feeding Infants and Toddlers Study 2008. *Nestle Nutr Workshop Ser Pediatr Program* **68**, 83-100.
108. Fox MK, Pac S, Devaney B *et al.* (2004) Feeding infants and toddlers study: What foods are infants and toddlers eating? *J Am Diet Assoc* **104**, S22-30.
109. Siega-Riz AM, Deming DM, Reidy KC *et al.* (2010) Food consumption patterns of infants and toddlers: where are we now? *J Am Diet Assoc* **110**, S38 - 51.
110. Fox MK, Reidy K, Novak T *et al.* (2006) Sources of energy and nutrients in the diets of infants and toddlers. *J Am Diet Assoc* **106**, S28-42.
111. Bates B, Lennox A & Swan G (2010) National Diet and Nutrition Survey: Headline results from Year 1 of the Rolling Programme (2008/2009). http://multimedia.food.gov.uk/multimedia/pdfs/publication/ndnsreport0809.pdf (accessed March 2014)
112. Skinner JD, Carruth BR, Bounds W *et al.* (2002) Do food-related experiences in the first 2 years of life predict dietary variety in school-aged children? *J Nutr Educ Behav* **34**, 310-5.
113. Owen CG, Martin RM, Whincup PH *et al.* (2005) Effect of infant feeding on the risk of obesity across the life course: a quantitative review of published evidence. *Pediatrics* **115**, 1367-77.
114. Briefel RR, Reidy K, Karwe V *et al.* (2004) Toddlers' transition to table foods: Impact on nutrient intakes and food patterns. *J Am Diet Assoc* **104**, S38-44.
115. Stallings VA, Baranowski T, Briefel RR *et al.* (2002) Dietary Risk Assessment in the WIC Program. Washington, DC: Institute of Medicine - Food and Nutrition Board.
116. Hu FB (2002) Dietary pattern analysis: a new direction in nutritional epidemiology. *Curr Opin Lipidol* **13**, 3-9.
117. Moeller SM, Reedy J, Millen AE *et al.* (2007) Dietary patterns: challenges and opportunities in dietary patterns research an Experimental Biology workshop, April 1, 2006. *J Am Diet Assoc* **107**, 1233-9.
118. Kant AK (2004) Dietary patterns and health outcomes. *J Am Diet Assoc* **104**, 615-35.
119. McNaughton SA (2011) Understanding the eating behaviors of adolescents: application of dietary patterns methodology to behavioral nutrition research. *J Am Diet Assoc* **111**, 226-9.

120. Magarey A, Golley R, Spurrier N *et al.* (2009) Reliability and validity of the Children's Dietary Questionnaire; a new tool to measure children's dietary patterns. *Int J Pediatr Obes* **4**, 257-65.
121. Magarey A, Watson J, Golley RK *et al.* (2010) Assessing dietary intake in children and adolescents: Considerations and recommendations for obesity research. *Int J Pediatr Obes* **6**, 2-11.
122. Nelson M, Black AE, Morris JA *et al.* (1989) Between- and within-subject variation in nutrient intake from infancy to old age: estimating the number of days required to rank dietary intakes with desired precision. *Am J Clin Nutr* **50**, 155-67.
123. Gwynn JD, Flood VM, D'Este CA *et al.* (2010) The reliability and validity of a short FFQ among Australian Aboriginal and Torres Strait Islander and non-Indigenous rural children. *Public Health Nutr* **14**, 388-401.
124. Serdula MK, Alexander MP, Scanlon KS *et al.* (2001) What are preschool children eating? A review of dietary assessment. *Annu Rev Nutr* **21**, 475-98.
125. Collins CE, Watson J & Burrows T (2010) Measuring dietary intake in children and adolescents in the context of overweight and obesity. *Int J Obes* **34**, 1103-15.
126. Thompson FE & Subar AF (2013) Dietary Assessment Methodology. In Nutrition in the Prevention and Treatment of Disease. 3rd ed. pp. 5-46 [Coulston AM, Boushey CJ and Ferruzzi MG, editors]. London: Elsevier Inc.
127. Cade JE, Burley VJ, Warm DL *et al.* (2004) Food-frequency questionnaires: a review of their design, validation and utilisation. *Nutr Res Rev* **17**, 5-22.
128. Cade J, Thompson R, Burley V *et al.* (2002) Development, validation and utilisation of food-frequency questionnaires - a review. *Public Health Nutr* **5**, 567-87.
129. Flood VM, Webb K & Rangan A (2005) Recommendations for short questions to assess food consumption in children for the NSW Health Surveys. Sydney: NSW Centre for Public Health Nutrition.
130. Rutishauser I, Webb K, Abraham B *et al.* (2001) *Evaluation of short dietary questions from the 1995 National Nutrition Survey. National Food and Nutrition Monitoring and Surveillance Project*. Canberra: Commonwealth Department of Health and Aged Care.
131. Huybrechts I, De Backer G, De Bacquer D *et al.* (2009) Relative validity and reproducibility of a food-frequency questionnaire for estimating food intakes among Flemish preschoolers. *Int J Environ Res Public Health* **6**, 382-399.
132. Huybrechts I, Vereecken C, De Bacquer D *et al.* (2010) Reproducibility and validity of a diet quality index for children assessed using a FFQ. *Br J Nutr* **104**, 135-44.
133. Calfas KJ, Zabinski MF & Rupp J (2000) Practical nutrition assessment in primary care settings: a review. *Am J Prev Med* **18**, 289-99.
134. Sinkowitz-Cochran RL (2013) Survey Design: To Ask or Not to Ask? That is the Question... *Clin Infec Dis* **56**, 1159-64.
135. Pietinen P, Hartman AM, Haapa E *et al.* (1988) Reproducibility and validity of dietary assessment instruments. II. A qualitative food frequency questionnaire. *Am J Epidemiol* **128**, 667-76.
136. Pietinen P, Hartman AM, Haapa E *et al.* (1988) Reproducibility and validity of dietary assessment instruments. I. A self-administered food use questionnaire with a portion size picture booklet. *Am J Epidemiol* **128**, 655-66.
137. Willett W (1998) *Nutritional Epidemiology*. 2nd ed. New York: Oxford University Press.

138. Margetts BM & Nelson M (1997) *Design Concepts in Nutritional Epidemiology*. 2nd ed. Oxford: Oxford University Press.
139. Pallant J (2011) *SPSS Survival Manual: A step by step guide to data analysis using SPSS*. 4th ed. Crows Nest: Allen and Unwin.
140. Peat JK (2001) *Health Science Research: A handbook of quantitative methods*. Victoria: Allen & Unwin.
141. Vogt WP (1999) *Dictionary of Statistics & Methodology: A Nontechnical Guide for the Social Sciences*. 2nd ed. Newbury Park, CA: SAGE Publications Inc.
142. Gleason PM, Harris J, Sheean PM *et al.* (2010) Publishing nutrition research: validity, reliability, and diagnostic test assessment in nutrition-related research. *J Am Diet Assoc* **110**, 409-19.
143. Streiner DL & Norman RG (2003) *Health measurement scales: a practical guide to their development and use.* 3rd ed. New York: Oxford University Press.
144. Marshall S, Burrows T & Collins CE (2014) Systematic review of diet quality indices and their associations with health-related outcomes in children and adolescents. *J Hum Nutr Diet*, (Epublication ahead of print version).
145. Bland JM & Altman DG (1995) Comparing methods of measurement: why plotting difference against standard method is misleading. *Lancet* **21**, 8982.
146. Bland JM & Altman DG (1999) Measuring agreement in method comparison studies. *Stat Methods Med Res* **8**, 135-60.
147. Masson LF, McNeill G, Tomany JO *et al.* (2003) Statistical approaches for assessing the relative validity of a food-frequency questionnaire: use of correlation coefficients and the kappa statistic. *Public Health Nutr* **6**, 313-21.
148. Sim J & Wright CC (2005) The kappa statistic in reliability studies: use, interpretation, and sample size requirements. *Phys Ther* **85**, 257-68.
149. Brenner H & Kliebsch U (1996) Dependence of weighted kappa coefficients on the number of categories. *Epidemiology* **7**, 199-202.
150. Bland JM & Altman DG (1986) Statistical methods for assessing agreement between two methods of clinical measurement. *Lancet* **1**, 307-10.
151. Maclure M & Willet WC (1987) Misinterpretation and misuse of kappa statistics. *Am J Epidemiol* **126**, 161-69.
152. Wilson AM, Magarey AM & Mastersson N (2008) Reliability and relative validity of a child nutrition questionnaire to simultaneously assess dietary patterns associated with positive energy balance and food behaviours, attitudes, knowledge and environments associated with healthy eating. *Int J Behav Nutr Phys Act* **5**, 5.
153. Altman DG (1991) *Practical statistics for medical research*. 1st ed. London: Chapman and Hall/CRC.
154. Newby PK & Tucker KL (2004) Empirically derived eating patterns using factor or cluster analysis: a review. *Nutr Rev* **62**, 177-203.
155. National Health and Medical Research Council (2003) Clinical practice guidelines for the management of overweight and obesity in children and adolescents. Canberra: Commonwealth of Australia.
156. Smithers LG, Golley RK, Brazionis L *et al.* (2011) Characterizing whole diets of young children from developed countries and the association between diet and health: a systematic review. *Nutr Rev* **69**, 449-467.
157. Burrows T, Golley RK, Khambalia A *et al.* (2012) The quality of dietary intake methodology and reporting in child and adolescent obesity intervention trials: a systematic review. *Obes Rev* **13**, 1125-1138.
158. Lartey A, Manu A, Brown KH *et al.* (2000) Predictors of growth from 1 to 18 months among breast-fed Ghanaian infants. *Eur J Clin Nutr* **54**, 41-49.

159. Marriott LD, Robinson SM, Poole J *et al.* (2008) What do babies eat? Evaluation of a food frequency questionnaire to assess the diets of infants aged 6 months. *Public Health Nutr* **11**, 751-6.
160. Ystrom E, Niegel S & Vollrath ME (2009) The impact of maternal negative affectivity on dietary patterns of 18-month-old children in the Norwegian Mother and Child Cohort Study. *Matern Child Health* **5**, 234-242.
161. Andersen LF, Lande B, Trygg K *et al.* (2004) Validation of a semi-quantitative food-frequency questionnaire used among 2-year-old Norwegian children. *Public Health Nutr* **7**, 757-764.
162. Smithers LG, Brazionis L, Golley RK *et al.* (2012) Associations between dietary patterns at 6 and 15 months of age and sociodemographic factors. *Eur J Clin Nutr* **66**, 658-66.
163. Dee DL, Sharma AJ, Cogswell ME *et al.* (2008) Sources of supplemental iron among breastfed infants during the first year of life. *Pediatrics* **122**, S98-104.
164. Andersen LF, B L, Arsky GH *et al.* (2003) Validation of a semi-quantitative food-frequency questionnaire used among 12-month-old Norwegian infants. *Eur J Clin Nutr* **57**, 881-888.
165. Pabayo R, Spence JC, Casey L *et al.* (2012) Food consumption patterns in preschool children. *Can J Diet Pract Res* **73**, 66-71.
166. Lanfer A, Hebestreit A, Ahrens W *et al.* (2011) Reproducibility of food consumption frequencies derived from the Children's Eating Habits Questionnaire used in the IDEFICS study. *Int J Obes* **35** S61-8.
167. Ebenegger V, Marques-Vidal P, Barral J *et al.* (2010) Eating habits of preschool children with high migrant status in Switzerland according to a new food frequency questionnaire. *Nutr Res* **30**, 104-109.
168. Kleiser C, Mensink GBM, Scheidt-Nave C *et al.* (2009) HuSKY: A healthy nutrition score based on food intake of children and adolescents in Germany. *Br J Nutr* **102**, 610-618.
169. Randall Simpson JA, Keller HH, Rysdale LA *et al.* (2008) Nutrition Screening Tool for Every Preschooler (NutriSTEP): validation and test-retest reliability of a parent-administered questionnaire assessing nutrition risk of preschoolers. *Eur J Clin Nutr* **62**, 770-80.
170. Romaguera D, Samman N, Rossi A *et al.* (2008) Dietary patterns of the Andean population of Puna and Quebrada of Humahuaca, Jujuy, Argentina. *Br J Nutr* **99**, 390-397.
171. Huybrechts I, De Bacquer D, Matthys C *et al.* (2006) Validity and reproducibility of a semi-quantitative food-frequency questionnaire for estimating calcium intake in Belgian preschool children. *Br J Nutr* **95**, 802-16.
172. Sullivan J, Ndekha M, Maker D *et al.* (2006) The quality of the diet in Malawian children with kwashiorkor and marasmus. *Matern Child Health* **2**, 114-122.
173. Cox DR, Skinner JD, Carruth BR *et al.* (1997) Food variety index for toddlers (VIT): development and application. *J Am Diet Assoc* **97**, 1382-1386.
174. Crombie IK, Kiezebrink K, Irvine L *et al.* (2009) What maternal factors influence the diet of 2-year-old children living in deprived areas? A cross-sectional survey. *Public Health Nutr* **12**, 1254-60.
175. Kranz S, Mitchell DC, Smiciklas-Wright H *et al.* (2009) Consumption of recommended food groups among children from medically underserved communities. *J Am Diet Assoc* **109**, 702-7.

176. Caliendo MA, Sanjur D, Wright J *et al.* (1977) Nutritional status of preschool children. *J Am Diet Assoc* **71**, 20-26.
177. Dewey KG, Onyango AW & Garza C (2006) Complementary feeding in the WHO Multicentre Growth Reference Study. *Acta Paediatrica* **95**, 27-37.
178. Fungwe T, Guenther PM, Juan WY *et al.* (2009) The quality of children's diets in 2003–2004 as measured by the Healthy Eating Index - 2005. *Nutr Insight* **43**, 1-2.
179. Kranz S, Findeis JL & Shrestha SS (2008) Use of the Revised Children's Diet Quality Index to assess preschooler's diet quality, its sociodemographic predictors, and its association with body weight status. *J Pediatr* **84**, 26-34.
180. Kranz S, Hartman T, Siega-Riz AM *et al.* (2006) A diet quality index for American preschoolers based on current dietary intake recommendations and an indicator of energy balance. *J Am Diet Assoc* **106**, 1594-604.
181. Krebs-Smith SM & Clark LD (1989) Validation of a nutrient adequacy score for use with women and children *J Am Diet Assoc* **89**, 775-783.
182. Glanville NT & McIntyre L (2006) Diet quality of Atlantic families headed by single mothers. *Can J Diet Pract Res* **67**, 28-35.
183. Hoerr SL, HorodynskI MA, Lee SY *et al.* (2006) Predictors of nutritional adequacy in mother-toddler dyads from rural families with limited incomes. *J Am Diet Assoc* **106**, 1766-1773.
184. Kranz S, Siega-Riz AM & Herring AH (2004) Changes in diet quality of American preschoolers between 1977 and 1998. *Am J Public Health* **94**, 1525-1530.
185. Libuda L, Alexy U, Buyken AE *et al.* (2009) Consumption of sugar-sweetened beverages and its association with nutrient intakes and diet quality in German children and adolescents. *Br J Nutr* **101**, 1549-1557.
186. Campbell ML & Sanjur D (1992) Single employed mothers and preschool-child nutrition: an ecological analysis. *J Nutr Educ Behav* **24**, 67-74.
187. Manios Y, Kourlaba G, Kondaki K *et al.* (2009) Diet quality of preschoolers in Greece based on the Healthy Eating Index: the GENESIS study. *J Am Diet Assoc* **109**, 616-23.
188. Steyn NP, Nel JH, Nantel G *et al.* (2006) Food variety and dietary diversity scores in children: are they good indicators of dietary adequacy? *Public Health Nutr* **9**, 644-50.
189. Ruel MT & Menon P (2002) Child feeding practices are associated with child nutritional status in Latin America: innovative uses of the demographic and health surveys. *J Nutr* **132**, 1180-7.
190. Parrish LA, Marshall JA, Krebs NF *et al.* (2003) Validation of a food frequency questionnaire in preschool children. *Epidemiology* **14**, 213-7.
191. Waijers PM, Feskens EJ & Ocke MC (2007) A critical review of predefined diet quality scores. *Br J Nutr* **97**, 219-31.
192. Bennett CA, de Silva-Sanigorski AM, Nichols M *et al.* (2009) Assessing the intake of obesity-related foods and beverages in young children: comparison of a simple population survey with 24 hr-recall. *Int J Behav Nutr Phys Act* **6**, 71.
193. Lazarou C & Newby PK (2011) Use of dietary indexes among children in developed countries. *Adv Nutr* **2**, 295-303.
194. Wirt A & Collins CE (2009) Diet quality--what is it and does it matter? *Public Health Nutr* **12**, 2473-92.
195. Venkaiah K, Brahmam GNV & Vijayaraghavan K (2011) Application of factor analysis to identify dietary patterns and use of factor scores to study their relationship with nutritional status of adult rural populations. *Health Popul Nutr* **29**, 327-338.

196. Craig LC, McNeill G, Macdiarmid JI *et al.* (2010) Dietary patterns of school-age children in Scotland: association with socio-economic indicators, physical activity and obesity. *BrJ Nutr* **103**, 319-34.
197. Togo P, Osler M, Sørensen TI *et al.* (2001) Food intake patterns and body mass index in observational studies. *Int J Obes Relat Metab Disord* **25**, 1741-51.
198. North K & Emmett P (2000) Multivariate analysis of diet among three-year-old children and associations with socio-demographic characteristics. The Avon Longitudinal Study of Pregnancy and Childhood (ALSPAC) Study Team. *Eur J Clin Nutr* **54**, 73-80.
199. Robinson S, Marriott L, Poole J *et al.* (2007) Dietary patterns in infancy: the importance of maternal and family influences on feeding practice. *Br J Nutr* **98**, 1029-37.
200. Smithers LG, Golley RK, Mittinty MN *et al.* (2012) Dietary patterns at 6, 15 and 24 months of age are associated with IQ at 8 years of age. *Eur J Epidemiol* **27**, 525-35.
201. Northstone K & Emmett P (2013) The associations between feeding difficulties and behaviours and dietary patterns at 2 years of age: the ALSPAC cohort. *Matern Child Health* **9**, 533-42.
202. Kristiansen AL, Lande B, Sexton JA *et al.* (2012) Dietary patterns among Norwegian 2-year-olds in 1999 and in 2007 and associations with child and parent characteristics. *Br J Nutr* **110**, 135-44.
203. Spence AC, McNaughton SA, Lioret S *et al.* (2013) A health promotion intervention can affect diet quality in early childhood. *J Nutr* **143**, 1672-8.
204. Kiefte-de Jong JC, de Vries JH, Bleeker SE *et al.* (2013) Socio-demographic and lifestyle determinants of 'Western-like' and 'Health conscious' dietary patterns in toddlers. *Br J Nutr* **109**, 137-47.
205. Kant AK (2010) Dietary patterns: biomarkers and chronic disease risk. *Appl Physiol Nutr Metab* **35**, 199-206.
206. Hu FB, Rimm E, Smith-Warner SA *et al.* (1999) Reproducibility and validity of dietary patterns assessed with a food-frequency questionnaire. *Am J Clin Nutr* **69**, 243-9.
207. Millen BE, Quatromoni PA, Copenhafer DL *et al.* (2001) Validation of a dietary pattern approach for evaluating nutritional risk: the Framingham Nutrition Studies. *J Am Diet Assoc* **101**, 187-94.
208. Smithers LG, Golley RK, Brazionis L *et al.* (2012) Dietary patterns of infants and toddlers are associated with nutrient intakes. *Nutrients* **4**, 935-948.
209. Cribb V, Emmett P & Northstone K (2013) Dietary patterns throughout childhood and associations with nutrient intakes. *Public Health Nutr* **16**, 1801-9.
210. Baird J, Poole J, Robinson S *et al.* (2008) Milk feeding and dietary patterns predict weight and fat gains in infancy. *Paediatr Perinat Epidemiol* **22**, 575-86.
211. Harvey NC, Robinson SM, Crozier SR *et al.* (2009) Breast-feeding and adherence to infant feeding guidelines do not influence bone mass at age 4 years. *Br J Nutr* **102**, 915-20.
212. Kiefte-de Jong JC, de Vries JH, Escher JC *et al.* (2013) Role of dietary patterns, sedentary behaviour and overweight on the longitudinal development of childhood constipation: the Generation R study. *Matern Child Health* **9**, 511-23.
213. Emmett P, North K, Noble S *et al.* (2000) Types of drinks consumed by infants at 4 to 8 months of age: a descriptive study. *Public Health Nutr* **3**, 211-217.
214. Devine CM (2005) A life course perspective: understanding food choices in time, social location, and history. *J Nutr Educ Behav* **37**, 121-8.

215. Daniels LA, Magarey A, Battistutta D *et al.* (2009) The NOURISH randomised control trial: positive feeding practices and food preferences in early childhood - a primary prevention program for childhood obesity. *BMC Public Health* **14**, 387.
216. Byrne RM, Magarey AM & Daniels LA (2014) Food and beverage intake in Australian children aged 12-16 months, participating in the NOURISH and SAIDI studies *Aust N Z J Public Health* **38**, 326-31.
217. Jonnalagadda SS, Mitchell DC, Smiciklas-Wright H *et al.* (2000) Accuracy of energy intake data estimated by a multiple-pass, 24-hour dietary recall technique. *J Am Diet Assoc* **100**, 303-311.
218. Noble S & Emmett P (2001) Food and nutrient intake in a cohort of 8-month-old infants in the south-west of England in 1993. *Eur J Clin Nutr* **55**, 698-707.
219. Xyris Software (2012) FoodWorks 7. http://www.xyris.com.au/ (accessed November 2012)
220. Food Standards Australia New Zealand (2008) AUSNUT 2007 – Australian Food Supplement and Nutrient Database for Estimation of Population Nutrient Intakes. Canberra: Department of Health and Ageing.
221. WHO Multicentre Growth Reference Study Group (2006) *WHO Child Growth Standards: Length/height-for-age, weight-for-age, weight-for-length, weight-for-height and body mass index-for-age*. Geneva: World Health Organization.
222. Pink B (2006) An introduction to socio-economic indexes for areas (SEIFA). Canberra: Australian Bureau of Statistics.
223. National Health and Medical Research Council (2011) A modelling system to inform the revision of the Australian Guide to Healthy Eating. Canberra: Commonwealth of Australia.
224. Garson D (2012) *Factor Analysis*. North Carolina: Statistical Associates Publishers.
225. Tabachnick BG & Fidell LS (2007) *Using Multivariate Statistics*. 5th ed. Boston: Allyn and Bacon.
226. Kaiser H (1974) An index of factorial simplicity. *Psychometrica* **39**, 31-36.
227. Bartlett MS (1954) A further note on the multiplying factors for various X2 approximations in factor analysis. *J R Stat Soc* **16**, 296-298.
228. Kim J & Mueller CW (1978) Factor Analysis: Statistical Methods and Practical Issues. *Quantiative Applications in the Social Sciences* [Uslaner EM, editor]. Newbury Park, CA: SAGE publications.
229. Cattell RB (1966) The scree test for the number of factors. *Multivar Behav Res* **1**, 245-276.
230. McCann SE, Marshall JR, Brasure JR *et al.* (2001) Analysis of patterns of food intake in nutritional epidemiology: food classification in principal components analysis and the subsequent impact on estimates for endometrial cancer. *Public Health Nutr* **4**, 989-97.
231. Northstone K & Emmett PM (2008) Are dietary patterns stable throughout early and mid-childhood? A birth cohort study. *Br J Nutr* **100**, 1069-76.
232. Northstone K & Emmett P (2005) Multivariate analysis of diet in children at four and seven years of age and associations with socio-demographic characteristics. *Eur J Clin Nutr* **59**, 751-60.
233. Grieger JA, Scott J & Cobiac L (2011) Dietary patterns and breast-feeding in Australian children. *Public Health Nutr* **14**, 1939-47.
234. Brazionis L, Golley RK, Mittinty MN *et al.* (2012) Characterization of transition diets spanning infancy and toddlerhood: a novel, multiple-time-point application of principal components analysis. *Am J Clin Nutr* **95**, 1200-8.

235. Beauchamp GK & Mennella JA (2009) Early flavor learning and its impact on later feeding behavior. *J Pediatr Gastroenterol Nutr* **48**, S25-30.
236. Schwartz C, Chabanet C, Laval C *et al.* (2012) Breast-feeding duration: influence on taste acceptance over the first year of life. *Br J Nutr* **109**, 1154-61.
237. Mennella JA (2009) Flavour programming during breast-feeding. *Adv Exp Med Biol* **639**.
238. Okubo H, Miyake Y, Sasaki S *et al.* (2012) Dietary patterns in infancy and their associations with maternal socio-economic and lifestyle factors among 758 Japanese mother–child pairs: the Osaka Maternal and Child Health Study. *Matern Child Health* **10**, 213-25.
239. Drewnowski A (2012) The economics of food choice behavior: why poverty and obesity are linked. *Nestle Nutr Inst Workshop Ser* **73**, 95-112.
240. Drewnowski A & Specter SE (2004) Poverty and obesity: the role of energy density and energy costs. *Am J Clin Nutr* **79**, 6-16.
241. Birch LL & Fisher JO (1998) Development of eating behaviours among children and adolescents. *Pediatrics* **101**, 539-49.
242. Ong KK, Ahmed ML, Emmett PM *et al.* (2000) Association between postnatal catch-up growth and obesity in childhood: prospective cohort study. *BMJ* **320**, 967-971.
243. Gardner DSL, Hosking J, Metcalf BS *et al.* (2009) Contribution of early weight gain to childhood overweight and metabolic health: a longitudinal study (EarlyBird 36). *Pediatrics* **123**, e67-73.
244. Barker DJ, Osmond C, Forsén TJ *et al.* (2005) Trajectories of growth among children who have coronary events as adults. *N Engl J Med* **353**, 1802-9.
245. Macdiarmid J & Blundell J (1998) Assessing dietary intake: Who, what and why of under-reporting. *Nutr Res Rev* **11**, 231-53.
246. Dwyer JT, Krall EA & Coleman KA (1987) The problem of memory in nutritional epidemiology research. *J Am Diet Assoc* **87**, 1509-12.
247. Livingstone MB, Robson PJ & Wallace JM (2004) Issues in dietary intake assessment of children and adolescents. *Br J Nutr* **92**, S213-22.
248. Leatherdale ST & Laxer RE (2013) Reliability and validity of the weight status and dietary intake measures in the COMPASS questionnaire: are the self-reported measures of body mass index (BMI) and Canada's food guide servings robust? *Int J Behav Nutr Phys Act* **10**, 42.
249. Gibson RS (2005) *Principles of Nutritional Assessment*. 2nd ed. Oxford: Oxford University Press.
250. Manios Y, Kourlaba G, Grammatikaki E *et al.* (2010) Development of a diet-lifestyle quality index for young children and its relation to obesity: the Preschoolers Diet-Lifestyle Index. *Public Health Nutr* **13**, 2000-9.
251. Golley RK, Smithers LG, Mittinty MN *et al.* (2012) An index measuring adherence to complementary feeding guidelines has convergent validity as a measure of infant diet quality. *J Nutr* **142**, 901-8.
252. Kennedy ET, Ohls J, Carlson S *et al.* (1995) The Healthy Eating Index: design and applications. *J Am Diet Assoc* **95**, 1103-8.
253. Dennison BA, Jenkins PL & Rockwell HL (2000) Development and validation of an instrument to assess child dietary fat intake. *Prev Med* **31**, 214-24.
254. Flood VM, Wen LM, Hardy LL *et al.* (2013) Reliability and validity of a short FFQ for assessing the dietary habits of 2-5-year-old children, Sydney, Australia. *Public Health Nutr* **17**, 498-509.

255. Landis JR & Koch GG (1977) The measurement of observer agreement for categorical data. *Biometrics* **33**, 159-74.
256. Turrell G, Bentley R, Thomas LR *et al.* (2009) A multilevel study of area socio-economic status and food purchasing behaviour. *Public Health Nutr* **12**, 2074-83.
257. James WP, Nelson M, Ralph A *et al.* (1997) Socioeconomic determinants of health. The contribution of nutrition to inequalities in health. *BMJ* **314**, 1545-9.
258. Hebert JR, Clemow L, Pbert L *et al.* (1995) Social desirability bias in dietary self-report may compromise the validity of dietary intake measures. *Int J Epidemiol* **24**, 389-98.
259. Roberts C & McNamee R (2005) Assessing the reliability of ordered categorical scales using kappa-type statistics. *Stat Methods Med Res* **14**, 493-514.
260. Scott JA, Chih TY & Oddy WH (2012) Food variety at 2 years of age is related to duration of breastfeeding. *Nutrients* **4**, 1464-74.
261. Knol LL, Haughton B & Fitzhugh EC (2004) Food insufficiency is not related to the overall variety of foods consumed by young children in low-income families. *J Am Diet Assoc* **104**, 640-4.
262. Brennan SF, Cantwell MM, Cardwell CR *et al.* (2010) Dietary patterns and breast cancer risk: a systematic review and meta-analysis. *Am J Clin Nutr* **91**, 1294-302.
263. Kant AK & Graubard BI (2005) A comparison of three dietary pattern indexes for predicting biomarkers of diet and disease. *J Am Coll Nutr* **24**, 294-303.
264. Mikkila V, Rasanen L, Raitakari OT *et al.* (2007) Major dietary patterns and cardiovascular risk factors from childhood to adulthood. The Cardiovascular Risk in Young Finns Study. *Br J Nutr* **98**, 218-25.
265. Cowin I, Emmett P & ALSPAC Study Team (2000) Diet in a group of 18-month old children in South West England, and comparison with the results of a national survey. *J Hum Nutr Diet* **13**, 87-100.
266. Bridges S & Thompson J (2011) Children's BMI overweight and obesity. In Health Survey for England 2010, Chapter 11 pp. 1-21. Leeds: Health and Social Care Information Centre.
267. Pulgaron ER (2013) Childhood obesity: a review of increased risk for physical and psychological comorbidities. *Clin Ther* **35**, A18-32.
268. Whitaker RC, Wright JA, Pepe MS *et al.* (1997) Predicting obesity in young adulthood from childhood and parental obesity. *N Engl J Med* **337**, 869-73.
269. Han J, Lawlor D & Kimm S (2010) Childhood obesity. *Lancet* **375**, 1737.
270. Lobstein T, Baur L, Uauy R *et al.* (2004) Obesity in children and young people: a crisis in public health. *Obes Rev* **5**, 4-104.
271. Smithers LG, Golley RK, Brazionis L *et al.* (2011) Methods for characterizing the diets of children under five and their association with nutrition and health outcomes: A systematic review. *Nutr Rev* **69**, 449-467.
272. Skinner AC, Miles D, Perrin EM *et al.* (2013) Source of parental reports of child height and weight during phone interviews and influence on obesity prevalence estimates among children aged 3-17 years. *Public Health Rep* **128**, 46-53.
273. Huybrechts I, Himes JH, Ottevaere C *et al.* (2011) Validity of parent-reported weight and height of preschool children measured at home or estimated without home measurement: a validation study. *BMC Pediatrics* **7**, 63.
274. Lobstein T, Baur L, Uauy R *et al.* (2004) Obesity in children and young people: a crisis in public health. Appendix 1. *Obes Rev* **5**, 96-97.
275. Stallings VA (1997) Calcium and bone health in children: a review. *Am J Ther* **4**, 259-73.

276. Bell LK, Hendrie GA, Hartley J *et al.* (2015) Impact of a nutrition award scheme on the food and nutrient intakes of 2- to 4-year-olds attending long day care. *Public Health Nutr*, 1-9.
277. Butte NF, Fox MK, Briefel RR *et al.* (2010) Nutrient intakes of US infants, toddlers, and preschoolers meet or exceed dietary reference intakes. *J Am Diet Assoc* **110**, S27-37.
278. Golley RK, Gilly A Hendrie GA & McNaughton SA (2011) Scores on the dietary guideline index for children and adolescents are associated with nutrient intake and socio-economic position but not adiposity. *Aus J Nutr Diet* **141**, 1340-7.
279. Willett WC, Howe GR & Kushi LH (1997) Adjustment for total energy intake in epidemiologic studies. *Am J Clin Nutr* **65**, S1220-1228.
280. Freedman DS, Wang J, Maynard LM *et al.* (2005) Relation of BMI to fat and fat-free mass among children and adolescents. *Int J Obes* **29**, 1-8.
281. Hurley KM, Oberlander SE, Merry BC *et al.* (2009) The healthy eating index and youth healthy eating index are unique, nonredundant measures of diet quality among low-income, African American adolescents. *J Nutr* **139**, 359-64.
282. Lissner L, Heitmann BL & Lindroos AK (1998) Measuring intake in free-living human subjects: a question of bias. *Proc Nutr Soc* **57**, 333-9.
283. Gersovitz M, Madden JP & Smiciklas-Wright H (1978) Validity of the 24-hr. dietary recall and seven-day record for group comparisons. *J Am Diet Assoc* **73**, 48-55.
284. Daniels LA, Wilson JL, Mallan KM *et al.* (2012) Recruiting and engaging new mothers in nutrition research studies: lessons from the Australian NOURISH randomised controlled trial. *Int J Behav Nutr Phys Act* **9**, 129.
285. Daniels LA, Mallan KM, Battistutta D *et al.* (2014) Child eating behavior outcomes of an early feeding intervention to reduce risk indicators for child obesity: The NOURISH RCT. *Obesity (Silver Spring).*
286. Grimes CA, Campbell KJ, Riddell LJ *et al.* (2013) Is socioeconomic status associated with dietary sodium intake in Australian children? A cross-sectional study. *BMJ Open* **3**, e002106. doi:10.1136/bmjopen-2012-002106.
287. Cameron AJ, Ball K, Pearson N *et al.* (2012) Socioeconomic variation in diet and activity-related behaviours of Australian children and adolescents aged 2-16 years. *Pediatr Obes* **7**, 329-42.
288. Spoth R, Goldberg C & Redmond C (1999) Engaging families in longitudinal preventive intervention research: discrete-time survival analysis of socioeconomic and social-emotional risk factors. *J Consult Clin Psychol* **67**, 157-63.
289. Weinberger DA, Tublin SK, Ford ME *et al.* (1990) Preadolescents' social-emotional adjustment and selective attrition in family research. *Child Dev* **61**, 1374-86.
290. Booker CL, Harding S & Benzeval M (2011) A systematic review of the effect of retention methods in population-based cohort studies. *BMC Public Health* **11**, 249.
291. Patel MX, Doku V & Tennakoon L (2003) Challenges in recruitment of research participants. *Adv Psychiatr Treat* **9**, 229-238.
292. Sim J & Wright C (2000) *Research in Health Care: Concepts, Designs and Methods*. Cheltenham, England: Nelson Thornes.
293. Collins C, Watson J & Guest M (2013) Healthy Eating Quiz. http://healthyeatingquiz.com.au/ (accessed June 2014)
294. Nicklas TA, O'Neil CE & Fulgoni VL, 3rd (2009) The role of dairy in meeting the recommendations for shortfall nutrients in the American diet. *J Am Coll Nutr* **28 Suppl 1**, 73S-81S.

295. Mascola AJ, Bryson SW & Agras WS (2010) Picky eating during childhood: a longitudinal study to age 11 years. *Eat Behav* **11**, 253-7.

7 APPENDICES

Appendix 1 - Papers, conference presentations and awards/prizes arising from this thesis

Papers

Bell L, Golley R, Magarey A (2013) Short tools to assess young children's dietary intake: a systematic review focusing on application to dietary index research, *Journal of Obesity,* volume 2013 (2013), Article ID 709626, 17 pages – attached below

Bell L, Golley R, Daniels L, Magarey A (2013) Dietary patterns of Australian children aged 14 and 24 months and associations with socio-demographic factors and adiposity, *European Journal of Clinical Nutrition*, 67(6): 638-45 [IF 2.756: 25/76 Nutrition & Dietetics] – attached below

Bell L, Golley R, Magarey A (2014) A short food-group based dietary questionnaire is reliable and valid for assessing toddlers' dietary risk in relatively advantaged samples, *British Journal of Nutrition,* 112(4): 627-37 [IF 3.302: 18/76 Nutrition & Dietetics] – attached below

Bell L, Golley R, Magarey A (2014) Dietary risk scores of Australian toddlers are associated with nutrient intakes and socio-demographic factors, but not adiposity, *accepted 8th March 2015 Nutrition & Dietetics* [IF 0.659: 69/79 Nutrition & Dietetics]

Short tools to assess young children's dietary intake: a systematic review focusing on application to dietary index research

Hindawi Publishing Corporation
Journal of Obesity
Volume 2013, Article ID 709626, 17 pages
http://dx.doi.org/10.1155/2013/709626

Review Article

Short Tools to Assess Young Children's Dietary Intake: A Systematic Review Focusing on Application to Dietary Index Research

Lucinda K. Bell,[1,2] Rebecca K. Golley,[3] and Anthea A. Magarey[1]

[1] *Department of Nutrition and Dietetics, Flinders University, Bedford Park, SA, 5042, Australia*
[2] *Department of Nutrition and Dietetics, Flinders Clinical and Molecular Medicine, School of Medicine, Flinders Medical Centre, Flinders University, Adelaide, SA, Australia*
[3] *Public Health Group, Sansom Institute of Health Research, University of South Australia, 5000, Australia*

Correspondence should be addressed to Lucinda K. Bell; lucy.bell@flinders.edu.au

Received 12 December 2012; Revised 19 April 2013; Accepted 18 July 2013

Academic Editor: Sarah McNaughton

Dietary indices evaluate diet quality, usually based on current dietary guidelines. Indices can therefore contribute to our understanding of early-life obesity-risk dietary behaviours. Yet indices are commonly applied to dietary data collected by onerous methods (e.g., recalls or records). Short dietary assessment instruments are an attractive alternative to collect data from which to derive an index score. A systematic review of studies published before April 2013 was conducted to identify short (≤50 items) tools that measure whole-of-diet intake of young children (birth-five years) and are applicable to dietary indices, in particular screening obesogenic dietary behaviours. The search identified 3686 papers of which 16, reporting on 15 tools ($n = 7$, infants and toddlers birth-24 months; $n = 8$, preschoolers 2–5 years), met the inclusion criteria. Most tools were food frequency questionnaires ($n = 14$), with one innovative dietary questionnaire identified. Seven were tested for validity or reliability, and one was tested for both. Six tools ($n = 2$, infants and toddlers; $n = 4$, preschoolers) are applicable for use with current dietary indices, five of which screen obesogenic dietary behaviours. Given the limited number of brief, valid and reliable dietary assessment tools for young children to which an index can be applied, future short tool development is warranted, particularly for screening obesogenic dietary behaviours.

1. Introduction

Individuals do not consume single nutrients, foods, or food groups, but rather combinations of foods [1]. Therefore in nutrition research it is appealing to capture the mix of foods and/or nutrients likely to influence health [2]. Dietary indices, for example evaluate diet quality by assessing dietary intake against predetermined criteria, usually reflecting current dietary guidelines [3].

Childhood overweight and obesity is a global health problem with 40 million children under the age of five classified as overweight [4]. Given the consequences of obesity and the persistence of obesity from childhood into adulthood [5], it is of major importance to address overweight early in life. As recommendations for overweight prevention and treatment are consistent with food-based dietary guidelines [6, 7], dietary indices offer a way of understanding the contribution of early life food intake to obesity risk.

Evaluation of diet against food-based dietary guidelines using an index [8] still requires accurate assessment of dietary intake at the food or food group level. In children under five, indices have commonly been applied to dietary data collected by 24-hour recalls, diet diaries, or weighed food records [9]. Yet, these methods are associated with high respondent burden and are cost- and time-intensive in terms of administration and analysis [10]. The use of these dietary assessment methods is a challenge in large epidemiological studies. Additionally, while energy and nutrient intakes can easily be derived from these detailed methods, it is often difficult to extract food intake data in a way that allows meaningful comparison with food-based dietary guidelines [8].

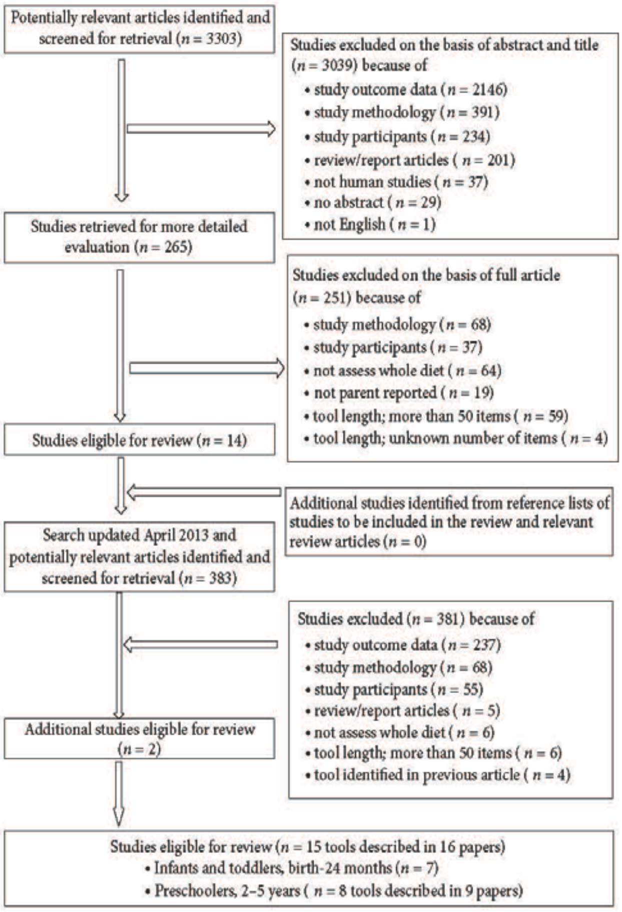


Figure 1: Quorom statement flow diagram. Studies assessing whole-of-diet intake of infants and toddlers and pre-schoolers using a short assessment tool.

Short, simple dietary assessment instruments are an attractive alternative to collect data from which to derive a diet quality score, as they are associated with reduced participant burden, data handling and processing, and costs. They are consequently suitable for survey or epidemiological research [11]. Further, as they supply information quickly [11], they are useful in clinical settings for the rapid assessment of individuals' food intake against food-based dietary guidelines. In view of the high worldwide childhood obesity rates, simple tools that assess early life obesogenic dietary habits are crucial. Given their advantages, short tools that enable evaluation of young children's dietary intake against food-based dietary guidelines using a dietary index are required.

Thus, this review aimed to (1) examine short tools, including their reliability and validity, that measure diet of children birth-five years, (2) identify the short tools that could be used in dietary index research, including screening of obesogenic dietary behaviours.

2. Methods

2.1. Search and Selection Strategy. A six-stage systematic search was conducted to identify existing short tools that measure whole diet in young children. The search strategy and article selection are summarised in Figure 1. In stage one, MEDLINE via PubMed, Web of Science, and SCOPUS were searched for relevant articles published prior to June 2011. The search terms were developed and combined under the following headings: (1) *child (birth-5 years)*, for example infant, toddler, preschooler, and child; (2) *diet*, for example food, nutrition, dietary intake, dietary pattern, eating pattern, food intake; (3) *assessment tool*, for example tool, dietary assessment, evaluate, questionnaire, checklist, validity, and reproducibility. Search term lists were comprehensive with small adaptations made for individual databases searched (see Supplementary information). Stage two involved elimination of irrelevant articles in Endnote using specific term searches through "title" and "keywords" (all terms presented in the Supplementary Information in Supplementary Material available online at http://dx.doi.org/10.1155/2013/709626). Subsequently, the title and abstract of the remaining 3303 articles were screened against the review inclusion and exclusion criteria, outlined below (stage three). If it was unclear whether an article should be included from the title and abstract, the full article was retrieved and screened (stage four). In stage five, reference lists of all included articles and relevant reviews were searched for additional studies. Lastly, searches were rerun in April 2013 to identify articles published after June 2011 (stage six). All resulting articles were screened according to stages two to five. Overall, all articles were assessed for eligibility independently by the primary author but in consultation with all coauthors.

2.2. Inclusion and Exclusion Criteria. The included studies were determined using the following criteria.

(1) Types of outcome measures: studies with whole-of diet intake data were included. Those assessing individual foods, food groups, nutrients or behaviours, and/or household, family, or group consumption were excluded.

(2) Types of dietary assessment methods: studies assessing dietary intake using a short dietary assessment tool were included. For example food frequency questionnaires, checklists, and other dietary questionnaires classified as 50 food intake questions or less. This criterion was set by the authors in an attempt to capture tools that were five pages or less and/or could be completed within 30 minutes. Articles were excluded if dietary assessment tools such as 24-hour recalls, diet histories or food records were used to measure food intake, as they are considered standardised methods that are limited by complex researcher-based administration [12]. If the number of questionnaire items was not reported, or if the tool had been captured in a previously identified paper, articles were excluded.

(3) Types of participants: studies assessing dietary intake of healthy children aged birth to five years, reported by a parent or primary caregiver without assistance from the child, were included. Studies not applicable to the general population (e.g., preterm infants or children with disabilities, health conditions, or behavioural/learning difficulties) were excluded.

(4) Other: studies were limited to the English language, humans and those with an abstract. Review studies, reports, conference papers, and similar documents were excluded.

2.3. Data Extraction and Analysis. Data, including sample characteristics, questionnaire details, and reliability and validity were extracted into standardized tables by the principal author and checked for completion and accuracy by all coauthors. Data synthesis comprised grouping studies by age group and comparing in terms of dietary assessment characteristics; reliability (i.e., tool reproducibility or repeatability using a test-retest procedure [13]); validity (i.e., the ability to accurately measure food consumption data that represents the true intake of the individual [14], determined by comparison with an already validated method); and usefulness for current dietary index applications and screening obesogenic dietary behaviours. Applicability of tools to dietary indices was determined by comparing tool characteristics with characteristics of available indices for children aged up to five years, based on those identified in a recent review [9]. Tools were defined as applicable to dietary indices if all index components could be assessed both easily and accurately. Indices covering the five "core" food groups (i.e., foods recommended to be consumed every day including fruits; vegetables; cereals (e.g., bread, rice, and pasta, noodles); meat and alternatives (e.g., fish, eggs, and nuts); dairy), are highlighted. Indices suitable for screening obesogenic dietary behaviours were defined by the assessment of foods not included in the "core" food groups, described as "noncore" (energy-dense, low nutrient) foods and recommended to be consumed in minimal amounts [6, 15].

3. Results

3.1. General Description of Included Studies. Sixteen studies met the review inclusion criteria (Figure 1). The most common reason for exclusion was the type of outcome data ($n = 2383$), followed by study assessment methodology ($n = 526$) and study participants ($n = 322$). The final 16 papers reported on 15 tools developed to assess dietary intake in early childhood (birth-5 years); seven evaluate infant and toddler dietary intake [16–22] eight evaluate preschoolers dietary intake [23–31] (Table 1). Studies included a range of population groups from predominately European [16, 17, 19–21, 24–28] and other western countries [18, 23, 29–31] and were largely published from 2006 onwards [16, 18, 19, 23–31], with no retrieved papers published prior to 2000. The number of participants varied from 44 [25] to 27 763 [17], with three studies presenting data from large, prospective birth cohorts UK Southampton Women's Study (SWS) [19], UK Avon Longitudinal Study of Parents and Children (ALSPAC) [16], and the Norwegian Mother and Child Cohort Study (MoBa) [17].

3.2. Dietary Assessment Methods and Testing. Most ($n = 14$ of 15) tools used a food frequency questionnaire (FFQs) format [16–28, 30, 31], with one innovative tool, the NutriSTEP nutrition screening tool for preschoolers, identified [29]. The majority of tools were self-administered [16–18, 20, 21, 23–29, 31] and nonquantitative [16–18, 22–25, 29, 31]. The average tool length was 33 items (range 6–47), with 5 tools comprising less than 25 items [18, 20, 21, 23, 29]. Reference periods for recalling foods varied from the past week [18, 19, 22] to past year [27, 28]. Fourteen of the 16 studies reviewed reported food or food group intake as a tool outcome measure [16–18, 20–27, 29–31], whilst two reported energy and nutrient intakes only [19, 28]. Overall, testing was undertaken on approximately half of identified tools ($n = 7/15$, described in 8 papers) (Table 2). A range of tests to assess reliability and

TABLE 1: Characteristics of included studies (n = 16) and their tools (n = 15).

Reference, details, country	Age diet assessed, sample size (gender)	Type and name (if provided) of tool[a]	Number of food items	Tool reference period	Dietary intake measurement: Self- or interviewer administered[b]	Dietary intake measurement: Number of response categories (range)	Other tool details	Outcomes (food, energy, and/or nutrient intakes)
Infants and toddlers (birth-24 months)								
Smithers et al. (2012) [16]; UK	6 mo, n = 7052 (NR)	Nonquantitative FFQ	43	"nowadays"	Self	Report "x" times a week	Items include milk drinks (including formula, BM), cereals (baby, other), rusks, bread/toast, biscuits, ready-to-eat meat/fish/vegetables/baby puddings (fruit, milk), home-cooked meat/fish/vegetables/potatoes/other vegetables/puddings (fruit, milk), raw fruit/vegetables, beverages (juice, fizzy drinks, tea, coffee, and water), sweets, crisps, and chocolate	Foods
Ystrom et al. (2009) [17]; Norway	18 mo, n = 27763 (51% boys)	Nonquantitative FFQ	36	"Current diet"; NFS	Self	Drinks, (never to ≥5 times/day); Foods, (never to ≥3 times/day)	Items include dairy products (milk, yoghurt), meat, fish, fruit, vegetables, potato, porridge, bread, rice, water, fruit juice, soda, chocolate, sweets, desserts, and cakes	Foods
Dee et al. (2008) [18]; USA	6 mo, n = 1984 (NR)	Nonquantitative FFQ	21	1 wk	Self	Report number of feedings per day or per week	Items include milk (BM, formula, cows, rice, goat, and soy), other dairy (yoghurt, cheese, ice-cream, and pudding), other soy foods (tofu, soy desserts), fruit and vegetable juice, sweet drinks, baby cereal, other cereals (breakfast cereals, biscuits, breads, rice, pasta, etc.), fruit, vegetables, French fries, meat and chicken, fish, nut-based foods, eggs, sweet foods (candy, cookies, cake, etc.), and other	Foods nutrients
Marriott et al. (2008) [19]; UK	6 mo, n = 50 (50% boys)	Quantitative FFQ	34	1 wk	Interviewer	Open responses	Items include meat, fish, vegetables, fruits, cereals, snack foods, commercial baby foods, non-milk drinks and human milk, baby formulas, and other milks. Portion size estimated using household measures	Energy nutrients
Andersen et al. (2004) [20]; Norway	24 mo, n = 187 (53% boys)	Semi-quantitative FFQ	15	2 wk	Self	Not specified (never/<1/month to several times/day)	125 foods grouped into 15 questions based on the Norwegian meal pattern. Items include dairy (milk, yoghurt, and cheese), bread, potatoes, vegetables, fruit, meat, fish, cake, chocolate, and soft drinks. Other questions on dietary supplements, food habits, and child nutrition information sources. Portion size estimated using a photographic booklet with four different sized (small–large) or household units (e.g., slices, pieces, and spoons)	Foods Energy Nutrients

Table 1: Continued.

Reference, details, country	Age diet assessed, sample size (gender)	Type and name (if provided) of tool[a]	Number of food items	Tool reference period	Self- or interviewer administered[b]	Number of response categories (range)	Other tool details	Outcomes (food, energy, and/or nutrient intakes)
Andersen et al. (2003) [21]; Norway	12 mo, $n = 64$ (58% boys)	Semiquantitative FFQ	18	2 wk	Self	Not specified (never/<1/month to several times/day)	140 foods grouped into 18 questions based on the Norwegian meal pattern. Items include dairy (milk, yoghurt, and cheese), baby cereal, bread, potatoes, vegetables, fruit, meat, sweetened drinks; and commercial baby foods. Other questions on dietary supplements food habits, child nutrition information sources. Portion size estimated using a photographic booklet with four different sized (small–large) or household units (e.g., slices, pieces, and spoons)	Foods Energy Nutrients
Lartey et al. (2000) [22]; Ghana	1–6 mo, $n = 216$ (53% girls)	Nonquantitative FFQ	28	1 wk	NR	NR	Items include porridges, fruits, vegetables, soups, cereals, legumes, roots and tubers, animal products, cereal-legume mixtures, and cereal-animal product mixtures. Other questions on breastfeeding frequency and daily number other milk feedings	Foods
Preschoolers (2–5 years; 25–60 months)								
Pabayo et al. (2012) [23]; Canada	4-5 y, $n = 2015$ (51.5% boys)	Nonquantitative FFQ	20	Usual intake; NFS	Self	Report total number of daily or weekly servings	Items include fruits, vegetables, grain products (bread, cereal, pasta, and rice), milk and alternatives (white or flavoured, soy or rice beverages, cheese, and yogurt), and meat and alternatives (meat, poultry, fish, peanut butter, nuts, and tofu), chips, French fries, candy, chocolate, regular soft drinks, and cakes and cookies	Foods
Lanfer et al. (2011) [24]; IDEFICS consortium; European countriesc	2–9 y (2–<6y, 39.5%; 6–<10 y, 60.5%), $n = 258$ (44% boys)	Nonquantitative FFQ; Children's Eating Habits Questionnaire (CEHQ-FFQ)	43	4 wk	Self	8 (never/<1/week to ≥4/day and "I have no idea")	Items include vegetables, potatoes, fruit, meat, fish, egg, cereals, bread, pasta, dairy (cheese, milk, and yoghurt), sweetened beverages, spreads, sauces, take-away products, salty snacks, chocolate, candy, cake, and ice-cream. Screening instrument investigating food consumption frequency and behaviours associated with child overweight, obesity, and general health	Foods
Ebenegger et al. (2010) [25]; Switzerland	Mean 5 y, $n = 44$ (64% boys)	Nonquantitative FFQ	39	4 wk	Self	7 (NR)	Items include fruit, vegetables, potato, meat, fish, dairy (yoghurt, cheese, and dairy desserts), bread, cereal, sauces, sweets and snacks (e.g., chocolate), and drinks (e.g., cola). Other questions on eating habits	Foods

Table 1: Continued.

Reference, details, country	Age diet assessed, sample size (gender)	Type and name (if provided) of tool[a]	Number of food items	Tool reference period	Dietary intake measurement: Self- or interviewer administered[b]	Dietary intake measurement: Number of response categories (range)	Other tool details	Outcomes (food, energy, and/or nutrient intakes)
Kleiser et al. (2009) [26]; Germany	3–17y, (3–6 y, 7–10 y, 11–17 y), $n = 14105$ (51% boys)	Semiquantitative FFQ	45	Previous "few wks"; NFS	Self	10 (never to >5/day)	Items include vegetables, fruit, fish, bread/cereal, rice/pasta/potatoes, milk/dairy products, eggs, meat, fats, sweets/fatty snacks/soft drinks, and other beverages. Other questions on eating habits, supplement intake, fortified foods, light products, convenience food, and probiotic products. Portion size estimated using illustrations or standard household measures	Foods energy nutrients
Huybrechts et al. (2009) [27]; Belgium Huybrechts et al. (2006) [28]; Belgium	2.5–6.5 y, $n = 650$ validity $n = 124$ reproducibility (NR) 2.5–6.5 y, mean 4.5 y $n = 1052$, (50% boys)	Semiquantitative FFQ	47	12 mo	Self	6 (every day to never or less than 1 day/month)	Items include beverages (water, juice, and milk drinks), dairy (cheese, yoghurt), meat and meat alternatives (fish, eggs), bread, pasta, rice, vegetables, fruit, potatoes (including fried), meat/fish products, chocolate, sweet snacks, salty snacks, and desserts. Other questions on food habits of some product groups. Portion size estimated using examples of common standard measures	Foods Energy Nutrients
Randall Simpson et al. (2008) [29]; Canada	3-4 y, $n = 269$ validity $n = 140$ reproducibility (94% girls)	Nonquantitative screening tool; NutriSTEP	6	Usual intake; NFS	Self	NR	Items include grains, milk, fruit, vegetables, meat, and fast food. Other questions on nutrition risk constructs: physical growth, physical activity and sedentary behaviour, and factors affecting food intake	Foods
Romaguera et al. (2008) [30]; Argentina	2–9 y (mean boys = 5.1; girls = 5.2), $n = 360$ (NR)	Semiquantitative FFQ	46	NR	Interviewer	NR	Items include cereals/grains, potatoes/tubers, pulses, fish, meat/meat products, eggs, milk/dairy products, fruits and vegetables, fats, added oil, sugary drinks, herbal teas, and added sugar and sweets, sweet and milky desserts. Portion sizes determined according to the observed amount usually consumed in population, measured prior to study.	Foods energy nutrients
Sullivan et al. (2006) [31]; USA	<60 mo, $n = 191$ (59% boys)	Nonquantitative FFQ	47	2 mo	Self	9 (1, 2, and 3/day; 1, 2, 3/week; 0, 1, and 2/month)	Items include fruits, vegetables, legumes and nuts, dairy products, meat, fish, and poultry.	Foods

FFQ: food frequency questionnaire; iDEFICS: Identification and prevention of dietary- and lifestyle-induced health effects in children and infants; NFS: not further specified; mo: months; NR: not reported; USA: United States of America; UK: United Kingdom; y: years.

[a]Tools were defined as quantitative (quantity of food consumed was estimated using weights, measures, or food models), semiquantitative (quantity of food consumed estimated using a standard portion size, serving, or a predetermined amount and respondent asked about the number of portions consumed), or nonquantitative (quantity of food consumed not assessed).

[b]Self-administered (primary caregiver completed the dietary assessment without assistance); interviewer-administered (a trained interviewer elicited the dietary assessment information from the primary care-giver in a one-on-one setting).

[c]Italy, Estonia, Cyprus, Belgium, Sweden, Germany, Hungary, and Spain.

Table 2: Summary of availability of validity and reproducibility data for each study according to energy and/or nutrient intake and food intake.

Reference details	Validity		Reliability	
	Energy and/or nutrients	Foods	Energy and/or nutrients	Foods
Infants and toddlers (birth-24 months)				
Smithers et al. (2012) [16]	—	—	—	—
Ystrom et al. (2009) [17]	—	—	—	—
Dee et al. (2008) [18]	—	—	—	—
Marriott et al. (2008) [19]	√	—	—	—
Andersen et al. (2004) [20]	√	√	—	—
Andersen et al. (2003) [21]	√	√	—	—
Lartey et al. (2000) [22]	—	—	—	—
Preschoolers (2–5 years)				
Pabayo et al. (2012) [23]	—	—	—	—
Lanfer et al. (2011) [24]	—	—	—	√
Ebenegger et al. (2010) [25]	—	—	—	√
Kleiser et al. (2009) [26]	—	—	—	—
Huybrechts et al. (2009) [27]	—	√	—	√
Huybrechts et al. (2006) [28]	√	—	√	—
Randall Simpson et al. (2008) [29]	—	—	—	√
Romaguera et al. (2008) [30]	—	—	—	—
Sullivan et al. (2006) [31]	—	—	—	—

validity were reported. Test definitions and review assessment criteria are presented in the Supplementary Table. Validity (Table 3) and/or reliability (Table 4) were most commonly tested using correlations, although agreement statistics were also used.

3.2.1. Infants and Toddlers (Birth-24 Months). All seven [16–22] tools assessing infant and toddler dietary intakes were FFQs, ranging in length from 15 [20] to 43 [16] items. Three tools were evaluated for validity [19–21] (Table 4) whilst none were evaluated for reliability.

Validity testing revealed that the FFQs overestimated energy and nutrient intakes compared with the selected reference standard (all weighed dietary records, WDR) [19–21]. Correlations for energy and nutrients were low to moderate and slightly higher when energy adjusted [20, 21]. Bland Altman plots for nutrient intakes showed mostly positive mean differences [19], systematic increases in difference with increasing intake for most nutrients [20, 21] and large limits of agreement [20, 21]. Little gross misclassification (3% [21], 5% [20]), defined as classification of intake by the tool in the opposite quartile or tertile of intake, was reported with over one-third of subjects (38% [21], 36% [20]) classified into the same category of nutrient intake. At the food level, FFQ's generally revealed higher median intakes for several food items (11/17 [21] and 7/15 foods [20]) than the WDR [20, 21]. Correlations for most foods were low or moderate with low ($r = 0.48$ [20]) and moderate ($r = 0.62$ [21]) overall median correlations. Importantly, no studies used agreement statistics at the food level.

3.2.2. Preschool Children (2–5 Years). Of the eight tools evaluating pre-schoolers' dietary intakes, described in nine papers [23–31], seven were FFQ's [23–28, 30, 31] but length varied widely (six [29] to 47 [27, 28, 31] items). Overall, three tools were assessed for reliability only [24, 25, 29] and one for reliability and validity of food [27] and nutrient [28] intake (Tables 3 and 4).

To assess test-retest reliability [24, 25, 27–29] the period between administrations varied, ranging from two to four weeks [29] to an average of four months (range 0–364 days) [24]. No tool was assessed for reliability of energy intake and only one for nutrients [28]. The latter revealed that for average daily calcium intakes readministrations were not significantly different ($P = 0.26$), were highly correlated ($r = 0.80$) with moderate agreement ($k = 0.60$) and that nearly all subjects were classified into the same or adjacent quartile of intake (93%) [28]. The reproducibility of food intake was assessed for four tools [24, 25, 27, 29] and showed no statistically significant differences for most foods (38/43 [24], 13/13 foods [27]). Mean spearman's correlations were moderate ($r = 0.59$ [24], $r = 0.62$ [25], and $r = 0.64$ [27]) with good intraclass correlation coefficients (ICC's) reported for many food items ($n = 28/39$ [25]; $n = 13/13$ [27]) and moderate overall mean ICC's ($r = 0.59$ [25, 27]). Two studies showed moderate overall agreement for food items ($k = 0.48$ [24], $k = 0.55$ [29]).

Only one tool was assessed for validity, reported in two studies [27, 28]. This tool significantly underestimated calcium intake measured by an estimated dietary record (EDR), yet methods were moderately correlated ($r = 0.52$, adjusted $r = 0.59$) [28]. Sensitivity and specificity of calcium intake was 62% and 77%, respectively, [28] and nearly half (42%) of subjects were correctly classified [28]. Agreement statistics showed fair agreement ($k = 0.38$) and large differences for higher average nutrient intakes (Bland-Altman plot) [28]. For

TABLE 3: Short dietary assessment tool validity studies among infants and toddlers (birth-24 months) and preschoolers (2–5 years).

	Reference details; tool length; validation standard; reference period; sample size				
	Infants and toddlers (birth-24 months)			Pre-schoolers (2–5 years)	
	Marriott et al. (2008) [19]; 34 items; 4 d WDR; 15 days; $n = 50$	Andersen et al. (2003) [21]; 18 items; 7 d WDR; 1-2 weeks; $n = 64$	Andersen et al. (2004) [20]; 7 d WDR; 15 items; 1-2 weeks; $n = 187$	Huybrechts et al. (2009) [27]; 47 items; 3 d EDR; 1 week; $n = 650$	Huybrechts et al. (2006) [28]; 47 items; 3 d EDR; 1 week; $n = 1052$
	Energy and nutrients				
Mean/median nutrient intakes	All median intakes significant higher ($P < 0.05$), except sodium	All median intakes significant higher ($P < 0.05$), except Ca	All median intakes significant higher ($P < 0.05$), except protein, Carb, SFA, and Ca	—	Significantly lower mean Ca intake: 777 mg/d v 838 ± 305 mg/d; difference 61 ± 294 mg/d ($P < 0.001$)
Mean/median nutrient densities	—	No significant differences except for protein, SFA, MUFA, fibre, vitamin A, vitamin C, calcium, and iron	No significant differences except for protein, SFA, MUFA, fibre, vitamin A, vitamin C, calcium, and iron	—	—
Pearson's correlation	—	—	—	—	$r = 0.52$, corrected for intravariability: $r = 0.59$
Spearman's correlation (nutrients)	$r = 0.63$ (range 0.39–0.86) *energy-adjusted*: $r = 0.55$–0.89	$r = 0.50$ (range 0.18–0.72) *energy-adjusted*: $r = 0.50$ (0.16–0.79)	$r = 0.38$ (range 0.26–0.50) *energy-adjusted* $r = 0.52$ (range 0.46–0.66)	—	—
Spearman's correlation (foods)	—	$r = 0.62$ (range 0.28–0.83)	$r = 0.48$ (range 0.26–0.69)	$r = 0.48$ (range 0.23–0.62) *corrected*: $r = 0.32$–0.75	—
Specificity	—	—	—	—	77%
Sensitivity	—	—	—	—	62%
Bland Altman, mean bias	Mostly positive, all nutrients within range −12.5% to 12.5%, except vitamin B12 (−18.9%).	Systematic increase in difference with increasing intake, except Ca	Systematic increase in difference with increasing intake for most nutrients	—	Large differences, higher for greater mean intakes
Bland Altman, limits of agreement	—	Large for all nutrients	Large for all nutrients	—	—
Cross classification; nutrients	—	Same quartile, 38% (range 22% fibre—56% SFA); opposite, 3%	Same quartile, 36% (range 29% fat—44% vitamin A); opposite, 5% Energy-adjusted: same, 42%; opposite, 4%	—	Same quartile, 42%; within one, 83%; opposite, 2.4%; difference between quartiles $P < 0.001$

Table 3: Continued.

	Reference details; tool length; validation standard; reference period; sample size				
	Infants and toddlers (birth-24 months)			Pre-schoolers (2–5 years)	
	Marriott et al. (2008) [19]; 34 items; 4 d WDR; 15 days; $n = 50$	Andersen et al. (2003) [21]; 18 items; 7 d WDR; 1-2 weeks; $n = 64$	Andersen et al. (2004) [20]; 7 d WDR; 15 items; 1-2 weeks; $n = 187$	Huybrechts et al. (2009) [27]; 47 items; 3 d EDR; 1 week; $n = 650$	Huybrechts et al. (2006) [28]; 47 items; 3 d EDR; 1 week; $n = 1052$
Foods					
Mean/median food group intakes	—	—	—	Mean differences within ±10% 6/13 food groups, 11–30% 6/13, >40% 1/13; median differences within ±10% 5/13 food groups, 11–20% 1/13, >20% 6/13; 100% for 1/13	—
Wilcoxon signed rank test	—	Significantly higher intakes 11/17 food groups, NS differences 6/17	Significantly higher intakes 7/15 food groups, significantly lower intakes 3/1, NS difference for 5/15	Significantly different intake distribution for 6/13 ($P < 0.01$) or 9/13 ($P < 0.05$) food groups; higher 5/13, lower 4/13, NS difference 4/13	—
Kappa statistic	—	—	—	<0.20 4/13 food groups, 0.20–0.40 4/13, 0.41–0.60 2/13, NR 3/13	0.38 (95% CI 0.34, 0.42)
Bland Altman, mean bias	—	—	—	Increasing bias with increasing intakes for "many foods" (n not reported)	—
Cross classification; foods	—	—	—	Same = NR, within one = 67%–88%, opposite <10% (2% fruit, fruit juices, and milk products—9% meat products)	—

Ca: calcium; carb: carbohydrates; d: day; EDR: estimated dietary record; LOA: limits of agreement; MUFA: monounsaturated fatty acids; NR: not reported; NS: not significant; %: percent; PUFA: polyunsaturated fatty acids; SFA: saturated fatty acids; WDR: weighed dietary record.

Table 4: Short dietary assessment tool reliability studies among preschoolers (2–5 years).

Tests	Reference details; tool length; readmission period; sample size				
	Lanfer et al. (2011) [24]; 43 items; 0–354 days, average 4 months; $n = 258$	Ebenegger et al. (2010) [25]; 39 items; within 4-weeks; $n = 44$	Huybrechts et al. (2009) [27]; 47 items; 5 weeks; $n = 124$	Huybrechts et al. (2006) [28]; 47 items; 5 weeks; $n = 124$	Randall Simpson et al. (2008) [29]; 5 items; 2–4 weeks; $n = 140$
Mean/median differences (foods)	—	—	Mean intakes 12/13 food groups within ±10%, 1/13 >10% (11%). Intakes generally lower first administration. Median intakes 10/13 within ±10%, 3/13 > 20%	—	—
Paired t-test	—	—	—	$P = 0.26$; 23.8 ± 161.2 mg ca/d (95% CI 17.8, 65.5; 774 ± 252 v 751 ± 255)	$P < 0.001$
Pearson's correlation	—	—	—	$r = 0.80$ for Ca	—
Spearman's correlation (foods)	$r = 0.59$ (range 0.32–0.76); $P < 0.001$ ($r < 0.50$ for 8/43 foods, 0.51–0.69 for 26/43, $r > 0.70$ for 9/43); readministration >4 months (0.28–0.73), <4 months (0.31–0.87)	$r = 0.62$ ($r < 0.50$ for 8/39 (7 $P < 0.05$ and 1 NS), 0.50-0.70 for 22/39 (all $P < 0.01$), >0.70 for 9/39 (all $P < 0.01$)	$r = 0.64$ ($r = 0.5$–0.7 for 10/13, >0.7 for 3/13)	—	—
ICC	—	0.59 (>0.50 28/39 foods)	0.59 (>0.50 13/13 foods)	—	—
Kappa statistic	0.48 (0.23–0.68)	—	—	0.60 (95% CI 0.49–0.71)	0.54 (0.39–0.71)
Wilcoxon signed-rank test:	$P < 0.05$ for 5/43 items, NS for 38/43 items	—	NS for 13/13 foods		
Cross classification	—	—	—	Grossly misclassified = 0%, correctly classified = 56.7%, and adjacent quartile = 36.7%	—

Abbreviations: Ca, calcium, NS, not significant.

food intake, mean differences were predominately less than 30% (12/13 foods) [27], whilst the median correlation was low ($r = 0.48$ [27]) and agreement mostly poor (4/13 foods) or fair (4/13 foods) [27]. Gross misclassification was less than 10% for all food groups whilst classification into the same or adjacent category ranged from 67% (meat products) to 88% (fruit juice) [27].

3.3. Dietary Index Applications. Dietary indices developed to characterise the diet quality of infants, toddlers or preschool-aged children are summarised in Table 5 [26, 31–48]. Overall, data from six tools ($n = 2$, infants and toddlers [20, 21]; $n = 4$, pre-schooler [26, 27, 30, 31]) can be applied to five measures of diet quality reviewed [26, 31, 39, 42, 47], all developed for use in pre-schoolers (Table 5). Two have been tested for validity only [20, 21] and one for both validity and reliability [27]. Of these six short tools, two [26, 31], both for use in pre-schoolers, have previously been used in dietary index applications. The Healthy Nutrition Score for Kids and Youth (HuSKY) has been applied to the 54-item (45 food-item) semi-quantitative FFQ assessing intakes of three to six-year-old German children [26], whilst the 47-item non-quantitative FFQ has been used to assess dietary diversity in American children under five [31].

No other short tools were identified that provide dietary data to which a dietary index could be applied, often because the level of detail provided by the tool was too minimal for application of an index. This is particularly evident for those indices comprising food-group subcategories (e.g., "vitamin A-rich vegetables") [33, 36, 38, 43, 44, 48]. Additionally, application of several tools to current indices would require detailed analysis to determine nutrient (e.g., total fat, cholesterol, and iron) intakes [32, 34, 40, 41, 43, 44, 46]. Lastly, portion size quantification is required for the majority of dietary indices reviewed [26, 32, 34, 36, 38–44, 46–48] and thus only quantitative or semiquantitative tools provide data to which these indices could be applied.

3.4. Screening Obesogenic Behaviours. Of the 15 tools reviewed, 13 assess the intake of "noncore" foods and/or beverages ($n = 6$, infant and toddlers [16–21]; $n = 7$ pre-schoolers [23–30]). Three of these were specifically designed to screen obesity related behaviours [24, 25, 29] whilst five were identified (above) as being useful for application of a dietary index. Of the 19 indices reviewed [9], three ($n = 1$, infants and toddlers [34]; $n = 4$, pre-schoolers [26, 39]) included food items associated with poor diet quality, such as intake of high fat or sugary foods and/or beverages. Two of these indices can be used with the short tools identified in this review [26, 39].

4. Discussion

This review identified 16 papers reporting on 15 short dietary assessment tools that measure whole diet of children under five years ($n = 7$, infants and toddlers; $n = 8$, pre-schoolers). Tool reliability and validity and applicability to dietary indices and for screening obesogenic dietary behaviours are highlighted. All but one tool was a FFQ, and approximately half ($n = 7$) of all tools were tested for either reliability or validity, and one tested for both. Six tools provide dietary intake data to which an index can be applied, five of which screen obesogenic dietary behaviours. Overall, testing of tool properties was limited and few tools are applicable to current dietary indices that screen obesogenic dietary behaviours of children from birth to five years of age.

Of the 15 tools identified in this review, only seven were tested for validity and/or reliability at the food or food group level. In general, there was a lack of reliability testing to accompany validity testing with only one of four tools assessed for validity also assessed for reliability. As validity requires reliability [49], the remaining three tools cannot be identified as valid. Moreover, there was a high reliance on correlations which assess association only and thus should not be used alone but alongside agreement measures such as kappa statistic and Bland-Altman analysis [50, 51]. Further, although the reference period covered by the validation standard should correspond to that of the questionnaire [52], 3- or 7-day food records were commonly used in the reviewed studies to assess the validity of FFQs covering two weeks [20, 21] or 12 months intake [27, 28]. For reliability studies, if readministration periods are too close, subjects may remember their previous responses, or if too far apart, lower reliability may reflect true variation in diet [52], particularly in young children at an age when dietary habits are rapidly changing [53]. This is evident as an average re-administration period of 4 months yielded weaker agreement [24] than studies with shorter re-administration periods. Despite these limitations in tool testing, and in considering the realistic estimates of measurement error between two dietary assessment methods [54] in conjunction with unstable dietary habits of young children, the reliability and validity results presented here can be considered reasonable. Thus, several short dietary assessment tools can be judged as useful for characterising the diet of children under 5.

Given the increasing interest in assessing diet quality using an index, resulting from an increased understanding of the complexity in which individuals consume foods [55], determining those short tools that are useful for dietary index applications is of interest. For the current indices available for children under five years of age, summarised in this review, diet quality is assessed based on intake of particular foods or food groups, nutrients, or a combination of both. Although most of the tools reviewed estimate whole-of-diet food intake making them potentially useful for food or food-group based index applications, few ($n = 6$ of 15) can be directly applied to current indices of diet quality [20, 21, 26, 27, 30, 31]. Further, these tools are limited by a lack of testing, with only one tested for reliability and validity [27, 28]. Thus the accuracy of the other five tools in assessing dietary intake, and diet quality when applied to an index, is questionable. Therefore, testing of tool properties is recommended prior to dietary index applications.

Several factors explain why other short tools reviewed are not useful for dietary index applications. First, as mentioned, many indices assess diet quality based on nutrient intakes or a combination of nutrient and food intakes. Applying an index of this type to a questionnaire-type tool requires linkage with

Table 5: Studies examining diet quality indices among infants and toddlers (birth-24 months) and preschoolers (2–5 years), details of the content of the indices and their applicability to short dietary assessment tools identified in Table 1.

Index name; reference details; age of sample	Index properties: Number of components: component labels	Assesses: Five "core" food groups	Assesses: "Noncore" foods	Assesses: Assessment of food-group subcategories	Applicability to short tools identified in Table 1, Requires: Detailed nutrient analysis	Applicability to short tools identified in Table 1, Requires: Portion size quantification[a]	Can be applied to dietary data assessed by short tools reviewed (Table 1)
Infants and toddlers (birth-24 months)							
Mean Adequacy Ratio (MAR); Hoerr et al. 2006 [32]; 11–25 m	Nutrients included in ratio score vary according to research interests. 8 key nutrients used in [32]	—	—	—	√	√	N
Dietary Diversity Score, international; Dewey et al. 2006 [33]; 1-2 y	8 or 9 food groups: cereals, roots and tubers, vitamin A-rich fruit and vegetables, other fruit and vegetables, legumes and nuts, meat and alternatives, fats and oils, dairy, and eggs, (fruits and vegetables separate for 9-food group DDS)	√	—	√	—	—	N
Healthy Eating Index-Canada (HEI-C); Glanville and McIntyre 2006 [34]; 1–3 y	9: grains, fruit and vegetables, milk, meat, other foods (high in fat, sodium, and sat fat), total fat, saturated fat, cholesterol, and variety	√	√	—	√	√	N
Food Variety Score (FVS), South Africa; Steyn et al. 2006 [35]; 1–3 y	1: dietary diversity. One point for every food item consumed over 24-hour period from 45-item list[b].	—	—	—	—	—	N
Diet Quality Score 2 (DQS2), USA; Caliendo et al. 1977 [36]; 1–4 y	6: vegetables, fruit, breads and cereals, meat and milk, citrus fruit, dark green, and yellow vegetables	√	—	√	—	√	N
Child Feeding Index; Ruel et al. 2002 [37]; 1–3 y	7: breastfeeding, does not use bottle[c], dietary diversity, food frequency, (egg/fish/poultry), food frequency (meat), food, frequency (grains/tubers), and meal frequency	—	—	—	—	—	N
Nutrient Adequacy Score; Krebs-Smith and Clark 1989 [38]; 1–3 y	12: milk and milk products, whole grains, enriched grains, total grains, citrus fruit, other fruit and vegetables, total fruit, green and yellow vegetables, starchy vegetables, other vegetables, total vegetables, and meat and alternatives	√	—	√	—	√	N

Table 5: Continued.

Index name; reference details; age of sample	Number of components: component labels	Index properties: Assesses: Five "core" food groups	"Noncore" foods	Applicability to short tools identified in Table 1: Requires: Assessment of food-group subcategories	Detailed nutrient analysis	Portion size quantification[a]	Can be applied to dietary data assessed by short tools reviewed (Table 1)
Preschoolers (2–5 years)							
Crombie et al. 2009 [39]; 2 y	vegetables; dairy products; meat, fish or alternatives; high-fat or high-sugar snacks	√	√	—	—	√	Y [20, 21, 26–28, 30]
Nutrient Quality Index (NQI), Germany; Libuda et al. 2009 [40]; 2–4 y	17: nutrients: vitamins A, E, K, B6, B12, and C, thiamine, riboflavin, niacin, pantothenic acid, folate; minerals calcium, magnesium, iron, phosphorus, potassium, and zinc	—	—	—	√	√	N
Healthy Eating Index (HEI), USA; Manios et al. 2009 [41]; 2–5 y	10: Grains, vegetables, fruits, milk, meat, total fat (% calories), saturated fat (% calories), total, cholesterol, sodium, and variety	√	—	—	√	√	N
Servings/day, USA; Kranz et al. 2009 [42]; 2–5 y	5: fruit, vegetables, grains, milk/dairy, meat/alternatives	√	—	—	—	√	Y [20, 21, 26–28, 30]
HEI-2005, USA; Fungwe et al. 2009 [43]	12: whole fruit (not juice), total vegetables, dark green and orange vegetables and legumes, total and alternatives and beans, food oils, saturated fat, sodium, extra calories from solid fats (including fat in milk), and added sugars	√	√	√	√	√	N
Healthy Nutrition score (HuSKY); Kleiser et al. 2009 [26]; 3–6 y	11: beverages, vegetables, fruit, fish, breads and dairy products, eggs, meat and sausage, fats and oils (butter/margarine), sweets and fatty snacks, and soft drinks	√	√	—	—	√	Y [26]
Revised Children's Diet USA; Kranz et al. 2008 [44] Kranz et al. 2006 [45]; 2–5 y	13: added sugar, total fat, fat quality—linoleic, fat docosahexaenoic, total grains, whole grains, vegetables, fruits, 100% fruit juice, dairy, iron intake, and energy balance	—	√	√	√	√	N
Dietary Diversity Score; Sullivan et al. 2006 [31]; <5y	Dietary diversity. 7: grains-roots-tubers, legumes and nuts, dairy, meat-poultry-fish-eggs, vitamin A-rich fruits and vegetables, other fruits and vegetables, and foods cooked with fat or oil	√	—	√	—	—	Y [31]

Table 5: Continued.

Index name; reference details; age of sample	Number of components: component labels	Index properties: Assesses: Five "core" food groups	Index properties: Assesses: "Noncore" foods	Applicability to short tools identified in Table 1: Requires: Assessment of food-group subcategories	Applicability to short tools identified in Table 1: Requires: Detailed nutrient analysis	Applicability to short tools identified in Table 1: Requires: Portion size quantification[a]	Can be applied to dietary data assessed by short tools reviewed (Table 1)
Diet Quality Index for Children; Kranz et al. 2004 [46]; 2–5 y Variety Index for toddlers	8: % total energy as added sugars, total fat, saturated fat, number of servings of grains, fruit and vegetables, dairy, excessive juice, and iron (mg/d) 5: bread group, vegetable group, fruit group, and dairy	—	—	—	√	√	N
(VIT); Cox et al. 1997 [47]; 2-3 y	Group, meat group	√	—	—	—	√	Y [20, 21, 26–28, 30]
Diet Quality Score 1 (DQS1), Canada; Campbell and Sanjur 1992 [48]; 2–4 y	6: milk, meat and alternatives, fruit and vegetables, breads and cereals, additional vegetables, and vitamin A-rich vegetables	√	—	√	—	√	N
Diversity Score (DS), USA; Caliendo et al. 1977 [36]; 2–4 y	1: dietary diversity using items consumed by 20% or more of the study samples. One point for every food item consumed from a list of 20 food items[b]	—	—	—	—	√	N

Table adapted from Smithers et al. 2011 [9].
Freq: frequency; FFQ: food frequency questionnaire; N: no; Y: yes.
Core foods: foods recommended to be consumed daily for example: fruit, vegetables, dairy, meat and alternatives, and cereals [6, 15].
Noncore foods: foods recommended to be consumed in minimal amounts for example: high fat, salt, and/or sugar foods [6, 15].
[a]If portion size-quantification required, index is only useful for data collected using semiquantitative or quantitative methods.
[b]Unlikely any short tool assess the same x-items.
[c]No tool assess bottle use.

appropriate food composition data to derive nutrient intakes. Alternatively, questionnaire-type tools are most applicable to food-based indices. Further, several indices assess food-group subcategories, such as "vitamin A-rich vegetables" or "dark green vegetables," which are not measured by the short tools reviewed. Also limiting applicability is that portion size quantification is required to apply dietary data to several indices. Although these factors limit the applicability of short tools to current indices, several tools that capture food groups of interest are ideal for development of a suitable index. For example the 47-item FFQ by Huybrechts et al. [27] is suitable as it assesses "core" and "noncore" food intake and was the one tool tested for both reliability and validity of food intake. Development of a dietary index based on food intake assessed using this short tool would be appropriate. Alternatively, future research to develop suitable short dietary assessment tools that measure whole diet to which a current index can be applied is ideal.

Moreover, in view of the high rates of overweight and obesity among children under five worldwide [4], indices are potentially a useful tool to evaluate early life dietary behaviours that contribute to obesity risk. Yet few current indices for children less than five years assess obesogenic dietary behaviours, with many evaluating "core" food and/or nutrient intakes only. Thus, future indices based on "core" and "noncore" food intake are warranted. Additionally, considering that few short tools assess "noncore" intakes and are useful for application of a dietary intake there is a need for future development of short tools that are useful for both dietary index applications and screening obesogenic dietary behaviours in children under five, particularly in those less than two years of age.

Overall, this systematic review highlights the lack of high quality short dietary intake assessment tools for young children, particularly less than two years, to which a dietary index can be applied. Further, as the majority of those tools available for dietary index applications were developed and tested in European populations, restricting their generalisability outside the European context, there is a need for short dietary assessment tools developed for use in other populations of young children to which an index can be applied. Lastly, it is important to note that several rapid dietary assessment tools have been designed for use in young children, yet are not presented in this review as they focus on limited aspects of food intake, for example fruit and vegetables [56], beverages [57], and obesity-related food and beverages only [58], not total diet. Future rapid dietary assessment tools should be designed to comprehensively measure young children's whole-of-diet intake, including obesogenic dietary behaviours, and should be tested for reliability and validity of food intake.

5. Conclusion

A key finding of this review is that although several short dietary assessment tools were identified as useful for characterising whole diet of children birth-5 years, there is an overall lack of brief, valid and reliable dietary assessment tools available for use in this age group. This highlights a need for greater testing of existing short tools. A second key finding is that few short dietary assessment tools, particularly those developed for under 2's, are suitable for dietary index applications and for screening obesogenic dietary behaviours of young children. Due to the benefits of assessing diet quality using indices and of capturing dietary intake using less demanding, time-consuming and expensive dietary assessment methodologies, this review identifies opportunities for short tool development for use in children under five that are adequately reliable and valid for use, applicable to dietary indices, and that assess obesogenic dietary behaviours.

Conflicts of Interests

The authors declare no conflict of interests.

Acknowledgments

Rebecca K. Golley is supported by a National Heart Foundation Fellowship, and Lucinda K. Bell is supported by an Australian Postgraduate Award (APA).

References

[1] A. K. Kant, "Dietary patterns and health outcomes," *Journal of the American Dietetic Association*, vol. 104, no. 4, pp. 615–635, 2004.

[2] F. B. Hu, "Dietary pattern analysis: a new direction in nutritional epidemiology," *Current Opinion in Lipidology*, vol. 13, no. 1, pp. 3–9, 2002.

[3] P. K. Newby and K. L. Tucker, "Empirically derived eating patterns using factor or cluster analysis: a review," *Nutrition Reviews*, vol. 62, no. 5, pp. 177–203, 2004.

[4] WHO, "Obesity and overweight," World Health Organization (WHO), 2011, http://www.who.int/mediacentre/factsheets/fs311/en/.

[5] A. M. Craigie, A. A. Lake, S. A. Kelly, A. J. Adamson, and J. C. Mathers, "Tracking of obesity-related behaviours from childhood to adulthood: a systematic review," *Maturitas*, vol. 70, no. 3, pp. 266–284, 2010.

[6] NHMRC, *Dietary Guidelines for Children and Adolescents in Australia Incorporating the Infant Feeding Guidelines for Health Workers*, National Health and Medical Research Council (NHMRC), Commonwealth of Australia, Canberra, Australia, 2003.

[7] NHMRC, *Clinical Practice Guidelines for the Management of Overweight and Obesity in Children and Adolescents*, National Health and Medical Research Council (NHMRC), Commonwealth of Australia, Canberra, Australia, 2003.

[8] A. Magarey, R. K. Golley, N. Spurrier, E. Goodwin, and F. Ong, "Reliability and validity of the children's dietary questionnaire; a new tool to measure children's dietary patterns," *International Journal of Pediatric Obesity*, vol. 4, no. 4, pp. 257–265, 2009.

[9] L. G. Smithers, R. K. Golley, L. Brazionis, and J. W. Lynch, "Characterizing whole diets of young children from developed countries and the association between diet and health: a systematic review," *Nutrition Reviews*, vol. 69, no. 8, pp. 449–467, 2011.

[10] A. Magarey, J. Watson, R. K. Golley et al., "Assessing dietary intake in children and adolescents: considerations and recommendations for obesity research," *International Journal of Pediatric Obesity*, vol. 6, no. 1, pp. 2–11, 2011.

[11] V. Flood, K. Webb, and A. Rangan, "Recommendations for short questions to assess food consumption in children for the NSW health surveys," NSW Centre for Public Health Nutrition, 2005, http://www0.health.nsw.gov.au/pubs/2005/pdf/qa_food_consump.pdf.

[12] T. Burrows, R. K. Golley, A. Khambalia et al., "The quality of dietary intake methodology and reporting in child and adolescent obesity intervention trials: a systematic review," *Obesity Reviews*, vol. 13, no. 12, pp. 1125–1138, 2012.

[13] P. M. Gleason, J. Harris, P. M. Sheean, C. J. Boushey, and B. Bruemmer, "Publishing nutrition research: validity, reliability, and diagnostic test assessment in nutrition-related research," *Journal of the American Dietetic Association*, vol. 110, no. 3, pp. 409–419, 2010.

[14] J. Pallant, *SPSS Survival Manual: A Step by Step Guide to Data Analysis Using SPSS*, Allen & Unwin, 4th edition, 2011.

[15] L. Kellet, A. Smith, and Y. Schmerlaib, *Australian Guide to Healthy Eating*, Department of Health and Family Services, Commonwealth of Australia, Canberra, Australia, 1998.

[16] L. G. Smithers, L. Brazionis, R. K. Golley et al., "Associations between dietary patterns at 6 and 15 months of age and sociodemographic factors," *European Journal of Clinical Nutrition*, vol. 66, no. 6, pp. 658–666, 2012.

[17] E. Ystrom, S. Niegel, and M. E. Vollrath, "The impact of maternal negative affectivity on dietary patterns of 18-month-old children in the Norwegian mother and child cohort study," *Maternal and Child Nutrition*, vol. 5, no. 3, pp. 234–242, 2009.

[18] D. L. Dee, A. J. Sharma, M. E. Cogswell, L. M. Grummer-Strawn, S. B. Fein, and K. S. Scanlon, "Sources of supplemental iron among breastfed infants during the first year of life," *Pediatrics*, vol. 122, supplement 2, pp. S98–S104, 2008.

[19] L. D. Marriott, S. M. Robinson, J. Poole et al., "What do babies eat? Evaluation of a food frequency questionnaire to assess the diets of infants aged 6 months," *Public Health Nutrition*, vol. 11, no. 7, pp. 751–756, 2008.

[20] L. F. Andersen, B. Lande, K. Trygg, and G. Hay, "Validation of a semi-quantitative food-frequency questionnaire used among 2-year-old Norwegian children," *Public Health Nutrition*, vol. 7, no. 6, pp. 757–764, 2004.

[21] L. F. Andersen, B. Lande, G. H. Arsky, and K. Trygg, "Validation of a semi-quantitative food-frequency questionnaire used among 12-month-old Norwegian infants," *European Journal of Clinical Nutrition*, vol. 57, no. 8, pp. 881–888, 2003.

[22] A. Lartey, A. Manu, K. H. Brown, J. M. Peerson, and K. G. Dewey, "Predictors of growth from 1 to 18 months among breast-fed Ghanaian infants," *European Journal of Clinical Nutrition*, vol. 54, no. 1, pp. 41–49, 2000.

[23] R. Pabayo, J. C. Spence, L. Casey, and K. Storey, "Food consumption patterns in preschool children," *Canadian Journal of Dietetic Practice and Research*, vol. 73, no. 2, pp. 66–71, 2012.

[24] A. Lanfer, A. Hebestreit, W. Ahrens et al., "Reproducibility of food consumption frequencies derived from the children's eating habits questionnaire used in the IDEFICS study," *International Journal of Obesity*, vol. 35, supplement 1, pp. S61–S68, 2011.

[25] V. Ebenegger, P. Marques-Vidal, J. Barral, S. Kriemler, J. J. Puder, and A. Nydegger, "Eating habits of preschool children with high migrant status in Switzerland according to a new food frequency questionnaire," *Nutrition Research*, vol. 30, no. 2, pp. 104–109, 2010.

[26] C. Kleiser, G. B. M. Mensink, C. Scheidt-Nave, and B. M. Kurth, "HuSKY: a healthy nutrition score based on food intake of children and adolescents in Germany," *The British Journal of Nutrition*, vol. 102, no. 4, pp. 610–618, 2009.

[27] I. Huybrechts, G. de Backer, D. de Bacquer, L. Maes, and S. de Henauw, "Relative validity and reproducibility of a food-frequency questionnaire for estimating food intakes among flemish preschoolers," *International Journal of Environmental Research and Public Health*, vol. 6, no. 1, pp. 382–399, 2009.

[28] I. Huybrechts, D. de Bacquer, C. Matthys, G. de Backer, and S. de Henauw, "Validity and reproducibility of a semi-quantitative food-frequency questionnaire for estimating calcium intake in Belgian preschool children," *The British Journal of Nutrition*, vol. 95, no. 4, pp. 802–816, 2006.

[29] J. A. Randall Simpson, H. H. Keller, L. A. Rysdale, and J. E. Beyers, "Nutrition screening tool for every preschooler (NutriSTEP): validation and test-retest reliability of a parent-administered questionnaire assessing nutrition risk of preschoolers," *European Journal of Clinical Nutrition*, vol. 62, no. 6, pp. 770–780, 2008.

[30] D. Romaguera, N. Samman, A. Rossi, C. Miranda, A. Pons, and J. A. Tur, "Dietary patterns of the Andean population of Puna and Quebrada of Humahuaca, Jujuy, Argentina," *The British Journal of Nutrition*, vol. 99, no. 2, pp. 390–397, 2008.

[31] J. Sullivan, M. Ndekha, D. Maker, C. Hotz, and M. J. Manary, "The quality of the diet in Malawian children with kwashiorkor and marasmus," *Maternal and Child Nutrition*, vol. 2, no. 2, pp. 114–122, 2006.

[32] S. L. Hoerr, M. A. Horodynski, S. Y. Lee, and M. Henry, "Predictors of nutritional adequacy in mother-toddler dyads from rural families with limited incomes," *Journal of the American Dietetic Association*, vol. 106, no. 11, pp. 1766–1773, 2006.

[33] K. G. Dewey, A. W. Onyango, and C. Garza, "Complementary feeding in the WHO multicentre growth reference study," *Acta Paediatrica*, vol. 95, no. 450, pp. 27–37, 2006.

[34] N. T. Glanville and L. McIntyre, "Diet quality of atlantic families headed by single mothers," *Canadian Journal of Dietetic Practice and Research*, vol. 67, no. 1, pp. 28–35, 2006.

[35] N. P. Steyn, J. H. Nel, G. Nantel, G. Kennedy, and D. Labadarios, "Food variety and dietary diversity scores in children: are they good indicators of dietary adequacy?" *Public Health Nutrition*, vol. 9, no. 5, pp. 644–650, 2006.

[36] M. A. Caliendo, D. Sanjur, J. Wright, and G. Cummings, "Nutritional status of preschool children," *Journal of the American Dietetic Association*, vol. 71, no. 1, pp. 20–26, 1977.

[37] M. T. Ruel and P. Menon, "Child feeding practices are associated with child nutritional status in Latin America: innovative uses of the demographic and health surveys," *Journal of Nutrition*, vol. 132, no. 6, pp. 1180–1187, 2002.

[38] S. M. Krebs-Smith and L. D. Clark, "Validation of a nutrient adequacy score for use with women and children," *Journal of the American Dietetic Association*, vol. 89, no. 6, pp. 775–783, 1989.

[39] I. K. Crombie, K. Kiezebrink, L. Irvine et al., "What maternal factors influence the diet of 2-year-old children living in deprived areas? A cross-sectional survey," *Public Health Nutrition*, vol. 12, no. 8, pp. 1254–1260, 2009.

[40] L. Libuda, U. Alexy, A. E. Buyken, W. Sichert-Hellert, P. Stehle, and M. Kersting, "Consumption of sugar-sweetened beverages

and its association with nutrient intakes and diet quality in German children and adolescents," *The British Journal of Nutrition*, vol. 101, no. 10, pp. 1549–1557, 2009.

[41] Y. Manios, G. Kourlaba, K. Kondaki et al., "Diet quality of preschoolers in Greece based on the healthy eating index: the GENESIS study," *Journal of the American Dietetic Association*, vol. 109, no. 4, pp. 616–623, 2009.

[42] S. Kranz, D. C. Mitchell, H. Smiciklas-Wright, S. H. Huang, S. K. Kumanyika, and N. Stettler, "Consumption of recommended food groups among children from medically underserved communities," *Journal of the American Dietetic Association*, vol. 109, no. 4, pp. 702–707, 2009.

[43] T. Fungwe, P. M. Guenther, W. Y. Juan et al., "The quality of children's diets in 2003-2004 as measured by the healthy eating index—2005," *Clinical Nutrition Insight*, vol. 43, pp. 1–2, 2009.

[44] S. Kranz, J. L. Findeis, and S. S. Shrestha, "Use of the revised children's diet quality index to assess preschooler's diet quality, its sociodemographic predictors, and its association with body weight status," *Jornal de Pediatria*, vol. 84, no. 1, pp. 26–34, 2008.

[45] S. Kranz, T. Hartman, A. M. Siega-Riz, and A. H. Herring, "A diet quality index for American preschoolers based on current dietary ntake recommendations and an indicator of energy balance," *Journal of American Dietetic Association*, vol. 106, no. 10, pp. 1594–1604, 2006.

[46] S. Kranz, A. M. Siega-Riz, and A. H. Herring, "Changes in diet quality of American preschoolers between 1977 and 1998," *The American Journal of Public Health*, vol. 94, no. 9, pp. 1525–1530, 2004.

[47] D. R. Cox, J. D. Skinner, B. R. Carruth, J. Moran III, and K. S. Houck, "A food variety index for toddlers (VIT): development and application," *Journal of the American Dietetic Association*, vol. 97, no. 12, pp. 1382–1386, 1997.

[48] M. L. Campbell and D. Sanjur, "Single employed mothers and preschool-child nutrition: an ecological analysis," *Journal of Nutrition Education and Behavior*, vol. 24, no. 2, pp. 67–74, 1992.

[49] W. P. Vogt, *Dictionary of Statistics & Methodology: A Nontechnical Guide for the Social Sciences*, Sage, Thousand Oaks, Calif, USA, 2nd edition, 1999.

[50] J. M. Bland and D. G. Altman, "Comparing methods of measurement: why plotting difference against standard method is misleading," *The Lancet*, vol. 346, no. 8982, pp. 1085–1087, 1995.

[51] J. M. Bland and D. G. Altman, "Measuring agreement in method comparison studies," *Statistical Methods in Medical Research*, vol. 8, no. 2, pp. 135–160, 1999.

[52] J. Cade, R. Thompson, V. Burley, and D. Warm, "Development, validation and utilisation of food-frequency questionnaires—a review," *Public Health Nutrition*, vol. 5, no. 4, pp. 567–587, 2002.

[53] L. A. Parrish, J. A. Marshall, N. F. Krebs, M. Rewers, and J. M. Norris, "Validation of a food frequency questionnaire in preschool children," *Epidemiology*, vol. 14, no. 2, pp. 213–217, 2003.

[54] B. M. Margetts and M. Nelson, *Design Concepts in Nutritional Epidemiology*, Oxford University Press, Oxford, UK, 1997.

[55] P. M. C. M. Waijers, E. J. M. Feskens, and M. C. Ocké, "A critical review of predefined diet quality scores," *The British Journal of Nutrition*, vol. 97, no. 2, pp. 219–231, 2007.

[56] C. Linneman, K. Hessler, S. Nanney, K. Steger-May, A. Huynh, and D. Haire-Joshu, "Parents are accurate reporters of their preschoolers' fruit and vegetable consumption under limited conditions," *Journal of Nutrition Education and Behavior*, vol. 36, no. 6, pp. 305–308, 2004.

[57] T. A. Marshall, J. M. E. Gilmore, B. Broffitt, S. M. Levy, and P. J. Stumbo, "Relative validation of a beverage frequency questionnaire in children ages 6 months through 5 years using 3-day food and beverage diaries," *Journal of the American Dietetic Association*, vol. 103, no. 6, pp. 714–720, 2003.

[58] C. A. Bennett, A. M. de Silva-Sanigorski, M. Nichols, A. C. Bell, and B. A. Swinburn, "Assessing the intake of obesity-related foods and beverages in young children: comparison of a simple population survey with 24 hr-recall," *International Journal of Behavioral Nutrition and Physical Activity*, vol. 6, article 71, 2009.

Dietary patterns of Australian children aged 14 and 24 months and associations with socio-demographic factors and adiposity

European Journal of Clinical Nutrition (2013), 1–8

www.nature.com/ejcn

ORIGINAL ARTICLE

Dietary patterns of Australian children aged 14 and 24 months, and associations with socio-demographic factors and adiposity

LK Bell[1], RK Golley[2], L Daniels[3] and AM Magarey[1]

BACKGROUND/OBJECTIVES: Previous research has shown, in predominantly European populations, that dietary patterns are evident early in life. However, little is known about early-life dietary patterns in Australian children. We aimed to describe dietary patterns of Australian toddlers and their associations with socio-demographic characteristics and adiposity.
SUBJECTS/METHODS: Principal component analysis was applied to 3 days (1 × 24-h recall and 2 × 24-h record) data of 14 ($n=552$)- and 24 ($n=493$)-month-old children from two Australian studies, NOURISH and South Australian Infant Dietary Intake (SAIDI). Associations with dietary patterns were investigated using regression analyses.
RESULTS: Two patterns were identified at both ages. At 14 months, the first pattern was characterised by fruit, grains, vegetables, cheese and nuts/seeds ('14-month core foods') and the second pattern was characterised by white bread, milk, spreads, juice and ice-cream ('basic combination'). Similarly, at 24 months the '24-month core foods' pattern included fruit, vegetables, dairy, nuts/seeds, meat and water, whereas the 'non-core foods' included white bread, spreads, sweetened beverages, snacks, chocolate and processed meat. Lower maternal age and earlier breastfeeding cessation were associated with higher 'basic combination' and 'non-core foods' pattern scores, whereas earlier and later solid introduction were associated with higher 'basic combination' and '24-month core foods' pattern scores, respectively. Patterns were not associated with body mass index (BMI) *z*-score.
CONCLUSIONS: Dietary patterns reflecting core and non-core food intake are identifiable in Australian toddlers. These findings support the need to intervene early with parents to promote healthy eating in children and can inform future investigations on the effects of early diet on long-term health.

European Journal of Clinical Nutrition advance online publication, 27 February 2013; doi:10.1038/ejcn.2013.23

Keywords: dietary patterns; PCA; Australia; socio-demographic; BMI

INTRODUCTION

Nutritional research has expanded to consider whole diet in addition to individual nutrients and foods.[1] Summarising multiple dietary components into an overall diet measure takes into account correlations between dietary constituents by exploring the effect of food combinations.[1,2]

Whole-diet measures can be based on food intake assessed against a pre-determined index, or empirically, whereby variables are reduced into a small number of components through statistical manipulation.[1] For example, factor analysis is used to derive a dietary pattern score reflecting foods that correlate with each other.[3] In adults, and less so in children,[4] dietary patterns have been shown to be associated with health outcomes[4–8] and socio-demographic factors.[4,8]

Although early life is a significant period when dietary preferences and habits are first established, laying the foundation of adult eating habits,[9–12] whole of diet patterns have rarely been characterised in children under 2 years.[4] As dietary patterns are likely to be age-specific, understanding early-life dietary patterns, their determinants and their influence on later health is important for developing strategies to improve nutrition in early childhood. Principal Component Analysis (PCA) is a common type of factor analysis technique[2] that has shown healthy and unhealthy patterns in the first years of life to be associated with adiposity measures,[13] later IQ,[13,14] and maternal age and education level.[3,14–16] However, these patterns have been characterised in predominantly European populations.[3,14–17]

To our knowledge, no studies have described PCA-derived dietary patterns of Australian toddlers. Given that dietary pattern analyses are data-dependent, and thus not generalisable to other populations, understanding Australian early-life dietary patterns and their predictors is important. Further, considering that in 2007 21% and 18% of Australian boys and girls, respectively, aged 2–3 years, were reported as being overweight,[18] it is of interest to investigate whether early-life dietary patterns predict adiposity.

We aimed to (1) describe dietary patterns of Australian children aged 14 and 24 months; (2) identify the socio-demographic determinants of observed dietary patterns; and (3) examine associations between dietary patterns and child adiposity.

MATERIALS AND METHODS

Study sample

This study is a secondary analysis of data collected as part of the NOURISH and South Australian Infant Dietary Intake (SAIDI) studies. NOURISH was a multi-site (Brisbane and Adelaide, Australia) obesity prevention, randomised controlled trial, targeting first-time mothers.[19] SAIDI was a concurrent longitudinal study of infant and toddler dietary intake.

[1]Nutrition and Dietetics, Flinders Clinical and Molecular Medicine, School of Medicine, Flinders Medical Centre, Flinders University, Adelaide, SA, Australia; [2]Public Health Group, Sansom Institute of Health Research, School of Health Sciences, University of South Australia, Adelaide, SA, Australia and [3]School of Exercise and Nutrition Sciences, Queensland University of Technology, Brisbane, Queensland, Australia. Correspondence: LK Bell, Nutrition and Dietetics, Flinders Clinical and Molecular Medicine, School of Medicine, Flinders Medical Centre, Flinders University, Level 7E107, Flinders Drive, Bedford Park, Adelaide, South Australia 5042, Australia.
E-mail: lucy.bell@flinders.edu.au
Received 17 October 2012; revised 5 December 2012; accepted 10 January 2013

Common recruitment, assessment and dietary intake protocols were used for both studies. Subjects were recruited between March 2008 and April 2009 (NOURISH), and September 2008 and March 2009 (SAIDI) in a two-stage process; mothers delivering healthy infants (⩾37 weeks gestation, ⩾2500 g) were approached for permission to be re-contacted approximately 3 months later for full enrolment in the study when written informed consent was obtained. For the present analysis, subjects exposed to the NOURISH intervention were ineligible. Thus, participants are NOURISH controls and SAIDI mother–child dyads. Ethics approval was obtained from Flinders Medical Centre, Queensland University of Technology, and the ethics committees required to cover all recruitment sites.

Data collection and entry

Data were collected at two points; when children were aged approximately 13–16 and 22–25 months.

Dietary data. Primary caregivers were phone-interviewed by a dietitian trained in a standard protocol about their child's food and beverage intake, using a multiple-pass 24-h recall.[20] Times not suitable to be called were previously identified to maximise successful contact, whilst avoiding primary caregivers knowing when they would be called to ensure feeding on the day recalled was usual practice. For dishes prepared at home, recipes with ingredient quantities and the amount that the child consumed were recalled. For breastfeeds, time (in minutes) the child spent suckling was recorded, and breast milk consumption was quantified as 10 g/min to a maximum of 10 min per feed.[21] Post interview, primary caregivers were allocated 2 days on which to record their child's food and beverage intake in a food diary, thus providing 3 days of dietary intake (2 weekdays and 1 weekend day). Measuring spoons and a measuring sheet with life-size images of spoon, cup and bottle sizes were provided to assist with estimating serve sizes for recalls and records.

Data were entered by dietitians into FoodWorks Professional[22] version 9, using AUSNUT 2007 database from the National Children's Nutrition and Physical Activity Survey.[23] Additional commercial infant food and formula product data were sourced from websites, the companies or nutrient information panels. Foods entered into FoodWorks have an eight-digit code (available from Food Standards Australia New Zealand for all items in the AUSNUT 2007 database[23]), which allows categorisation of foods into food groups. Additional new foods were assigned an appropriate code. Unclear coding decisions were discussed between study investigators and managed by a single dietitian. For recipes including items from several food groups, this code was based on the item that made the greatest contribution by weight while also reflecting that it was a mixed dish. Although macro- and micro-nutrient data are provided for all foods in the AUSNUT 2007 database, the complete nutrient profile was often not available for additional infant products. A comprehensive data-cleaning protocol included assessing reasonability of food and beverage quantities, and checking for extreme energy and nutrient intakes. Data were exported from FoodWorks into Access, merged with the food code and exported into SPSS (SPSS Inc., Chicago, IL, USA).

Anthropometric data. Child weight (to the nearest 10 g, 13–16 months, or 50 g, 22–25 months) and length/height (to the nearest 0.5 cm, 13–16 months, or 0.1 cm, 22–25 months) were measured without clothing (13–16 months) or without shoes and heavy garments (22–25 months) by trained study staff at an assessment appointment. If unable to attend an appointment, children were weighed and measured at their local Child Health Clinic or general practitioner (approximately 17%). Body mass index (BMI, kg/m^2) was calculated and converted to age- and sex-specific z-scores using a computer programme containing World Health Organisation reference data.[24]

Child and maternal socio-demographic data. At birth, child gender and maternal parity were collected from medical records. Maternal age, education, country of birth, marital status and self-report pre-pregnancy weight status were collected via questionnaire. Maternal education was reported as the highest completed level of six categories and collapsed into three (Table 1). Marital status and maternal weight status were reported from five and three categories, respectively, and collapsed into two (Table 1). At 13–16 and 22–25 months, maternal smoking status, age of introduction to solids and breastfeeding status (yes/no), including age of breastfeeding cessation if applicable, were obtained via questionnaire. Information from both times was combined to provide complete data.

Table 1. Characteristics of mother–child dyads included in PCA analysis at 14 and 24 months

	14 months (n = 552)	*24 months (n = 493)*
Maternal characteristics		
Age at child's birth (years)[a]	31.2 (5.1)	31.3 (5.0)
Highest education level[b]		
School	126 (23)	104 (21)
Trade/TAFE	153 (28)	128 (26)
University	273 (49)	261 (53)
Smoking status[c]		
Never smoked	417 (75)	366 (74)
Quit	37 (7)	25 (5)
Current smoker	32 (6)	31 (6)
Not recorded/missing	66 (12)	71 (14)
Marital status[d]		
Not partnered	23 (4)	16 (3)
Partnered	527 (96)	476 (97)
Not recorded/missing	2 (0)	1 (0)
Weight status[e]		
Not overweight	438 (79)	386 (78)
Overweight	111 (20)	104 (21)
Not recorded/missing	3 (1)	3 (1)
Parity		
Primiparous	364 (66)	331 (67)
Multiparous	184 (33)	158 (32)
Not recorded/missing	4 (1)	4 (1)
SEIFA decile[a,f]	6.3 (2.8)	6.3 (2.8)
Born in Australia		
Yes	473 (86)	417 (85)
No	77 (14)	74 (15)
Not recorded/missing	2 (0)	2 (0)
Study		
NOURISH	286 (52)	267 (54)
SAIDI	266 (48)	226 (46)
Child characteristics		
Gender		
Boys	254 (46)	227 (46)
Age (months)[a]	13.7 (1.2)	23.6 (1.1)
Age of introduction to solids (weeks)[a,g]	20.9 (5.1)	20.8 (5.1)
Breastfeeding duration		
Never breastfed	18 (3)	14 (3)
Up to 6 months	187 (34)	164 (33)
6–12 months	158 (29)	147 (30)
Longer than 12 months	158 (29)	151 (31)
Not recorded/missing	31 (6)	17 (3)

Abbreviations: PCA, Principal Component Analysis; TAFE, Technical and Further Education; SEIFA, Socio-Economic Index for Areas; SAIDI, South Australian Infant Dietary Intake; IRSAD, Index of Relative Socio-Economic Advantage and Disadvantage. [a]Values are presented as mean (s.d.). All other values are presented as number (%). [b]Reported at consent and categorised as: (1) school (less than age 10 years, 10/11 years, 12 years), (2) trade/TAFE (trade/apprenticeship, TAFE/college certificate), (3) university (university degree). [c]Reported at each time and categorised as: (1) never smoked (do not smoke at all), (2) quit (used to smoke but no longer do so), (3) current smoker (less than once/day, at least once/day). [d]Reported at consent and categorised as: (1) not partnered (single/never married, separated/divorced, widowed), (2) partnered (*de facto*, married). [e]Reported at consent and categorised as: (1) not overweight (underweight, normal weight), (2) overweight (overweight). [f]SEIFA decile categorised by applying the IRSAD to postal code,[25] reported at consent. [g]Missing/not reported = 12.

Breastfeeding data were categorised into four categories reflecting duration (Table 1). Smoking status was reported from four categories and collapsed into three (Table 1). Child age at each time was calculated using date of birth and the respective recall date. The Index of Relative Socio-Economic Advantage and Disadvantage, one of four Socio-Economic Index for Areas indices that rank geographic areas across Australia, was applied to postal code. The Index of Relative Socio-Economic Advantage and Disadvantage scores areas on a continuum of disadvantage (lowest score, 1) to advantage (highest score, 10),[25] providing a Socio-Economic Index for Areas decile.

Dietary pattern analysis

Food grouping. The large number of foods and beverage items consumed (1621, 13–16 months; 1967, 22–25 months) were grouped into interpretable and meaningful categories to use as input variables for PCA. First, dietary supplements and cooking agents (for example, gelatin, wine) were eliminated as they do not represent children's usual intake. Second, foods were grouped into food groups of interest based on their nutrient profiles, recommendations for consumption according to the Australian dietary guidelines[26] and the accompanying Australian Guide to Healthy Eating,[27] and the new Australian Food Modelling System categorisation.[28] Foods recommended to be consumed every day are described as 'core' foods, covering five core food groups (fruits; vegetables/legumes; breads/cereals/rice/pasta/noodles; lean meat/fish/poultry/eggs/nuts/legumes; milk/yoghurt/cheese).[26,27] Foods not included in the core food groups are described as 'non-core' (that is, energy-dense, low-nutrient) foods. Sixty-nine food groups at 13–16 months and 73 groups at 22–25 months were created and included in the analysis (Supplementary Table S1).

Principal component analysis. Dietary patterns were extracted using PCA. All dietary data (14/24 months; 1 day $n=136/122$, 2 days $n=7/7$ and 3 days $n=409/364$) were kept in the analysis. Two and three days data were averaged and daily food (g), energy and nutrient intake determined per person. To determine whether a meaningful PCA could be performed several factors (correlation matrix, Kaiser–Meyer–Olkin measure of sampling adequacy, Bartlett's test of sphericity, communalities) were inspected.[29] All criteria were sufficient, indicating all variables contributed to extracted dietary patterns, and thus no variables (that is, food groups) were eliminated for subsequent analysis. Orthogonal (Varimax) rotation was applied to aid interpretability of the pattern loadings by maximising the variance within components and thus making them more distinguishable. The number of dietary patterns identified was based on eigenvalues >1.5, identification of a break point in the scree plot and interpretability.[3,30] Potential PCA solutions were assessed for strength of loadings of food items on and across components. For every participant, a dietary pattern score for each identified pattern was determined by summing the product of a standardised gram of each item consumed by its factor loading. Patterns were approximately normally distributed (mean 0, s.d. 1). To aid interpretation, patterns were named based on those foods loading ≥ 0.25.

Statistical analysis

Statistical analyses were conducted using SPSS version 19.0 (SPSS Inc.). Data are presented as means (s.d.) where normally distributed, or as medians (interquartile range) where not. Validity of dietary patterns was investigated by comparing food, energy and energy-adjusted nutrient intakes across quartiles of dietary pattern scores using Kruskal–Wallis test for non-parametric data. Analyses were conducted on all available nutrient data. Standard linear regression was employed to investigate the relationship of dietary patterns with socio-demographic characteristics and BMI z-score. For each time, two regression models were used, which included (1) socio-demographic covariates and respective dietary pattern scores; (2) dietary patterns scores and respective BMI z-scores, adjusting for covariates. The final regression model included 14-month dietary pattern scores and 24-month BMI z-scores, adjusting for covariates. For each model, univariate and multivariate associations were explored. Regression assumptions were tested by checking the normality, linearity and variance (homoscedasticity) of residuals.[30] Standardised regression coefficients (β) and 95% confidence intervals were used to evaluate the strength and precision of associations. The level of significance was set at $P<0.05$.

RESULTS

Dietary intake data were provided for 552 and 493 children (54% girls at both times) at 14 (10–17) months and 24 (22–28) months, respectively. Participant characteristics are reported in Table 1. Mothers were mostly university educated, partnered, not overweight, born in Australia, primiparous and had never smoked.

Dietary patterns

At 14 months, two patterns were extracted (Table 2). The first pattern was termed '14-month core foods' as fruit, grains, non-white bread, vegetables, cheese, eggs, and nuts and seeds loaded positively. The second pattern included basic core (white bread, milk) and non-core (spreads, juice and frozen milk products, for example, ice-cream) foods and beverages, with no fruit or vegetables, and was therefore termed 'basic combination'. Similarly, two distinct patterns were extracted at 24 months (Table 2). The first pattern was similar to that at 14 months, with several foods covering all core food groups, in addition to water, loading positively, and was therefore named '24-month core foods'. The second pattern was labelled 'non-core foods', as it included sweetened beverages, spreads, high-fat potatoes, snack products, chocolate and processed meat.

Construct validity of dietary patterns

To assess the validity of identified dietary patterns, their underlying nutrient profiles were examined (Table 3). Consistent associations were seen across ages. The '14-month core foods' and '24-month core foods' patterns were positively associated with intake of energy, protein, dietary fibre and several micronutrients. Conversely, the 'basic combination' and 'non-core foods' patterns at 14 and 24 months, respectively, were positively associated with energy and sodium intake, and negatively associated with iron intake. In addition, the '24-month core foods' pattern was positively associated with iron and negatively associated with fat intake, whereas the 'non-core foods' pattern was negatively associated with dietary fibre intake.

Dietary patterns and socio-demographic characteristics

After adjustment for covariates several maternal (age, education, smoking status, country of birth, study) and child (age, breastfeeding duration, age of introduction to solids) factors were independently associated with 14- and/or 24-month pattern scores (Table 4; non-significant variables not shown). For example, a maternal university education was associated with a 0.12 (95% confidence interval 0.04, 0.28) higher '14-month core foods' pattern score than a maternal school-level education. Higher scores on this pattern at 14 months were also associated with longer breastfeeding duration and older children at assessment, whereas higher scores on the '24-month core foods' pattern were associated with later solid introduction and Australian-born mothers. Conversely, 'basic combination' pattern scores at 14 months were positively associated with younger mothers, smoking mothers, SAIDI participants, older children at assessment and earlier solid introduction and breastfeeding cessation. Younger mothers and earlier breastfeeding cessation also predicted higher scores on the 'non-core foods' pattern at 24 months.

Dietary patterns and adiposity

Median BMI z-scores at 14 and 24 months were 0.41 (interquartile range -0.24, 1.03) and 0.78 (interquartile range 0.05, 1.51), respectively. After adjustment for covariates, dietary pattern scores at both ages were not significantly associated with concurrent or subsequent BMI z-scores (Table 5).

DISCUSSION

This study enhances the small body of literature on dietary patterns in early life, describing the dietary patterns of Australian toddlers aged 14 and 24 months, and their association with socio-demographic factors and child adiposity.

Two dietary patterns were identified in 14- and 24-month-old children representing core (rich in fruits, vegetables and grains) and non-core (low-fibre, fatty and sugary foods and beverages)

Table 2. Varimax-rotated food group loadings on each of the two dietary patterns extracted by PCA analysis at 14 and 24 months[a]

Foods[f]	*14 months*[b] (n = 552)			*24 months*[c] (n = 493)		
	n (%)[d]	*Dietary patterns*[e]		n (%)[d]	*Dietary patterns*[e]	
		14-month core foods	*Basic combination*		*24-month core foods*	*Non-core foods*
Infant meat-based dinners	126 (23)	**−0.50**	−0.19	15 (3)	0.02	−0.02
Fruit: fresh	506 (92)	**0.48**	−0.05	453 (92)	**0.47**	−0.01
Infant fruit-based desserts	135 (24)	**−0.47**	−0.25	46 (9)	−0.11	−0.03
Flours and grains	226 (41)	**0.47**	**−0.36**	220 (45)	0.04	**−0.37**
Formula	188 (34)	**−0.35**	**−0.26**	56 (11)	−0.08	−0.11
Bread: non-white	291 (53)	**0.35**	−0.03	287 (58)	**0.32**	−0.16
Infant vegetable-based dinners	41 (7)	**−0.33**	−0.15	5 (1)	−0.06	−0.03
Infant milk-based desserts	163 (30)	**−0.32**	−0.15	159 (32)	−0.21	−0.03
Vegetables: other	387 (70)	**0.30**	−0.15	356 (72)	**0.41**	−0.16
Cheese	394 (71)	**0.30**	0.12	390 (79)	0.20	−0.07
Butter	194 (35)	**0.29**	−0.06	156 (32)	0.10	−0.11
Eggs	166 (30)	**0.29**	−0.15	157 (32)	0.00	0.07
Oil	95 (17)	**0.29**	−0.21	91 (18)	−0.09	0.02
Nuts and seeds	72 (13)	**0.26**	−0.19	126 (26)	**0.37**	−0.17
Infant cereal products	87 (16)	**−0.26**	−0.13	12 (2)	−0.01	−0.16
Poultry and feathered game	175 (32)	0.23	0.03	161 (33)	0.19	0.07
Vegetables: green and brassica	299 (54)	0.22	−0.03	254 (52)	**0.45**	0.10
Pasta	211 (38)	0.20	0.18	212 (43)	−0.10	0.02
Water	534 (97)	0.20	0.15	481 (98)	**0.32**	0.24
Potatoes: high fat	102 (18)	−0.20	0.17	137 (28)	−0.21	**0.30**
Meat: muscle, game and organ	211 (38)	0.20	0.13	177 (36)	**0.30**	0.08
Potatoes: low fat	267 (48)	0.18	0.07	188 (38)	**0.31**	0.06
Other beverages	16 (3)	−0.17	0.01	52 (11)	0.24	0.13
Chocolate and chocolate products	34 (6)	0.16	0.05	92 (19)	−0.11	**0.29**
Vegetables: orange	352 (64)	0.15	0.02	258 (52)	**0.51**	0.04
Dairy yoghurt: whole fat	269 (49)	0.15	0.00	160 (32)	**0.30**	−0.16
Tea and coffee	7 (1)	0.15	−0.01	23 (5)	−0.07	−0.05
Custard	64 (12)	−0.11	0.04	47 (10)	**0.31**	−0.08
Flavourings	135 (24)	0.09	−0.08	149 (30)	−0.01	−0.07
Vegetables: home-style MD	149 (27)	0.09	−0.02	153 (31)	−0.08	**−0.26**
Soup	45 (8)	0.06	−0.03	48 (10)	−0.07	−0.15
Fish and seafood: packaged	57 (10)	0.05	−0.03	38 (8)	0.17	−0.03
Bread: white	272 (49)	−0.03	**0.48**	273 (55)	0.01	**0.60**
Dairy milk: whole fat	445 (81)	0.07	**0.43**	430 (87)	−0.10	−0.16
Margarine and table spreads	174 (32)	0.07	**0.43**	223 (45)	0.18	**0.46**
Fruit and vegetable juice	109 (20)	−0.02	**0.38**	224 (45)	−0.14	**0.41**
Vegemite-type spreads	280 (51)	0.09	**0.38**	247 (50)	0.15	**0.37**
Breast milk	132 (24)	0.12	**−0.32**	35 (7)	−0.04	−0.02
Fish and seafood: fresh	71 (13)	0.24	**−0.27**	56 (11)	0.18	−0.03
Frozen milk products	57 (10)	0.00	**0.25**	133 (27)	−0.01	0.05
Breakfast cereal: cold type	384 (70)	0.10	0.25	384 (78)	0.19	**−0.31**
Processed meat	231 (42)	0.08	0.23	286 (58)	0.04	**0.28**
Sugar and sugar products	183 (33)	0.03	0.23	272 (55)	0.20	0.13
Savoury sauces and condiments	161 (29)	0.08	0.22	253 (51)	0.07	0.17
Pastries	67 (12)	−0.04	0.21	108 (22)	−0.10	−0.04
Breakfast cereal: hot type	29 (5)	0.10	−0.20	23 (5)	0.04	−0.13
Cordial and soft drink	22 (4)	−0.10	0.20	71 (14)	−0.07	**0.48**
Cereal: home-style MD	152 (28)	0.03	0.19	160 (32)	0.06	0.15
Infant drinks	19 (3)	0.02	0.19	12 (2)	−0.03	−0.06
Cereal, fruit and nut bars	74 (13)	0.00	0.18	109 (22)	−0.12	0.11
Legumes and pulses	29 (5)	0.15	−0.17	11 (2)	0.05	−0.13
Sweet biscuits and cakes	326 (59)	0.05	0.17	345 (70)	−0.07	0.03
Bread: other	141 (26)	0.10	−0.16	138 (28)	−0.09	−0.14
Other dairy products	40 (7)	0.06	0.16	84 (17)	−0.18	0.17
Confectionary	13 (2)	−0.08	0.14	82 (17)	−0.02	0.24
Meat: home-style MD	78 (14)	0.02	0.03	81 (16)	0.02	−0.17
Snack products	38 (7)	−0.02	0.03	109 (22)	−0.06	**0.29**
Poultry: home-style MD	88 (16)	−0.01	0.02	50 (10)	−0.14	−0.15
Cereal: take away-style MD[g]	—	—	—	39 (8)	−0.21	0.02
Poultry: high-fat MD[g]	—	—	—	89 (18)	−0.19	0.18
Fruit: dried[g]	—	—	—	215 (44)	0.16	−0.10
Fish and seafood: home-style MD[g]	—	—	—	15 (15)	0.15	−0.02

Abbreviations: MD, mixed dishes; PCA, Principal Component Analysis. [a]In interest of table length, foods loading < 0.15 across all patterns are not shown. These are legume and pulse MD, infant gels, fish and seafood: high fat, savoury biscuits, infant desserts: other, dairy milk: reduced fat, dairy yoghurt: reduced fat, dairy alternatives, dairy blends, fruit: home-style MD, fruit: packaged, meat: high-fat MD. [b]Total number of food groups included in the PCA; 69. [c]Total number of food groups included in the PCA; 74. [d]Total number of respondents who consumed food. [e]Loadings ⩾0.25 in bold to aid labelling of dietary patterns. [f]Food variables entered into PCA as g/day. [g]Food group at 24 months only.

intake. Each pattern shares similarities with identified patterns in equivalent aged European populations. The '14-month core foods' pattern is similar to the 'infant guidelines' pattern extracted in the 12-month Southampton Women's Study cohort[15] and comparable to the 'herbs, raw fruit and vegetables' (Avon Longitudinal Study of Parents and Children sample, 15 months[3]), 'wholesome'

Table 3. Median (IQR) of energy-adjusted nutrient intakes across quartiles of PCA-derived dietary pattern scores in 14 ($n = 552$)- and 24 ($n = 493$)-month-old children[a]

Nutrient	*Quartiles of dietary pattern score*[a]				*P-value*
	Q1		*Q4*		
	Median	*IQR*	*Median*	*IQR*	
n	138		138		
14-month core foods					
Total energy intake (kJ)	3787	3319–4352	4653	4069–5201	<0.001
Protein (%E)	15.7	14.1–17.8	17.8	16.1–20.3	<0.001
CHO (%E)	48.2	43.9–52.0	45.4	41.5–48.3	<0.001
Fibre (g/MJ)	2.0	1.5–2.5	2.9	2.3–3.5	<0.001
Iron (mg/MJ)	1.8	1–2.7	1.4	1.1–1.8	0.001
Calcium (mg/MJ)	184	140–219	153	130–192	<0.001
Sodium (mg/MJ)	178	150–223	217	173–276	<0.001
Vitamin C (mg/MJ)	12.4	6.6–19.7	11.6	8.5–17.2	0.028
Vitamin A (RE/MJ)	124	98–166	142	111–191	0.033
Total folate (μg/MJ)	42.7	33.2–57.8	51.8	46.3–66	<0.001
Potassium (mg/MJ)	371	310–420	420	362–485	<0.001
Basic combination					
Total energy intake (kJ)	3833	3331–4440	4588	4133–5413	<0.001
Protein (%E)	15.6	13.8–17.8	18.1	16.7–20.1	<0.001
CHO (%E)	47.8	44.0–51.7	45.5	41.6–48.8	0.002
Iron (mg/MJ)	1.7	1.1–2.4	1.3	1.0–1.6	<0.001
Calcium (mg/MJ)	150	117–199	167	141–199	<0.001
Sodium (mg/MJ)	175	143–220	254	219–299	<0.001
Vitamin C (mg/MJ)	13.9	9.8–20.1	7.9	4.7–13.8	<0.001
Thiamin (mg/MJ)	0.2	0.1–0.3	0.3	0.2–0.4	0.001
Riboflavin (mg/MJ)	0.3	0.3–0.4	0.5	0.4–0.6	<0.001
Total folate (μg/MJ)	42.3	35.2–53.5	59.8	45.9–82.8	<0.001
Potassium (mg/MJ)	382	314–444	403	355–465	0.025
n		123		124	
24-month core foods					
Total energy intake (kJ)	4616	3981–5103	5287	4650–6315	<0.001
Protein (%E)	16.4	14.9–18.5	18.2	16.1–20.0	<0.001
Fat (%E)	34.1	31.0–37.9	31.2	27.5–34.1	<0.001
Fibre (g/MJ)	1.9	1.6–2.4	2.9	2.4–3.5	<0.001
Iron (mg/MJ)	1.1	0.8–1.4	1.4	1.1–1.7	<0.001
Vitamin C (mg/MJ)	8.1	3.5–14.1	12.1	8.0–17.4	<0.001
Vitamin A (RE/MJ)	104	81–124	125	102–151	<0.001
Thiamin (mg/MJ)	0.2	0.1–0.3	0.2	0.2–0.3	<0.001
Total folate (μg/MJ)	44.5	33.9–58.8	53.0	44.5–72.3	<0.001
Potassium (mg/MJ)	345	301–387	427	388–472	<0.001
Non-core foods					
Total energy intake (kJ)	4815	4301–5590	4939	4483–5920	<0.001
Protein (%E)	17.9	15.8–19.6	16.8	14.9–18.6	0.030
Fibre (g/MJ)	2.7	2.1–3.3	2.3	1.8–2.8	<0.001
Iron (mg/MJ)	1.3	1.1–1.7	1.2	0.9–1.4	0.003
Calcium (mg/MJ)	170	144–199	131	108–164	<0.001
Sodium (mg/MJ)	237	195–283	289	242–337	<0.001
Vitamin C (mg/MJ)	8.0	4.5–13.5	11.0	5.9–17.7	0.007
Vitamin A (RE/MJ)	117	93–141	104.0	77.5–128.8	0.024
Riboflavin (mg/MJ)	0.4	0.3–0.5	0.4	0.3–0.5	0.009
Total folate (μg/MJ)	46.0	37.4–57.1	53.0	39.6–78.7	0.004
Potassium (mg/MJ)	405	358–449	374	326–421	0.005

Abbreviation: CHO, carbohydrate; IQR, interquartile range; PCA, Principal Component Analysis; Q, quartile; RE, retinol equivalents; %E, per cent energy. [a]Kruskal–Wallis test used to compare differences in total energy intake and energy-adjusted nutrient (protein, fat, carbohydrate, fibre, iron, calcium, sodium, vitamin C, vitamin A, riboflavin, thiamin total folate, potassium) intakes across quartiles of dietary pattern score. In interest of table length, Q2 and Q3, and non-significant ($P > 0.05$) nutrient variables are not shown.

(Norwegian Mother and Baby Cohort, 18 months[14]) and 'health-conscious' (Generation R Study, 14 months[17]) patterns. Likewise, the 'basic combination' pattern at 14 months is consistent with the Generation R Study,[17] 'western-like' and Norwegian Mother and Baby Cohort[14] 'unhealthy' patterns. At 24 months, the '24-month core foods' and 'non-core foods' patterns are similar to the Avon Longitudinal Study of Parents and Children[16] 24-month 'health-conscious' and 'sweet and easy' patterns, respectively. Thus, our findings suggest comparable dietary patterns are evident in similar aged populations of European and Australian toddlers.

Consistent with previous studies that demonstrated tracking of dietary patterns between 6 and 12 months,[15] and 3, 4 and 7 years of age,[31] our study identified similar patterns at 14 and 24 months ('14-month core foods' and '24-month core foods' patterns; 'basic combination' and 'non-core foods' patterns). Beyond 12 months of age, children begin to exert independence in food choices and develop fussy eating behaviours, contributing to rapidly changing day-to-day dietary habits.[32] However, our findings suggest dietary patterns are relatively stable longer-term, supporting the persistence of food preferences and eating habits over time[9,11] and raising concerns for those with poor dietary patterns in early life.

We described the construct validity of extracted dietary patterns in terms of energy and nutrient intakes across quartiles of pattern scores, which confirmed that dietary patterns reflect meaningful differences in underlying combinations of nutrient intake. Few studies have reported this relationship in the first years of life. In children aged 6 and 15 months of age, protective micronutrients (for example, calcium and iron) were associated with healthier dietary patterns and nutrients linked to disease risk (for example, sodium, saturated fat) with less healthy patterns.[33] At 14 months, macronutrient (protein, polysaccharide, saturated fat) intakes were associated with 'health-conscious' and 'western-like' pattern scores in expected directions.[17] Comparing our findings, consistency is evident as healthier patterns were related to better nutrient intakes, including fibre, iron, vitamin A and vitamin C, compared with less healthy patterns. Overall, these relationships can contribute to resolving the controversy around whether data-reduction techniques measure true differences in nutrient density or reflect greater food consumption.[4]

In accordance with other studies, poorer-quality dietary patterns were seen in children of younger mothers[3,15,16] and those breastfeed for shorter durations[15,17] (at both ages), and in children with smoking mothers[13,15] and those introduced to solids earlier[15,34] (at 14 months only). Conversely, higher-quality dietary patterns were associated with highly educated mothers.[3,14–16] Associations between maternal factors and health behaviours, such as diet, are well documented, reflecting the influence of socio-economic disadvantage on health. At 14 months, poorer-quality dietary patterns were further associated with SAIDI participants, likely reflecting the multi-parity of SAIDI mothers and thus the influence of siblings on diet quality, reported elsewhere.[3] The associations of earlier and later breastfeeding cessation and introduction to solids with poorer- and higher-quality dietary patterns, respectively, suggests that maternal feeding practices translate between breastfeeding, weaning and eating patterns. Beyond this, however, these associations may be partially explained by the effect of early feeding experiences on later food and taste acceptance.[35,36] For example, previous research found that earlier solid introduction was associated with liking a greater proportion of non-core foods,[37] and early solid introduction (before 17 weeks of age) predicted introduction of non-core foods by 52 weeks.[34] These findings suggest that mothers who introduce solids early may also introduce non-core foods early, thus escalating the innate preference for and acceptance of sweet and salty foods.[36] Furthermore, earlier breastfeeding cessation has previously been associated with liking a greater proportion of non-core foods,[37] whereas longer breastfeeding duration positively influences children's taste preferences[38] and vegetable intake.[35] This is likely explained by evidence that breastfeeding provides ongoing exposure to a variety of flavours not experienced by formula-fed infants and results in improved later flavour acceptance.[39] Overall, the

Table 4. Associations between dietary patterns and maternal and child characteristics, at 14 and 24 months, after adjustment for covariates[a]

	Dietary patterns 14 months(n = 476)						*Dietary patterns 24 months (n = 410)*					
	14-month core foods			*Basic combination*			*24-month core foods*			*Non-core foods*		
	β	*95% CI*	P-value	β	*95% CI*	P-value	β	*95% CI*	P-value	β	*95% CI*	P-value
Maternal characteristics												
Age at child's birth (years)	0.021	−0.014, 0.023	0.654	−0.150	−0.043, −0.012	0.001	0.035	−0.011, 0.023	0.504	−0.154	−0.042, −0.009	0.003
Highest education level	0.122	0.035, 0.278	0.012	−0.049	−0.161, 0.047	0.279	0.101	−0.003, 0.221	0.058	0.028	−0.078, 0.138	0.584
Smoking status	0.003	−0.163, 0.175	0.944	0.114	0.054, 0.343	0.007	−0.061	−0.248, 0.057	0.220	−0.002	−0.150, 0.143	0.959
Born in Australia						Referent = No						
Yes	−0.045	−0.372, 0.121	0.318	0.060	−0.055, 0.366	0.148	0.141	0.101, 0.582	0.005	0.040	−0.135, 0.327	0.413
Study						Referent = SAIDI						
Nourish	−0.032	−.0133, 0.090	0.703	−0.301	−0.281, −0.090	< 0.001	0.125	−0.053, 0.197	0.258	−0.137	−0.198, 0.042	0.204
Child characteristics												
Age (months)	0.109	0.004, 0.042	0.020	0.177	0.018, 0.051	< 0.001	0.035	−0.021, 0.034	0.625	0.013	−0.024, 0.029	0.857
Age of introduction to solids (weeks)	0.016	−0.020, 0.026	0.784	−0.116	−0.041, −0.001	0.036	0.131	0.001, 0.043	0.041	−0.027	−0.025, 0.016	0.659
Breastfeeding duration	0.232	0.160, 0.366	< 0.001	−0.151	−0.245, −0.070	< 0.001	0.040	−0.058, 0.137	0.429	−0.124	−0.213, −0.025	0.013

Abbreviations: CI, confidence interval; SAIDI, South Australian Infant Dietary Intake; SEIFA, Socio-Economic Index for Areas. [a]Results were obtained from standard linear regression models, with diet pattern score for each age as the dependent variable and all respective covariates as independent predictors. Data are presented as regression model β-coefficients, 95% CIs and *P*-value of significance. Non-significant ($P > 0.05$) maternal (marital status, weight status, parity, SEIFA decile) and child (gender) predictor variables across both ages are not shown. For definitions and categorisation of maternal and child predictor terms, see Table 1.

Table 5. Associations between BMI *z*-score and dietary patterns, at 14 and 24 months, after adjustment for covariates[a]

	BMI z-score 14 months (n = 467)			*BMI z-score 24 months* (n = 404)		
	β	*95% CI*	*P-value*	β	*95% CI*	*P-value*
Dietary patterns at 14 months[b]						
14-month core foods	0.032	−0.060, 0.118	0.521	−0.006	−0.128, 0.113	0.906
Basic combination	−0.002	−0.107, 0.103	0.968	0.029	−0.104, 0.180	0.603
Dietary patterns at 24 months						
24-month core foods	—	—	—	0.075	−0.034, 0.236	0.144
Non-core foods	—	—	—	−0.080	−0.248, 0.033	0.132

Abbreviations: BMI, body mass index; CI, confidence interval; SEIFA, Socio-Economic Index for Areas. [a]Results were obtained from standard linear regression models, with BMI *z*-score for each age as the dependent variable, and all respective dietary pattern scores and covariates as independent predictors. Data are presented as regression model β-coefficients, 95% CIs and *P*-value of significance. Maternal (age, education level, smoking status, marital status, weight status, parity, SEIFA decile, study) and child (age, gender, age of introduction to solids, breastfeeding duration) covariates adjusted for in all analyses. [b]Association between dietary patterns at 14 months and BMI *z*-scores at 24 months, $n = 417$.

association between early feeding practices and dietary patterns may be influenced by maternal choices or by the effect of early dietary exposures on children's food acceptance. Either way, targeting young mothers of potential disadvantage before commencement of early feeding practices may improve their child's eating habits.

Despite the increase in median BMI *z*-scores from 14 to 24 months, we did not show an association between dietary patterns and BMI *z*-scores. Inconsistent results have previously been reported between early-life dietary patterns and measures of adiposity.[40,41] For example, in 12-month-old children dietary patterns were associated with lean mass but not with other adiposity measures, including BMI.[13] Although weight status is not only influenced by diet, but by genetic, behavioural (for example, activity levels) and environmental factors (for example, parent–child interaction),[42] a possible explanation for our findings is that each pattern at both ages was positively associated with total energy intake. This supports evidence that children can respond to the energy density of foods consumed and regulate their daily energy intake.[43] Further, it may be too early to detect the influence of diet on weight status as previous research has shown that weight gain from birth—2 years is largely influenced by intrauterine factors,[44] with the effect of environmental factors not manifesting until 2–5 years,[44,45] and that weight gain between 2–11 years may be a more important predictor of obesity risk than BMI at 2 years.[46] Therefore, continuation of a non-nutritious dietary pattern beyond 2 years may lead to a clear distinction in weight status across the population later, and thus investigating this association longitudinally is warranted.

A limitation of the present study is our highly educated sample of mothers who may have greater knowledge of dietary recommendations and thus may have reported more favourable dietary intakes.[47] In addition, associations of dietary patterns with socio-demographic variables and BMI *z*-scores may be influenced by missing data or by evaluating associations in different time periods (for example, maternal weight status reported post-birth and diet reported at 14 and 24 months). Another consideration is that approximately one-fifth of child anthropometric data were collected by general practitioners or child health nurses, not by study staff, and thus accuracy is questionable. Nevertheless, our study is strengthened by investigation of dietary patterns at two different ages in one sample and derivation of patterns from recall and record data compared with food frequency questionnaires[3,14–17] that often lack portion sizes, as the former methods provide comprehensive energy and nutrient data from which construct validity can be assessed.

In conclusion, dietary patterns reflecting core and non-core food intake can be described in Australian toddlers and are influenced by maternal age, breastfeeding duration and age of introduction to solids in expected directions. Although we did not find an association between children's dietary patterns and adiposity, it is of concern that dietary patterns characterised by non-nutritious foods were identified at this young age. These findings support the need to intervene early with parents to promote healthy eating in children and establish positive life-long eating behaviours. Further longitudinal studies are warranted to provide evidence of associations of dietary patterns with adiposity beyond 2 years and with a broader range of health outcomes.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

ACKNOWLEDGEMENTS

We thank all families who willingly gave up their time to participate in the NOURISH and SAIDI studies. We thank the study teams for their assistance in recruitment, data collection and entry, in particular the Flinders University research staff Dr Rebecca Perry, Chelsea Mauch, Kylie Markow and Rachel Elovaris, and the Queensland University of Technology research staff Jo Meedeniya and Rebecca Byrne. We also thank Meat and Livestock Australia who provided financial support for both studies. Fundings were obtained from the National Health and Medical Research Council of Australia (426704, NOURISH) and SA Health (SAIDI). RKG is supported by a National Heart Foundation Fellowship and LKB by an Australian Postgraduate Award (APA).

REFERENCES

1 Hu FB. Dietary pattern analysis: a new direction in nutritional epidemiology. *Curr Opin Lipidol* 2002; **13**: 3–9.
2 Moeller SM, Reedy J, Millen AE, Dixon LB, Newby PK, Tucker KL *et al.* Dietary patterns: challenges and opportunities in dietary patterns research an Experimental Biology workshop, April 1, 2006. *J Am Diet Assoc* 2007; **107**: 1233–1239.
3 Smithers LG, Brazionis L, Golley RK, Mittinty MN, Northstone K, Emmett P *et al.* Associations between dietary patterns at 6 and 15 months of age and socio-demographic factors. *Eur J Clin Nutr* 2012; **66**: 658–666.
4 Smithers LG, Golley RK, Brazionis L, Lynch J. Methods for characterizing the diets of children under five and their association with nutrition and health outcomes: a systematic review. *Nutr Rev* 2011; **69**: 449–467.
5 Newby PK, Tucker KL. Empirically derived eating patterns using factor or cluster analysis: a review. *Nutr Rev* 2004; **62**: 177–203.
6 Brennan SF, Cantwell MM, Cardwell CR, Velentzis LS, Woodside JV. Dietary patterns and breast cancer risk: a systematic review and meta-analysis. *Am J Clin Nutr* 2010; **91**: 1294–1302.
7 Kant AK. Dietary patterns: biomarkers and chronic disease risk. *Appl Physiol Nutr Metab* 2010; **35**: 199–206.
8 Kant AK. Dietary patterns and health outcomes. *J Am Diet Assoc* 2004; **104**: 615–635.
9 Birch L, Savage JS, Ventura A. Influences on the development of children's eating behaviours: from infancy to adolescence. *Can J Diet Pract Res* 2007; **68**: s1–s56.

10 Devine CM. A life course perspective: understanding food choices in time, social location, and history. *J Nutr Educ Behav* 2005; **37**: 121–128.
11 Birch LL. Development of food preferences. *Annu Rev Nutr* 1999; **19**: 41–62.
12 Drewnowski A. Taste preferences and food intake. *Annu Rev Nutr* 1997; **17**: 237–253.
13 Robinson SM, Marriott LD, Crozier SR, Harvey NC, Gale CR, Inskip HM *et al.* Variations in infant feeding practice are associated with body composition in childhood: a prospective cohort study. *J Clin Endocrinol Metab* 2009; **94**: 2799–8050.
14 Ystrom E, Niegel S, Vollrath ME. The impact of maternal negative affectivity on dietary patterns of 18-month-old children in the Norwegian Mother and Child Cohort Study. *Matern Child Nutr* 2009; **5**: 234–242.
15 Robinson S, Marriott L, Poole J, Crozier S, Borland S, Lawrence W *et al.* Dietary patterns in infancy: the importance of maternal and family influences on feeding practice. *Br J Nutr* 2007; **98**: 1029–1037.
16 Northstone K, Emmett P. The associations between feeding difficulties and behaviours and dietary patterns at 2 years of age: the ALSPAC cohort. *Matern Child Nutr* 2012; e-pub ahead of print 29 March 2012; doi:10.1111/j.740-8709.2012.00399.x.
17 Kiefte-de Jong JC, de Vries JH, Bleeker SE, Jaddoe VW, Hofman A, Raat H *et al.* Socio-demographic and lifestyle determinants of 'Western-like' and 'Health conscious' dietary patterns in toddlers. *Br J Nutr* 2013; **109**: 137–147.
18 Commonwealth Scientific and Industrial Research Organisation (CSIRO). *2007 Australian National Children's Nutrition and Physical Activity Survey: Main Findings*. Australian Government Publishing Service: Canberra, ACT, Australia, 2008.
19 Daniels LA, Magarey A, Battistutta D, Nicholson JM, Farrell A, Davidson G *et al.* The NOURISH randomised control trial: positive feeding practices and food preferences in early childhood—a primary prevention program for childhood obesity. *BMC Public Health* 2009; **14**: 387.
20 Jonnalagadda SS, Mitchell DC, Smiciklas-Wright H, Meaker KB, Van Heel N, Karmally W *et al.* Accuracy of energy intake data estimated by a multiple-pass, 24-hour dietary recall technique. *J Am Diet Assoc* 2000; **100**: 303–311.
21 Noble S, Emmett P. Food and nutrient intake in a cohort of 8-month-old infants in the south-west of England in 1993. *Eur J Clin Nutr* 2001; **55**: 698–707.
22 Xyris Software. FoodWorks 7 (cited 27 November 2012); available from http://www.xyris.com.au/ 2012.
23 Food Standards Australia New Zealand (FSANZ). *AUSNUT 2007—Australian Food Supplement and Nutrient Database for Estimation of Population Nutrient Intakes*. Australian Government Publishing Service: Canberra, ACT, Australia, 2008.
24 World Health Organisation (WHO). *WHO Child Growth Standards. Length/Height-for-Age, Weight-for-Age, Weight-for-Length, Weight-for-Height and Body Mass Index-for-Age: Methods and Development.* World Health Organisation (WHO): Geneva, 2006.
25 Australian Bureau of Statistics (ABS). *Information Paper: An Introduction to Socio-Economic Indexes for Areas (SEIFA). Report no. 2039.0*. Australian Bureau of Statistics: Canberra, ACT, Australia, 2006.
26 National Health and Medical Research Council (NHMRC). *Dietary Guidelines for Children and Adolescents in Australia; Incorporating the Infant Feeding Guidelines for Health Workers*. Australian Government Publishing Service: Canberra, ACT, Australia, 2003.
27 Kellet L, Smith A, Schmerlaib Y. *Australian Guide to Healthy Eating (AGHE)*. Commonwealth Department of Health and Family Services: Canberra, 1998.
28 National Health and Medical Research Council (NHMRC). *A Modelling System to Inform the Revision of the Australian Guide to Healthy Eating*. Australian Government Publishing Service: Canberra, ACT, Australia, 2011.
29 David Garson G. *Factor Analysis*. Statistical Associates Publishers: North Carolina, 2012.
30 Pallant J. *SPSS Survival Manual: A Step by Step Guide to Data Analysis Using SPSS*. 4th edn, Allen & Unwin: Crows Nest, NSW, Australia, 2011.
31 Northstone K, Emmett P. Multivariate analysis of diet in children at four and seven years of age and associations with socio-demographic characteristics. *Eur J Clin Nutr* 2005; **59**: 751–760.
32 Cowbrough K. Feeding the toddler: 12 months to 3 years—challenges and opportunities. *J Fam Health Care* 2010; **20**: 49–52.
33 Smithers LG, Golley RK, Brazionis L, Emmett P, Northstone K, Lynch J. Dietary patterns of infants and toddlers are associated with nutrient intakes. *Nutrients* 2012; **4**: 935–948.
34 Koh GA, Scott JA, Oddy WH, Graham KI, Binns CW. Exposure to non-core foods and beverages in the first year of life: results from a cohort study. *A J Nutr Diet* 2010; **67**: 137–142.
35 Cooke L. The importance of exposure for healthy eating in childhood: a review. *J Hum Nutr Diet* 2007; **20**: 294–301.
36 Beauchamp GK, Mennella JA. Early flavor learning and its impact on later feeding behavior. *J Pediatr Gastroenterol Nutr* 2009; **48**: S25–S30.
37 Howard AJ, Mallan KM, Byrne R, Magarey A, Daniels LA. Toddlers' food preferences. The impact of novel food exposure, maternal preferences and food neophobia. *Appetite* 2012; **59**: 818–825.
38 Schwartz C, Chabanet C, Laval C, Issanchou S, Nicklaus S. Breast-feeding duration: influence on taste acceptance over the first year of life. *Br J Nutr* 2012; **4**: 1–8.
39 Mennella JA. Flavour programming during breast-feeding. *Adv Exp Med Biol* 2009; **639**: 113–120.
40 Friedman LS, Lukyanova EM, Serdiuk A, Shkiryak-Nizhnyk ZA, Chislovska NV, Zvinchuk AV *et al.* Social-environmental factors associated with elevated body mass index in a Ukrainian cohort of children. *Int J Pediatr Obes* 2009; **4**: 81–90.
41 Shin KO, Oh SY, Park HS. Empirically derived major dietary patterns and their associations with overweight in Korean preschool children. *Br J Nutr* 2007; **98**: 416–421.
42 Kamik S, Kanekar A. Childhood obesity: a global public health crisis. *Int J Prev Med* 2012; **3**: 1–7.
43 Birch LL, Fisher JO. Development of eating behaviours among children and adolescents. *Pediatrics* 1998; **101**: 539–549.
44 Ong KKL, Ahmed ML, Emmett PM, Preece MA, Dunger DB. Association between postnatal catch-up growth and obesity in childhood: prospective cohort study. *BMJ* 2000; **320**: 967–971.
45 Gardner DSL, Hosking J, Metcalf BS, Jeffrey AN, Voss LD, Wilkin TJ. Contribution of early weight gain to childhood overweight and metabolic health: a longitudinal study (EarlyBird 36). *Pediatrics* 2009; **123**: e67–e73.
46 Barker DJ, Osmond C, Forsén TJ, Kajantie E, Eriksson JG. Trajectories of growth among children who have coronary events as adults. *Engl J Med* 2005; **353**: 1802–1809.
47 Macdiarmid J, Blundell J. Assessing dietary intake: who, what and why of under-reporting. *Nutr Res Rev*, 1998; 11: 231–253.

Supplementary Information accompanies the paper on European Journal of Clinical Nutrition website (http://www.nature.com/ejcn)

A short food-group based dietary questionnaire is reliable and valid for assessing toddlers' dietary risk in relatively advantaged samples

British Journal of Nutrition, page 1 of 11
doi:10.1017/S0007114514001184

A short food-group-based dietary questionnaire is reliable and valid for assessing toddlers' dietary risk in relatively advantaged samples

Lucinda K. Bell[1*], Rebecca K. Golley[2] and Anthea M. Magarey[1]

[1]*Nutrition and Dietetics, Faculty of Medicine, Nursing and Health Sciences, School of Medicine, Flinders University, GPO Box 2100, Adelaide, SA 5001, Australia*

[2]*Division of Health Sciences, Sansom Institute for Health Research, University of South Australia, Adelaide, SA, Australia*

(Submitted 6 January 2014 – Final revision received 29 April 2014 – Accepted 2 May 2014)

Abstract

Identifying toddlers at dietary risk is crucial for determining who requires intervention to improve dietary patterns and reduce health consequences. The objectives of the present study were to develop a simple tool that assesses toddlers' dietary risk and investigate its reliability and validity. The nineteen-item Toddler Dietary Questionnaire (TDQ) is informed by dietary patterns observed in Australian children aged 14 (*n* 552) and 24 (*n* 493) months and the Australian dietary guidelines. It assesses the intake of 'core' food groups (e.g. fruit, vegetables and dairy products) and 'non-core' food groups (e.g. high-fat, high-sugar and/or high-salt foods and sweetened beverages) over the previous 7 d, which is then scored against a dietary risk criterion (0–100; higher score = higher risk). Parents of toddlers aged 12–36 months (Socio-Economic Index for Areas decile range 5–9) were asked to complete the TDQ for their child (*n* 111) on two occasions, 3·2 (SD 1·8) weeks apart, to assess test–retest reliability. They were also asked to complete a validated FFQ from which the risk score was calculated and compared with the TDQ-derived risk score (relative validity). Mean scores were highly correlated and not significantly different for reliability (intra-class correlation = 0·90, TDQ1 30·2 (SD 8·6) *v.* TDQ2 30·9 (SD 8·9); P=0·14) and validity (r 0·83, average TDQ ((TDQ1 + TDQ2)/2) 30·5 (SD 8·4) *v.* FFQ 31·4 (SD 8·1); P=0·05). All the participants were classified into the same (reliability 75 %; validity 79 %) or adjacent (reliability 25 %; validity 21 %) risk category (low (0–24), moderate (25–49), high (50–74) and very high (75–100)). Overall, the TDQ is a valid and reliable screening tool for identifying at-risk toddlers in relatively advantaged samples.

Key words: **Toddlers: Dietary risk: Questionnaires: Validity: Reliability**

'Dietary risk' is a term used to describe 'any inappropriate dietary pattern' that may impair health[1]. Toddlers are vulnerable to dietary risk as they begin to exert their independence in food choices and demonstrate fussy eating behaviours[2,3]. As dietary risk habits may persist over time[4,5] and influence short-term and long-term health[6,7], early risk identification is important.

The current dietary intakes of toddlers are inadequate, suggesting that many are at dietary risk. In general, intakes of nutrient-rich foods are below the national dietary guideline recommendations and consumption of energy-dense, nutrient-poor foods is common. For example, the 2008/09 UK National Diet and Nutrition Survey revealed that about 50 % of 1·5- to 3-year-olds consumed energy-dense, nutrient-poor items such as meat products, fried potato products, confectionery and sweetened beverages over the 4 d food diary period[8]. Nutrient-rich foods such as fish, raw vegetables and eggs were consumed by less than half the sample[8]. Similarly, a recent Australian study demonstrated that 11–15 % of 12- to 36-month-olds consumed no fruit or vegetables, respectively, less than one-quarter consumed eggs (24 %), fish (11 %) and legumes (17 %), and nearly all (89 %) consumed energy-dense, nutrient-poor item/s in the previous 24 h[9]. Similar trends are observed in other countries including the USA[10,11]. These data highlight that toddlers' dietary patterns are not consistent with dietary guidelines and may place them at risk of nutrient (e.g. Fe and folate[12,13]) deficiencies and chronic diseases, including excess weight[4,14] and CVD[15]. Therefore, the need to screen toddlers' dietary intakes against current dietary guidelines to identify those at risk is evident.

Timely, accurate and cost-effective assessment of dietary intake is important. Traditional dietary assessment methods, such as recalls and records, are time intensive, costly and burdensome[16]. Furthermore, it can be difficult to easily extract food intake data using these methods for meaningful comparison with food-group-based dietary guidelines[17]. Conversely,

Abbreviations: ICC, intra-class correlation; SAIDI, South Australian Infant Dietary Intake; SEIFA, Socio-Economic Index for Areas; TDQ, Toddler Dietary Questionnaire; TDQ_{ave}, average Toddler Dietary Questionnaire.

* **Corresponding author:** L. K. Bell, fax +61 8 8204 6406, email lucy.bell@flinders.edu.au

less costly, time-consuming and laborious methods such as FFQ[18] quickly measure food or food-group intakes, allowing easy comparison with food-group-based dietary guidelines[17]. Nonetheless, increasing questionnaire length is associated with increasing burden, likely to result in reduced cooperation and completion[19]. Therefore, an ideal screening questionnaire that identifies toddlers at dietary risk would be short and simple while providing food or food-group data that can easily be compared with dietary guidelines.

Dietary risk identification requires the assessment of whole diets. In comparison with that of individual dietary components, the assessment of whole diets refers to capturing the intake data of all five 'core' food groups (i.e. foods recommended to be consumed every day including fruit, vegetables, grains (e.g. bread, rice, pasta and noodles), meat and alternatives (e.g. fish, eggs and nuts, and dairy products) and 'non-core' food groups (energy-dense, nutrient-poor items)[20,21]. However, current short food or food-group-based questionnaires generally aim to measure a specific aspect of diet (e.g. fat intake[22]) or a limited number of food groups (e.g. only fruit and vegetables[23]). Supporting this, our recent review[24] highlighted the lack of short tools (≤50 items) assessing the whole diets of children aged <5 years[24].

Due to the lack of population-specific, age-appropriate, short tools that characterise whole diets of Australian toddlers, the present study aimed to develop a short, simple food-group-based dietary risk assessment tool for toddlers aged 12–36 months and determine its reliability and validity.

Methods

The Toddler Dietary Questionnaire (TDQ) is a nineteen-item, parent-completed, semi-quantitative tool that assesses food-group intake over the previous 7 d. The intake of 'core' food groups (e.g. fruit, vegetables and dairy products) and 'non-core' food groups (e.g. high-fat, high-sugar and/or high-salt foods and sweetened beverages) is then evaluated against a dietary risk criterion. The TDQ risk scores range from 0 to 100, with a higher score representing a higher dietary risk (i.e. poorer dietary intake).

Development of the Toddler Dietary Questionnaire

The development of the TDQ was informed by dietary patterns observed in the recent dietary intake data of Australian toddlers[25], the Australian Dietary Guidelines Modelling System[26] and the Australian Dietary Guidelines[27,28]. Questionnaire drafts were pilot tested for readability, understanding and timing with three parent–toddler dyads (university researchers, *n* 2, and a family member of the researchers, *n* 1) and changes made to the questionnaire format.

The TDQ items were primarily informed by the dietary patterns of Australian children[25], derived using principal component analysis. Principal component analysis is a common type of factor analysis[29] that identifies the underlying 'patterns' of intake from a large number of variables by grouping foods commonly consumed together. Principal component analysis was applied to the average of 24 h recall data collected over 3 d from 14-month-old (*n* 552) and 24-month-old (*n* 493) children. Data were derived from two Australian studies, the control arm of NOURISH[30], an obesity prevention randomised controlled trial, and the South Australian Infant Dietary Intake (SAIDI) study, a longitudinal study of infants' and toddlers' dietary intake. The foods that represent extracted patterns account for the greatest variation in diet between individuals[31]. At both ages, two patterns were identified representing (1) 'core' intake (e.g. fruit, vegetables, grains, dairy products, meat and water) and (2) 'non-core' intake (e.g. high-fat, high-sugar and/or high-salt products and sweetened beverages)[25]. Based on these patterns and the Australian Dietary Guidelines[26,27], a nineteen-item questionnaire comprising three sections was developed. Section 1 assesses 'core' intake (eight items: fruit, vegetables (green, orange and other), dairy products, grains, lean red meat and fish), section 2 'non-core' intake (eight items: spreadable fats, vegemite-type spreads, snack products, hot potato products, meat products, sweet biscuits and cakes, chocolates and ice creams) and section 3 'usual' intake (three items: bread type, milk beverages and non-milk beverages, e.g. fruit juice, soft drink, and cordial (a fruit-flavoured concentrate that is usually mixed with water)).

Sections 1 and 2 comprise questions asking the respondents to report how often and how much their child ate of each food group over the previous week. Based on the appropriateness of categories for a 1-week period of intake, four consumption frequency categories (nil, once, 2–4 times and ≥5 times) were developed. In addition, three consumption quantity categories (representing 'small' (e.g. <50 g), 'medium' (e.g. 50–100 g) and 'large' (e.g. >100 g) portions) were developed. For section 1, portion-size categories were informed by the average serving sizes and weekly number of servings recommended for 13- to 23-month-olds and 2- to 3-year-olds outlined in the Australian Dietary Guidelines Modelling System[26]. For TDQ food groups not directly comparable to those in the modelling system, a proportion of the recommended intake was used. For example, for the TDQ food group 'yogurt/custard', portion sizes were informed by applying 25 % to the recommended intake of 'dairy foods (milks, yogurts and cheese)'. For section 2, portion-size categories were informed by the tertiles of consumption of 24-month-old NOURISH and SAIDI children (*n* 742). Food labels that reflect each portion-size category ('small', 'medium' and 'large') were added for each food-group item. For example, a 'small' portion of 'other vegetables' was labelled 'less than one cup of raw salad vegetables or less than half a cup of cooked vegetables', representing <75 g of vegetables.

Section 3 comprises the following three questions: (1) What proportion of white:non-white bread (e.g. some white:mostly non-white) does your child usually consume? (2) What milk drinks (breast, plain, flavoured or formula) does your child usually consume? (3) What non-milk drinks (water, diluted juice, juice, or cordial/soft drink) does your child usually consume? The final questionnaire is given in Table S1 (available online).

British Journal of Nutrition

Scoring of the Toddler Dietary Questionnaire

The dietary risk score is derived by evaluating food-group intake against a scoring criterion (Table 1). For sections 1 and 2 of the TDQ, food-group intake per week in grams is calculated by multiplying the frequency response (zero (nil), one (once), three (2–4) and seven (≥5) times per week) with the median quantity response (e.g. small = <50, 25 g; medium = 50–100, 75 g). For example, if the median of the 'small category' is 25 g, then a response of '2–4 times' and 'small' amount is 75 g (3 × 25 g). As the median of the 'large' (e.g. >100 g) category could not be established based on the TDQ categories, an upper limit of consumption of 24-month-old NOURISH and SAIDI children was used (e.g. 300 g) and the median determined (e.g. 200 g). Intake is then compared against recommendations[26]. That is, a scale of 0 (lowest score = lowest risk) to 18 (highest score = highest risk) is applied per question, with '0' reflecting intake closest in line with the recommendations and '18' reflecting intake furthest from the recommendations (Table 1). For section 1, a response of '2–4 times' and 'medium' amount reflects intake most closely in line with the recommendations and is therefore scored a '0'. Lower and higher intakes are scored between 2 and 18 according to the percentage of deviation from the recommendations. Underconsumption is scored slightly more severely than overconsumption due to greater severity of health risks. For example, underconsumption of 'core' foods may result in nutrient deficiencies leading to suboptimal growth and development and/or chronic diseases such as CVD and cancer[20]. Furthermore, insufficient 'core' intake may lead to the overconsumption of 'non-core' items and thus an increased risk of overweight and obesity[20]. Alternatively, overconsumption of 'core' foods may also contribute to overweight through the establishment of a positive energy balance[32] and may displace the intake of other core foods from the diet, thus decreasing variety[20]. Conversely, for section 2, scores increase proportionally from 0 with increasing consumption frequency and quantity, as the consumption of 'non-core' foods should be limited[20,21,27] and increasing exposure and familiarity increase the preference for these foods[33].

Each question in section 3 is scored on a scale of 0 (ideal intake, e.g. none white:all non-white, breast milk or plain milk, and water) to 12 (non-ideal intake, e.g. all white:none non-white, no milk drinks, and soft drink or cordial) (Table 1). For questions 2 and 3, a proportionally increasing scale of 0, 4, 8, 12, is applied, with multiple responses being accepted. However, for question 1, a scale of 0, 3, 9, 12 is applied, as the proportions 25 %:75 % and 75 %:25 % were used to represent the responses some white:mostly non-white and mostly white:some non-white, respectively.

Dietary risk scores are created for each section, tallied to give a score out of 336, which is converted to a total dietary risk score (range 0–100; higher score = higher risk). Total risk scores are categorised into four levels of dietary risk: (1) low (0–24); (2) moderate (25–49); (3) high (50–74); (4) very high (75–100).

Reliability and validity of the Toddler Dietary Questionnaire

Study design

A validation study was conducted between October 2012 and February 2013 to determine the reliability and relative validity of the TDQ. Ethics approval was granted by the Flinders University Social and Behavioural Research Ethics Committee (SBREC).

Study sample

The participants were primary carers of toddlers aged 12–36 months recruited via (1) flyers distributed at South Australian private child care centres, (2) advertisements in Flinders University newsletters and on notice boards, (3) a study-specific Facebook page, and (4) parents enrolled in the SAIDI study who had another eligible child. Children with a food allergy or intolerance or a diagnosed medical condition affecting their dietary intake were excluded. Parents with two eligible children chose one child to participate in the study to prevent a clustering effect. Parental consent was obtained.

Data collection

Data collection occurred in two stages. In stage 1, the participants completed a demographic questionnaire and the TDQ (i.e. TDQ1). In stage 2, the participants were mailed a second TDQ (i.e. TDQ2) and a validated semi-quantitative FFQ[34,35] to be completed on the same day approximately 2–4 weeks after the completion of TDQ1.

Demographic questionnaire. Child (age, sex, country of birth, and parent-reported weight and height), parent (age, country of birth, marital status, education level and employment status) and family (postal code and household numbers) demographic characteristics were assessed via a questionnaire. As a measure of socio-economic status, the Index of Relative Socio-Economic Advantage and Disadvantage, one of the four Socio-Economic Index for Areas (SEIFA) indices that rank geographical areas across Australia on a continuum of disadvantage (lowest score = 1) to advantage (highest score = 10), was applied to the postal code[36].

FFQ. To determine the validity of the TDQ, a dietary assessment tool that allowed collected data to be translated into the TDQ and dietary risk calculated was necessary. A recently developed seventeen-item FFQ for Australian 2- to 5-year olds[37] was not suitable as the validation tool due to the lack of assessment of dairy product and grain food intakes, preventing the calculation of a dietary risk score. Furthermore, alternative measures, such as 24 h recalls and 2 or 3 d records, do not provide data collected over sufficient number of days to cover that of the TDQ, while 7 d records are associated with high participant burden[16,38]. Therefore, a FFQ developed and validated in Belgian 2·5- to 6·5-year-olds[34,35] was chosen as the validation reference tool. This FFQ was identified in a recent review as the only short dietary assessment tool for children aged 0–5 years tested for reliability and validity[24] from which a TDQ score could be calculated. Food-group items are mostly compatible with those in the TDQ and the

British Journal of Nutrition

Table 1. Scoring template for the Toddler Dietary Questionnaire

Sections	Question	Response		Score		Maximum score per question	Possible section score range
		Frequency	Quantity	Section 1	Section 2		
1 and 2	Each question (sixteen items) scored according to the combination of frequency and quantity categorical responses	Nil	Nil	18	0	18	0–144
		Once	Small	14	2		
		Once	Medium	11	4		
		Once	Large	8	6		
		2–4 times	Small	6	8		
		2–4 times	Medium	0	10		
		2–4 times	Large	4	12		
		≥5 times	Small	2	14		
		≥5 times	Medium	6	16		
		≥5 times	Large	12	18		
3	What proportion of white:non-white bread does your child usually* consume? (tick one only)	None white:all non-white		0		12	0–48
		Some white:mostly non-white		3			
		Mostly white:some non-white		9			
		All white:none non-white		12			
	What milk drinks does your child usually* consume? (tick all that apply)	Breast milk or plain milk (dairy or non-dairy)		0		12†	
		Formula		4			
		Flavoured milk (dairy or non-dairy)		8			
		None of the above, i.e. no milk drinks		12			
	What non-milk drinks does your child usually* consume? (tick all that apply)	Water		0		24	
		Diluted juice (fruit and/or vegetable)		4			
		Undiluted juice (fruit and/or vegetable)		8			
		Cordial or soft drink		12			
Total							0–336 (converted to out of 100)

* Usually = on most days.

† Despite the option to tick all that apply, if a response of 'none of the above, i.e. no milk drinks', is provided, no other responses are possible; therefore, any combination of the first three responses, providing a maximum score of 12, or the response 'none of the above, i.e. no milk drinks' only (score = 12) is possible.

Table 2. Section and total dietary risk scores for each administration of the Toddler Dietary Questionnaire (TDQ; TDQ1 and TDQ2), average TDQ (TDQ_{ave}) and FFQ and classification into dietary risk categories (*n* 111)

(Mean values and standard deviations; number of participants and percentages)

		Test–retest reliability				Relative validity			
		TDQ1		TDQ2		TDQ_{ave}*		FFQ	
Dietary risk measures	Possible score range	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Dietary risk score									
Section 1	0–144	56·0	18·0	56·7	19·5	56·3	17·7	61·0	18·1
Section 2	0–144	39·3	18·6	40·1	19·1	39·7	17·8	39·3	19·3
Section 3	0–48	6·2	6·4	7·1	7·3	6·6	6·6	5·3	5·9
Total	0–100	30·2	8·6	30·9	8·9	30·5	8·4	31·4	8·1
Dietary risk score category									
Low	0·0–24·9								
n		31		33		33		21	
%		27·9		29·7		29·7		18·9	
Moderate	25·0–49·9								
n		76		74		76		87	
%		68·5		66·7		68·5		78·4	
High	50·0–74·9								
n		4		4		2		3	
%		3·6		3·6		1·8		2·7	
Very high	75·0–99·9								
n		0		0		0		0	
%		0·0		0·0		0·0		0·0	

* TDQ_{ave} = ((TDQ1 risk scores + TDQ2 risk scores)/2).

1-month assessment period of the FFQ covers the 1-week assessment period of the TDQ. Small adaptations were made to the FFQ to reflect culturally appropriate foods and terminology (e.g. sugared milk replaced with flavoured milk) and to capture intake over the past month rather than that over the past year.

Comparative validity was assessed to evaluate dietary risk scores determined using the nineteen-item TDQ relative to those determined using the fifty-four-item (forty-seven-food item) FFQ. The final FFQ included six frequency categories (never, 1–3 d/month, 1 d/week, 2–4 d/week, 5–6 d/week and every day) and three quantity categories (representing 'small' (e.g. <40 g), 'medium' (e.g. 40–120 g) and 'large' (e.g. ≥120 g) portions). FFQ data were converted to a third dietary risk score using a standardised format based on comparative quantity and frequency categories, and the risk score was calculated. That is, responses 'never' and '1–3 d/month' were translated to 'nil' in the TDQ, '1 d/week' to 'once', '2–4 d/week' to '2–4 times', and '5–6 d/week' and 'everyday' to '≥5 times'. Quantity responses were translated to the most appropriate TDQ quantity category ('small', 'medium' or 'large') based on gram amount.

Statistical analysis

Data were analysed using SPSS statistical software package for Windows version 19.0 (SPSS, Inc.). The level of significance was set at $P<0·05$.

Individual Toddler Dietary Questionnaire item agreement

The proportion of parents reporting within the same response category (product of frequency and quantity; data not shown) between each administration of the TDQ (TDQ1 and TDQ2) was determined and the percentage of agreement calculated. The percentage of agreement between the administrations beyond that expected by chance[39] was determined by calculating weighted kappa (K_w) (for ordinal data) using MedCalc statistical software version 12.7.7.0 (Microsoft). K_w values were defined as poor (<0·20), fair (0·21–0·40), moderate (0·41–0·60), good (0·61–0·80) and very good (0·81–1·00)[40,41].

Reliability and validity of dietary risk scores

Risk scores were evaluated for test–retest reliability and relative validity of section and total scores. Reliability was assessed by comparing scores obtained during the first administration (TDQ1) and second administration (TDQ2) of the TDQ and relative validity by evaluating average scores (termed 'TDQ_{ave}') derived from two administrations of the TDQ ((TDQ1 + TDQ2)/2) against FFQ risk scores. Average risk scores were used in the validity analysis instead of the TDQ1 or TDQ2 scores as these cover a 2-week period of intake, more in line with the 4-week assessment period of the FFQ, and are thus a better representation of 'usual' intake and risk. As the majority of scores were normally distributed, parametric tests were used in all analyses for consistency.

To assess reliability and relative validity at the individual level, intra-class correlations (ICC) and Pearson's correlations, defined as low ≤0·50, moderate 0·51–0·69, and high ≥0·70[42], were used. At the group level, paired *t* tests were used for both analyses. A Bland–Altman plot was constructed to assess the strength of agreement between the two tools by plotting the mean bias, i.e. difference between the TDQ_{ave} and FFQ risk scores, against the mean of the tools. The plot was assessed visually and linear regression analysis performed to

British Journal of Nutrition

Table 3. Agreement of Toddler Dietary Questionnaire (TDQ) items (product of frequency and quantity categories, categorical) between each administration among Australian children aged 12–36 months (*n* 111)

		TDQ1 and TDQ2	
Sections	TDQ items	Percentage of agreement*	K_w†
1	Fruit	64	0·48
	Green vegetables	51	0·52
	Orange vegetables	48	0·51
	Other vegetables	52	0·50
	Yogurt or custard	54	0·61
	Grains	40	0·40
	Red meat	55	0·46
	Fish	57	0·55
2	Spreadable fats	51	0·64
	Vegemite-type spreads	32	0·51
	Snack products	56	0·46
	Hot potato products	48	0·53
	Meat products	42	0·51
	Sweet biscuits or cakes	41	0·46
	Chocolates	65	0·60
	Ice creams or frozen yogurt	56	0·52
3	Bread type	80	0·78
	Milk drinks	89	0·67
	Non-milk drinks	85	0·74

K_w, weighted kappa.

* Percentage within the same category response, i.e. combination of frequency and quantity categories for sections 1 and 2 (*n* 10). For question 1 on bread type in section 3, one response was allowed and five response options were provided: (1) none white:all non-white; (2) some white:mostly non-white; (3) mostly white: some non-white; (4) all white:none non-white; (5) does not eat bread. For question 2 on milk drinks in section 3, multiple responses were allowed and eight response options were provided: (1) breast milk or plain milk only; (2) formula only; (3) flavoured milk only; (4) no milk drinks; (5) breast milk/plain milk and formula; (6) breast milk/plain milk and flavoured milk; (7) breast milk/plain milk and formula milk and flavoured milk; (8) formula and flavoured milk. For question 3 on non-milk drinks in section 3, multiple responses were allowed and eight response options were provided: (1) water; (2) diluted juice only; (3) water and diluted juice; (4) water and undiluted juice; (5) water and cordial/soft drink; (6) water and diluted juice and cordial/soft drink; (7) water and diluted juice and undiluted juice; (8) water and undiluted juice and cordial/soft drink.

† K_w was calculated for categorised data as described above.

test for any systematic bias. Agreement at the individual level is defined as the limits of agreement (±2 SD) of the mean bias and that at the group level by the mean bias and slope of the mean bias line[17].

Cross-classification into dietary risk categories (low–very high)

Classification analysis was conducted to determine whether the participants were classified into the same dietary risk category (low, moderate, high and very high) during each TDQ administration and by TDQ_{ave} scores compared with the FFQ scores.

Results

Sample characteristics

Of the 117 parents (100% biological mother), 111 completed all the study measures. Mothers (mean age 34 (SD 4) years) were mostly partnered (94%), Australian born (95%), in paid employment (74%) with a university education (67%), and in the top five SEIFA deciles (range 5–9). Children (54% girls) were, on average, 23·0 (SD 6·9) months of age, primarily Australian born (95%), and lived in a household of 4 (SD 1) members.

Reliability and validity

The duration between the repeat administrations of the TDQ ranged from 1·0 to 11·9 weeks (average 3·2 (SD 1·8) weeks). The average dietary risk scores ranged from 30·2 (SD 8·6) for TDQ1 to 31·4 (SD 8·1) for the TDQ derived from the FFQ (Table 2). Over two-thirds of children were classified as moderate risk and less than one-third as low risk (Table 2).

Test–retest reliability. The percentage of agreement and K_w for each TDQ item are summarised in Table 3. The percentage of agreement ranged from 32% for vegemite-type spreads to 85% for non-milk drinks. K_w values ranged from 0·40 to 0·78, indicating fair (grains), moderate (fruit, vegetables (orange, green and other), red meat, fish, vegemite-type spreads, snack products, hot potato products, meat products, sweet biscuits and cakes, chocolates and ice creams) and good (yogurt, spreadable fats, bread, milk drinks and non-milk drinks) agreement.

The results of the test–retest analysis of dietary risk scores are given in Table 4. The total risk scores calculated from each TDQ administration were highly correlated (ICC = 0·90, $P<0·001$) and not statistically different (30·2 (SD 8·6) *v.* 30·9 (SD 8·9); $P=0·14$). For section risk scores, all ICC were good (0·88–0·91). Risk scores for section 3 (6·2 (SD 6·4) *v.* 7·1 (SD 7·3); $P=0·017$), but not for section 1 ($P=0·55$) or section 2 ($P=0·45$), were significantly different between each administration. Mean bias ranged from −0·88 for section 3 to −0·71 for section 1 (TDQ1 scores were lower than the TDQ2 scores). All children were classified into the same (*n* 83, 75%) or adjacent (*n* 28, 25%) dietary risk category during each administration (Table 5).

Relative validity. The total and section dietary risk scores derived from the TDQ_{ave} and those derived from the FFQ were highly correlated (all *r* 0·71 or greater, $P<0·001$; Table 4). Risk scores were significantly different for section 1 (TDQ_{ave} 56·3 (SD 17·7), FFQ 61·0 (SD 18·1); $P<0·001$) and section 3 (TDQ_{ave} 6·6 (SD 6·6), FFQ 5·3 (SD 5·9); $P=0·005$), but not for section 2 ($P=0·69$), and total risk scores were not significantly different (TDQ_{ave} 30·5 (SD 8·4), FFQ 31·4 (SD 8·1); $P=0·05$). Mean bias between the TDQ_{ave} and FFQ risk scores ranged from −4·68 (section 1; TDQ_{ave} scores were lower than the FFQ scores) to 1·31 (section 3; TDQ_{ave} scores were greater than the FFQ scores).

The Bland–Altman plot (Fig. 1) revealed a small negative mean difference between the TDQ_{ave} and FFQ risk scores; i.e. the TDQ_{ave} tends to provide a lower estimate of risk than the FFQ (mean bias −0·89 (−1·79, 0·02)). However, most measurements fell within the 95% limits of agreement and there was no significant linear trend for the fitted regression line ($\beta=0·51$, 95% CI −0·08, 0·15; $P=0·60$), i.e. no systematic bias between the two tools. Classification analysis between the TDQ_{ave} and FFQ revealed that all the participants were classified into the same (*n* 88, 79%) or adjacent (*n* 23, 21%) dietary risk category (Table 5).

British Journal of Nutrition

British Journal of Nutrition

Table 4. Test–retest reliability of the Toddler Dietary Questionnaire (TDQ) risk scores and relative validity of the average TDQ (TDQ_{ave}) and FFQ risk scores for each section and total risk scores (*n* 111)

(Correlations, 95 % confidence intervals and 95 % limits of agreement (LOA))

	Test–retest reliability (TDQ1 and TDQ2)					Relative validity (TDQ_{ave}* and FFQ)					
Dietary risk scores	ICC†	Mean bias	95 % CI	*P*‡	Pearson's correlation†	Mean bias	95 % CI	*P*‡	95 % LOA	Slope of the mean bias line§	*P*§
Section 1	0·88	−0·71	−3·06, 1·64	0·550	0·71	−4·68	−7·24, −2·12	<0·001	−31·32, 21·96	−0·03	0·742
Section 2	0·89	−0·86	−3·15, 1·42	0·454	0·84	0·40	−1·57, 2·37	0·691	−20·12, 20·91	−0·08	0·136
Section 3	0·91	−0·88	−1·61, −0·16	0·017	0·71	1·31	0·40, 2·22	0·005	−8·16, 10·78	0·12	0·133
Total	0·90	−0·73	−1·72, 0·25	0·143	0·83	−0·89	−1·79, 0·02	0·054	−10·30, 8·52	0·03	0·595

ICC, intra-class correlation.
* TDQ_{ave} = ((TDQ1 risk scores + TDQ2 risk scores)/2).
† For all correlations, $P<0·001$.
‡ Paired *t* test was used to compare differences in risk scores.
§ Linear regression analysis of difference in risk scores (TDQ_{ave} − FFQ) and the mean of difference of risk scores ((TDQ_{ave} − FFQ)/2). Agreement at the individual level is defined as the LOA (±2 SD) of the mean bias and that at the group level by the mean bias and slope of the mean bias line.

Discussion

In the present article, the development and testing of a nineteen-item TDQ that assesses the dietary risk of children aged 12–36 months are described. Our findings revealed that the TDQ-derived dietary risk scores of toddlers in the study sample were highly correlated and not significantly different between the two administrations or on comparison with scores derived from a fifty-four-item FFQ. The TDQ is a reliable and valid screening tool for assessing the dietary risk of Australian toddlers from relatively advantaged backgrounds and categorising them into dietary risk categories. The reliability and validity of the TDQ in samples that include Australian toddlers from the lower five SEIFA deciles are yet to be assessed.

The TDQ performed well in terms of reliability. Repeatability analysis of individual questionnaire items revealed predominately moderate agreement. The percentage of agreement (32–86 %; *n* 19 items) was slightly lower than that reported for a FFQ tested in Australian 2- to 5-year-olds (53–97 %; *n* 16 items)[37]. Yet K_w values derived from the FFQ (0·37 (red meat)–0·85 (take-away foods)) and those derived from the TDQ used in the present study (0·40 (grains)–0·78 (bread)) were similar; the reproducibility of the TDQ was predominately 'moderate' (*n* 13/19 items) or 'good' (*n* 5/19 items). Test–retest analysis of dietary risk scores revealed that the TDQ is reliable for assessing individuals' dietary risk. At the group level, total risk scores were not significantly different, with less than one risk score point being observed between the mean scores during each administration. The mean bias was greatest for section 3, with risk scores being statistically, but not meaningfully different (0·9 points out of 48; 1·9 %), between the administrations. Classification analysis revealed three-quarters of the children to be in the same dietary risk category during each TDQ administration. Overall, these results suggest that the TDQ is reliable for assessing dietary risk in this population, an important finding considering that the validity of a tool requires reliability[43].

The TDQ performed well in terms of validity. The nineteen-item TDQ accurately derives dietary risk scores and assigns toddlers to risk categories in comparison with a longer fifty-four-item FFQ. The total dietary risk scores derived from the TDQ_{ave} and those derived from the FFQ were highly correlated and not significantly different. The Bland–Altman plot for total dietary risk scores revealed narrow limits of agreement, indicating that the TDQ can accurately distinguish dietary risk at the individual level[44]. As the slope of the mean bias line indicated no overall bias, the TDQ is acceptable for measuring the dietary risk of toddlers at the group level[17]. Classification analysis revealed promising results with the majority of children (approximately three-quarters) being classified into the same dietary risk category by the TDQ_{ave} and FFQ. Thus, the TDQ is a valid toddler dietary risk assessment tool suitable for this population in a clinical (individual) or community (group) setting.

The fifty-four-item FFQ developed by Huybrechts *et al.*[34,35] was chosen as the reference tool to assess validity. In the absence of a gold standard to measure dietary intake, this FFQ was determined to be the best available validation tool.

British Journal of Nutrition

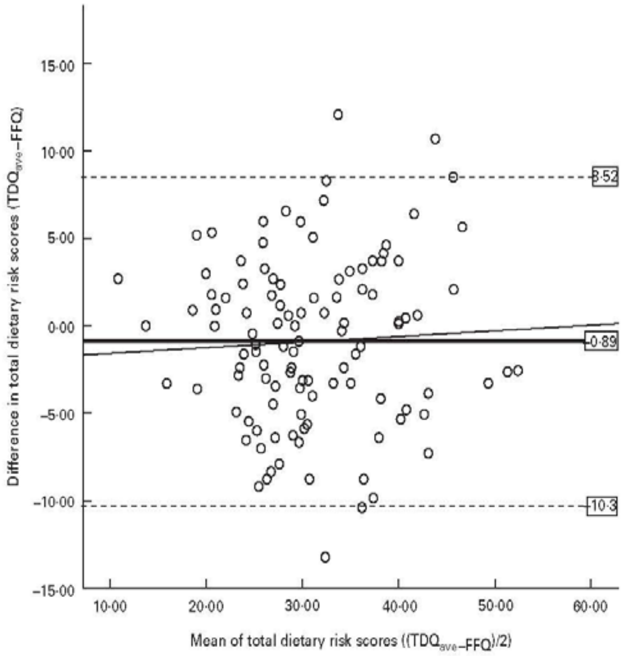


Fig. 1. Bland–Altman plot assessing the validity of total dietary risk scores derived from the average Toddler Dietary Questionnaire (TDQ$_{ave}$) *v.* those derived from the FFQ among Australian children (*n* 111) aged 12–36 months. The plot shows the mean difference (▬), the 95 % limits of agreement (- - - - - -) and the fitted regression line (——) for total dietary risk scores (*P* for linear trend=0·595). R^2 linear = 0·003.

It has been shown to be reliable and valid in terms of food[34] and nutrient[35] intake assessment compared with the estimated diet records and provides a reasonable measure when compared with the TDQ, capturing the intake data of key foods of interest over a similar time period. Despite this, minor changes were made to the FFQ primarily to reflect cultural differences, possibly altering the reliability and validity of the tool. Ideally, the tool would have been retested in the Australian population; however, this was not feasible within the study constraints. Additionally, translation of items from the FFQ into the TDQ was challenged by incompatible portion-size categories for some items (e.g. fish, snack products, chocolates and ice creams/frozen yogurt). That is, a 'small' response in the FFQ was translated to 'medium' in the TDQ, while both 'medium' and 'large' responses in the FFQ were translated to 'large' in the TDQ. Nonetheless, this FFQ was the most compatible tool that allowed derivation of dietary risk scores, could be completed in the participants' own time and was considered least burdensome for the participants.

The novelty of the TDQ is demonstrated by the innovative approach to the selection of food items, through the use of principal component analysis-derived dietary patterns and the formation of portion-size categories, based on toddlers' intakes. Due to its novel nature, there are few similar tools evaluating an overall score of diet quality in young children with which it can be compared. In a Canadian study of 3- to

Table 5. Cross-classification of participants into dietary risk categories (low, moderate, high and very high) between the administrations of the Toddler Dietary Questionnaire (TDQ) and average TDQ (TDQ$_{ave}$) and FFQ (*n* 111)*

(Number of participants and percentages)

	Test–retest reliability (TDQ1 and TDQ2)							Relative validity (TDQ$_{ave}$† and FFQ)					
	TDQ2							FFQ					
	Low		Moderate		High			Low		Moderate		High	
	n	%	*n*	%	*n*	%		*n*	%	*n*	%	*n*	%
TDQ1							TDQ$_{ave}$						
Low	20	18	11	10	–	–	Low	16	14	17	15	–	–
Moderate	13	12	61	55	2	2	Moderate	5	5	70	63	1	1
High	–	–	2	2	2	2	High	–	–	–	–	2	2

* No subject was classified as 'very high risk' by the TDQ1, TDQ2, TDQ$_{ave}$ or FFQ.
† TDQ$_{ave}$ = ((TDQ1 risk scores + TDQ2 risk scores)/2).

5-year-old preschool children, a seventeen-item Nutritional Screening Tool for Every Preschooler questionnaire, which derives a nutrition risk score from five food-group questions and twelve questions on other nutrition risk constructs, was reliable between the administrations (ICC = 0·89) and valid (r 0·48) on comparison with a dietitian rating[45]. The total dietary risk scores (reliability, ICC = 0·90; validity, r 0·83) obtained in the present study were comparatively better.

Besides the reliability and validity results of the TDQ, the present study provides information on the dietary risk of Australian toddlers. Scores derived from the TDQ categorised approximately one-third of the study sample as 'low' risk and two-thirds as 'moderate' risk. Few toddlers were categorised as 'high' risk and none as 'very high' risk. This is probably explained by our homogeneous sample, whereby the majority were highly educated, in paid employment and of a relatively high socio-economic status. Additionally, enrolment in the present study was voluntary and thus the participants were likely to be highly motivated parents. The assessment of dietary risk in a more representative sample of toddlers may yield higher proportions at 'high' or 'very high' risk.

There are several potential uses of the TDQ. In the clinical setting, it could be used by health professionals to rapidly screen the dietary intakes of toddlers from relatively advantaged backgrounds, accurately identify those at risk, and facilitate referral to a dietitian for detailed assessment and intervention to improve dietary patterns. Once tested in a more generalisable sample, the TDQ could be applied in this manner to low-socio-economic status populations. This is important considering that diet quality is socially patterned, whereby consumption of a less-healthy diet is observed in socio-economically disadvantaged populations[46,47]. Furthermore, it could potentially be useful in the research setting, for population health monitoring of toddlers' dietary risk, for exploring the sociodemographic predictors of dietary risk, and for furthering our understanding of the relationship between dietary risk and health outcomes. Additionally, as contemporary interventions commonly focus on food-based dietary guidelines, the food-group-based TDQ is particularly useful for developing relevant interventions that aim to improve toddlers' dietary patterns and for determining the effectiveness of these interventions. Thus, further testing of the TDQ is warranted to ensure wider applicability.

The findings of the present study should be interpreted within the context of the strengths and limitations. The TDQ is a novel tool developed based on population-specific evidence and age-appropriate public health dietary recommendations. It is easy and inexpensive to administer and calculates an overall dietary risk score. It does not rely heavily on memory, particularly, in comparison with other short tools[34,35,48,49]. Additionally, the high participation rate in the present study suggests that completion of the TDQ is not burdensome for the respondents. Reliability and validity testing was undertaken in a sample size consistent with that recommended for validation studies (>100[44,50]) and the size was comparatively larger than that used in similar studies[37,51,52]. Furthermore, we investigated the repeatability of individual questionnaire items in addition to the reliability and validity of dietary risk scores. Nonetheless, our findings may not be representative of those in the general population due to the highly educated and motivated study sample, although social desirability bias is possible given the self-reporting nature of dietary intake[53]. Moreover, while attempts were made to ensure that stage 2 questionnaires were completed approximately 2–4 weeks after the completion of stage 1 questionnaires, this could not be standardised. Consequently, participants completing each stage within 1–2 weeks (n 15) may have remembered their previous responses, while true changes in diet may have occurred for those completing each stage over 5 weeks apart (n 7). To overcome this, however, average risk scores from each TDQ administration were used in the validity analysis. Lastly, despite its limitations[54,55], we used K_w as a measure of agreement as it is frequently used for ordinal food frequency data[37,48] and chose linear analysis over quadratic analysis due to its lower sensitivity to increasing number of categories[56].

In conclusion, the TDQ is a short assessment tool that provides information on toddlers' dietary risk, allowing identification of those requiring intervention. The present study showed that the TDQ is reliable and valid and accurately categorises toddlers from relatively advantaged backgrounds into dietary risk categories. The TDQ may be useful in the clinical setting, enabling screening of toddlers to identify those at risk requiring intervention, and potentially in the research setting for the development and evaluation of interventions. Overall, the TDQ is a multi-purpose tool ideal for preventative nutrition promotion efforts.

Supplementary material

To view supplementary material for this article, please visit http://dx.doi.org/10.1017/S0007114514001184

Acknowledgements

The authors thank the families that took part in the present study and all child care centre directors for their help with recruitment. The present study was funded by the National Health and Medical Research Council of Australia and Health. R. K. G. is supported by a National Heart Foundation Fellowship and L. K. B. by an Australian Postgraduate Award.

The authors' contributions are as follows: A. M. M. and R. K. G. designed the research; L. K. B., A. M. M. and R. K. G. contributed to the development of the TDQ; L. K. B. was responsible for the conduct of the study and performed the statistical analysis; L. K. B. wrote the manuscript. All authors reviewed, edited and approved the final manuscript.

None of the authors has any conflicts of interest to declare.

References

1. Stallings VA, Baranowski T, Briefel RR, *et al.* (2002) *Dietary Risk Assessment in the WIC Program. Food and Nutrition Board, Institute of Medicine*. Washington, DC: The National Academies Press.

2. Cowbrough K (2010) Feeding the toddler: 12 months to 3 years – challenges and opportunities. *J Fam Health Care* **20**, 49–52.
3. Dovey TM, Staples PA & Gibson EL (2008) Food neophobia and 'picky/fussy' eating in children: a review. *Appetite* **50**, 181–193.
4. Craigie AM, Lake AA, Kelly SA, *et al.* (2011) Tracking of obesity-related behaviours from childhood to adulthood: a systematic review. *Maturitas* **70**, 266–284.
5. Skinner JD, Carruth BR, Bounds W, *et al.* (2002) Do food-related experiences in the first 2 years of life predict dietary variety in school-aged children? *J Nutr Educ Behav* **34**, 310–315.
6. Owen CG, Martin RM, Whincup PH, *et al.* (2005) Effect of infant feeding on the risk of obesity across the life course: a quantitative review of published evidence. *Pediatrics* **115**, 1367–1377.
7. Wu TC & Chen PH (2009) Health consequences of nutrition in childhood and early infancy. *Pediatr Neonatol* **50**, 135–142.
8. Bates B, Lennox A & Swan G (2010) *National Diet and Nutrition Survey: Headline Results from Year 1 of the Rolling Programme (2008/2009)*. London: Food Standards Agency and Department of Health http://multimedia.food.gov.uk/multimedia/pdfs/publication/ndnsreport0809.pdf (accessed March 2014)
9. Chan L, Magarey AM & Daniels LA (2011) Maternal feeding practices and feeding behaviors of Australian children aged 12–36 months. *Matern Child Health J* **15**, 1363–1371.
10. Siega-Riz AM, Kinlaw A, Deming DM, *et al.* (2011) New findings from the Feeding Infants and Toddlers Study 2008. *Nestle Nutr Workshop Ser Pediatr Program* **68**, 83–100.
11. Siega-Riz AM, Deming DM, Reidy KC, *et al.* (2010) Food consumption patterns of infants and toddlers: where are we now? *J Am Diet Assoc* **110**, Suppl. 12, S38–S51.
12. Morgan J (2005) Nutrition for toddlers: the foundation for good health – 1. toddlers' nutritional needs: what are they and are they being met? *J Fam Health Care* **15**, 56–59.
13. Lioret S, McNaughton SA, Spence AC, *et al.* (2013) Tracking of dietary intakes in early childhood: the Melbourne InFANT Program. *Eur J Clin Nutr* **67**, 275–281.
14. World Health Organisation (WHO) (2002) *Diet, Nutrition and the Prevention of Chronic Diseases: Report of a Joint WHO/FAO Expert Consultation*. Geneva: WHO.
15. Brazionis L, Golley RK, Mittinty MN, *et al.* (2013) Diet spanning infancy and toddlerhood is associated with child blood pressure at age 7.5 y. *Am J Clin Nutr* **97**, 1375–1386.
16. Collins CE, Watson J & Burrows T (2010) Measuring dietary intake in children and adolescents in the context of overweight and obesity. *Int J Obes* **34**, 1103–1115.
17. Magarey A, Golley R, Spurrier N, *et al.* (2009) Reliability and validity of the Children's Dietary Questionnaire; a new tool to measure children's dietary patterns. *Int J Pediatr Obes* **4**, 257–265.
18. Cade J, Thompson R, Burley V, *et al.* (2002) Development, validation and utilisation of food-frequency questionnaires – a review. *Public Health Nutr* **5**, 567–587.
19. Sinkowitz-Cochran RL (2013) Survey design: to ask or not to ask? That is the question. *Clin Infect Dis* **56**, 1159–1164.
20. National Health and Medical Research Council (NHMRC) (2013) *Eat for Health: Australian Dietary Guidelines; Providing the Scientific Evidence for Healthier Australian Diets*. Canberra: NHMRC.
21. National Health and Medical Research Council (NHMRC) (2013) *Australian Guide to Healthy Eating*. Canberra: NHMRC.
22. Dennison BA, Jenkins PL & Rockwell HL (2000) Development and validation of an instrument to assess child dietary fat intake. *Prev Med* **31**, 214–224.
23. Bennett CA, de Silva-Sanigorski AM, Nichols M, *et al.* (2009) Assessing the intake of obesity-related foods and beverages in young children: comparison of a simple population survey with 24 hr-recall. *Int J Behav Nutr Phys Act* **6**, 71.
24. Bell LK, Golley RK & Magarey AM (2013) Short tools to assess young children's dietary intake: a systematic review focusing on application to dietary index research. *J Obes* **2013**, 709626.
25. Bell LK, Golley RK, Daniels L, *et al.* (2013) Dietary patterns of Australian children aged 14 and 24 months, and associations with socio-demographic factors and adiposity. *Eur J Clin Nutr* **67**, 638–645.
26. National Health and Medical Research Council (NHMRC) (2011) *A Modelling System to Inform the Revision of the Australian Guide to Healthy Eating*. Canberra: NHMRC.
27. National Health and Medical Research Council (NHMRC) (2003) *Dietary Guidelines for Children and Adolescents in Australia; Incorporating the Infant Feeding Guidelines for Health Workers*. Canberra: NHMRC.
28. Kellet L, Smith A & Schmerlaib Y (1998) *Australian Guide to Healthy Eating (AGHE)*. Canberra: Commonwealth Department of Health and Family Services.
29. Waijers PM, Feskens EJ & Ocke MC (2007) A critical review of predefined diet quality scores. *Br J Nutr* **97**, 219–231.
30. Daniels LA, Magarey A, Battistutta D, *et al.* (2009) The NOURISH randomised control trial: positive feeding practices and food preferences in early childhood – a primary prevention program for childhood obesity. *BMC Public Health* **14**, 387.
31. Craig LC, McNeill G, Macdiarmid JI, *et al.* (2010) Dietary patterns of school-age children in Scotland: association with socio-economic indicators, physical activity and obesity. *Br J Nutr* **103**, 319–334.
32. World Health Organisation (WHO) (2000) Obesity: preventing and managing the global epidemic. Report of a WHO consultation. *World Health Organ Tech Rep Ser* **894**, 1–253.
33. Cooke L (2007) The importance of exposure for healthy eating in childhood: a review. *J Hum Nutr Diet* **20**, 294–301.
34. Huybrechts I, De Backer G, De Bacquer D, *et al.* (2009) Relative validity and reproducibility of a food-frequency questionnaire for estimating food intakes among Flemish preschoolers. *Int J Environ Res Public Health* **6**, 382–399.
35. Huybrechts I, De Bacquer D, Matthys C, *et al.* (2006) Validity and reproducibility of a semi-quantitative food-frequency questionnaire for estimating calcium intake in Belgian preschool children. *Br J Nutr* **95**, 802–816.
36. Australian Bureau of Statistics (ABS) (2006) *Information Paper: An Introduction to Socio-Economic Indexes for Areas (SEIFA). ABS Report* no. 2039.0. Canberra: ABS.
37. Flood VM, Wen LM, Hardy LL, *et al.* (2013) Reliability and validity of a short FFQ for assessing the dietary habits of 2–5-year-old children, Sydney, Australia. *Public Health Nutr* **17**, 498–509.
38. Magarey A, Watson J, Golley RK, *et al.* (2010) Assessing dietary intake in children and adolescents: considerations and recommendations for obesity research. *Int J Pediatr Obes* **6**, 2–11.
39. Sim J & Wright CC (2005) The kappa statistic in reliability studies: use, interpretation, and sample size requirements. *Phys Ther* **85**, 257–268.
40. Altman DG (1991) *Practical Statistics for Medical Research*, 1st ed. Boca Raton, London, New York, Washington, DC: Chapman and Hall/CRC.

41. Landis JR & Koch GG (1977) The measurement of observer agreement for categorical data. *Biometrics* **33**, 159–174.
42. Pallant J (2011) *SPSS Survival Manual: A Step by Step Guide to Data Analysis using SPSS*, 4th ed. Crows Nest: Allen and Unwin.
43. Vogt WP (1999) Dictionary of Statistics & Methodology. A Nontechnical Guide for the Social Sciences. 2nd ed. Newbury Park, CA: SAGE Publications Inc.
44. Bland JM & Altman DG (1999) Measuring agreement in method comparison studies. *Stat Methods Med Res* **8**, 135–160.
45. Randall Simpson JA, Keller HH, Rysdale LA, *et al.* (2008) Nutrition Screening Tool for Every Preschooler (NutriSTEP): validation and test–retest reliability of a parent-administered questionnaire assessing nutrition risk of preschoolers. *Eur J Clin Nutr* **62**, 770–780.
46. Turrell G, Bentley R, Thomas LR, *et al.* (2009) A multilevel study of area socio-economic status and food purchasing behaviour. *Public Health Nutr* **12**, 2074–2083.
47. James WP, Nelson M, Ralph A, *et al.* (1997) Socioeconomic determinants of health. The contribution of nutrition to inequalities in health. *BMJ* **314**, 1545–1549.
48. Lanfer A, Hebestreit A, Ahrens W, *et al.* (2011) Reproducibility of food consumption frequencies derived from the Children's Eating Habits Questionnaire used in the IDEFICS study. *Int J Obes* **35**, Suppl. 1, S61–S68.
49. Ebenegger V, Marques-Vidal P, Barral J, *et al.* (2010) Eating habits of preschool children with high migrant status in Switzerland according to a new food frequency questionnaire. *Nutr Res* **30**, 104–109.
50. Bland JM & Altman DG (1986) Statistical methods for assessing agreement between two methods of clinical measurement. *Lancet* **1**, 307–310.
51. Marriott LD, Robinson SM, Poole J, *et al.* (2008) What do babies eat? Evaluation of a food frequency questionnaire to assess the diets of infants aged 6 months. *Public Health Nutr* **11**, 751–756.
52. Andersen LF, Lande B, Arsky GH, *et al.* (2003) Validation of a semi-quantitative food-frequency questionnaire used among 12-month-old Norwegian infants. *Eur J Clin Nutr* **57**, 881–888.
53. Hebert JR, Clemow L, Pbert L, *et al.* (1995) Social desirability bias in dietary self-report may compromise the validity of dietary intake measures. *Int J Epidemiol* **24**, 389–398.
54. Maclure M & Willet WC (1987) Misinterpretation and misuse of the kappa statistic. *Am J Epidemiol* **126**, 161–169.
55. Roberts C & McNamee R (2005) Assessing the reliability of ordered categorical scales using kappa-type statistics. *Stat Methods Med Res* **14**, 493–514.
56. Brenner H & Kliebsch U (1996) Dependence of weighted kappa coefficients on the number of categories. *Epidemiology* **7**, 199–202.

Conference presentations

Bell L, Golley R, Magarey A 'Dietary risk scores of Australian toddlers are associated with nutrient intakes and socio-demographic factors, but not adiposity" *12th International Congress on Obesity* Kuala Lumpar, Malaysia 17-20 March 2014 [poster]

Bell L, Golley R, Magarey A 'Reliability and validity of a short tool assessing Australian toddlers' dietary risk', *Nutrition Society of Australia ASM.* Brisbane, Australia. 4-6 Dec 2013 [oral]

Bell L, Golley R, Magarey A 'Development, reliability and relative validity of a short tool assessing Australian toddlers' dietary risk', *Australia and New Zealand Obesity Society.* Melbourne, Australia. 17-19 Oct 2013 [poster]

Bell L, Golley R, Daniels L, Magarey A 'Development of a short dietary risk assessment tool for us in populations of Australian toddlers aged 1-3 years', *Annual Meeting of International Society of Behavioral Nutrition and Physical Activity.* Ghent, Belgium. 22-25 May 2013 [poster]

Bell L, Golley R, Daniels L, Magarey A (2013) Dietary patterns of Australian children aged 14 and 24 months and associations with socio-demographic factors and adiposity' *Dietitians Association of Australia 30th National Conference.* Canberra, Australia. 23-25 May 2013 [Accepted poster]

Awards/prizes and other related output

2013 - Flinders University Best Student Research Paper Award

2013 - Nutrition Society of Australia (NSA) prize for *Best Student Oral Presentation (1st Prize)* at the ASM (Brisbane)

2013 - Nutrition Society of Australia (NSA) *Student Travel Grant* for the 2013 ASM (Brisbane)

InDaily News Article: Student research earns Flinders praise (10th January 2014) available at: http://indaily.com.au/flinders-news/2014/01/10/student-research-earns-flinders-praise/

InDaily News Article: Screening Aussie Toddlers' diets (19th July 2013) available at: http://indaily.com.au/flinders-news/2013/07/19/screening-aussie-toddlers-diets/

Appendix 2 - Literature review search process

Supplementary 1 material details the search process used for the literature review. Six stages were undertaken, from searching major databases, including and excluding articles and re-running the searches to update the results in 2013. Details of inclusion and exclusion criteria are detailed in the table. Supplementary 2 defines statistical tests used to assess realibility and validity of reviewed studies and the review assessment criteria.

Supplementary 1: Search process including search terms and exclusion criteria

Stage 1: Searching major science databases (search terms used)

1) Web of Science

Topic=((child* OR infant* OR toddler* OR preschool*))
AND Topic=((diet* OR food* OR nutrition OR dietary pattern OR eating pattern OR dietary intake OR food intake OR diet quality OR infant food OR infant nutrition OR child nutrition))
AND Topic=((assess* OR tool OR assessment tool OR dietary assessment OR questionnaire* OR evaluat* OR instrument OR checklist OR validit* OR correlat* OR compar* OR reproducibility OR accuracy))
Refined by: Topic=(assess) AND Research Areas=(NUTRITION & DIETETICS) AND Research Areas=(NUTRITION & DIETETICS OR PEDIATRICS) AND Research Areas=(NUTRITION & DIETETICS OR PEDIATRICS)
Timespan=All Years. Databases=SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, CCR-EXPANDED, IC.

2) Pubmed

((((((((("child"[All Fields]) OR "infant"[All Fields]) OR "toddler"[All Fields]) OR "preschool"[All Fields])))
AND ((((((((((("diet"[All Fields]) OR "nutrition"[All Fields]) OR "food"[All Fields]) OR "dietary pattern"[All Fields]) OR "eating pattern"[All Fields]) OR "dietary intake"[All Fields]) OR "food intake"[All Fields]) OR "diet quality"[All Fields]) OR "infant food"[All Fields]) OR infant nutrition) OR "child nutrition"[All Fields]))
AND ((((((((((("assess"[All Fields]) OR "tool"[All Fields]) OR "assessment tool"[All Fields]) OR "dietary assessment"[All Fields])) OR "checklist"[All Fields]) OR "reproducibility"[All Fields]) OR "valid"[All Fields]) OR "correlate"[All Fields]) OR "evaluate"[All Fields]) OR "food frequency questionnaire"[All Fields])
AND (Humans[Mesh]
AND English[lang]
AND (infant[MeSH] OR infant, newborn[MeSH] OR infant[MeSH:noexp] OR child, preschool[MeSH] OR child[MeSH:noexp]))))
AND ("assess"[All Fields])

3) Scopus

(TITLE-ABS-KEY((child* OR infant* OR toddler* OR preschool*))
AND TITLE-ABS-KEY((diet* OR food* OR nutrition OR dietary pattern OR eating pattern OR dietary intake OR food intake OR diet quality OR infant food OR infant nutrition OR child nutrition)) AND TITLE-ABS-KEY((assess* OR tool OR assessment tool OR dietary assessment OR questionnaire* OR

evaluat* OR instrument OR checklist OR validit* OR correlat* OR compar* OR reproducibility OR accuracy)))
AND ORIG-LOAD-DATE AFT 1365250549
AND (LIMIT-TO(LANGUAGE, "English"))

Stage 2: Cleaning in Endnote

1) Duplicates were removed
2) Words were searched in TITLE and KEYWORDS to eliminate irrelevant articles

Abuse
Advert
Agriculture
AIDS
Alcohol
Anaemia / Anemia
Allergic/allergy
Anaphylaxis
Asthma
Atresia
Bacteria
burns
Case report
Case Study
Celiac disease / coeliac disease
Cerebral palsy
Colitis
Contamin (i.e. contamination)
Depress (i.e. depression)
Diabetes
Diarrhoea (diarrhea)
Dietary sup
Disabilit (I.e. disabilities, disability) / disabled
Disease
Disorder
Drug
Drug effects
Drug therapy
Down syndrome
Eating Disorders
Esophagitis
Epilepsy
Excretion
Exposure
Fertility
Fibrosis
Gastro
Genetic
Guideline
Heavy metal
HIV
Hormone
Hypertension
Illness
Immun (i.e. Immunology, Immunization, Immunisation)
In vitro
Infection
Injury
Intensive care
Intravenous
Leukemia
Malaria
Mental health
Meta-Analysis
Microb
Mice
Monkey
Otitis Media
Outbreak
Parenteral nutrition
Patient
Pesticide
Phenylketonuria
PKU
Pig
Poison
Practice Guidelines
Premature
Preterm infant / preterm
Primate
Rabbit
Rats
Renal
Retarded
Review
Rickets
Smoke
Soil
Steroid
Spina Bifida
Surgery
Syndrome
Therapy
Toxic
Transplant
Tube (i.e. neural tube defects, tube feeding)
Urinary
Urine
Vaccin (i.e. vaccinate, vaccine, vaccination)
Violen (i.e. Violence, Violent)
Virus

3) 'Cochrane' was searched in JOURNAL to eliminate review articles

Stage 3 and Stage 4: Inclusion and exclusion of articles

- The resulting articles were screened firstly according to *title and abstract* (stage 3) and if uncertain, the *full text* (stage 4) was retrieved, using the screening process detailed in the tbale below.

Stage 5: Searching reference lists

- Reference lists of all included articles and relevant reviews were searched for additional studies.

Stage 6: Updating search results

- Stages 1-5 were re-run using articles published between 01.06.13 and 01.04.13 to identify any recently published short dietary assessment tools for 0-5 years that assess whole diet.

	EXCLUSION POINT						
	1	**2**	**3**	**4**	**5**	**6**	**7**
	Study Outcomes	**Study Assessment Method**	**Participants**	**Other**	**Dietary intake**	**Assessment of whole diet**	**Food items in short tool**
Included	Studies on individual dietary intake in infants and children (Outcome data includes nutrition-related measure - e.g. dietary intake, dietary patterns, energy intake, nutrient intake	Diet assessed using short dietary assessment tool - Food Frequency Questionnaires - other dietary questionnaires/ checklists	Healthy - Infants and toddlers (1-23 months) - Pre-schooler's (2-5 years)	- English language - Humans	- Reported by primary caregiver/ parent	- Investigates intake of foods from all 5 food groups (fruit, vegetables, meat/alternatives, dairy, cereals) with/without high-fat/sugar 'extras' foods	- $\leq$50 items - *Items described as food intake questions. Excludes questions on dietary behaviour
Excluded	- Nutrition related outcomes such as nutrition knowledge, efficacy, attitudes, preference, behaviours (e.g. breastfeeding duration, weaning) etc. - Group, school, family intake Other studies, for example those - Testing food/menu content e.g. additives, contaminants, nutritional content - Describing supplement prescription and/or intake - Measuring energy expenditure, urinary and blood concentrations of nutrients	Diet assessed using standard tool: - dietary recall - dietary record - food diaries - dietary indices - dietary interviews - large survey's	- Children and adolescents $\geq$5 years - Diseased or institutionalis-ed subjects (e.g. Coeliac disease, CF, Cancer, FTT, Diabetes)	- Studies without an abstract - NE = Language other than English - NH = Not humans (animals) - EO=excluded for other reason, describe here (e.g. review/report articles, study protocols)	- Reported by child	- Assesses intake of foods form $<$5 food groups e.g. only fruit and vegetable intake	- $>$50 items *Items described as food intake questions. Excludes questions on dietary behaviours.
Code assigned	NDI = Not assessing dietary intake (no dietary intake outcome data)	**NST = Not Short Tool**	**NP = Not Population**	NE = Not in English NH = Not humans NA = No Abstract EO = Excluded other	NPR = Not parent reported	NWD = Not whole diet	NST50 = Not short tool $\leq$50 items

Appendix 3 - Study data collection forms

Eligibility screening form

ID:

Associate Professor Anthea Magarey
Research Fellow
Nutrition and Dietetics
Flinders Clinical and Molecular Medicine
School of Medicine

Rm 7E-109, Level 7, Flinders Medical Centre
Flinders Drive, Bedford Park SA 5042

GPO Box 2100
Adelaide SA 5001

Telephone: +61 8 8204 6304
Facsimile: +61 8 8204 6406
Email: anthea.magarey@flinders.edu.au
www.flinders.edu.au/medicine/sites/nutrition-and-dietetics/

ELIGIBILITY FORM

Assessing Toddler's Dietary Intake

(Pease complete and return to Flinders University using the reply-paid envelope provided)

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

   ______ / ______ / ________
   Day Month Year

2. Does your child have any of the food intolerances or allergies, such as lactose intolerance, coeliac disease, egg-, nut-, fish- allergy?

   Yes ☐ No ☐

   If Yes, please explain ______________________

3. Does your child have any other pre-existing medical condition affecting his/her dietary intake, not mentioned in question 1?

   Yes ☐ No ☐

   If Yes, please explain ______________________

Thank you for completing this form

Office Use only	
INELIGIBLE	ELIGIBLE

inspiring achievement

Consent form

Flinders UNIVERSITY

ID:

Associate Professor Anthea Magarey
Research Fellow
Nutrition and Dietetics
Flinders Clinical and Molecular Medicine
School of Medicine

Rm 7E-109, Level 7, Flinders Medical Centre
Flinders Drive, Bedford Park SA 5042

GPO Box 2100
Adelaide SA 5001

Telephone: +61 8 8204 6304
Facsimile: +61 8 8204 6406
Email: anthea.magarey@flinders.edu.au
www.flinders.edu.au/medicine/sites/nutrition-and-dietetics/

CONSENT FORM FOR PARTICIPATION IN RESEARCH

(Please complete and return to Flinders University using the reply-paid envelope provided)

I, ...

being over the age of 18 years hereby consent to participate as requested in the research project:

Assessing Toddler's Dietary Intake

Social and Behavioural Research Ethics Committee Approval Number: 5769

1. I have read and understand the information provided.
2. Details of procedures and any risks have been explained to my satisfaction.
3. I am aware that I should retain a copy of the Information Sheet and Consent Form for future reference.
4. I understand that:
   - I may not directly benefit from taking part in this research.
   - I am free to withdraw from the project at any time and am free to decline to answer particular questions.
   - While the information gained in this study will be published as explained, I will not be identified, and individual information will remain confidential.
5. I understand that the study involves the following:
   - Completion of a questionnaire asking about my child and family
   - Completion of a 30-minute food frequency questionnaire
   - Completion of 2 x 10-minute food questionnaires (Toddler Dietary Questionnaire) at home approximately 2 weeks apart
6. I have been informed that the confidentiality of my information will be maintained and safeguarded. I understand that while information gained during this study may be published, we will not be identified and our personal results will not be divulged.

Signature of Research Participant: .... Date: ....

I certify that I have explained the study to the volunteer and consider that she/he understands what is involved and freely consents to participation.

Researchers Name: ....

Researchers Signature: .... Date: ....

inspiring achievement

Demographic questionnaire

Flinders UNIVERSITY

YOU AND YOUR CHILD

ID:

Assessing Toddler's Dietary Intake

1. What is your child's **date of birth**?

   ________ / ________ / ____________
   Day Month Year

2. What is your child's **gender**?

   male ☐ female ☐

3. What is your child's **weight?** Please refer to *'how to measure your child's weight'* on the *'Measuring Your Child'* sheet.

   Date of measure ____/____/____ Measure 1 ____________ kg Measure 2 ____________ kg

4. What is your child's **height?** Please refer to *'how to measure your child's height'* on the *'Measuring Your Child'* sheet.

   Date of measure ____/____/____ Measure 1 ____________ cm Measure 2 ____________ cm

5. What is **your date of birth**?

   ________ / ________ / ____________
   Day Month Year

6. Which of the following best describes **your relationship with your child**?

   ☐ Biological Mother ☐ Biological Father ☐ Step-Mother ☐ Step-Father ☐ Other

   If OTHER, please describe? ______________________________

7. Which of the following best describes your current **marital status?**

   ☐ Single/ Never married ☐ Married ☐ Defacto ☐ Separated /divorced ☐ Widowed

inspiring achievement

ABN 65 542 596 200, CRICOS No. 00114A

8. What is your **highest level of education**?

☐	☐	☐	☐	☐
School; Year 10 or less	School; Year 11 or 12	Trade/ Apprenticeship	TAFE/college certificate	University degree

9. Are you currently in **paid employment**?

Yes ☐ No ☐

If Yes, is this

Full time ☐ Part time ☐

If yes, approximately how many hours/week? ____________________

10. Were you **born in Australia**?

Yes ☐ No ☐

If No, where were you born? ____________________

11. Was your **child born in Australia**?

Yes ☐ No ☐

If No, where was your child born? ____________________

12. Are you **aboriginal or Torres Strait Islander**?

Yes ☐ No ☐

13. How many people typically **live in your household** (including you and your child)? __________

14. What is your **postcode**?

☐☐☐☐

Thank you for completing this questionnaire!

inspiring
achievement

ABN 65 542 596 200, CRICOS No. 00114A

‘Measuring Your Child’ instruction sheet

Flinders UNIVERSITY

Associate Professor Anthea Magarey
Research Fellow
Nutrition and Dietetics
Flinders Clinical and Molecular Medicine
School of Medicine

Rm 7E-109, Level 7, Flinders Medical Centre
Flinders Drive, Bedford Park SA 5042

GPO Box 2100
Adelaide SA 5001

Telephone: +61 8 8204 6304
Facsimile: +61 8 8204 6406
Email: anthea.magarey@flinders.edu.au
www.flinders.edu.au/medicine/sites/nutrition-and-dietetics/

MEASURING YOUR CHILD

Assessing Toddlers Dietary Intake

If you have height and weight measurements recently taken by a healthcare provider, enter those measurements and the date the measurements were taken on the ‘You and your child’ questionnaire.

Otherwise, to take height and weight measurements at home, follow these guidelines:

How to measure your child’s weight

1. **If your child will stand still by him/herself,** weigh your child alone.
   a. Be sure that the scale is placed on a flat, hard, even surface such as tile or wood, rather than carpet.
   b. Remove all your child’s clothing or at a minimum remove your child’s shoes and heavy clothing i.e. jacket/jumper
   c. Ask your child to stand on the middle of the scale, feet slightly apart, and remain still.
   d. When your child’s weight has displayed, record this weight to the nearest 0.1kg.
   e. Record your child’s weight on the ‘You and your child’ questionnaire.
   f. Repeat steps a-e if possible.

2. **If your child will not stand still on the scale,** weigh your child with yourself.
   a. Be sure that the scale is placed on a flat, hard, even surface such as tile or wood, rather than carpet.
   b. Remove all your child’s clothing or at a minimum remove your child’s shoes and heavy clothing i.e. jacket/jumper
   c. Remove your shoes and step on the scales to be weighed first alone. Stand in the middle of the scale, feet slighlty apart, and remain still. When your weight has displayed, record this weight to the nearest 0.1kg.
   d. Step onto the scales again holding your unclothed/lightly clothed child. Stand in the middle of the scale, feet slighlty apart, and remain still. When the weight has displayed, record this weight to the nearest 0.1kg.
   e. Determine your child’s weight using the following formula:

      Weight (d) – weight (c) = child’s weight

   f. Record your child’s weight on the ‘You and your child’ questionnaire.
   g. Repeat steps a-f if possible.

Note: If you do not have scales at home, community scales are often located at major shopping centres, community health centres, or your local GP.

inspiring achievement

ABN 65 542 596 200, CRICOS No. 00114A

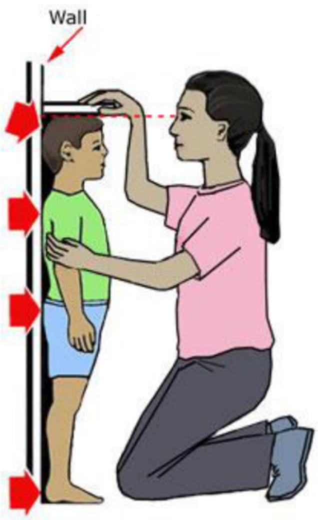
How to measure your child's height

Be prepared to measure height immediately after weighing, while the child's clothes are off.
Before weighing:

- Remove the child's shoes and socks.
- Undo braids and remove hair ornaments if they will interfere with the measurement

1) Measuring your child's height standing up.

a. Take the height measurement on flooring that is not carpeted and against a flat surface
b. Ask your child to stand with his/her back to the wall so that the head, shoulders, buttocks and heels all touch the wall (See illustration)
c. Ensure your child's feet are flat, together and against the wall, legs are straight, arms are at sides and shoulders are level.
d. Ensure your child's head is in an upright position (neck straight) eyes looking straight ahead so that the line of sight is parallel with the floor.
e. Ask child to take a deep breathe in and out and stand as tall as he/she can.
f. Use a flat headpiece to form a right angle with the wall and lower the headpiece until it firmly touches the crown of the head.
g. Make sure the measurer's eyes are at the same level as the headpiece.
h. Lightly mark where the bottom of the headpiece meets the wall.
i. Use a measuring tape to measure from the base of the floor to the marked measurement on the wall to get the height measurement.
j. Accurately record the height to the nearest 0.1 centimeter on the 'You and your child' questionnaire.
k. Repeat steps a-j if possible.



Toddler Dietary Questionnaire (TDQ)

Flinders UNIVERSITY

TODDLER DIETARY QUESTIONNAIRE

ID:

Please write the date you completed this questionnaire:_______ / ___ / 2012

This questionnaire asks about the food habits of your child. It is important that this questionnaire is completed by the person who spends the most time with your child. There are 3 sections:

Section 1 and 2 list a variety of foods which we ask you to report *how often* and *how much* your child ate or drank **over the previous week (7 full days)** by ticking the appropriate box (do not fill out the boxes in the column labelled 'score'). Please consider all foods (meals and snacks, however small) consumed by your child in the 7 day period.

How often

There are 4 response categories to indicate how many **times** the food was consumed in the last 7 days (nil, once, 2-4 times, ≥5 times). Please ensure you report how many **times** your child consumed each food, **NOT** on how many **days,** as a child may consume a food twice in a day e.g. fruit at morning tea and afternoon tea.

How much

There are 4 response categories to indicate the **average amount your child consumed per time**.

Example: Child ate approximately ½ banana 3 times and ¼ apple 4 times over the past 7 days. *How often* = 7 times, *How much* = Average ¼ - ½ regular piece. Therefore, you would tick the following boxes.

Food items	**How many times** in the past 7 days has your child consumed the following food items?		and **how much** did your child consume per time??		**Score (office use only)**
Fresh Fruit e.g. whole fruit or stewed fruit. DO NOT include fruit juice, dried fruit, or packaged (cans/tubs) fruit	☐	Nil	☐	Nil	☐
	☐	Once	√	Less than 5 Tb (½C) stewed fruit OR Less than ¾ regular piece fruit* OR less than 15 (½C) small piece fruit**	
	☐	2-4 times	☐	5-10 Tb (½ - 1C) stewed fruit OR ¾ - 1 ½ regular piece fruit* OR 15-30 (½ - 1C) small piece fruit**	
	√	≥5 times	☐	More than 10 Tb (1C) stewed fruit OR More than 1½ regular piece fruit* OR More than 30 (1C) small piece fruit**	

*Regular piece e.g. banana, apple, pear, orange, medium mandarin
**Small piece e.g. grapes, strawberries, chopped melon

Section 3 asks about the types of foods and drinks your child usually consumes.

The table to the right explains the abbreviations used in the questionnaire.

Feel free to take as much time as you require answering each question as accurately as possible.

Thank you for your time!

Abbreviation	Full Term
Tsp.	Teaspoon
Tb.	Tablespoon
C	Cup
1/8	One eighth i.e. half of one quarter
¼	One quarter
1/3	One third
½	Half
2/3	Two thirds
¾	Three quarters
≥	More than or equal to
Approx.	Approximately

inspiring achievement

ABN 65 542 596 200, CRICOS No 00114A

THIS PAGE IS INTENTIALLY LEFT BLANK

SECTION 1 Please tick (√) the appropriate box

Food items	**How many times** in the past 7 days has your child consumed the following food items?		and **how much** did your child consume per time?		**Score (office use only)**
Fresh Fruit e.g. whole fruit or stewed fruit. DO NOT include fruit juice, dried fruit, or packaged fruit (e.g. in cans/tubs)	☐	Nil	☐	Nil	☐
	☐	Once	☐	Less than 5 Tb (½C) stewed fruit OR Less than ¾ regular piece fruit* OR less than 15 (½C) small piece fruit**	
	☐	2-4 times	☐	5-10 Tb (½ - 1C) stewed fruit OR ¾ - 1 ½ regular piece fruit* OR 15-30 (½ - 1C) small piece**	
	☐	≥5 times	☐	More than 10 Tb (1C) stewed fruit OR More than 1½ regular piece fruit* OR More than 30 (1C) small piece fruit**	
Green and Brassica Vegetables e.g. broccoli, cauliflower, green beans, peas, spinach	☐	Nil	☐	Nil	☐
	☐	Once	☐	Less than 4 Tb.(¼C) peas/beans OR Less than 5 floret broccoli/cauliflower	
	☐	2-4 times	☐	4-8 Tb. (¼ - ½C) peas/beans OR 5-10 floret broccoli/cauliflower	
	☐	≥5 times	☐	More than 8 Tb. (½C) peas/beans OR more than 10 floret broccoli/cauliflower	
Orange Vegetables e.g. carrot, pumpkin and sweet potato	☐	Nil	☐	Nil	☐
	☐	Once	☐	¾ raw carrot or less OR Less than 4 Tb. (1/3C) cooked orange veg.	
	☐	2-4 times	☐	¾ - 1½ raw carrot OR 4-8 Tb. (1/3 – 2/3C) cooked orange veg.	
	☐	≥5 times	☐	1½ or more raw carrot OR More than 8 Tb. (2/3C) cooked orange veg.	
Other Vegetables e.g. tomato, mushroom, avocado, zucchini, cucumber, sweetcorn. DO NOT include potatoes.	☐	Nil	☐	Nil	☐
	☐	Once	☐	Less than 1 cup raw salad vegetables OR Less than ½ cup cooked vegetables	
	☐	2-4 times	☐	1-3 cups raw salad vegetables OR ½ - 1½ cups cooked vegetables	
	☐	≥5 times	☐	3 cups or more raw salad vegetables OR 1½ cup or more cooked vegetables	

*Regular piece e.g. banana, apple, pear, orange, medium mandarin
**Small piece e.g. grapes, strawberries, diced melon

SECTION 1 continued		Please tick (√) the appropriate box

Food items	How many times in the past 7 days has your child consumed the following food items?	and how much did your child consume per time?	Score (office use only)
Yoghurt or Custard INCLUDE dairy and non-dairy	☐ Nil	☐ Nil	☐
	☐ Once	☐ Less than 5 Tb (½C) OR 1 x 60g* or 70-100g tub** OR less than ½ x 200g tub***	
	☐ 2-4 times	☐ 5-10 Tb (½ - ¾C) OR 1½ - 2 x 70g-100g tub OR ½ - 1 x 200g tub	
	☐ ≥5 times	☐ More than 10 Tb.(¾C) OR 2 x120g tub**** OR more than 1 x 200g tub	
Grains e.g. rice, couscous, quinoa, barley. DO NOT include bread, noodles or pasta.	☐ Nil	☐ Nil	☐
	☐ Once	☐ Less than 2 Tb. cooked rice or couscous	
	☐ 2-4 times	☐ 2-5 Tb. cooked rice or couscous	
	☐ ≥5 times	☐ More than 5 Tb. (1/2C) cooked rice or couscous	
Red Meat e.g. beef, lamb, kangaroo, pork. DO NOT include chicken or processed meats such as ham or bacon	☐ Nil	☐ Nil	☐
	☐ Once	☐ Less than 4 Tb. (½C) cooked meat/mince OR Less than 2 medium slice roast+	
	☐ 2-4 times	☐ 4-8 Tb. (½ - 1C) cooked meat/mince OR 2-3 medium slice roast#	
	☐ ≥5 times	☐ More than 8Tb (1C) cooked meat/mince OR More than 3 medium slice roast+	
Fresh Fish e.g. finfish, Atlantic salmon etc. DO NOT include crumbed or battered fish	☐ Nil	☐ Nil	☐
	☐ Once	☐ Less than ¾ Tb (1/8) fish fillet (approx. 15cm long)	
	☐ 2-4 times	☐ ¾ - 1½ Tb (1/8 - ¼) fish fillet (approx. 15cm long)	
	☐ ≥5 times	☐ More than 1½ Tb. (¼) fish fillet (approx. 15cm long)	

*60g tub e.g. petit miam
**70-100g tub e.g. Pauls/Dairy Farmers children's, Rafferty's Garden yoghurt smooth, Yoplait baby/toddlers yoghurt
***200g tub (Standard adult size yoghurt tub) e.g. Nestle Diet, Ski D'lite, Dairy Farmers Thick & Creamy, Yoplait forme
****120g tub e.g. Heinz smooth custard or yoghurt dessert, Only Organic dessert pouch
+e.g. roast beef or lamb or pork

SECTION 2 Please tick (√) the appropriate box

Food items	How many times in the past 7 days has your child consumed the following food items?	and how much did your child consume per time?	Score (office use only)
Spreadable fats e.g. butter, dairy spreads, margarine	☐ Nil	☐ Nil	☐
	☐ Once	☐ Less than ½ Tsp.	
	☐ 2-4 times	☐ ½- ¾ Tsp.	
	☐ ≥5 times	☐ More than ¾ Tsp.	
Vegemite-type spread e.g. vegemite, marmite, promite	☐ Nil	☐ Nil	☐
	☐ Once	☐ Less than ½ Tsp.	
	☐ 2-4 times	☐ ½- ¾ Tsp.	
	☐ ≥5 times	☐ More than ¾ Tsp.	
Chips, Popcorn INCLUDE potato, corn, soy, vegetable, and cheese or non-cheese flavoured snack chips*	☐ Nil	☐ Nil	☐
	☐ Once	☐ Less than ½ small packet (20g) chips OR Less than 1C popcorn	
	☐ 2-4 times	☐ ½ - 1 small packet (20g) chips OR 1 - 2C popcorn	
	☐ ≥5 times	☐ More than ¾ small packet (20g) chips OR More than 2C popcorn	
Hot potato products e.g. chips, wedges, potato gems/nuggets, hash browns. INCLUDE homemade, frozen-style and takeaway. DO NOT include boiled, roast or mashed potatoes	☐ Nil	☐ Nil	☐
	☐ Once	☐ Less than ¼C chips, wedges or gems OR Less than ½ small fries**/hash brown	
	☐ 2-4 times	☐ ¼ - ½C chips, wedges or gems OR ½-1 small fries**/hash brown	
	☐ ≥5 times	☐ More than ½C chips, wedges or gems OR More than 1 small fries**/hash brown	

*e.g. Twisties (cheese or chicken flavoured), Cheezels, Cheese rings, Toobs, Burger rings
**e.g. McDonalds/Hungry Jacks size or equivalent

SECTION 2 continued   Please tick (√) the appropriate box

Food items	**How many times** in the past 7 days has your child consumed the following food items?	and **how much** did your child consume per time?	**Score (office use only)**
Meat products e.g. sausages, frankfurts, fritz/devon, bacon, salami, ham	☐ Nil	☐ Nil	☐
	☐ Once	☐ Less than ¾ slice fritz/rasher bacon (approx. 15cm) OR Less than ¼ sausage/regular frankfurt	
	☐ 2-4 times	☐ ½ - 1 slice fritz/rasher bacon (approx. 15cm) OR ¼ - ¾ sausage/regular frankfurt	
	☐ ≥5 times	☐ More than 1 slice fritz/rasher bacon (approx. 15cm) OR More than ¾ sausage/regular frankfurt	
Sweet Biscuits, Cakes, Buns, Muffins INCLUDE all cake-type desserts	☐ Nil	☐ Nil	☐
	☐ Once	☐ Less than 2½ sweet biscuits OR Less than ½ cupcake/small muffin/thin slice cake/crumpet OR Less than 1 small pancake/pikelet	
	☐ 2-4 times	☐ 2½ - 5 sweet biscuits OR ½ - 1 cupcake/small muffin/thin slice cake/crumpet OR 1–2 small pancake/pikelet	
	☐ ≥5 times	☐ More than 5 sweet biscuits OR More than 1 cupcake/small muffin/thin slice cake/crumpet OR More than 2 small pancake/pikelet	
Chocolate or Chocolate-based confectionary INCLUDE plain, filled and those with additions such as nuts, dried fruit etc.	☐ Nil	☐ Nil	☐
	☐ Once	☐ Less than 2 piece chocolate from block OR Less than 7 pieces chocolate-coated confectionary*	
	☐ 2-4 times	☐ 2-3 piece chocolate from block OR 7-12 pieces chocolate-coated confectionary*	
	☐ ≥5 times	☐ More than 3 piece chocolate from block OR More than 12 pieces chocolate-coated confectionary*	
Ice cream, Frozen Yoghurt INCLUDE tub and stick varieties	☐ Nil	☐ Nil	☐
	☐ Once	☐ Less than ½ scoop ice-cream/frozen yoghurt OR Less than ¼ stick ice-cream	
	☐ 2-4 times	☐ ½ - 1½ scoop ice-cream/frozen yoghurt OR Approx. ¼ stick ice-cream	
	☐ ≥5 times	☐ More than 1½ scoop ice-cream/frozen yoghurt OR More than ¼ stick ice-cream	

*e.g. chocolate coated dried fruit, nuts, fruit and nut mix

SECTION 3 Please tick (√) the appropriate box

Question	Response	Score (office use only)
What proportion of **white:non-white*** bread does your child usually** consume? (tick one only)	☐ None white : All non-white	☐
	☐ Some white: Mostly non-white	
	☐ Mostly white: Some non-white	
	☐ All white: None non-white	
What **milk drinks** does your child usually** consume? (tick all that apply)	☐ Breast milk or plain milk***	☐
	☐ Formula	
	☐ Flavoured milk***	
	☐ None of the above i.e. no milk drinks	
What **non-milk drinks** does your child usually** consume? (tick all that apply)	☐ Water	☐
	☐ Diluted juice (fruit and/or vegetable)	
	☐ Un-diluted juice (fruit and/or vegetable)	
	☐ Cordial or soft drink****	

*Non-white includes wholemeal, wholegrain, rye
**Usually=on most days
***include cow-, goat-, and soy-milks
****include diet and non-diet drinks

You are finished, Well done ☺

Thank you again for your time!

Note: please make sure you have recorded the date you completed this questionnaire on front page

Food Frequency Questionnaire

Flinders UNIVERSITY

FOOD FREQUENCY QUESTIONNAIRE

ID:

Please write the date you completed this questionnaire:______/______/ 2012

General remark

In this food-frequency questionnaire we ask about the food habits of your child. Therefore it is important that this questionnaire is completed by the person who spends most time with the child (child care time excepted).

In the following table a variety of food s/food groups is listed. Please describe (as exact as possible) how often your child has consumed the listed products **over the past month** and indicate the average portion your child consumed on that day. Also consider the foods consumed at child care/day care.

How often (frequency)?

In the column with the heading *'How often did your child consume the following products **in the last month**?'* there are 5 possible answers:

- never
- 1–3 days per month
- 1 day per week
- 2–4 days per week
- 5–6 days per week every day

How much?

In the column with the heading *'and what is the average portion **per day**?'*, 3 or 4 portion size options are given. In the column with the heading *'Example portion sizes'*, a number of directive weights and measures are given. These can help you to quantify the average portion sizes consumed by your child on the day of consumption. Indicate your choice by filling in the circle near the answer that is most suitable for your child.

Example

- A child eats 2 big slices of bread every morning and 3 big slices of bread in the evening. On Sunday morning, he/she eats 2 small slices of fruit-bread instead of normal bread.
- Every morning he/she drinks a cup of plain milk at home and a carton of chocolate milk at school (5 days per week). During the weekend he/she drinks a carton/tetra pack of whole milk instead of a carton of chocolate milk.

Food groups	How often did your child consume the following products in the last month?	And what was the average portion per day?	Example portion sizes
Bread/rusk/crusted roll	○ never ○ 1–3 days per month ○ 1 day per week ○ 2–4 days per week ● 5–6 days per week ○ every day	○ 40 g or less ○ between 40 and 120 g ● 120 g or more	1 rusk = 10g 1 crusted roll = 40g
Sweet bread (e.g. fruit bread)	○ never ○ 1–3 days per month ● 1 day per week ○ 2–4 days per week ○ 5–6 days per week ○ every day	● 40 g or less ○ between 40 and 120 g ○ 120 g or more	1 slice of big bread = 30g 1 slice of a small bread = 20g
Flavoured milk (e.g. chocolate/strawberry milk, iced coffee, milkshake)	○ never ○ 1–3 days per month ○ 1 day per week ○ 2–4 days per week ● 5–6 days per week ○ every day	○ 200ml or less ● Between 200ml and 400ml ○ Between 400ml and 600ml ○ 600ml or more	**1 cup = 250ml** **1 glass = 200ml** **1 carton = 300ml / 600ml** **1 tetra pack = 250ml**
Plain milk (without additional sugars)	○ never ○ 1–3 days per month ○ 1 day per week ○ 2–4 days per week ● 5–6 days per week ○ every day	○ 200ml or less ● Between 200ml and 400ml ○ Between 400ml and 600ml ○ 600ml or more	**1 cup = 250ml** **1 glass = 200ml** **1 tetra pack = 250ml**

inspiring achievement

FOOD FREQUENCY QUESTIONNAIRE

Food groups	How often did your child consume the following products in the last month?	And what was the average portion per day?	Example portion sizes
Water (tap water, bottled water..)	○ never ○ 1 – 3 days per month ○ 1 day per week ○ 2 – 4 days per week ○ 5 – 6 days per week ○ every day	○ 200ml or less ○ Between 200ml and 400ml ○ Between 400ml and 600ml ○ 600ml or more	1 cup = 250ml 1 bottle = 500-750ml 1 glass = 200ml
Coffee and tea without sugar	○ never ○ 1 – 3 days per month ○ 1 day per week ○ 2 – 4 days per week ○ 5 – 6 days per week ○ every day	○ 200ml or less ○ Between 200ml and 400ml ○ Between 400ml and 600ml ○ 600ml or more	1 cup = 250ml
Coffee and tea with sugar	○ never ○ 1 – 3 days per month ○ 1 day per week ○ 2 – 4 days per week ○ 5 – 6 days per week ○ every day	○ 200ml or less ○ Between 200ml and 400ml ○ Between 400ml and 600ml ○ 600ml or more	1 cup = 250ml
Fruit juice	○ never ○ 1 – 3 days per month ○ 1 day per week ○ 2 – 4 days per week ○ 5 – 6 days per week ○ every day	○ 200ml or less ○ Between 200ml and 400ml ○ Between 400ml and 600ml ○ 600ml or more	1 cup = 250ml 1 glass = 200ml 1 juice box = 250ml
Diet beverages (diet soda drinks, e.g. diet cola, diet lemonade)	○ never ○ 1 – 3 days per month ○ 1 day per week ○ 2 – 4 days per week ○ 5 – 6 days per week ○ every day	○ 200ml or less ○ Between 200ml and 400ml ○ Between 400ml and 600ml ○ 600ml or more	1 cup = 250ml 1 glass = 200ml 1 can = 375ml 1 small bottle = 600ml 1 large bottle = 1L / 2L
Sugared beverages (soda drinks such as cola, lemonade, iced tea..)	○ never ○ 1 – 3 days per month ○ 1 day per week ○ 2 – 4 days per week ○ 5 – 6 days per week ○ every day	○ 200ml or less ○ Between 200ml and 400ml ○ Between 400ml and 600ml ○ 600ml or more	1 cup = 250ml 1 glass = 200ml 1 can = 375ml 1 small bottle = 600ml 1 large bottle = 1000ml/2000ml
Cordial (e.g. fruit juice cordial)	○ never ○ 1 – 3 days per month ○ 1 day per week ○ 2 – 4 days per week ○ 5 – 6 days per week ○ every day	○ 200ml or less ○ Between 200ml and 400ml ○ Between 400ml and 600ml ○ 600ml or more	1 cup = 250ml 1 glass = 200ml
Vegetable beverages (e.g. vegetable juice)	○ never ○ 1 – 3 days per month ○ 1 day per week ○ 2 – 4 days per week ○ 5 – 6 days per week ○ every day	○ 200ml or less ○ Between 200ml and 400ml ○ Between 400ml and 600ml ○ 600ml or more	1 cup = 250ml 1 glass = 200ml 1 juice box = 250ml
Soup	○ never ○ 1 – 3 days per month ○ 1 day per week ○ 2 – 4 days per week ○ 5 – 6 days per week ○ every day	○ 200ml or less ○ Between 200ml and 400ml ○ Between 400ml and 600ml ○ 600ml or more	1 soup bowl = 250ml 1 bowl / cup = 250ml

Food groups	How often did your child consume the following products in the last month?	And what was the average portion per day?	Example portion sizes
Probiotic yoghurt drink (e.g. Yakult)	○ never ○ 1 – 3 days per month ○ 1 day per week ○ 2 – 4 days per week ○ 5 – 6 days per week ○ every day	○ 40ml or less ○ Between 40 and 120ml ○ 120ml or more	1 Yakult = 65ml
Flavoured milk (e.g. chocolate milk, iced coffee, milkshake) Include cow-, soy-, goat- milk	○ never ○ 1 – 3 days per month ○ 1 day per week ○ 2 – 4 days per week ○ 5 – 6 days per week ○ every day	○ 200ml or less ○ Between 200ml and 400ml ○ Between 400ml and 600ml ○ 600ml or more	1 cup = 250ml 1 glass = 200ml 1 carton = 300ml / 600ml 1 tetra pack = 250ml
Plain milk (without additional sugars; not flavoured) Include cow-, soy-, goat- milk	○ never ○ 1 – 3 days per month ○ 1 day per week ○ 2 – 4 days per week ○ 5 – 6 days per week ○ every day	○ 200ml or less ○ Between 200ml and 400ml ○ Between 400ml and 600ml ○ 600ml or more	1 cup = 250ml 1 glass = 200ml 1 tetra pack = 250ml
Formula (infant or toddler commercial formula)	○ never ○ 1 – 3 days per month ○ 1 day per week ○ 2 – 4 days per week ○ 5 – 6 days per week ○ every day	○ 200ml or less ○ Between 200ml and 400ml ○ Between 400ml and 600ml ○ 600ml or more	1 cup = 250ml 1 glass = 200ml 1 small bottle = 125ml 1 medium bottle = 260ml 1 large bottle = 330ml
Breast milk	○ never ○ 1 – 3 days per month ○ 1 day per week ○ 2 – 4 days per week ○ 5 – 6 days per week ○ every day	○ 10 minutes or less ○ 10 – 20 minutes ○ More than 20 minutes	In minutes
Soft cheese (e.g. camembert, brie)	○ never ○ 1 – 3 days per month ○ 1 day per week ○ 2 – 4 days per week ○ 5 – 6 days per week ○ every day	○ 65 g or less ○ between 65 and 195g ○ 95g or more	1 serving = 25g 1 whole round packet = 200g
Custard and yoghurt (with/without fruit; not frozen)	○ never ○ 1 – 3 days per month ○ 1 day per week ○ 2 – 4 days per week ○ 5 – 6 days per week ○ every day	○ 65 g or less ○ between 65 and 195g ○ 195g or more	1 baby size tub= 60-70g 1 child size tub= 100-120g 1 adult size tub= 200g 1 tablespoon = 20g ½ cup = 130g
Milk-based desserts (pudding, rice pudding)	○ never ○ 1 – 3 days per month ○ 1 day per week ○ 2 – 4 days per week ○ 5 – 6 days per week ○ every day	○ 65 g or less ○ between 65 and 195g ○ 195g or more	1 small serve pudding = 90g 1 medium serve pudding = 120g
Chocolate mousse, tiramisu	○ never ○ 1 – 3 days per month ○ 1 day per week ○ 2 – 4 days per week ○ 5 – 6 days per week ○ every day	○ 65 g or less ○ between 65 and 195g ○ 195g or more	1 serving mousse = 100g 1 slice tiramisu = 100g

Food groups	How often did your child consume the following products in the last month?	And what was the average portion per day?	Example portion sizes
Ice cream, frozen yoghurt	○ never ○ 1 – 3 days per month ○ 1 day per week ○ 2 – 4 days per week ○ 5 – 6 days per week ○ every day	○ 65 g or less ○ between 65 and 195g ○ 195g or more	2 scoop of ice-cream = 50g 1 scoop of frozen yoghurt = 45g
Nuts and seeds	○ never ○ 1 – 3 days per month ○ 1 day per week ○ 2 – 4 days per week ○ 5 – 6 days per week ○ every day	○ 25 g or less ○ between 25 and 75 g ○ 75 g or more	10 peanuts without shells = 20g 1 tablespoon of nuts = 25g
Olives	○ never ○ 1 – 3 days per month ○ 1 day per week ○ 2 – 4 days per week ○ 5 – 6 days per week ○ every day	○ 20 g or less ○ between 20 and 60 g ○ 60 g or more	5 olives = 20g 15 olives = 60g
Dried fruit	○ never ○ 1 – 3 days per month ○ 1 day per week ○ 2 – 4 days per week ○ 5 – 6 days per week ○ every day	○ 1 tablespoon ○ 1-3 tablespoons ○ 3 tablespoons	1 tablespoon of dried fruit = 1 dried fig = 20g
Canned fruit	○ never ○ 1 – 3 days per month ○ 1 day per week ○ 2 – 4 days per week ○ 5 – 6 days per week ○ every day	○ 75 g or less ○ between 75 and 225g ○ 225g or more	1 slice canned pineapple = 35g 1 half apricot canned with syrup = 17g
Fresh fruit	○ never ○ 1 – 3 days per month ○ 1 day per week ○ 2 – 4 days per week ○ 5 – 6 days per week ○ every day	○ 75 g or less ○ between 75 and 225g ○ 225g or more	1 kiwi = 75g 1 orange = 130g 1 banana = 100g 1 apple = 140g ½ punnet strawberries = 185g
Chocolate	○ never ○ 1 – 3 days per month ○ 1 day per week ○ 2 – 4 days per week ○ 5 – 6 days per week ○ every day	○ 25 g or less ○ between 25 and 75 g ○ 75 g or more	1 individual bar = 50g 1 row from block = 30g 1 large block = 250g
Sweet snacks (e.g. biscuits, cake, muffin, pancake, crumpet) No milk-based desserts.	○ never ○ 1 – 3 days per month ○ 1 day per week ○ 2 – 4 days per week ○ 5 – 6 days per week ○ every day	○ 25 g or less ○ between 25 and 75 g ○ 75 g or more	1 un-filled biscuit = 10g 1 filled biscuit = 20g 1 cupcake/small muffin = 55g 1 pikelet = 20g 1 pancake = 40g
Salty snacks (crisps, popcorn, salted biscuits)	○ never ○ 1 – 3 days per month ○ 1 day per week ○ 2 – 4 days per week ○ 5 – 6 days per week ○ every day	○ 25 g or less ○ between 25 and 75 g ○ 75 g or more	1 small bag of crisps = 20g 1 large bag of crisps = 50g 1 family bag of crisps = 200g 1 cup popcorn = 10g

Food groups	How often did your child consume the following products in the last month?	And what was the average portion per day?	Example portion sizes
Breakfast cereals	○ never ○ 1 – 3 days per month ○ 1 day per week ○ 2 – 4 days per week ○ 5 – 6 days per week ○ every day	○ 15 g or less ○ between 15 and 45 g ○ 45 g or more	1 bowl/cup of cereals = 30g 1 individual box = 30g
Sweet bread (e.g. fruit/raisin bread)	○ never ○ 1 – 3 days per month ○ 1 day per week ○ 2 – 4 days per week ○ 5 – 6 days per week ○ every day	○ 40 g or less ○ between 40 and 120 g ○ 120 g or more	1 slice of big bread = 30g 1 slice of a small bread = 20g
Bread/rusk/crusted roll	○ never ○ 1 – 3 days per month ○ 1 day per week ○ 2 – 4 days per week ○ 5 – 6 days per week ○ every day	○ 40 g or less ○ between 40 and 120 g ○ 120 g or more	1 slice of big bread = 30g 1 slice of a small bread = 20g 1 rusk = 10g 1 crusted roll = 40g
Spreadable fats (e.g. margarine, butter, dairy spreads)	○ never ○ 1 – 3 days per month ○ 1 day per week ○ 2 – 4 days per week ○ 5 – 6 days per week ○ every day	○ 2.5 g or less ○ between 2.5 and 5 g ○ 5 g or more	7g for 1 slice of bread 1 teaspoon = 5g
Chocolate spread, sprinkles or flakes	○ never ○ 1 – 3 days per month ○ 1 day per week ○ 2 – 4 days per week ○ 5 – 6 days per week ○ every day	○ 15 g or less ○ between 15 and 45 g ○ 45 g or more	15g for 1 large loaf 10g for 1 small loaf
Other sweet spread (honey, jam or marmalade)	○ never ○ 1 – 3 days per month ○ 1 day per week ○ 2 – 4 days per week ○ 5 – 6 days per week ○ every day	○ 15 g or less ○ between 15 and 45 g ○ 45 g or more	15g for 1 large loaf 10g for 1 small loaf
Non-sweet spread (e.g. vegemite, marmite, promite)	○ never ○ 1 – 3 days per month ○ 1 day per week ○ 2 – 4 days per week ○ 5 – 6 days per week ○ every day	○ 2.5 g or less ○ between 2.5 and 5 g ○ 5 g or more	5g for thin spread on 1 slice bread 10g for thick spread on 1 slice bread 1 teaspoon = 6g
Cheese spread/melted cheese (fondue, slice of processed cheese)	○ never ○ 1 – 3 days per month ○ 1 day per week ○ 2 – 4 days per week ○ 5 – 6 days per week ○ every day	○ 10 g or less ○ between 10 and 30gg ○ 30 g or more	1 triangle = 20g 1 slice = 20g
Hard cheese (e.g. Cheddar, Gouda)	○ never ○ 1 – 3 days per month ○ 1 day per week ○ 2 – 4 days per week ○ 5 – 6 days per week ○ every day	○ 10 g or less ○ between 10 and 30g ○ 30 g or more	1 slice of cheese (10 x 10cm) = 20g

Food groups	How often did your child consume the following products in the last month?	And what was the average portion per day?	Example portion sizes
Fish products (e.g. smoked salmon)	○ never ○ 1 – 3 days per month ○ 1 day per week ○ 2 – 4 days per week ○ 5 – 6 days per week ○ every day	○ 15 g or less ○ between 15 and 45 g ○ 45 g or more	15 g for 1 slice of bread
Meat products (sausage, frankfurt, fritz/devon, sliced cold meat e.g. ham, chicken, salami)	○ never ○ 1 – 3 days per month ○ 1 day per week ○ 2 – 4 days per week ○ 5 – 6 days per week ○ every day	○ 15 g or less ○ between 15 and 45 g ○ 45 g or more	25 g cold meat for 1 slice of bread 1 sausage/frankfurt = 55g 1 slice fritz/devon = 30g
Eggs (not in preparations such as cakes or biscuits)	○ never ○ 1 – 3 days per month ○ 1 day per week ○ 2 – 4 days per week ○ 5 – 6 days per week ○ every day	○ 1 piece or less ○ 2 pieces ○ 3 pieces or more	per piece
Vegetarian products (e.g. Tofu, pulses)	○ never ○ 1 – 3 days per month ○ 1 day per week ○ 2 – 4 days per week ○ 5 – 6 days per week ○ every day	○ 25 g or less ○ between 25 and 75 g ○ 75 g or more	1 small / large vegetarian burger patty = 55g / 95g 2 tablespoons of cooked pulses = 50g ½ cup cooked tofu =140g
Fresh fish/shellfish (e.g. fresh fish/salmon, cod, prawns, mussels) No fish products	○ never ○ 1 – 3 days per month ○ 1 day per week ○ 2 – 4 days per week ○ 5 – 6 days per week ○ every day	○ 25 g or less ○ between 25 and 75 g ○ 75 g or more	1 tbsp fish = 20g 1 fish fillet (~16cm) =115g 5 king prawns= 80g
Poultry (chicken, duck)	○ never ○ 1 – 3 days per month ○ 1 day per week ○ 2 – 4 days per week ○ 5 – 6 days per week ○ every day	○ 25 g or less ○ between 25 and 75 g ○ 75 g or more	1 chicken fillet = 150g 1 chicken nugget= 25g
Meat (beef, lamb, pork, kangaroo) No poultry or meat products	○ never ○ 1 – 3 days per month ○ 1 day per week ○ 2 – 4 days per week ○ 5 – 6 days per week ○ every day	○ 25 g or less ○ between 25 and 75 g ○ 75 g or more	1 large pork chop = 130g 1 lamb chop = 50g 1 medium steak = 185g ½ cup mince = 85g 1 medium slice roast = 30g
Pasta (spaghetti, macaroni, lasagne...)	○ never ○ 1 – 3 days per month ○ 1 day per week ○ 2 – 4 days per week ○ 5 – 6 days per week ○ every day ○	○ 75 g cooked or less ○ between 75 and 225g cooked ○ 225g cooked or more	50g uncooked pasta gives 125g cooked pasta ½ cup cooked pasta = 60g
Rice and couscous	○ never ○ 1 – 3 days per month ○ 1 day per week ○ 2 – 4 days per week ○ 5 – 6 days per week ○ every day	○ 75 g cooked or less ○ between 75 and 225g cooked ○ 225g cooked or more	40g uncooked rice gives 115g boiled rice 1 tablespoon cooked rice = 15g 1 tablespoon cooked couscous = 6g

Food groups	How often did your child consume the following products in the last month?	And what was the average portion per day?	Example portion sizes
Fried potato products (chips, fries, hash browns, potato nuggets/gems)	○ never ○ 1 – 3 days per month ○ 1 day per week ○ 2 – 4 days per week ○ 5 – 6 days per week ○ every day	○ 50 g or less ○ between 50 and 150g ○ 150 g or more	10 chips= 55g 10 fries = 40g 10 gems = 90g 1 hash brown = 55g
Potatoes (cooked, steamed, baked, mashed...)	○ never ○ 1 – 3 days per month ○ 1 day per week ○ 2 – 4 days per week ○ 5 – 6 days per week ○ every day	○ 75 g cooked or less ○ between 75 and 225g cooked ○ 225 g cooked or more	1 cooked medium potato =140g 1 tablespoon of mashed potatoes = 20g
Green and Brassica Vegetables (e.g. broccoli, cauliflower, green beans, peas)	○ never ○ 1 – 3 days per month ○ 1 day per week ○ 2 – 4 days per week ○ 5 – 6 days per week ○ every day	○ 50 g cooked or less ○ between 50 and 100 g cooked ○ 100 g cooked or more	2 floret cooked broccoli =20g 2 green beans = 15g 2 tbsp peas = 25g
Orange vegetables (e.g. carrot, pumpkin and sweet potato)	○ never ○ 1 – 3 days per month ○ 1 day per week ○ 2 – 4 days per week ○ 5 – 6 days per week ○ every day	○ 50 g cooked or less ○ between 50 and 100 g cooked ○ 100 g cooked or more	½ cooked carrot = 30g 2 tablespoon of cooked pumpkin = 20g 2 tablespoon cooked sweet potato = 30g
Other vegetables (e.g. tomato, mushroom, avocado, zucchini, cucumber, sweetcorn) DO NOT include potatoes.	○ never ○ 1 – 3 days per month ○ 1 day per week ○ 2 – 4 days per week ○ 5 – 6 days per week ○ every day	○ 100 g cooked or less ○ Between 100 and 200 g cooked ○ 200 g cooked or more	2 tbsp avocado = 40g 2 tbsp sweetcorn = 30g 1 tomato = 150 g 1 cup mixed veg = 150g

Please indicate for the following questions the food product your child consumes mostly

What kind of water does your child usually drink?

- tap water
- bottled water
- not applicable (my child never drinks water)

What kind of fruit juice does your child usually drink?

- diluted (with water) fruit juice
- non-diluted fruit juice
- not applicable (my child never drinks fruit juice)

What kind of milk does your child usually drink?

- low fat milk
- reduced fat milk
- whole milk
- not applicable (my child never drinks milk)

What kind of yoghurt does your child usually eat?

- low fat yoghurt
- reduced fat yoghurt
- whole yoghurt
- not applicable (my child never eats yoghurt)

What kind of cheese does your child usually eat?

- low fat cheese
- reduced fat cheese
- whole fat cheese
- not applicable (my child never eats cheese)

What other kind of sweet spreads does your child usually eat?

- peanut butter
- maple syrup
- jam or marmalade
- honey
- other, please specify: ....
- not applicable (my child never eats other sweet spreads)

What kind of bread does your child usually eat?

- brown bread
- white bread
- mostly brown, some white bread
- mostly white, some brown bread

What kind of rice does your child usually eat?

- brown rice
- white rice
- not applicable (my child never eats rice)

What kind of pasta does your child usually eat?

- wholemeal pasta
- white pasta
- not applicable (my child never eats pasta)

What kind of fat spread does your child usually use on his/ her bread, rusk...?

- no-fat spread
- reduced fat spread
- full fat spread
- butter
- other, please specify: ....

You are finished, Well done ☺

Thank you again for your time!

Appendix 4 - Ethics approval letter

5769 SBREC - Final approval notice

Human Research Ethics <human.researchethics@flinders.edu.au>

Tue 9/18/2012 6:13 AM

To:Lucy Bell <lucy.bell@flinders.edu.au>; Anthea Magarey <anthea.magarey@flinders.edu.au>; rebecca.golley@unisa.edu.au <rebecca.golley@unisa.edu.au>;

Dear Lucy,

The Chair of the Social and Behavioural Research Ethics Committee (SBREC) at Flinders University considered your response to conditional approval out of session and your project has now been granted final ethics approval. Your ethics final approval notice can be found below.

FINAL APPROVAL NOTICE

Project No.:	**5769**
Project Title:	Validation and test-retest reliability of a parent-administered Toddler Food Questionnaire assessing nutrition risk of children aged 1-3 years
Principal Researcher:	Ms Lucy Bell
Email:	lucy.bell@flinders.edu.au
Address:	School of Medicine Nutrition and Dietetics

Approval Date:	18 September 2012	Ethics Approval Expiry Date:	**30 July 2013**

The above proposed project has been **approved**on the basis of the information contained in the application, its attachments and the information subsequently provided.

RESPONSIBILITIES OF RESEARCHERS AND SUPERVISORS

1. **Participant Documentation**
Please note that it is the responsibility of researchers and supervisors, in the case of student projects, to ensure that:

- all participant documents are checked for spelling, grammatical, numbering and formatting errors. The Committee does not accept any responsibility for the above mentioned errors.
- the Flinders University logo is included on all participant documentation (e.g., letters of Introduction, information Sheets, consent forms, debriefing information and questionnaires – with the exception of purchased research tools) and the current Flinders University letterhead is included in the header of all letters of introduction. The Flinders University international logo/letterhead should be used and documentation should contain international dialling codes for all telephone and fax numbers listed for all research to be conducted overseas.
- the SBREC contact details, listed below, are included in the footer of all letters of introduction and information sheets.

This research project has been approved by the Flinders University Social and Behavioural Research Ethics Committee (Project Number 'INSERT PROJECT No. here following approval'). For more information regarding ethical approval of the project the Executive Officer of the Committee can be contacted by telephone on 8201 3116, by fax on 8201 2035 or by email human.researchethics@flinders.edu.au.

2. **Annual Progress / Final Reports**
In order to comply with the monitoring requirements of the*National Statement on Ethical Conduct in Human Research (March 2007)* an annual progress report must be submitted each year on the **18 September** (approval anniversary date) for the duration of the ethics approval using the annual progress / final report pro forma. *Please retain this notice for reference when completing annual progress or final reports.*

If the project is completed *before* ethics approval has expired please ensure a final report is submitted immediately. If ethics approval for your project expires please submit either (1) a final report; or (2) an extension of time request and an annual report.

Your first report is due on **18 September 2013** or on completion of the project, whichever is the earliest.

3. **Modifications to Project**
Modifications to the project must not proceed until approval has been obtained from the Ethics Committee. Such matters include:

- proposed changes to the research protocol;
- proposed changes to participant recruitment methods;
- amendments to participant documentation and/or research tools;
- extension of ethics approval expiry date; and
- changes to the research team (addition, removals, supervisor changes).

To notify the Committee of any proposed modifications to the project please submit a Modification Request Form to the Executive Officer. Please note that extension of time requests should be submitted priorto the Ethics Approval Expiry Date listed on this notice.

Change of Contact Details

Please ensure that you notify the Committee if either your mailing or email address changes to ensure that correspondence relating to this project can be sent to you. A modification request is not required to change your contact details.

4. Adverse Events and/or Complaints

Researchers should advise the Executive Officer of the Ethics Committee on 08 8201-3116 or human.researchethics@flinders.edu.au immediately if:

- any complaints regarding the research are received;
- a serious or unexpected adverse event occurs that effects participants;
- an unforseen event occurs that may affect the ethical acceptability of the project.

Joanne Petty
Administration Support
Social and Behavioural Research Ethics Committee

c.c Dr Anthea Magarey
Dr Rebecca Golley

Joanne Petty
Administration Support, Social and Behavioural Research Ethics Committee
Research Services Office |Union Building Basement
Flinders University
Sturt Road, Bedford Park | South Australia | 5042
GPO Box 2100 | Adelaide SA 5001
P: +61 8 8201-3116 | F: +61 8 8201-2035 |Web:Social and Behavioural Research Ethics Committee

Appendix 5 - Recruitment materials

Advertisement/flyer

Flinders UNIVERSITY

Associate Professor Anthea Magarey
Research Fellow
Nutrition and Dietetics
Flinders Clinical and Molecular Medicine
School of Medicine

Rm 7E-109, Level 7, Flinders Medical Centre
Flinders Drive, Bedford Park SA 5042

GPO Box 2100
Adelaide SA 5001

Telephone: +61 8 8204 6304
Facsimile: +61 8 8204 6406
Email: anthea.magarey@flinders.edu.au
www.flinders.edu.au/medicine/sites/nutrition-and-dietetics/

PARENTS OF TODDLERS NEEDED

Assessing Toddlers Dietary Intake

Flinders University is looking for parents of toddlers who are willing to participate in a study to assess toddler's dietary intake.

We would like to hear from you if:

- You are a parent of a healthy toddler aged between 12 and 36 months
- Your toddler does not have any food intolerances or allergies
- Your toddler does not have any pre-existing medical condition which affects his/her dietary intake
- You are willing to participate in a study that involves completion of 4 questionnaires at home; 1 x questionnaire about your child and family, 1 x 30 minute food questionnaire, and 2 x 15 minute food questionnaires

You will receive brief individual feedback on your child's diet at the completion of the study and a copy of the '*CSIRO Wellbeing Plan for Kids*' book. If you would like to receive an information package please contact us by phone on 08 8204 5957, or email us at lucy.bell@flinders.edu.au. Please pass this information onto anyone you believe may be interested and eligible.

✂...

Post in this slip for an information package

Assessing Toddler's Dietary Intake

Miss Lucy Bell
Nutrition and Dietetics
Flinders Clinical and Molecular Medicine
School of Medicine

Rm 7E-107, Level 7, Flinders Medical Centre
Flinders Drive, Bedford Park SA 5042

GPO Box 2100
Adelaide SA 5001

Name:...

Email address: .... Phone Number: ....

Postal Address: .... Post Code ....

inspiring achievement

Flinders In Touch email advertisement

Assessing Toddler's Dietary Intake

Parents of Toddlers Needed!

We are looking for parents of toddlers aged 12-36 months who do not have any food intolerances, allergies or pre-existing medical conditions that affect dietary intake. The study involves completion of 1 x questionnaire about your child and family, 1 x 30 minute food questionnaire, and 2 x 15 minute food questionnaires. A copy of the **'CSIRO Wellbeing Plan for Kids'** book will be provided at study completion. Please contact Lucy (08 8204 5957; lucy.bell@flinders.edu.au) if you are interested.

Facebook page content

Appendix 6 - Participant incentives

Example Feedback Form

Flinders UNIVERSITY

Associate Professor Anthea Magarey
Research Fellow
Nutrition and Dietetics
Flinders Clinical and Molecular Medicine
School of Medicine

Rm 7E-109, Level 7, Flinders Medical Centre
Flinders Drive, Bedford Park SA 5042

GPO Box 2100
Adelaide SA 5001

Telephone: +61 8 8204 6304
Facsimile: +61 8 8204 6406
Email: anthea.magarey@flinders.edu.au
www.flinders.edu.au/medicine/sites/nutrition-and-dietetics/

11 February 2013

Dear XXX,

We would like to warmly thank you for participating in the study titled 'Assessing Toddlers Dietary Intake'. We appreciate you and your child's involvement in the study which has enabled us to test whether a newly developed Toddler Food Questionnaire accurately assesses toddler's dietary intake. This will allow us to gain a greater understanding of toddler's eating habits in the future. The 'CSIRO Wellbeing Plan for Kids' book is enclosed to thank you for your contribution.

The comments below provide some brief feedback on your child's diet based on the questionnaires you completed as part of this study. Pages 2-4 provide some practical tips to achieve these changes. This information is to be used as a *guide* only and if you are interested in receiving more detailed advice about your child's diet you can find an Accredited Practicing Dietitian, who can provide tailored advice and support for you and your family, by visiting the Dietitians Association of Australia website http://daa.asn.au/for-the-public/. Alternatively, you can call the Children, Youth and Women's Health Services (CYWHS) Parent Hotline on 1300 364 100 for nutrition information and support.

Feedback

Continue providing ***fresh fruit***, a range of ***vegetables daily, yoghurt/custard, grains (rice/couscous)*** and ***red meat*** as you have been doing, well done!! ☺

Offer the following foods more often;

- ***Fish:*** *1-2 times/week* (good source of protein and provides many vitamins to help your child's body function well)
- ***Grains*** such as rice/couscous/quinoa: *2-4 times/week* (good alternative sources of carbohydrate to pasta, noodles and potatoes as they are higher in dietary fibre).

Offer the following foods less often (they are high in fat, sugar and/or salt and low in the nutrients your child needs);

- ***Sweet biscuits, cakes, muffins and cake-type products***
- ***Salty snack products*** (chips, popcorn, pretzels)
- ***Meat products*** (sausages, fritz, bacon, salami, ham)
- ***Ice-cream and frozen yoghurt***
- ***Hot potato products*** (chips/fries, wedges, gems, hash browns)
- ***Chocolate***
- ***Juice, Cordial, Soft Drink, Flavoured milk*** (high in sugar and lower in fibre than whole fruit or vegetables). Water and plain milk are the best drinks for children. If you do provide juice, dilute with water.

inspiring achievement

Tips to include more…

Fish:

- Try marinating (e.g. with lemon juice, garlic and herbs) and grilling fish "steaks" such as salmon or barramundi
- Canned tuna, salmon and sardines *in springwater (not oil)* are great to have on standby for quick snacks or meals. For example:
    - tuna or sardines on crackers
    - tuna and salad sandwich
    - fish patties/burgers
    - served with cooked pasta or rice and vegetables (e.g. tuna and pasta bake)
- Try making a fish curry using any firm, white-fleshed fish
- Try frozen supermarket fish products (*not crumbed*)
    - e.g. oven baked fish; serve with potato and vegetables or salad

Grains such as rice/couscous:

- Serve rice:
    - As a risotto with roasted vegetables and lean chicken
    - With cooked frozen diced vegetables and fried egg, meat or tofu (e.g. fried rice)
    - As a side dish to stir-fry instead of noodles
- *Try different flavours of sushi with meat, chicken or fish*
- Serve couscous with:
    - Leftover roast meat and chargrilled vegetables
    - Chicken or fish and cooked frozen diced vegetables
    - Roasted vegetables and chickpeas
    - Meatballs (instead of pasta)
    - Salad or vegetables and use as a side dish instead of potato

Tips to reduce...

Meat products:

Alternatives to processed meats (ham/salami/fritz/sausage) include

- lean roast beef, lamb or chicken
- barbecued steak, chops or chicken
- egg (boiled, poached, scrambled)
- tuna or sardines
- baked beans
- cheese
- legumes

Try the following ideas

- Sandwiches; Try a variety of fillings with wholemeal bread, English muffins or flat bread
    - Hommus and grated carrot
    - Canned tuna mashed with avocado
    - Mashed boiled egg, grated carrot and shredded lettuce
    - Finely sliced roast meat or chicken with salad
    - Tomato and cheese
    - Salad and cheese
    - Peanut butter
- Lean meat meals;
    - Spaghetti bolognaise or meatballs
    - Shepherd's pie
    - Lamb, beef or chicken casserole/curry
    - Roast or barbequed meat
    - Meat stir-fry with rice or noodles
    - Lamb and salad wraps
    - Cold meats in a sandwich or on a salad plate
    - Beef or chicken patty
- Baked beans in tomato sauce (*reduced or no added salt*) on wholemeal toast
- Jacket potato (microwaved), topped with baked beans and grated cheese, served with salad
- Egg (boiled, poached or scrambled) with vegetables and toast
- Lentil patty

Tips to reduce…

Unhealthy snacks such as salty snack products, hot potato products and sweets:

Try these healthy snack ideas instead:

Breads and cereals

- Wholemeal crackers/corn or rice cakes with avocado, vegemite, mashed banana or cheese
- Bread fingers (toast cut into fingers) or crackers, lightly spread with peanut butter, mashed avocado, Vegemite or ricotta cheese
- Savoury pikelets made with finely grated vegetables
- English muffin topped with tomato and cheese
- Raisin toast with small amount of margarine
- Tinned spaghetti or baked beans on toast
- Sandwiches; Try a variety of fillings with wholemeal bread, English muffins or flat bread
  - Hommus and grated carrot
  - Canned tuna mashed with avocado
  - Mashed boiled egg, grated carrot and shredded lettuce
  - Finely sliced roast meat with salad
  - Tomato/salad and cheese
  - Peanut butter

Fruit and vegetables

- Pieces of fresh fruit e.g. fruit kebabs (cube of fruit on bamboo skewers)
- Tinned fruit in natural juice
- Sultanas
- Soft vegetable sticks served with dipping sauce, dip, cottage cheese or peanut butter

Milk, cheese and yoghurt

- Cheese cubes or slices
- Small tub of yoghurt
- Homemade custard or fruit smoothie

Lean meats, fish, chicken, nuts, eggs and legumes

- Hard-boiled egg
- Tuna or sardines on bread
- Baked beans on toast
- Peanut butter on toast
- Strips of cooked roast meat or chicken

Further tips and recipe ideas are provided in the 'CSIRO Wellbeing Plan for Kids' book.

Additionally, for more information on nutrition for under 5's, visit the Women's and Children's Hospital website:
http://www.wch.sa.gov.au/services/az/other/nutrition/nutres_under5.html

If you wish to discuss these details or any other matter please do not hesitate to ring me on (08) 8204 6304 or Lucy Bell on (08) 8204 5957.

Best wishes

A/Prof Anthea Magarey
School of Medicine, Nutrition and Dietetics

CSIRO Kids Wellbeing Diet Book