Associations of Home Environment, Food and Growth among Pacific Children in Auckland, New Zealand.

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A thesis submitted to the Auckland University of Technology in fulfilment of the requirement for the degree of Doctor of Philosophy (PhD)

2017

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Abbreviations and glossary

AOR	Adjusted odds ratio. Statistical measure of association between an exposure variable and an outcome, which is adjusted for a confounding variable/s
BMI	Body mass index. A measure of body fat calculated on weight in kilograms divided by height squared in metres that applies to adult men and women. BMI = weight (kg) / height $(m)^2$
BMI Z	Body mass index z-scores (PIF sample SDS)
CDC	Centres for Disease Control and Prevention (U.S.)
Chi square / χ^2	Statistical hypothesis test determining whether there is a significant difference between expected and observed frequencies
cm	Centimetres – measure of height
FFQ	Food Frequency Questionnaire
HFA / HFA Z	Height-for-age (cm) / Height-for-age z-score (PIF sample SDS)
IQR	Interquartile Range - a measure of statistical dispersion, being equal to the difference between 75th and 25th percentiles, or between the upper and lower quartiles (middle 50%)
kg	kilograms – measure of mass
Mixed vegetables	Frozen combination of chopped and small vegetables – commonly peas, corn and carrot
NZiDep	New Zealand index of deprivation (for individuals)
Pacific	Refers to a person(s) of Pacific Island (Oceanic) ethnicity. Most people of Pacific ethnicity in New Zealand are predominantly Polynesian with smaller Pacific groups of Melanesian and Micronesian
PIF	Pacific Islands Families study
PPQ	Parenting Practices Questionnaire
Pr or p-value	Probability-value indicating strength of evidence to either reject (typically $p \leq 0.05$) or fail to reject ($p > 0.05$) the null hypothesis. Typically, a p-value is considered statistically significant at the ≤ 0.05 level or not significant at >0.05
rho	Spearman correlation coefficient
SD	Standard deviation: a measure that is used to quantify the amount of variation or dispersion of a set of data values
SDS	Standard deviation score (also sample 'z-score') is a value expressing by how much a member/s of a sample differ/s from the median value (0) for that sample, range (-4, +4). SDS is sex- and age-specific

wave(s)	Refers to a wave of follow-up/data collection of the PIF cohort
WFA / WFA Z	Weight-for-age (kg) / Weight-for-age z-score (PIF sample SDS)
WHO	World Health Organization
y	Refers to the 'year' of follow-up after baseline (birth) and represents the approximate age of the PIF child cohort
Z (z-score)	Zero score for a large representative population (e.g. WHO or CDC). Zero (0) represents the median of a sample's measurement (e.g. BMI)

Attestation of Authorship

I hereby declare that this submission is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person (except where explicitly defined in the acknowledgements), nor material which to a substantial extent, has been submitted for the award of any other degree or diploma of a university or other institution of higher learning.

Signed…………………… ……………………………………………………

Date………26 October 2017……………………………………………………………

Acknowledgements

This thesis would not have been possible without the support and guidance of many individuals and groups throughout this journey.

First, I would like to acknowledge and thank the mothers and caregivers of the children in the Pacific Islands Families (PIF) study for giving their time, effort and information for this important programme. Without their participation, the information used for this thesis would not have been possible. Fa'afetai tele lava ia tina, tama ma fanau mo le latou fesoasoani i le PIF study.

With my utmost respect and humility, I would like to give immense recognition to my primary supervisor Professor Elaine Rush (MNZM) for her remarkable support, commitment, guidance, insight, and advice from the beginning through to the very end. You were always there to answer my questions, to offer thought provoking advice, and to provide motivation when it was low. Thank you for sharing your knowledge, time, energy, support and faith, it will always be remembered.

I would also like to acknowledge and express much gratitude to my associate supervisors Dr Nick Garrett (PhD) and Dr Gerhard Sundborn (PhD) for their support, knowledge and guidance. Your collegial advice and critical feedback relating to communication of academic writing, statistics, public and Pacific health are valued and respected deeply. Dr Sundborn enabled my re-entry to Pacific Public Health, motivated me to take up the PhD, and provided great support when I needed it most. I am truly indebted to you.

I would like to thank my advisors Mr Steve Taylor and Mr Victor Obolonkin for their significant contributions in undertaking complicated statistical procedures, not only within the thesis project but also with related endeavours, such as journal publications and conference presentations. Victor Obolonkin created the correlation graphs in Chapter 3 and Steve Taylor generated the growth curves in Chapter 4.Thank you both for your extremely valuable knowledge and for skill, which contributed greatly to the story of this thesis. I wish you well on your respective academic and life journeys.

I would like to acknowledge the PIF study team for all the work in collecting and coordinating the data and providing collegial support. Thanks to study directors Dr Janis Paterson and Dr El-Shadan 'Dan' Tautolo for the study days throughout 2016 and allowing me to work on the thesis in the quiet times. A special thanks to Study Manager Leon Iusitini, who knows the PIF study inside and out, for making access to information on the PIF study so easy – you are one of the PIF study's most valuable assets.

I would like to acknowledge and thank the Health Research Council (HRC) New Zealand for the financial and collegial support provided through the Pacific PhD Scholarship programme. In particular, Ms Everdina Fuli and Dr Nuhisifa Seve-Williams for their support and advice through the HRC.

I would like to acknowledge and thank my lifelong partner Sarah McCarthy for her patience, confidence, love and support provided throughout the thesis journey. When I was engaged in thesis related pursuits, you spent many lonely evenings and weekends caring for our children, cooking dinners, and tending to their concerns and worries about school and life. Even when I was home, I was short-wicked or away with the thesis fairies. To my children Kahi and Solomon for their support and patience when I was not around or paying attention, and for reminding me to stay positive and grounded, and most of all, to keep going.

I would also like thank my parents Lynette and Sama Savila for their unconditional love and support throughout these last few years. You were always offering dinners and weekend lunches, picking up the children from school and providing childcare when needed, even though you yourselves struggled to keep your own heads above water. You are the reason I pursued public health because you raised me with the principles of respect and care for others, and to value knowledge as a guide to thriving in an ever-challenging world. Thank you so very much.

I would like to acknowledge the support provided by colleagues of the wider community at the Auckland University of Technology and beyond. Thank you for the academic discussion and workshops, the writing retreats, study skills and advice, and administrative support. The list is long and the names many. Thank you all for your support.

Finally, I would like to thank my friends and family who were always curious, supportive and caring. You showered me with genuine praise, encouraging words and understanding. Thank you for your respect and thank you for thinking of me. Your friendship is valued immensely and helped me accomplish one of the most significant milestones of my life.

Author's Note

A publication arising from this thesis includes some material, which has been reproduced in Chapter 4 with permission from the editor of *The New Zealand Medical Journal*. Thus, Chapter 4 is an original and extended version of the following publication:

Savila, F., Obolonkin, V., & Rush, E. (2014). Tracking food consumption frequency of children from age 4 to 6 years: the Pacific Islands Families study. *The New Zealand Medical Journal*, 128(1420), 16-24.

Contribution to the publication by Savila was 80%, by Rush 15% and by Obolonkin 5%.

Abstract

Pacific adults and children in New Zealand have the highest prevalence of obesity and overweight compared with any other group. The relationships of home environments with food consumption and rapid growth among Pacific children residing in South Auckland, New Zealand are not well understood. These factors were examined in the Pacific Islands Families (PIF) birth cohort study, which started in the year 2000 with the last wave of physical measurements in 2014.

At recruitment, participant families (n=1376) were representative of the Pacific population in South Auckland, an area where 37% of Pacific people in New Zealand reside. As well as birth weight, anthropometric measurements were recorded for PIF children followed up at 4, 6, 9, 11 and 14 years (y). Examination of growth trajectory to age 14 y confirmed that the child cohort continued to grow at an accelerated rate compared to the World Health Organisation (WHO) child growth reference. The increase in mean BMI among PIF boys and girls from 11 to 14y was 77% and 108% higher than the WHO references. The prevalence of overweight including obesity was 78.1% for boys and 71.8% for girls at mean age 14.5 years using the International Obesity Task Force reference.

Analysis of food frequency patterns at ages 4 and 6 y highlighted 12 most frequently eaten foods accounting for 25% of all food consumed on a daily basis. Average frequency of consumption of these 12 foods remained relatively stable over this period of transition to school ($r^2 = 0.53$). Three carbohydrate foods, bread, breakfast cereal and rice, were the most frequently eaten, followed by milk and fruit (apples and pears, oranges and mandarins, and bananas). Snack foods, including powdered fruit drinks, crisps, noodles, and food

drinks (e.g. Milo™) constituted a third of the most frequently eaten foods and chicken was the only protein in the most frequently eaten foods.

At age 9 years for 972 children, small positive associations of household size and daily intake of bread (rho=0.138, p<0.001) and weekly intake of soft drink (rho=0.088, p<0.05), and a negative association of household size and BMI Z among girls (rho=-0.099, p<0.05) were found. Two-parent status was positively associated with BMI Z (rho=0.084, p<0.05) and maternal education was positively associated with fast food intake (rho=0.106, p<0.05) and negatively with BMI Z (rho=-0.086, p<0.05). Maternal deprivation was positively associated with higher consumption of bread (rho=0.213, p<0.01), fast food (rho=0.108, p<0.05) and soft drink (rho=0.111, p<0.05) and negatively associated with fruit (rho=-0.094, p<0.01) and vegetables (rho=-0.094, p<0.001).

Two styles of parenting, authoritative and authoritarian, were found to have acceptable internal reliability ($0.8 > \alpha \geqslant 0.7$), allowing further examination against food habits and BMI Z. Described simply, authoritative parenting practices are highly controlled yet highly nurturing styles of parenting. Whereas authoritarian parenting practices encompass highly controlled but low nurturing styles of parenting. Authoritative parenting was significantly positively associated with daily consumption of fruit (rho=0.129, p<0.001) and vegetables (rho=0.082, p<0.05) among boys and girls, and with bread (rho=0.119, p<0.05) but only among girls. Authoritative parenting was also significantly negatively associated with consumption of fast food (rho=-0.186, p<0.001) and soft drink (rho=-0.094, p<0.01). Authoritative parenting was negatively associated with overall BMI Z. Alternatively, authoritarian parenting was significantly negatively associated with vegetable consumption (rho=-0.174, p<0.001) (boys and girls), and positively associated with consumption of fast food (rho=0.096, $p<0.01$) (girls) and soft drink (rho=0.114, $p<0.001$) particularly for boys. Authoritarian parenting was not associated with BMI Z.

This body of work has presented evidence that home environments play an important role in shaping Pacific children's food consumption patterns especially in light of the need to address rapid growth and obesity. Analyses point to the continued influence of macro environmental socioeconomic pressures mediated through Pacific family homes such as in the positive relationship between household size and consumption of energy-dense foods, bread and soft drink; the two foods that were significantly related to BMI Z (at 9, 11 and 14 y). These observations were consistent and reinforced by the associations observed between indicators of maternal deprivation and all selected food habits at age 9 y. However, positive indications may be gleaned from characteristics in parenting styles that maintain high levels of control and responsiveness, moderating children's food consumption and growth. As such, authoritative parenting practices were seen to have a positive effect on good eating habits and on cross-sectional and, importantly, longitudinal BMI Z among children.

In order to counter poor nutrition, rapid growth and increased body size, a variety of macro- and micro-environmental measures must be addressed. At the macro level, policies must address increasing levels of poverty and the undersupply of housing in New Zealand, which are key environmental determinants of health. Improved social services to support families experiencing socioeconomic deprivation is recommended to improve food security particularly for children and pregnant mothers. In community settings, food retail environments that support heathier choices could also be a helpful strategy for improving child nutrition. At the micro-level, benefits may be gained in health and nutrition literacy for parents and support strategies to improve food environments in the home. Improved nutrition for Pacific children will have positive flow-on effects in other areas of health apart from body size, improvement of overall quality of life, a more productive workforce, improved health of the next generation and reduction in the cost of non-communicable diseases on the national health budget.

Chapter 1 Introduction: Setting the scene

An obesity pandemic has prompted urgent calls for evidence to inform local environmental interventions that prevent excesses in calorific intake and weight gain (Swinburn et al., 2011). Poor nutrition, physical inactivity and high body weight are primary determinants of preventable chronic disease, quality of life and premature mortality (World Health Organization, [WHO] 2003). However, the backdrop of powerful commercial environmental factors have driven an oversupply of food, supporting the unrestrained consumption of energy and increasing rates of obesity (Vandevijvere, Chow, Hall, Umali, & Swinburn, 2015). High body mass index (BMI) has now overtaken tobacco as the leading risk to health in New Zealand (Ministry of Health, [MoH] 2016b). Within wealthy countries, disparate rates of nutrition-related illness are associated with socioeconomic status, with economically deprived groups experiencing higher rates than the wealthy (Swinburn et al., 2011). Of the major ethnic groups in New Zealand, Pacific people have the lowest incomes, and the highest rates of food insecurity, overweight and obesity. This thesis investigates body size and growth trajectory of a sample New Zealand-born Pacific children from birth through to age 14 years (y). It also examines specific micro-environmental factors of the Pacific family home environment and associations with child food frequency and growth.

According to the New Zealand Census of 2013, Pacific people are the fourth largest ethnic group in New Zealand, making up 7.4% of the total population (Statistics New Zealand, 2014). Pacific are a growing community increasing by 14.7 percent between 2001 and 2006, and by 11.3 percent between 2006 and 2013. Pacific had the highest proportion of children aged 0-14 y at 35.7 percent compared with the four other main ethnic groups: Māori (33.8%), Middle Eastern/Latin American/African (25.5%), Asian (20.6%) and European

(19.6%). In addition, more than three out of five (62.3%) people who identified with a Pacific ethnicity were New Zealand-born. Pacific children also have the highest levels of overweight and obesity from the time of birth. The World Health Organisation have identified some Pacific nations as among countries with the highest rates of corpulence globally (Parry, 2010).

People of Pacific ethnicity (Pacific people) are a linguistically and culturally diverse Oceanic group and are the ancestral cousins of the ethnically unique and indigenous Māori of Aotearoa, New Zealand. Pacific people are interchangeably described as Pasifika, Pacific Islander, or briefly, as Pacific. Most Pasifika in New Zealand are linked to the Oceanic sub-region of Polynesia, a Grecian term meaning ‘many islands’, appropriate given the diversity of cultures, immigration histories, and contributions to their adopted community.

Conversely, more nuanced self-descriptions of Pasifika identity have suggested their indigeneity as descending from ‘Tagata o le Moana’, translating as People of the Pacific Ocean (e.g. Mallon, Māhina-Tuai, Salesa (eds) (2012) *Tagata O Le Moana. New Zealand and the People of the Pacific*). These descriptions highlight the discourse around personal identity of Pacific people, which is an influential compass on socialisation: individual behaviour is influenced by social values, beliefs, perceptions and pressure. Identity then also relates to health because health is intrinsically linked to how social systems (economic and political) determine people’s social status and how people navigate society’s pressures.

With this in mind, the question arises as to what it means to be Pacific in the New Zealand public health context. Demographically, Pacific are characterised as a youthful population and have unique environmental health challenges and needs. In particular, Pacific children have experienced high rates of rapid physical growth and accompanying weight gain, which are precursors to a myriad of debilitating chronic illnesses such as type-2 diabetes, cardiovascular disease and high blood pressure (WHO 2003). Yet this long-known fact has not resulted in effective interventions to prevent or stall the intergenerational effects of obesity in the Pacific community.

Rapid physical growth increases risk of overweight and obesity, defined by body mass index (BMI) cut-offs: body weight in kilograms divided by the square of body height in metres relative to age and sex. Overweight and obesity are defined as abnormal or excessive body fat accumulation that is strongly associated with health risk (WHO 2000). Globally, the prevalence of adult (age 20+ years) overweight (35%) and obesity (11%) is a preventable epidemic (WHO 2014). However, this prevalence is not distributed evenly across all demographic groups or geographic locations. In wealthier countries, obesity prevalence is higher in lower socioeconomic and ethnic minority groups, whereas in developing countries, higher rates of obesity are prevalent among the urban sections of society (World Health Organization, 2000). In New Zealand, the socioeconomically disadvantaged and Māori and Pacific peoples have the highest levels of overweight and obesity (Ministry of Health, 2016a).

1.1 Structure of this thesis

With this background in mind, Chapter 1 proceeds to describe the rationale and significance of this body of work for Pasifika public health in New Zealand. Chapter 2 follows with a brief literature review, a summary and synthesis of research that examines general ecological perspectives of child health and growth. The review provides the basis for the main research questions to be addressed in three separate studies in this thesis, which each have their own literature reviews. Chapter 3 describes the methodology of the thesis, the order of examination of propositions on the interrelationships of home environments, food and growth. It provides an overview of the Pacific Islands Families study where the sample and data for the present thesis originates. Chapter 3 also summarises the general analytical approach. Chapters 4, 5, and 6 are a series of studies addressing the main research questions. Chapter 4 provides a representation of the cross-section of weight status and growth trajectory of Pacific children in Auckland, New Zealand. Chapter 5 examines, for Pacific children age 9-10 years, the home environment by looking at associations with food habits and body mass outcomes. Chapter 6 then turns to examine the home environments of Pacific families, highlighting associations with food habits and body weight. Chapter 7 concludes the thesis with a summarised discussion of all the findings, strengths and weaknesses, and suggestions for future research.

1.2 Rationale and significance of this enquiry

A key reason for undertaking this investigation is to improve understanding of the underlying influences of nutrition-related health for Pacific children, particularly in regards to physical growth. Importantly, an environmental approach was adopted to distinguish from the nature versus nurture dichotomy, which although conceptually limited, is still prevalent in current discourse around childhood nutrition (Kvalsvig, D'Souza, Duncanson, & Jean, 2015). Adopting an environmental approach assumes that children's environments play a powerful role in children's options, choices, resultant behaviours and health outcomes. Second, although essential, it is assumed that food alone is not the only determinant of growth trajectory but that nutrition-related environmental characteristics are significant determinants of food consumption patterns. Thus, a wider and deeper investigation of Pacific children's environments will illuminate underlying influences of food and body weight patterns.

People who identify as being Pasifika represent a growing multi-ethnic community on New Zealand’s demographic landscape. The Pacific population is young and fertile compared with national averages and other ethnic groups. Like children of all ethnicities, the health of Pacific children is crucial to realising their full potential in their contribution to society, culture and economy. Yet across the life-course, Pacific peoples have a disproportionally high prevalence of risk factors for chronic disease. Pacific children are born bigger and have the highest rate of overweight of all ethnic groups in New Zealand. Relevant sociocultural, socioeconomic and physical environments must be explored to inform health, social and economic policy to prevent excess body weight and improve wellbeing of Pasifika people to the benefit of New Zealand society.

1) **Rapid growth among Pacific children**. It is well known that Pacific adults and children experience the highest rates of overweight and obesity compared with other ethnic groups but the physical mechanisms that explain rapid growth trajectory in the transition through prepubescence are not well known. Understanding Pacific children’s physical growth throughout childhood will help to justify policy and other strategies that aim to support healthier body size and reduce the propensity for rapid growth.

2) **Nutrition and Pacific children**. Nutrition encompasses quality and quantity of food and physical growth. An obesogenic food environment is acknowledged to be responsible for easy access to energy-dense, nutrient-poor foods and excess weight gain. Although suboptimal nutrition in childhood can lead to rapid weight gain, very little is known about longitudinal food consumption and relationships with weight among children of Pacific ethnicity. This inquiry aims

to provide an illustration of food consumption to provide a context for anthropometric development.

3) **Pacific home environments**. Despite living in a developed country, surveys show that a majority of Pacific children endure compromised home environments compared with their non-Māori, non-Pacific counterparts. Many endure impoverished living conditions because of low family incomes, substandard housing, poor quality of life and exposure to risk factors for ill health, such as food insecurity. Investigations into the associations between home food environments, consumption patterns and weight gain are well documented but few studies are prospective or relevant to multi-ethnic community groups, such as the Pacific community in New Zealand. The longitudinal Pacific Islands Families study offers a unique opportunity to explore nutrition patterns (food and growth) among this ethnic community in the home and family context.

Overcoming environmental circumstances is a significant challenge to achieving healthy food and weight for Pacific families. Exploring modifiable risk factors and navigating positive pathways across the life-course (Ben-Shlomo & Kuh, 2002) is a way forward to improving the health and wellbeing of current and future generations of Pacific peoples.

Significance

This study will contribute to the body of knowledge that relates to the micro-environmental sphere of home environment factors, which are associated with food consumption and rapid growth among NZ-born Pacific children.

1.3 Research aim and objectives

The overall aim of this body of work was to increase knowledge of a range of underlying home environment factors related to food consumption and weight gain among Pacific children by:

1) Examining the trajectory of physical growth throughout childhood of Pacific children from birth to 15 years;
2) Exploring food consumption patterns that might contribute to rapid growth in Pacific children;
3) Exploring features within the home environments of Pacific families that might influence the type and frequency of foods eaten.

A systematic understanding of these social and environmental characteristics will help to inform strategies and policy aimed at promoting healthy nutrition, the prevention of obesity and enhancing the health and wellbeing of Pacific peoples.

Chapter 2 Literature review

This literature review summarises and synthesises evidence regarding the associations between home food environments, food consumption and physical growth. It describes the literature in relation to the environment that Pacific families live in, with a focus on children's experience of rapid physical growth. In an effort to articulate the obesogenic environment Swinburn, Egger, and Raza (1999) identified factors within the environment as being micro (proximal) or macro (distal) with regard to their levels of influence. Proximal level influences of the environment refer to factors in close proximity to individuals, such as home and family. Distal level influences refer to structural factors, such as features and characteristics of national and global food trade. In terms of environmental influences on childhood growth, this review focuses on the micro levels of home and family, and associations with child food, physical outcomes and growth.

To begin with, the review will build context by providing some definitions of health. This is followed by a brief account of the demographic profile of the Pacific community in New Zealand (NZ), focussing on Auckland as one of the most significant Pacific cities internationally and the location of this study. Next, literature on children's diet and growth patterns, with particular attention to Pacific children, is reviewed. The influence of food availability and consumption patterns within the home environment using the model proposed by Rosenkranz and Dzewaltowski (2008) is described.

A primary function of this review is to identify gaps in knowledge relating to Pacific environments. These are taken as opportunities for further enquiry and specific research questions are offered. To address these research questions, the aims, objectives and hypotheses of the proposed body of work are presented.

2.1 Definitions of health

Definitions of health and illness are social constructs designed to describe culturally relevant perspectives of the state of mind, body and spirituality of people and communities (Conrad & Barker, 2010). The World Health Organization (WHO) provides the most relied upon definition of health within Western/ised societies like New Zealand (NZ), which defines health as "… a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity" (World Health Organization, 1946). However, indigenous and other ethnic definitions of health exist and are relevant to social contexts and public health perspectives in New Zealand. For example, Māori and Pacific definitions or models of health identify wider, holistic concepts by recognising the significance of spatial and physical relationships (e.g. Pacific concept of 'va') and spiritual dimensions (e.g. spiritual health or 'taha wairua' in the Māori model of health, Te whare tapa whā) (Ministry of Health, 2015c; Suaalii-Sauni et al., 2009). It is through the lens of Māori or Pacific concepts of health that illness and wellness can be assessed and responded to accordingly. Knowledge of culturally specific understandings of health and wellbeing contributes to cultural competence and relevance to health service delivery through the spectrum of health users and providers, from public health promotion through to the treatment of patients (Pulotu-Endemann, 2001; Suaalii-Sauni et al., 2009; Tiatia, 2008).

Child health is about supporting and promoting healthy development, which can be realised in the context of resilience as a foundation for prevention of illness and successful adaption in changing or adverse environments (Rutten et al., 2013). This positive perspective is aligned with the United Nations Convention on the Rights of the Child (UNCRC) (United Nations General Assembly, 1989), which was ratified by the New Zealand government in 1993. The basis of the UNCRC is underpinned by 'basic human needs for life, growth and development' for all children up to age 18 years and acknowledges the rights of children to live healthy and meaningful lives (Kvalsvig et al., 2015). The approach is predicated on the idea of creating the conditions for positive biological and psychological wellbeing as the optimal pathway to a healthy and productive human being.

Consistent with the positive view of health is the bio-developmental framework, which centres on developing effective and equitable evidence-based policy and programme strategies in early childhood (Shonkoff, Richter, van der Gaag, & Bhutta, 2012). The bio-developmental framework is grounded in Bronfenbrenner's ecological theory where causal pathways in 'complex and dynamic social and physical environments' are identified at the micro- (family and peer), meso- (neighbourhood) and macro- (structural) levels of society (Bronfenbrenner, 1994). Accordingly, the framework centres on policies and programmes that focus on positive outcomes by removing disparities at different social and physical environmental levels. It is important then to understand the wider sociodemographic context of Pacific community in New Zealand as an initial step to appreciating the social ecological environment of Pacific families and children.

2.2 Demography of the Pacific community in New Zealand

According to the New Zealand Census 2013, Pacific people represented 7.4% (n=295,941) of the total population, and the proportion and number was estimated to grow to 10-12% (n=480,000) by 2026 (Statistics New Zealand, 2012, 2014). It is the fourth largest and the second fastest growing ethnic group, after the Asian ethnic population (Statistics New Zealand, 2014). With minimal migration, this growth is exemplified in a youthful population who provide an increasing social, cultural and economic contribution to New Zealand.

Population growth forecasts for Pacific peoples are influenced by a high fertility rate. Pacific women give birth to an average of three children. Proportionally, there are more Pacific women of childbearing age compared with other ethnic groups. The median age of the Pacific population was 22 years compared to 36 years for the total population. In 2013, children age 0-14 years constituted 35.7% of the Pacific population compared with the total population, which was less than 22%.

Two thirds (65.8%) of the Pacific community live in New Zealand's largest economic centre of Auckland, constituting 14.6% of the city's population (Auckland Council, 2015; Statistics New Zealand, 2012). In 2013, a quarter of babies born in Auckland were of Pacific heritage and projections estimate the Auckland Pacific population to exceed a quarter of a million before 2021. Perhaps not surprising then is that the Samoan language was the second most commonly spoken language in Auckland, spoken by 4.4% of the population after English and the third most commonly spoken language in NZ (2.2%) after English (96.1%) and Māori (3.7%) (Statistics New Zealand, 2014).

Table 2.1 Number of people identifying as belonging to a Pacific ethnic group in the 2001, 2006, 2013 Census (whether as the only ethnic group or as one of several)

Year	**Pacific peoples**
2001	231,798
2006	265,974
2013	295,941

Ethnically, Pacific peoples identify as Samoan (48.7%), Cook Islands Maori (20.9%), Tongan (20.4%), Niuean (8.1%), Fijian (4%), and several other Pacific Island nationalities (Ministry for Pacific Peoples). Each ethnic group has their own distinct culture, language and worldviews alluding to high diversity. A strong ethnic identity can engender positive psychosocial effects (St. Louis & Liem, 2005). However, ethnic identity is in flux due to both acculturation and cross-cultural integration, resulting in mixed ethnicity within individuals, particularly in the younger generations. In the 2013, 30% of Pacific people had indicated mixed ethnic status and almost two-thirds were (62.3%) of the Pacific population reported that they were NZ-born (Statistics New Zealand, 2014). Living in a multicultural society and having mixed ethnicity can challenge ones sense of identity and influence lifestyles, behaviour and health (Fairbairn-Dunlop, 2003).

2.3 Prevalence of excess weight in Pacific people

Internationally, excess body weight is defined in relation to height. For application to the adult population, the WHO defines body mass index (BMI) as weight in kilograms divided by height in metres squared (kg/m^2). A BMI in excess of 25 kg/m^2 as defined overweight and above 30 kg/m^2 as obese. For children, the most commonly used definitions are related to BMI but are adjusted for age and gender and predict BMI at age 18 years (Cole, Belizzi, Flegal, & Dietz, 2000). Excess body weight is associated with major health problems including non-communicable diseases. Of all the major ethnic groups in NZ, the Pacific peoples have the highest rates of obesity (62%), compared with Māori (44%), NZ European/Other (26%) and Asian (16%) (Ministry of Health, 2012c). This predisposes Pacific people to greater risk of chronic disease (e.g. type-2 diabetes), psychosocial and psychological problems compared with other ethnic groups (World Health Organization, 2000).

National health surveys repeatedly report relatively high and growing rates of type-2 diabetes (10%) among Pacific adults compared with the national prevalence of 5% (Ministry of Health, 2012c). Further, of all children (5-14 years of age), Pacific children were three times more likely to be obese (23%) compared with NZ European/Other (6%)

(Ministry of Health, 2012d), using international criteria (Cole et al., 2000; Cole, Flegal, Nicholls, & Jackson, 2007). These statistics are a worrying indicator for the future health of the Pacific population, as childhood obesity is a precursor to early onset type-2 diabetes (Hannon, Rao, & Arslanian, 2005) and can increase the risk of obesity in adulthood (Serdula et al., 1993). Preventing excessive weight gain among expecting and new mothers and their offspring using dietary interventions alone has had some short-term benefit (Tanentsapf, Heitmann, & Adegboye, 2011). Yet the sustainability of successful intervention would depend heavily on food environments, and social, economic, and political circumstances that support healthier diets and physical activity for children and families.

2.4 Nutrition and physical development of children

While the 'causal web' for optimal growth and development of children is complex and multifactorial, there is no argument that nutrition is a fundamental determinant of growth and health with lifelong implications. Despite the key contributions of genetic and intrauterine factors to healthy development, early to mid-childhood remain critical periods for reinforcing lifetime dietary patterns, health behaviours and growth trajectory (Bisset, Gauvin, Potvin, & Paradis, 2007; Rodgers et al., 2013; Smithers, Golley, Brazionis, & Lynch, 2011). There is growing and convincing evidence that poor childhood diet, rapid growth and obesity can increase the risks of chronic illness such as diabetes, cardiovascular disease and some cancers across the life-course (Hannon et al., 2005; Kaikkonen et al., 2013; Maffeis & Tatò, 2001; Uauy & Solomons, 2005). Stability in individuals' dietary patterns across the life-course from childhood through to adulthood have been observed with increasing frequency and quantity of obesogenic foods consumed as children age (Mikkilä, Räsänen, Raitakari, Pietinen, & Viikari, 2005). However, empirical investigations trying to link food patterns with weight gain in children have found positive and negative relationships (Smithers et al., 2011). Studies among adults have found more consistent associations, with increased weight gain and intake, for example, of potatoes and sugary drinks (Mozaffarian, Hao, Rimm, Willett, & Hu, 2011). The lack of consistent associations among children may be due to generally greater variation in children's physical growth compared to that of adults. Furthermore, it suggests that monitoring of diet and weight in children may require greater frequency to track reliably any relationships between the two (Wall, Thompson, Robinson, & Mitchell, 2013).

Rush, Paterson, and Obolonkin (2008) examined relationships between food frequency and body composition among the Pacific Islands Families (PIF) child cohort to age 4 years (y). They found that BMI and weight gain reduced when fruit and vegetable and fat consumption increased. In contrast, BMI and body fat percent increased with dairy consumption. Interestingly, BMI, body fat, weight and weight gain were negatively associated with frequency of fatty foods such as peanut butter, spreads and tomato sauce consumption. Whereas BMI, weight and weight gain were positively associated with total protein and energy-dense/nutrient-poor protein food consumption: eggs, meat, fish, poultry and sausages.

Growth patterns in children from the PIF study from birth to age 4 y and separately to age 6 y were examined in conjunction with the World Health Organization (WHO) growth standards (Rush et al., 2010; Rush, Paterson, Obolonkin, & Puniani, 2008). On average, these children were born bigger than the standard WHO child. Average birth weight and z-score were 300 g (3.67 kg vs WHO median birth weight of 3.35 kg) and 0.61 units higher respectively than the WHO standard. Daily weight gain from birth to 4 y was also higher than the WHO standard by approximately 2.3 grams per day (~3.4 kg more). Between ages

2 and 4 y, height also increased faster than the reference WHO child. However, maternal smoking was associated with smaller birth weight followed by an increased rate of weight gain than those whose mothers did not smoke, and children who were not breastfed gained weight faster than children who were breastfed. At 6 y the influence of breastfeeding or smoking during pregnancy was no longer apparent but growth had continued on a similar trajectory as birth to 4 y (Rush et al., 2010).

More recently the growth trajectory of the PIF cohort were tracked from age 2 to 10 y and were compared with the WHO (2-5 y) and Centres for Disease Control's (CDC; 5-10 y) growth reference charts (Rush, Obolonkin, & Savila, 2013). The accelerated growth among the cohort seen earlier continued and "the proportion of children whose weight and height were above the reference 50th centile increased with age". An astonishing 70% prevalence of overweight including over 50% obesity by age 10 y, according to the CDC standard criteria, was recorded. Apart from highlighting the urgency for earlier intervention, these findings signal the need to understand better the external (developmental) environments that may be associated with rapid growth among this population.

The only longitudinal study of Pacific children, the PIF birth cohort, (see Chapter 2 Methodology) is a rich and ongoing longitudinal exploration of the family environment and child development. Investigation of the characteristics of home environments and how different factors contribute to consumption and help to understand unprecedented rapid growth (Rush et al., 2013). One systematic review has highlighted a lack of studies examining longitudinal associations between nutritional health and physical development (Smithers et al., 2011). Further, longitudinal studies on eating patterns and growth among pre-adolescent Pacific children are not recorded in the literature. This body of work will add contextual evidence related to rapid growth among Pacific children, by examining the multifactorial aspects of home environments influencing children's food consumption.

2.4.1 Children's home environments, food consumption and growth

What characteristics of Pacific children's home environments influence food consumption and excess physical growth? To address this question, this review follows the framework of a model describing home environment factors associated with childhood obesity proposed by Rosenkranz and Dzewaltowski (2008) and attempts to apply it to the New Zealand Pacific context. Rosenkranz and Dzewaltowski review child obesity risk factors within home food environments under three broad domains: 'political and economic', 'sociocultural', and 'built or natural' (physical) environments. Within each environmental domain, a myriad of factors interact across macro (distal) and micro (proximal) levels of influence.

An adaption of the socio-ecological approach, the home environment model of influences on obesity is consistent with the Analysis Grid for Environments Linked to Obesity (ANGELO) framework proposed by Swinburn, Egger and Raza (1999). The ANGELO framework has led to the development of other variant models such as that proposed by Rosenkranz and Dzewaltowski (2008). This review focusses on influences related to the home environment are reviewed. The micro or proximal environments of the family, particularly with respect to parental education and parenting style, are of relevance. Macro level influences such as the effect of the national food supply and food legislation is outside the scope of this review.

Micro political and economic environments linked to food

Within the micro-level of political and economic environments, factors that can influence a child's diet include family socioeconomic status, deprivation and food security. Family socioeconomic status is determined by level of parental education, employment and income and is one of the most important determinants of disparities in health and mortality between population groups (Wilkinson, 1997). In 2006, more than half of people of Pacific ethnicity live in the most deprived quintile of areas – by definition, this is where 20% of NZ people reside (White, Gunston, Salmond, Atkinson, & Crampton, 2008). The NZ deprivation quintiles are an indicator of lower socioeconomic status (SES) and several studies have found strong associations between SES and diet (Martikainen, Brunner, & Marmot, 2003), weight (Knai, Lobstein, Darmon, Rutter, & McKee, 2012), and mortality (Marmot, 2005).

Utter, Scragg, Schaaf, and Fitzgerald (2006) delved into ethnic group differences in socioeconomic status and nutrition patterns in the NZ National Children's Nutrition Survey 2002/03 (NCNS02/03) data. Almost two-thirds (64.6%) of Pacific and just under half (44.7%) of Māori children were in the top quintile of increasing deprivation compared to one in ten (9.9%) NZ European and Other (NZEO) children. Pacific and Māori had similar dietary patterns when compared with NZEO children, yet Pacific had greater odds of engaging in suboptimal dietary habits and consuming more energy-dense foods relative to Māori. Suboptimal dietary habits included skipping breakfast and buying school food from tuck-shops and dairies. Energy-dense foods that were highlighted as chosen more frequently included soft drinks, hamburgers and pies.

Socioeconomic status is linked to food security, which for children, is determined by the level of a household's social and economic resources. Food security refers to having easy access to sufficient, nutritious, and socially acceptable foods for the whole family at all times (Rush, Puniani, Snowling, & Paterson, 2007). Food insecurity and hunger, on the other hand, are inextricably linked to poverty and financial insecurity (Cook & Frank, 2008). The NCNS02/03 recorded higher levels of food insecurity in the most deprived homes and, in terms of ethnicity, Pacific homes were more likely to experience food insecurity compared to Māori and New Zealand European and Other (NZEO) homes (MoH 2003). Over half of Pacific (53.9%), over one third of Māori (37.5%) and 13% of NZEO homes reported insufficient food in the last 3 months.

Since the NCNS02/03 however, reported food insecurity among Pacific had increased by around 25%. In the 2008/09 New Zealand Adult Nutrition Survey, approximately seven out of ten (~70%) Pacific homes had moderate or low food security (MoH 2012a). "Pacific people were more likely to live in households classified as having low and moderate food security […] compared to non-Pacific people" (MoH 2012a, p. viii). Less than one quarter of Pacific people reported complete or almost complete food security.

Food programme participation relates to food insecurity where food is provided by social services to families lacking sufficient income for food. Examples of food programmes include Work and Income New Zealand food grants and the Salvation Army's food banks. Pacific households (15%) are more likely to report using food grants or food banks to feed household members compared with only 2% of NZEO households (Rush, Freitas, & Plank, 2009). Cheer, Kearns, and Murphy (2002) found that food is the first necessity that Pacific families discount on, often prioritising other expenses and going without or opting for cheaper food options. Yet there are reports that Pacific people are more likely to ask family and friends for food before going to a food bank (Cheer et al., 2002; Rush et al., 2009). Seeking assistance from extended family or close friends may be related to the Pacific sociocultural practice of communalism seen in many Pacific Island homelands (Mavoa & McCabe, 2008).

Sociocultural environments of food

Sociocultural microenvironments related to food and growth stem from customs and traditions that shape styles of parenting, eating patterns, structure, stress, education and nutrition knowledge including food preparation skills (Rosenkranz & Dzewaltowski, 2008). Referring to what they termed as sociocultural factors within Fijian and Tongan societies, Rosenkranz and Dzewaltowski (2008) noted that the literature highlighted “the importance of food exchanges in cementing and sustaining social relationships” (p. 381). This concept of social maintenance is consistent with interpretations of food security arising in a qualitative investigation among Tongan mothers. Food security did not refer to what was available for the family within the home but for the extended family and community, “mothers gave priority to sharing food immediately required within the community, rather than focusing on individual family needs and responsibilities and the future” ('Ahio, 2011, p. xii). Social prioritisation of food is applicable to other Pacific cultures, though more research into the relevance of specific customs upon family eating patterns is required.

The persistence of customs and traditions related to food practices is likely to change over time or in other geographical and cultural settings. Teevale, Thomas, Scragg, Faeamani, and Nosa (2010) found that sociocultural norms and behaviours of NZ based Pacific adolescents did not independently explain risk of obesity. Instead, adolescents reported that time for parents to focus on family was limited due to parental employment demands. The authors concluded that adolescent eating practices were related to parental availability, health education and experience. Thus parental time limitations resulting from living in the NZ socioeconomic setting and the need for income, may negatively affect the eating patterns of Pacific adolescents. This evidence demonstrates that socioeconomic factors are associated with family eating patterns in general.

Family eating patterns relate to practices such as breakfast consumption, meal sharing, meal skipping and eating while viewing television (Rosenkranz & Dzewaltowski, 2008). Among NZ children, skipping breakfast, purchasing food from dairies and tuck-shops, and television use have been associated with higher BMI (Utter, Scragg, Schaaf, Fitzgerald, & Wilson, 2007). However, Pacific and Māori children were significantly more likely to skip breakfast and lunch, and purchase school food from food outlets (such as dairies and tuck-shops) compared to NZEO children (Utter et al., 2006). In a cross-sectional study of family meal sharing, Pacific and Māori adolescents were less likely to share family meals compared with other ethnic groups (Utter et al., 2013). However, although the frequency of meal sharing was positively associated with healthier eating behaviours, such as eating the recommended daily amount of fruit and vegetables, it was not associated with BMI. Nevertheless, as family meal sharing was lower among Pacific and Māori, suggests that Pacific and Māori may have less than optimal home food environments.

Built and natural environments associated with food consumption

Considerations around family meal sharing must account for potential underlying factors that might inhibit meal sharing such as the physical and spatial characteristics of Pacific homes. This relates to what Rosenkranz and Dzewaltowski (2008) refer to as the built and natural micro-level of the environment that relates to issues such as lack of appropriate cooking and dining facilities, and housing in general.

In recent NZ history, many Pacific peoples have experienced poor housing conditions, which have been responsible for poor health outcomes for families in the Pacific community (Butler, Williams, Tukuitonga, & Paterson, 2003; Cheer et al., 2002; Milne & Kearns, 1999). Thus, in efforts to understand health in Pacific families, housing conditions should be factored in conjunction with family/household characteristics such as size and composition. In terms of size, Pacific households are more likely to have a higher average number of usual occupants per household (5.4) compared with the national population (3.5) (SNZ 2002). In addition to this, low incomes have led to many Pacific families living in houses that are too small, experiencing high levels of overcrowding (Schluter, Carter, & Kokaua, 2007). Having a larger family size where furnishings or housing is insufficient may inhibit family meal sharing. Family meal sharing, particularly family dinners, has been linked to higher likelihood of having a healthier diet compared with those who did not share family meals (Utter et al., 2013).

In terms of composition, Pacific households are more likely to both have a higher ratio of children to working-age adults (due to a youthful population) and include extended family members (29%) compared with the national population (8%) (NZ Institute of Economic Research (2003) cited in (Rush et al., 2009)). Extended family compositions allude to the potential financial stress experienced by larger Pacific households when purchasing food (MoH 2012a), resulting in poor quality or insufficient food. About 40% of bigger families reported food insecurity because of lack of money, potentially creating adverse consequences on children’s nutrition, growth, health and development.

Insufficient household income is also associated with being unable to pay for necessities like bills (e.g. electricity and food) and accommodation costs. Thus, another way that housing may affect health is through change in home or residence. Residential mobility is a common yet hidden stressor, which can negatively affect children and a family’s social and economic stability and, therefore, health (Jelleyman & Spencer, 2008). A high frequency of house moving can act as a significant stressor resulting in physiological and neurobiological mechanisms that can effectively increase obesity propensity (D'Argenio et al., 2009). Giles and colleagues (2013) found that a high frequency of house moves in early childhood ‘amplified the detrimental effects of earlier rapid growth on both body size and composition at age 9 years.’

Lack of money is also associated with purchasing cheaper food (for quantity) which often have higher caloric but lower micronutrient value (Drewnowski & Darmon, 2005a, 2005b). Having greater access to these foods is made easy by the increasing number of food outlets in urban neighbourhoods, which in Bronfenbrenner’s ecological model would be referred to as influences in the meso-level of built environment. Exploration of the environment external to the home is beyond the scope of this thesis but examination of food and eating frequency is examined in Chapters 5 and 6.

2.5 Conclusion

There are currently no longitudinal investigations studying the impact of food environments and food consumption on growth among Pacific populations. Research by Rush and colleagues (Rush et al., 2010; Rush, Paterson, & Obolonkin, 2008; Rush, Paterson, Obolonkin, et al., 2008) focus on early childhood and school years of the Pacific Islands Families cohort where the rate of growth and the prevalence of overweight is high. Information related to the cohort that is more recent (age 11 and 14 y) is now available a unique opportunity to investigate the long-term home and family environmental contexts on food consumption and growth has been presented.

2.6 Research questions

To take advantage of this unique opportunity, and to evaluate the impact of environments on pre-adolescent Pacific children, the proposed study asked the three following research questions related to Pacific children in Auckland:

1) How can physical growth patterns of Pacific children be defined?
2) What sorts of food combinations and patterns do Pacific children have and how are they related to body growth?
3) What is the strength of association of home environment factors with food consumption and growth?

2.7 Aims, objectives and hypotheses

To address these questions this study proposed the following aims, objectives and hypotheses. The aims of the proposed project were to explore and define information about Pacific children's food environments, and to examine how environmental factors are associated with food consumption, growth and weight. Hence, the following three objectives and associated hypotheses:

1) Derive the BMI distribution of Pacific children and describe growth trajectory to age 14 y.

   Hypothesis: There will be a higher prevalence of overweight and obesity at age 14, resulting from a faster increase in weight than in height, compared with earlier age periods.

2) Describe the characteristics of foods eaten and how often at ages 4 and 6 years, and investigate possible associations with growth for Pacific children.

Hypothesis: Common characteristics of children's food will be energy-dense and frequency of consumption will track. Prospective growth (weight and BMI) will be positively associated with consumption of energy-dense foods.

3) Describe sociocultural (parenting styles) and socioeconomic home environments of Pacific children and investigate associations with food consumption and growth.

Hypothesis: Suboptimal food consumption and body size will be positively associated with higher socioeconomic deprivation. Healthier food habits and lower body size will be positively associated with responsive parenting styles.

Chapter 3 Method to understanding home environments, food and growth

The purpose of this chapter is to provide an overview of the systematic approach to this body of work and the assumptions employed to investigate the aims and objectives. To begin with, the Pacific Islands Families (PIF) study is described briefly, providing an illustration of the study sample from where the data originates. This is followed by a description of the design of the thesis including the underlying assumptions linking the individual studies of growth, food and home environments. This is followed by a brief description of the data used for the separate studies and the chapter concludes with a summary of the ethics approvals obtained for the various phases of the PIF study.

3.1 The Pacific Islands Families study

The Pacific Islands Families (PIF) study is a cohort of NZ-born Pacific children (baseline n=1398) recruited in 2000 from a large tertiary hospital based in South Auckland (Sundborn et al., 2011). Eligibility was based on a child born at full term, who had at least one parent of Pacific Island descent and had at least permanent residency status in New Zealand. The first maternal interview (baseline) took place at 6-weeks post-partum and subsequent follow-ups occurred at ages 1, 2, 4, 6, 9, 11 and 14 years (y) post-partum (Table 3.1).

In general, the PIF study holds a variety of datasets of varying sizes ranging from sub-studies (of n~200 children) to the larger general follow-up surveys of up to 1398 children. Apart from a variety of other psychosocial information, the datasets contain a multitude of variables related to family/home environments such as demographic and socioeconomic measures, and repeated measures such as physical body measurements. Several peer reviewed articles have been published from information collected in the PIF study, some of which have contributed to the development of programmes in Pacific health organisations such as with the New Zealand Heart Foundation's Pacific Heartbeat programme.

Table 3.1 Number of Pacific Islands Families study members participating from age 6 weeks in 2000 to age 14-years in 2014-2015[a]

Year Phase[b]	**2000 (Birth)**	**2000 6w**	**2001 1y**	**2002 2y**	**2004 4y[c]**	**2006 6y[c]**	**2009 9y**	**2011 11y**	**2014 14y**
Mother	1477[d]	1376	1224	1144	1048	1001	996	1045	957
Father			825	757		591		790	646
Child		1398[e]		1064	909	897	1015	952	931

[a] Participants are differentiated from the eligible maternal cohort at 'Birth'; [b] Follow-ups are also referred to as phases or measurement waves from 6-weeks onwards; [c] Food frequency data collected; [d] eligible sample; [e] Plunket and hospital birth records, constituting baseline cohort including 11 twin pairs.

At 6-weeks, mothers self-identified their ethnicity as Samoan (47.2%), followed by Tongan (21.0%), Cook Island Māori (16.9%), Other Pacific (7.7%), and non-Pacific (7.2%), respectively (Table 3.2). Non-Pacific children (identified by non-Pacific mothers) were eligible when the biological father identified with Pacific ethnicity.

3.2 Design of the thesis

The design of this thesis is grounded in the interrelated nature of home environment, food consumption and physical growth (see Figure 3.1) with three separate studies centred on the following assumptions:

Study 1: That growth patterns observed in early childhood are indicative of growth patterns in later childhood;

Study 2: That food and eating patterns are similar across the cohort and are associated with prospective patterns in physical growth;

Study 3: That home environment factors - such as, parenting, family characteristics and socioeconomic factors - are related to childhood food consumption and physical growth.

Physical growth patterns (Study 1) are a primary outcome for this thesis and are examined in detail in Chapter 4. Anthropometric measurements of height and weight from birth, then age 4, 6, 9, 11 and 14 years are presented together with derived body mass index. For Study 2, food and eating patterns are addressed in Chapter 5, as an early indicator of the food environment associated with growth (Figure 3.1). A food frequency questionnaire (Appendix C) administered only at ages 4 and 6 y was examined for characteristics and frequency of foods eaten by the PIF child cohort. Finally, for Study 3, home environment information collected at age 9 y are examined in Chapter 6 for relationships with food and child BMI Z. Age 9 y was selected because both child dietary habits and parenting styles questionnaires were administered at that age. (At the time of writing, these specific factors were not collected at other ages). This allowed for cross-sectional and, importantly, prospective analysis of associations between these environment factors and BMI Z. Longitudinal associations are more powerful than cross-sectional because of the temporal relationship between the hypothesised risk factor(s) and outcome(s). For cross-sectional associations the direction of the relationship between outcome and risk factor is difficult, if not impossible, to discern.

Table 3.2 Self-identified maternal ethnicity at 6 weeks

Ethnicity	**6 weeks**	
	N	**(%)**
Samoan	650	(47.2)
Tongan	289	(21.0)
Cook Island Māori	232	(16.9)
Other Pacific	106	(7.7)
Niuean	59	(4.3)
Fijian / Indo-Fijian	9	(0.7)
Tokelauan	10	(0.7)
Tahitian	3	(0.2)
Tuvaluan	4	(0.3)
I-Kiribati	4	(0.3)
Solomon Islander	1	(0.1)
Wallis Islander	1	(0.1)
Other[a]	15	(1.1)
Non-Pacific	99	(7.2)
NZ Māori	59	(4.3)
NZ Pakeha	32	(2.3)
Total	1376	

[a] includes mothers who cited multiple ethnicities both non-Pacific and Pacific, but did not indicate an ethnic group that they 'identify with the most'.

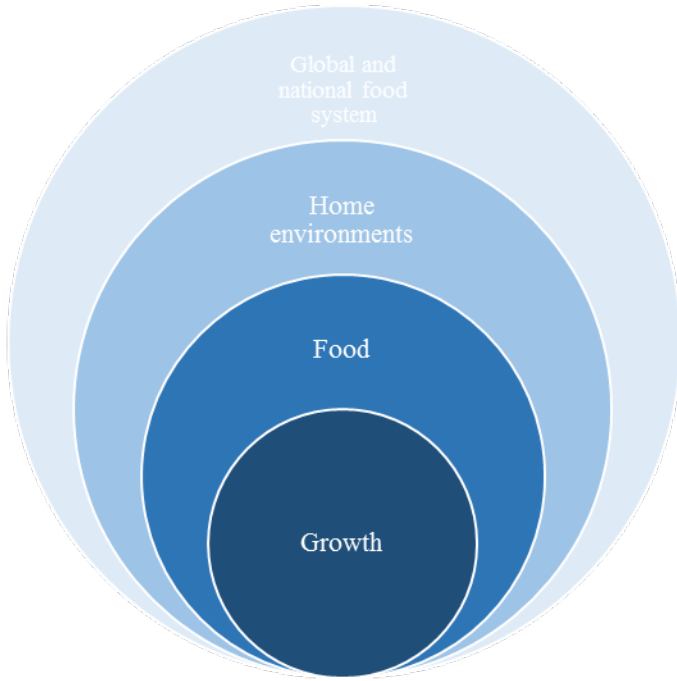

Figure 3.1 Encapsulation of the global and national food system, home environments, food and growth patterns.

3.3 Data

This thesis employed a quantitative methodology using a number of individual and combined datasets from the Pacific Islands Families (PIF) study. Cross-sectional general survey datasets were aggregated for which participation counts are presented above in Table 3.1. In addition, two separate food frequency datasets from the age 4- and age 6-year follow-up surveys were aggregated. An in-depth description of the food frequency methods are described in Chapter 5.

Descriptive and more complex data analyses were carried out using appropriate software (SPSS, Excel, Stata and R) depending on which data of the study was being investigated and depending on statistical assistance. Particular statistical expertise was sought and obtained from the Department of Biostatistics and Epidemiology at the Auckland University of Technology (AUT) for the generation of the growth curves in Chapter 4.

Assistance for multivariable, longitudinal regression analysis of food frequency data was obtained from statistical expertise in the School of Child Health Sciences (AUT). Statistical advice was taken for all approaches and other analyses presented in this thesis. Specific analysis approaches are described in detail in each of the three following chapters. Where a statistical test for effect or difference had an error probability (p) lower than 0.05% the test was determined as statistically significant and was expressed as $p < 0.05$.

3.4 Ethics approval

Ethics approval for the different waves of the PIF study were obtained from the relevant ethics committee(s) at application. For baseline at 6 weeks, approval was obtained from the Auckland Branch of the National Ethics Committee for the First Two Years of Life Phase, approval number AIT801. For the 4 and 6 year waves, the Auckland Branch of the National Ethics Committee also approved the Transition to School Phase, approval number AITX0202. For the 9 and 11 year waves, the Toward Adolescence phase, ethical approval of procedures and interview protocols was obtained from Northern Y Regional Ethics Committee (HDEC), approval number NTY/08/12/119. Finally, for the 14 year wave, the Transition Through Adolescence phase, approval was obtained from the Southern Health and Disability Ethics Committee, approval number 13/STH/159.

Chapter 4 Body size and relative rate of growth of Pacific children

What are the physical growth patterns of NZ-born children of Pacific Islands' heritage? This chapter examines body size measurements and growth trajectory from age 4 to 14. However, considerations around the impact of puberty on growth in the latter years (from 11 to 14 y) are the subject of a pending publication. Height, weight, body mass index (BMI), BMI z-scores (BMI Z) and associated growth curves of the child cohort from the Pacific Islands Families (PIF) study are presented. First, this chapter begins with a review of some background literature on Pacific children's growth and anthropometry. Second, methods of the investigation are described, such as data collection, equipment, and strengths and limitations of the measures. This followed by a summary of internationally recognised tools of reference for analysing and understanding anthropometric outcomes and growth trajectory is provided. Third, findings from cross-sectional and longitudinal measures are presented. Finally, a discussion section sets the stage for exploring growth in terms of food and home environments related to consumption and physical growth of Pacific children.

4.1 Literature review

Public health research has highlighted an ongoing concern for the increasing prevalence of overweight and obesity internationally (M. Ng et al., 2014), and particularly for Pacific peoples in New Zealand (MoH 2015d). Attention to preventing rapid weight gain should begin prior to conception and during gestation (Salsberry & Reagan, 2005). To illustrate, McCowan, Stewart, Francis, and Gardosi (2004) found significant differences in mean birthweight between European and Pacific babies where Samoan and Tongan new-borns were 84g and 124g heavier respectively than European babies. Further, there is growing evidence correlating birthweight to later obesity (Yu et al., 2011). Other studies provide convincing evidence that body weight and BMI track across the life-course, with growth patterns starting in early childhood and progressing into adolescence and adulthood (Araújo, Santos, & Prado, 2016; Singh, Mulder, Twisk, van Mechelen, & Chinapaw, 2008; WHO 2016). These studies recommend that intervention must continue through early childhood and adolescence to curtail an epidemic of non-communicable illnesses that include diabetes and cardiovascular disease among young people (WHO 2016). In the most recent National Health Survey (2013-2014), 30% of Pacific children (2-14 y) compared to 11% of the total child population were obese according to the extended Cole criteria (Cole & Lobstein, 2012), giving an unadjusted rate ratio of 3.6 when compared with non-Pacific children (MoH 2015d). Pacific adults were 2.5 times as likely to be obese (65%) compared with non-Pacific adults (MoH 2015d, p. 10). These rates had increased since the previous national surveys of 2011-2013 where 26% of Pacific children and 58% of Pacific adults were classified as obese (MoH 2015d).

In evaluating weight status in children and young people, comparison of crude body weight between gender groups is not appropriate due to biological differences. In addition, exact age at time of measurement is not accounted for in the description of crude weight. Instead, variation in age influences dispersion of weight data points. Internationally accepted reference points for sex-specific height, weight and BMI standards require, at minimum, exact age at measurement to be accounted for. Further, the WHO recommend that standard deviation scores (or z-scores) are a more appropriate method for understanding young people's physical growth.

Studies by Rush et al. (2007) and Rush, Paterson, and Obolonkin (2008) were the first to highlight food (in)security and the longitudinal impacts on nutrition outcomes in a Pacific birth cohort in New Zealand. Rush, Paterson, Obolonkin, et al. (2008) examined birthweight, and height, weight and BMI at age 2 and 4 years (y), tracking growth trajectory and comparing these with the 2006 WHO growth standards (WHO 2006). Mean birthweight z-score was within the ideal range, but by age 2 y, mean weight and BMI z-score had risen significantly above the ideal, increasing further still at age 4 y. It was observed that mean weight gain was higher from age 0-2 y at 13 grams/day than at age 2-4 y at 8 grams/day.

Later, the PIF cohort birthweight and growth trajectory were examined to age 6 y (Rush et al., 2010). A gender difference existed with boys having higher birthweight and then growth rate than girls and when divided into quartiles the heavier birthweight children were heaviest at age six. However, “for children born small their weight SD score accelerated across the mean.” (p 192). Overall, “weight SD score increased faster than height SD score” (p 192) resulting in a steep increase in weight trajectory which tracked from birth and a high prevalence of overweight (31.1%) and obesity (29.2%) at age six.

In an effort to understand this rapid weight gain and differences by sex, the individual contributions of maternal acculturation and puberty on child growth trajectory were examined by Tseng et al. (2015), and by Rush, Tautolo, Paterson, and Obolonkin (2015), respectively. Tseng et al. (2015) investigated the moderating effects of maternal acculturation (Pacific mother’s adoption of New Zealand cultural norms) and nativity (birthplace) on their child’s anthropometric measures and weight gain. Higher scores of (NZ) maternal acculturation was not significantly associated with children’s weight-for-age or BMI z-scores overall. However, “in stratified analyses, change in maternal acculturation score was inversely associated with WFA z-score change among children of NZ-born, but not immigrant, mothers (beta= -0.021; 95% confidence interval, -0.036 to -0.007; p = 0.006;

interaction, p = 0.005)" (Tseng et al., 2015, p. 430). The findings highlight implications for lifestyle and behavioural factors based on maternal cultural orientation especially among NZ-born mothers and weight gain in their offspring.

Rush et al. (2015) also wanted to test the potential effect of the onset of pubertal signs on anthropometric outcomes of these Pacific children at age 9 and 11 years. Indeed, at both ages, girls who had shown signs of puberty had "substantially greater height, weight and BMI" (Rush et al., 2015, p. 24) than girls who had not. Boys, on the other hand, only exhibited a positive association between growth spurt and fat mass at age 9 y, yet no associations were observed at age 11.

Finally, to assess growth trajectory of the PIF cohort to age 11 y, Rush et al. (2013) derived gender-specific age-related centile curves for weight, height and BMI using the skew (L), median (M) and coefficient of variation (S) parameters as described by Cole and Green (1992). The curves enabled longitudinal centile comparison of the PIF cohort with the WHO and Centres for Disease Control (CDC) growth references for ages 2-5 y and 5-10 y respectively. By age 10 y, "almost 95% of Pacific boys and girls were above the CDC 50th centile" (Rush et al., 2013, p. 407) and the prevalence of overweight and obesity had more than doubled with that seen at age 5 y, to 70% and 50% respectively.

In concert, the various studies mentioned above, underscore the significance of longitudinal investigation in understanding dynamism of corporal growth and trajectory of weight gain. What is not known is the magnitude of anthropometric outcomes among these Pacific children and the trajectory of rapid growth across 11-14 y. The aim of this chapter is to address this gap by examining height, weight and BMI through ages 4 to 14 y, to describe the relative rate of childhood growth in the Pacific cohort. The hypothesis is that based on rapid growth at earlier ages, weight gain between age 11 and 14 will be greater than that seen between age 9 to 11.

4.2 Methods

4.2.1 Data collection and equipment

Birthweight, but not supine length, were obtained from hospital records for 1398 children. Later, anthropometric (height and weight) measurements used for this investigation were obtained at the age 4, 6, 9, 11 and 14 y measurement waves. Data points from the 1 and 2 y waves are only present in growth trajectory graphs for context, however, they were not included in analyses as children were only measured once at each of these waves. From 4 y, weight and height were recorded at least twice per child. If a difference of the two measurements varied by ±1.0cm for height, or ±0.5 kg for weight, subsequent measurements were recorded until two measurements were within the relevant threshold. A final average was calculated from measurements from each child and used in the analyses. From 4 y, weight was measured in light clothing and standing height measured with no shoes and recorded by trained assessors using the standardised procedures, allowing for calculation of BMI (WHO 2008). Height was measured to the nearest (±0.5cm) and weight to the nearest 0.1 kilogram (kg). Weighing scales (Wedderburn, Soehlne) and height stadiometers (Mentone) were calibrated at every measurement wave. Instruments were often replaced due to wear-and-tear, and regularly updated with newer models with improved technology, such as improved mobility (compact, lightweight), durability, and measurement range and accuracy. Despite these changes, instruments were calibrated against length and weight standards and measurement protocols were calibrated and standardised prior to each data wave.

4.2.2 Data treatment and analysis

All anthropometric data were vetted and cleaned for potential error at measurement and/or data entry. At age 4 y, data were visually checked for outliers, and maintained if biologically plausible. If data were not plausible, they were removed and deemed missing. At ages 6, 9 and 11 y, maximum and minimum numeric thresholds in SPSS® Data Entry Builder v. 4.0 software were set so that extreme values were checked, verified, overridden or omitted dependant on specified conditions. For example, at age 9 y, height was programmatically restricted to a minimum of 1.25cm and maximum of 1.55cm. However, if a measurement was recorded outside of a threshold, as long as the recording protocol was followed (2-3 measurements within range) and deemed biologically plausible, the measurement was entered as a legitimate record. If a measurement was implausible, it was omitted and recorded as missing. At age 14 y, similar thresholds were employed but were programmed into the online survey software SurveyMonkey (Survey Monkey Inc. San Mateo, California, USA. www.surveymonkey.com) as data were collected digitally onsite using Microsoft® Surface™ tablets (www.microsoft.com/surface). Measurements exceeding thresholds set at 14 y could not be recorded in SurveyMonkey onsite, but were recorded on paper and entered manually by a research supervisor post-survey. Body mass index was derived by dividing a child's weight in kilograms by height in metres squared (kg/m^2)

For this analysis, children were not tracked individually but as a cohort, in gender- and age-specific ranking within each age. Physical measures were continuous variables from which the z-scores (age and gender adjusted) relative to the WHO, CDC, and International Obesity Taskforce reference children were derived. Pacific-specific growth curves were derived. Median and 95th percentile growth curves from the WHO 2007 growth standards (ages 0-5 y) and Centres for Disease Control growth references (ages 0-20 y) were compared against the PIF children's growth trajectory percentiles (5%, 15% 50%, 85% and 95%) (Cole et al., 2007; Kuczmarski et al., 2002; Onis, Onyango, & Borghi, 2007; World Health Organization, 2006).

4.2.3 Age and gender specific z-scores

Age- and sex-specific z-scores for weight, height and BMI were derived and expressed, respectively, as WFA Z (weight-for-age z-score), HFA Z (height-for-age z-score), and BMI Z (body mass index-for-age z-score). Z-scores are reference points relative to the median (0) of a random sample of a population at a given time and can be used for describing the relative nutritional and developmental characteristics of the sample. To calculate z-scores, the Microsoft Excel add-in titled LMS (lambda-mu-sigma) growth was applied to the main anthropometric dataset (Cole, Freeman, & Preece, 1998). The z-scores indicate physical growth outcomes above or below the sample median relative to the child's age on a given day. From age 0 to 5 y, the z-score indicators are only used to assess child underweight or severely underweight, but are not used to classify a child as overweight or obese (Appendix A) (WHO 2008). Instead, reference to the International Obesity Taskforce Grades and the WHO 2007 age and gender-specific 85^{th} and 95^{th} percentiles for BMI are international references for defining child growth outcomes of overweight and obesity.

4.2.4 International Obesity Taskforce Grades

The International Obesity Taskforce (IOTF) grades are defined by BMI (kg/m^2) cut-offs based on predicted age- and sex-specific centiles of BMI to age 18 y (Cole et al., 2000). For this investigation, the prevalence of IOTF grades were estimated for PIF children from age 4 to 14 y. The grade classifications of child overweight (>+1SD, equivalent to BMI 25 kg/m^2) and obesity (>+2SD, equivalent to BMI 30 kg/m^2) when the growth curve is extrapolated to age 18 years were determined for children (age 2 to 18 y) by Cole et al. (2000). For BMI between +1SD and -2SD at age 18 years, body size is considered healthy, below -2SD is classified as thin, and below -3SD as severely thin.

4.2.5 Cohort growth curves

Smoothed, gender and age-related centile curves for the PIF children ages 4 to 10 y have been derived previously (Rush et al., 2013) using the skewness (L), median (M), and coefficient of variation (S) method (Cole & Green, 1992). Reference centile curves show the distribution of a measurement as it changes according to age (Pan & Cole, 2012). The benefit of using the LMS method is that it accounts for the non-normal, right-skewed distribution of body weight in the cohort. For this investigation, a more recent generalised additive model for location, scale and shape (GAMLSS) package for statistics software R was used to fit quantile regression models to derive smoothed centile growth curves to 14 y (Rigby & Stasinopoulos, 2005).

4.2.6 World Health Organisation Growth Curves

The WHO 2007 growth curves were developed from the WHO Multicentre Growth Reference Study (MGRS) carried out between 1997 and 2003 to develop growth curves for populations to assess the growth of children and young people internationally (http://www.who.int/childgrowth/mgrs/en/). The MGRS represented 8500 children from a broad range of ethnic and cultural backgrounds in six countries: Brazil, Ghana, India, Norway, Oman and the USA. The World Health Organisation (WHO) released their most recent growth standards for children aged 0 to 59 months in 2006, and growth references for ages 5 to 19 years in 2007 (Onis et al., 2007). The WHO 2006 standards illustrate 'internationally recommended' growth trajectories for children who were born full-term, to non-smoking, non-diabetic mothers and were predominantly breastfed for at least 4 months and continued up to 12 months.

However, WHO weight-for-age reference data are not available for children beyond age 10 years. The WHO position is that as growth spurt is common at this age, weight may be overestimated due to rapid linear growth.

> "Weight-for-age reference data are not available beyond age 10 because this indicator does not distinguish between height and body mass in an age period where many children are experiencing the pubertal growth spurt and may appear as having excess weight (by weight-for-age) when in fact they are just tall." (WHO website accessed 12/12/2016, http://www.who.int/growthref/who2007_weight_for_age/en/)

Thus, because the WHO growth reference data are international standards, continuous age-specific data relevant to this investigation (age 4 to 14 years) are only available for height and BMI. As a result, the child growth curves developed by the United States Centres for Disease Control and Prevention were used for weight and z-scores for all growth measures.

4.2.7 Centres for Disease Control and Prevention Growth Curves

The US Centres for Disease Control and Prevention (CDC) growth references 2000 were released 'for use in clinical practice and research to assess size and growth in U.S. infants, children, and adolescents' (Kuczmarski et al., 2002, p. 1). The CDC growth curves are a revision of earlier national growth charts (National Centre for Health Statistics, 1977) which only provided growth references only for children from birth to 36 months. Updated in 2000, the CDC charts were improved to include a separate set of growth references allowing a smoothed transition of growth curve references from age 2 to 20 y. In addition, new charts of gender-specific BMI-for-age growth references were developed. Data for the charts were gathered in five National Health and Nutrition Examination Surveys (NHANES) providing a better representation of 'racial-ethnic diversity and a combination of breast- and formula-feeding in the United States' (p.1 Kuczmarski et al 2002). Data required to reproduce the 2000 CDC gender-specific growth curves for ages 2–20 years were available and, therefore, used as a comparison reference for height SDS, weight/weight SDS and BMI SDS.

4.3 Results

4.3.1 Body size

Crude weight

As expected with attrition over 14-15 years, the number of children measured at each time point gradually decreased by 33.2% (n=1379 birth; n=917 14 y) (see **Error! Reference source not found.**). Throughout the period, proportion by gender (girls 49%; boys 51%) from birth remained constant. However, the retention rate across the period was not constant, particularly at 11 y when participation (69%) was greater than the previous three waves (4, 6 and 9 y) which was 65% on average. In other words, children, for one reason or another may not be measured at one time point but then be measured at a later time point.

In this cohort, 5.2% of babies were classed as having low birth weight (LBW = <2.5 kg) (girl n=42, boys n=30; data not shown). Even without adjustment for LBW, there was only a small difference of 0.10 kg (or 3.5 ounces) between girl and boys mean birth weight (3.52 kg and 3.62 kg, respectively). Girls continued to have lower weight and less variation in weight than boys throughout the period of investigation, except at 11 y when girl mean was 0.10 kg higher. For example, by 14 y the coefficient of variation for weight for girls was 24% (19.0/78.1) and for boys was 29% (23.5/82.1)

Table 4.1 Mean birthweight with 95% confidence intervals (CI) and mean weight in kilograms with standard deviation (SD) and count (N) by measurement wave and gender for the PIF child cohort for eight measurement waves to 14 years[1]

Measurement wave[2]	Variable unit[3]	Girls	Boys	Total (Retention from birth %)[1]
Birth	N m (SD) 95%CI	674 3.52 (0.64) 3.47 – 3.57	705 3.62 (0.61) 3.57 – 3.66	1379
1-year	N m (SD)	592 10.5 (1.5)	636 11.1 (1.6)	1228 (88%)
2-years	N m (SD)	503 14.3 (2.0)	538 14.9 (2.0)	1041 (75%)
4-years	N m (SD)	434 20.2 (3.3)	461 21.3 (4.2)	896 (65%)
6-years	N m (SD)	442 27.6 (6.3)	453 29.0 (7.0)	895 (65%)
9-years	N m (SD)	450 43.9 (11.7)	435 47.1 (13.6)	885 (65%)
11-years	N m (SD)	480 55.8 (14.3)	469 55.7 (15.8)	949 (69%)
14-years	N m (SD)	452 78.1 (19.0)	465 82.1 (23.5)	917 (66%)

[1] Sibling twins excluded; rounded to 1 decimal place except for birthweight.
[2] Measurement waves equate approximately to age at follow-up.
[3] m = mean; (r) = range; SD = Standard deviation; N = number of participants.

Height and height-for-age z (HFA Z)

Overall, measures showed a rapid increase and little variation in linear growth from 4 to 14 y (Table 4.2). There was, on average, a 9% difference in linear growth between girls (59.1 cm) and boys (64.9 cm) cross the period, with notable changes between 11 and 14 y. Although mean girl height was significantly greater than boys at 11 y, relative linear growth appeared to slow by 14 y, when boys were significantly taller than girls. Variation in height increased at a similar rate within the sexes until 14 y, where it continued to widen for boys but narrow for girls. Compared with the WHO reference, which standardises for sex and age, the cohort of boys was on average 0.95 SDS taller and girls 0.89 SDS taller.

Weight and weight-for-age z (WFA Z)

Overall, weight gain was rapid throughout the investigation period, exceeding the WHO sex- and age-specific reference child. On average, mean body weight for boys increased at a rate of ~6.08 kg per year (kg/y) and for girls at ~2.2 kg/y between 4 and 14 y (Table 4.2). However, mean weight velocities fluctuated over time. For example, lowest mean weight velocity occurred between 4 and 6 y (boys~3.8 kg/y, girl~3.7 kg/y) and the highest between 11 and 14 y (boys ~8.8 kg/y; girl ~7.43 kg/y). The estimate for the latter period is most likely confounded by expected accelerated growth during puberty, contributing to substantial outliers (Figure 4.1 and Figure 4.2). Compared with girls, weight variation was greater among boys at every measurement wave and at 14 y, variation was 8% greater than girls.

On average, boys were >1.5 SDS heavier than the WHO boy median at every age/wave to 11 y, but at 14 y they were >2.5 SDS heavier. In contrast, the cohort of girls were >1.5 SDS heavier than the WHO girl median at 6, 9 and 11 y and at 14 y, they were 2.0 SDS heavier.

BMI and BMI Z

Up to 11 y, children's mean BMI and 95% CI were within the normal range for individuals and at 14 y were in the range of overweight according to Cole et al. (2000) cut-offs. However, children's means were >1.0 SDS above the WHO BMI Z median from 4 to 11 y and above 2.0 SDS by 14 y.

Outliers in the upper weight ranges for boys are an obvious feature at each age, beginning especially from age 4, and rapidly increasing through to 14 y (Figure 4.1). For example, from 9 y, outliers appear in the 75 to 100 kg range, increasing into the 90 to 125 kg range at age 11, followed by a jump into the 150 to 200 kg range at 14 y. The upper whisker also exhibits increasing width upwards especially from 9 y (in the 55 to 75 kg range), jumping considerably at 14 y (into the 95 to 145 kg range). The boxes (representing between the 1st and 3rd quartiles) show a similar pattern, crossing beyond 50 kg at 9 y and occupying the weight range of 65 to 95 kg. These findings demonstrate a growing dispersion of weight in the cohort of boys, especially in the heavier weight ranges.

Table 4.2 Boys and girls mean height, height-for-age (HFA Z), weight, weight-for-age (WFA Z), BMI, and BMI-for-age (BMI Z) with 95% confidence intervals (CI) for age 4, 6, 9, 11 and 14 years (Z-scores derived from (Cole et al., 1998)).

Data phase	**4 y**	**6 y**	**9 y**	**11 y**	**14 y**
Boys (n)	**454**	**452**	**435**	**469**	**464**
Height (cm)	106.8	122.4	142.7	152.3	171.7
95% CI	106.4, 107.2	121.9, 122.9	142.1, 143.3	151.7, 152.9	171.0, 172.4
HFA Z	0.65	0.88	1.13	1.21	0.90
95% CI	0.55, 0.74	0.79, 0.98	1.03, 1.23	1.11, 1.30	0.81, 0.98
Weight (kg)	21.3	28.9	47.1	55.7	82.1
95% CI	20.9, 21.6	28.3, 29.6	45.8, 48.4	54.2, 57.1	79.9, 84.2
WFA Z	1.64	1.65	1.80	1.70	2.54
95% CI	1.54, 1.75	1.54, 1.76	1.70, 1.91	1.59, 1.80	2.40, 2.67
BMI	18.5	19.1	22.8	23.7	27.6
95% CI	18.3, 18.8	18.8, 19.5	22.4, 23.3	23.2, 24.2	27.0, 28.3
BMI Z	1.58	1.52	1.78	1.62	1.85
95% CI	1.47, 1.68	1.42, 1.63	1.67, 1.89	1.50, 1.73	1.74, 1.97
Girl (n)	**430**	**441**	**449**	**479**	**452**
Height	105.8	121.3	141.8	154.0	164.9
95% CI	105.3, 106.2	120.8, 121.8	141.2, 142.4	153.4, 154.6	164.4, 165.5
HFA Z	0.67	0.83	1.02	1.28	0.67
95% CI	0.57, 0.77	0.73, 0.92	0.92, 1.11	1.20, 1.37	0.59, 0.75
Weight (kg)	20.2	27.6	43.9	55.8	78.1
95% CI	19.9, 20.5	27.0, 28.2	42.8, 45.0	54.6, 57.1	76.3, 79.8
WFA Z	1.29	1.53	1.69	1.93	2.00
95% CI	1.17, 1.40	1.41, 1.65	1.60, 1.79	1.84, 2.01	1.90, 2.11
BMI	17.9	18.6	21.6	23.4	28.6
95% CI	17.8, 18.2	18.3, 18.9	21.2, 21.9	22.9, 23.8	28.0, 29.2
BMI Z	1.44	1.57	1.77	1.82	2.29
95% CI	1.32, 1.55	1.45, 1.69	1.67, 1.87	1.72, 1.92	2.20, 2.38

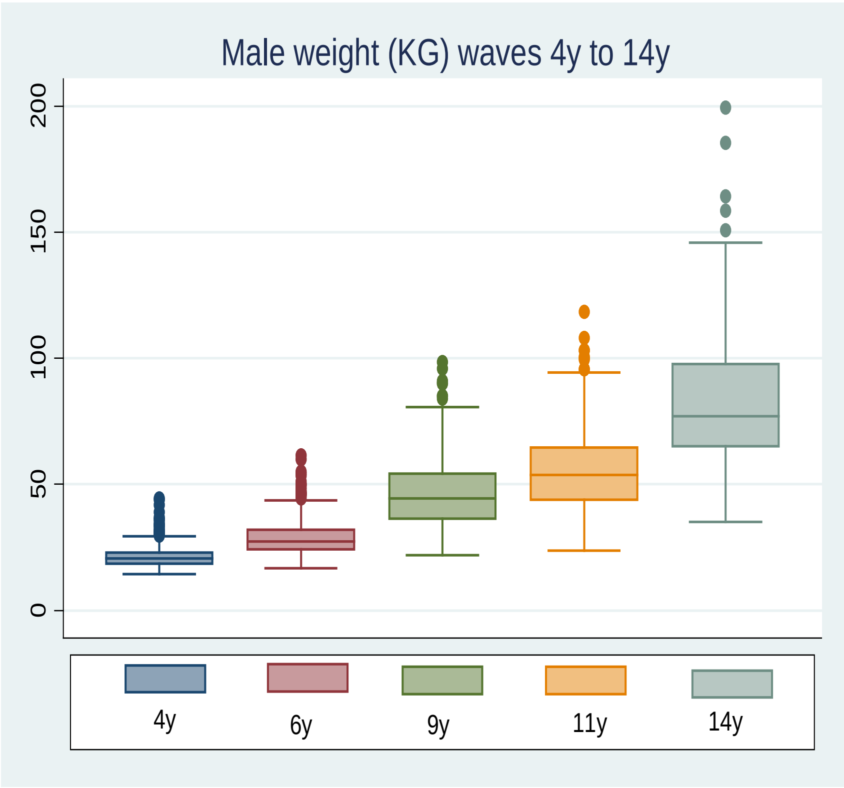

Figure 4.1 Box-plot of boys weight by age 4 to 14 years

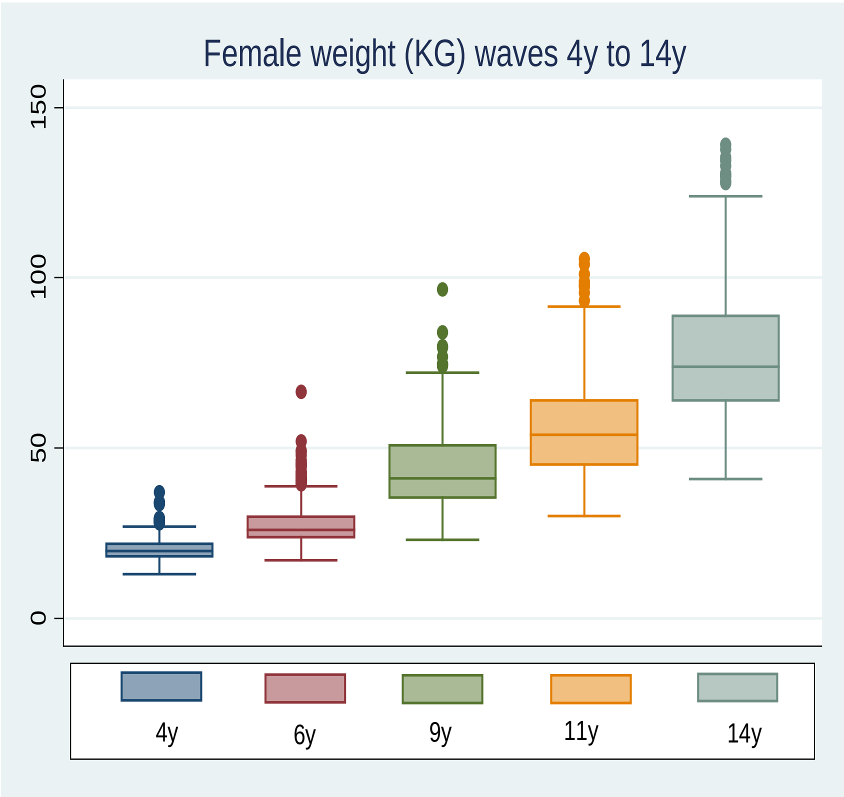

Figure 4.2 Box-plot of girl weight by age 4 to 14 years

IOTF grades

From age 4 to age 14 y, the prevalence of healthy weight in the cohort reduced and the prevalence of overweight and obesity increased (Figure 4.3 and Figure 4.4). For boys, the prevalence of healthy weight nearly halved from around 40% down to 22% at 14 y. For girls, prevalence of healthy weight reduced by around 10 percentage points from around 39% to around 29%. Corresponding increases in the prevalence of overweight and obesity (combined) meant prevalence in boys increased from around 60% to 78% and prevalence for girls increased from 61% to 71%.

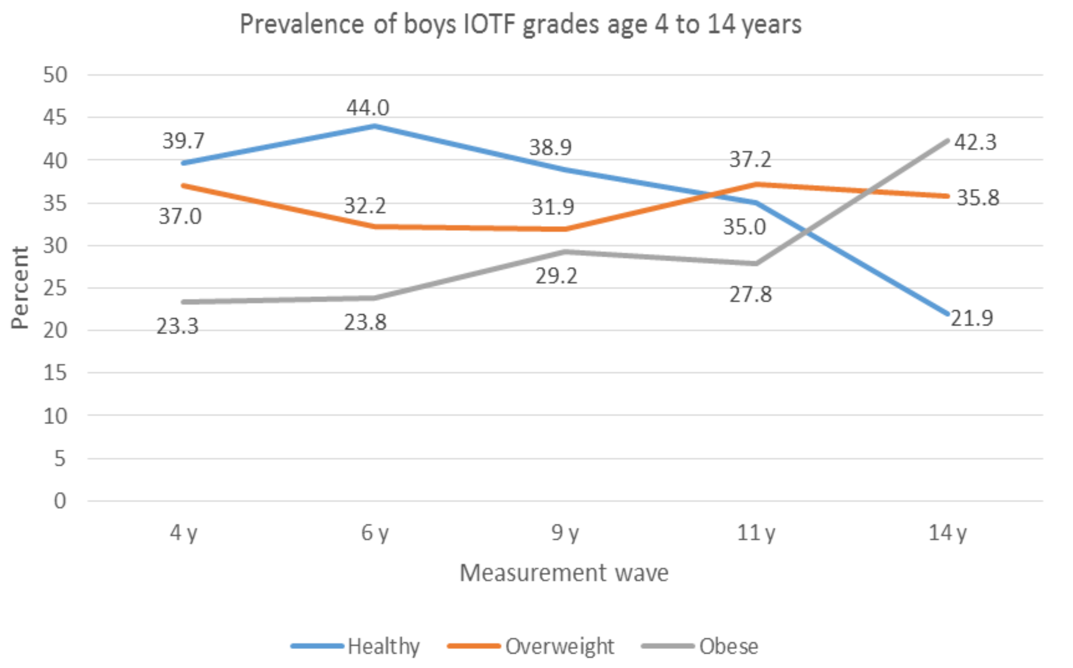

Figure 4.3 International Obesity Taskforce grades from 4y to 14y for PIF boys

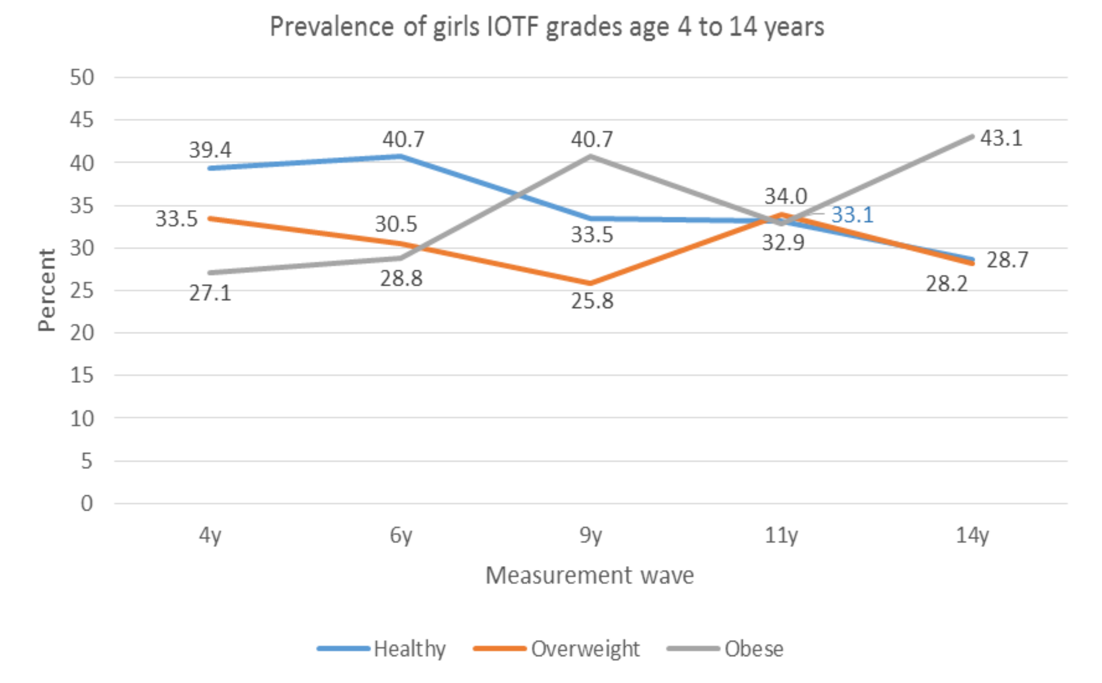

Figure 4.4 International Obesity Taskforce grades from 4y to 14y for PIF girls

4.3.2 Centile growth trajectory

Separately for boys and girls, smoothed centile growth curves were derived to illustrate growth trajectory. Birth weight (kg) and weight SDS were used to generate growth curves for weight/weight SDS from birth to age 15 y.

Table 4.3 Quartiles of mean birthweight Z-score for girls and boys (N=1379)

Quartile	**N**	**Girls**		**N**	**Boys**	
		Mean	**(min, max)**		**Mean**	**(min, max)**
1st	168	-1.83	(-6.92, -0.83)	175	-1.30	(-6.85, -0.30)
2nd	166	-0.41	(-0.82, -0.07)	176	0.16	(-0.31, 0.52)
3rd	171	0.32	(-0.06, 0.71)	176	0.86	(0.53, 1.27)
4th	169	1.48	(0.72, 3.29)	178	1.93	(1.28, 4.00)
Total	674			705		

Height and height SDS quartiles

Measured height (cm) and height z-scores age 1 to 14 y were used to generate height and height SDS Pacific-specific growth trajectories, and compared with the WHO (2007) and CDC (2000) median references, respectively (Figure 4.5 and Figure 4.6). In general, Pacific children were taller than the reference WHO child was at every age. From between age 2-4 y, the PIF median began to progress past the WHO median, where at age 4 y the PIF median was at least 2.0cm above that of the WHO child (boys ~3.1cm; girls ~2.3cm). By age 9 y, the PIF median had accelerated to around 6.0cm (girls) and 7.0cm (boys) taller than the WHO reference child. Generally, this median height difference continued through to age 14 y, where around 80-85% of PIF children were above the WHO median over this age period. At 14 y, Pacific boys' median showed continued upward growth, which is consistent with the linear growth pattern observed for WHO boys. On the other hand, PIF girls' median began to plateau, which is not consistent with the WHO girls for whom a continued upward trajectory is presented. Indeed, the results show that the PIF girls' median began to converge with the WHO girls' median at age 14 y.

At all ages (except for age 1 y) for all PIF children, height SDS median (zero) was greater than the CDC SDS median (Figure 4.7 and Figure 4.8). Patterns of height SDS trajectory were also very similar across the sexes. Median height SDS-scores peaked during age 11 y to approximately +1.30 CDC SDS. For PIF girls, this was followed by a relatively quick decline by age 14-15 y to 0.80-0.50 CDC Z compared to 1.00-0.80 CDC Z for PIF boys, a difference of 0.20-0.30 z-score between the sexes.

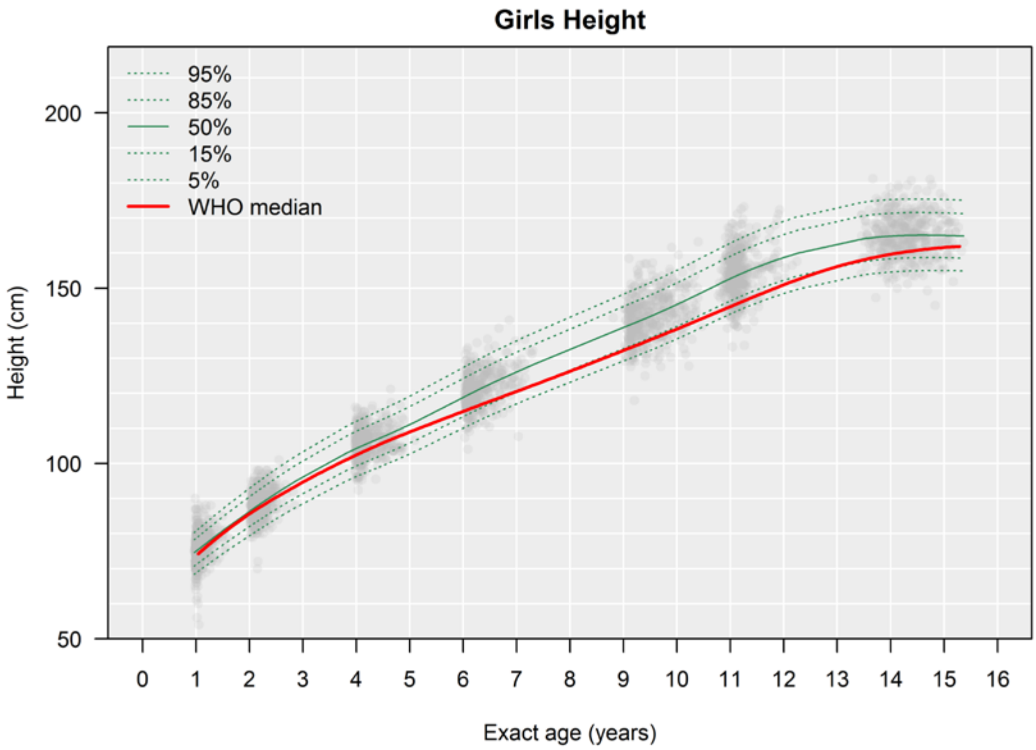

Figure 4.5 Growth curves of height for Pacific girls from age 1 to 14 y against the WHO median

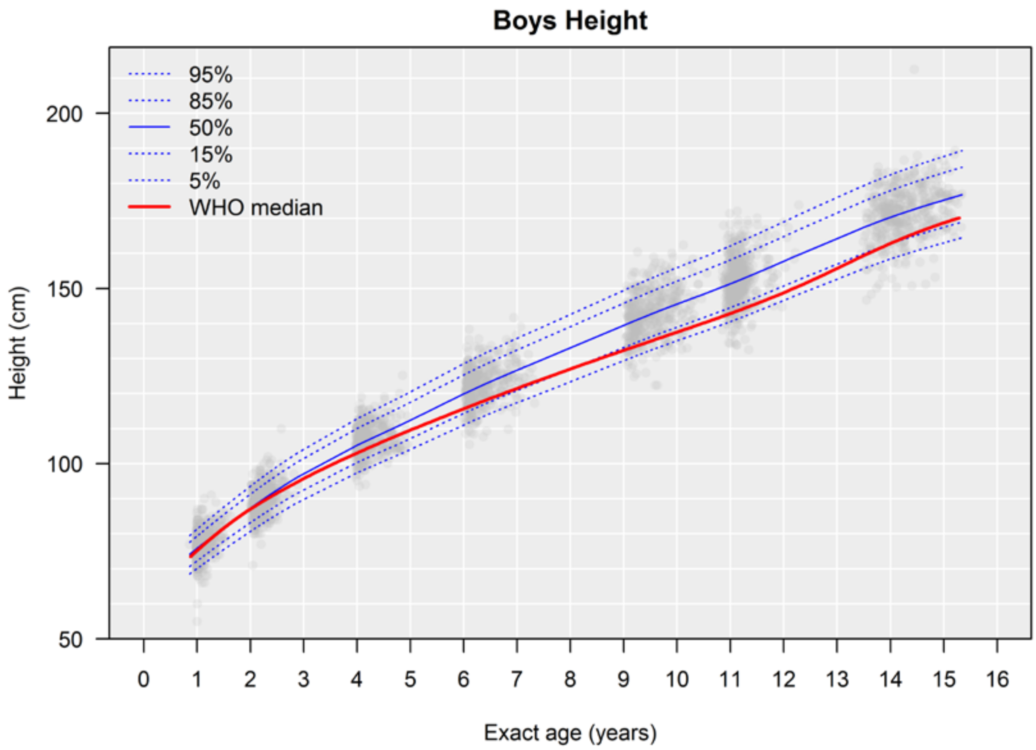

Figure 4.6 Growth curves of height for Pacific boys from age 1 to 14 y against the WHO median

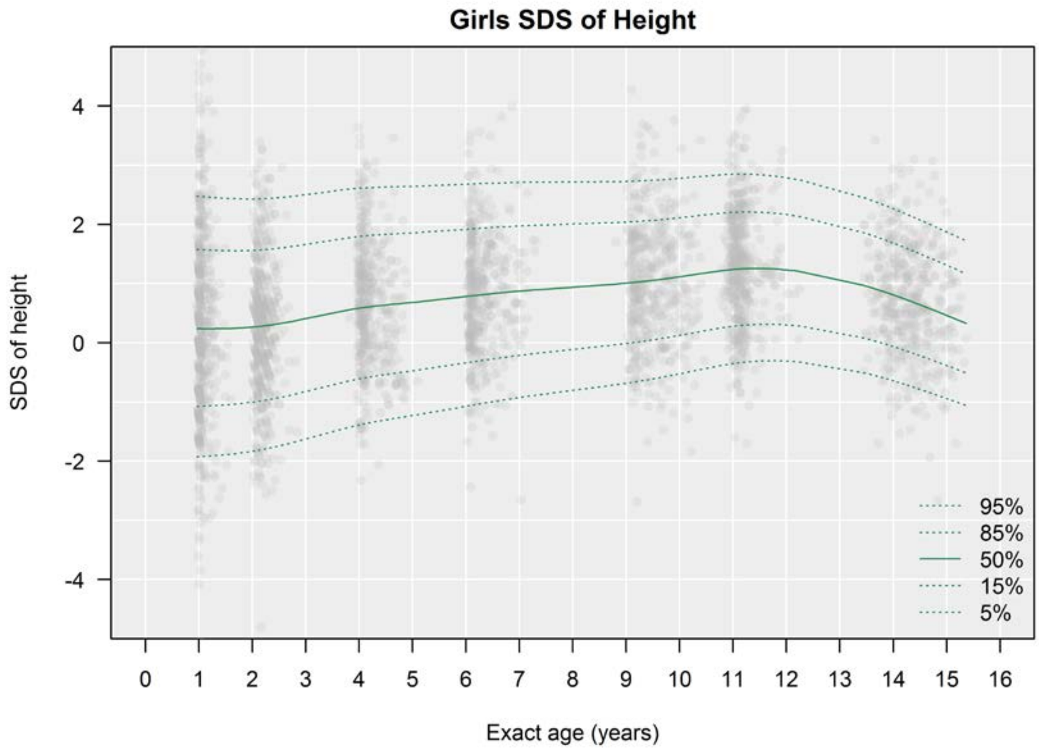

Figure 4.7 Growth curves of height SDS for Pacific girls from age 1 to 14 y against CDC SDS for height (white horizontal lines)

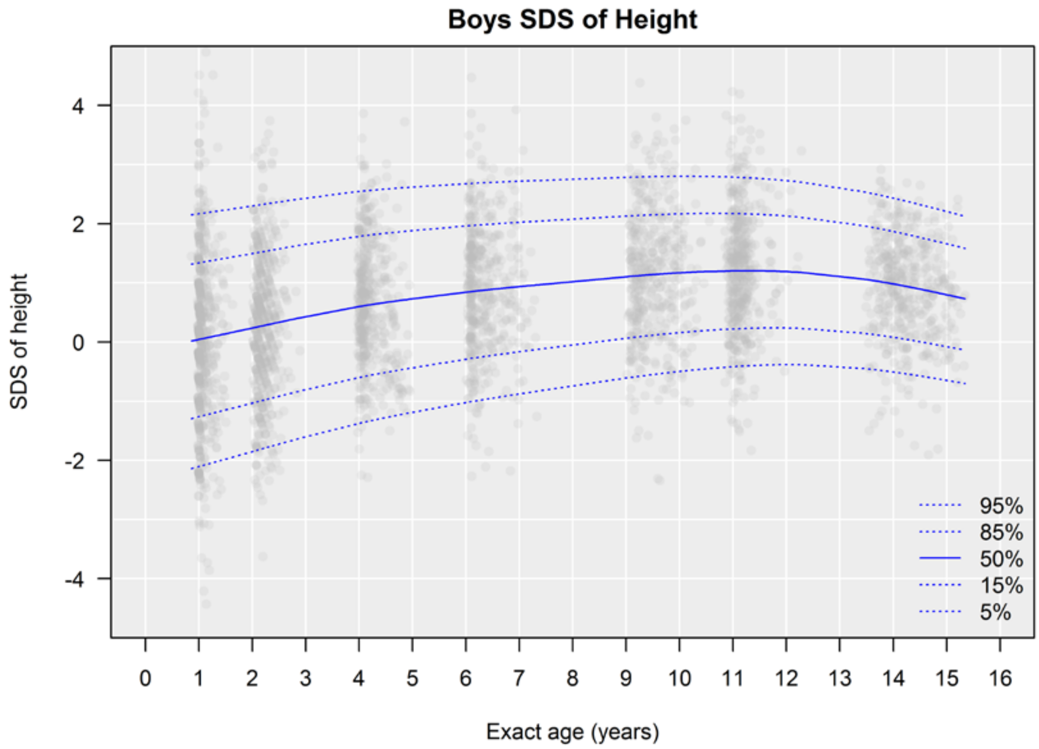

Figure 4.8 Growth curves of height SDS for Pacific boys from age 1 to 14 y against CDC SDS reference for height (white horizontal lines)

Weight and weight SDS

From age 1 to 11 y, the Pacific girl median weight curve lay just below the CDC reference's 95th percentile (Figure 4.9). However, from age 14, the PIF median curve converged with, and then climbed above, the CDC 95th percentile. Using this cut-off (95^{th}), the prevalence of obesity for girls from 11 to 14 y increased from ~45% to ~50%. A similar pattern was observed for PIF boys though the prevalence of obesity increased from 50% to 55% from 11 to 14 y (Figure 4.10). At 14 y, the median for both sexes had begun to project upward, beyond CDC's 95th centile but particularly for boys.

Centile growth curves for weight SDS for PIF study girls (Figure 4.11) and boys (Figure 4.12) show a similar pattern, with the median being greater than zero from birth to age 14 y. The PIF boys median indicated high risk of obesity (≥+2.00 SDS) earlier (~9 y) than girls (~12 y). Interestingly, the PIF boys 95th centile remained below +4.00 SDS throughout the entire follow-up, whereas the girl 95th centile surpassed +4.00 SDS between the 11 and 14 y phases.

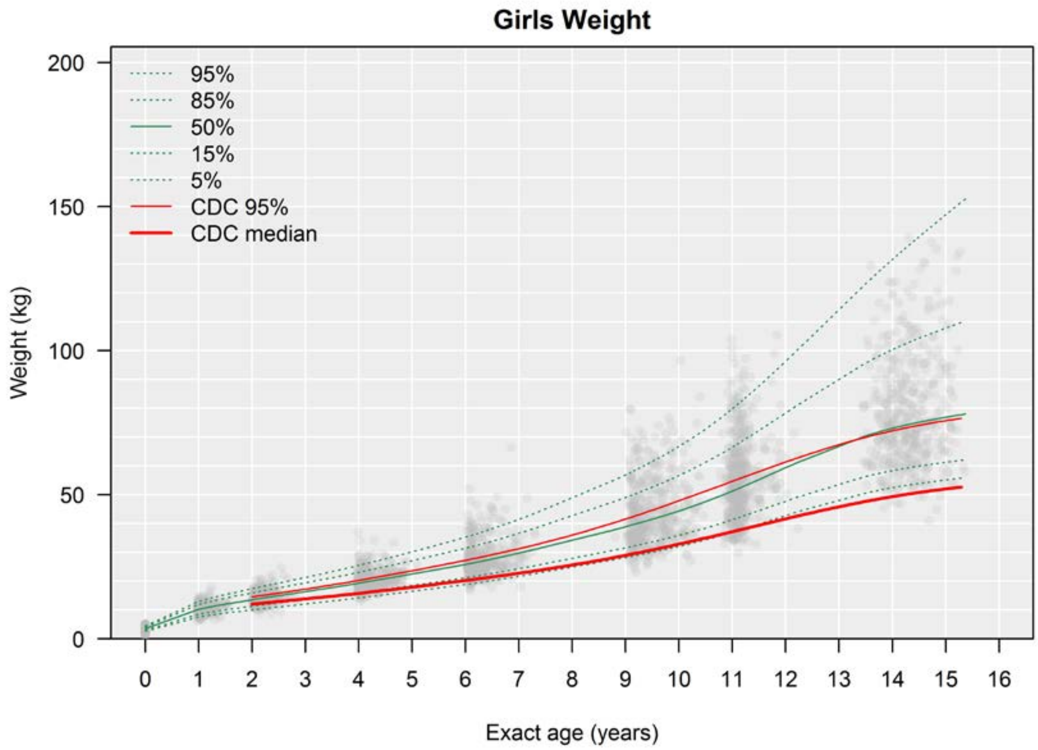

Figure 4.9 Growth curves for weight (KG) of Pacific girls from birth to 14-15 y against the CDC median and 95th percentile

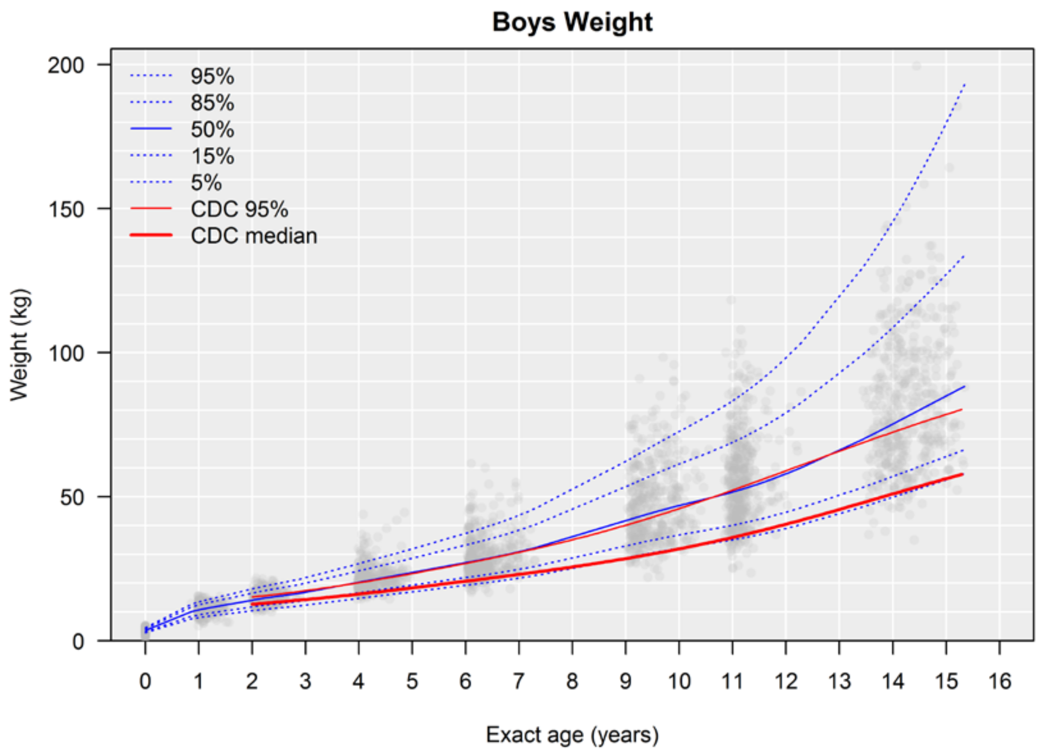

Figure 4.10 Growth curves for weight (KG) of Pacific boys from birth to 14-15 y against the CDC median and 95th percentile

Figure 4.11 Growth curves for weight SDS of Pacific girls from birth to 14-15 y against the CDC SDS for weight (white horizontal lines)

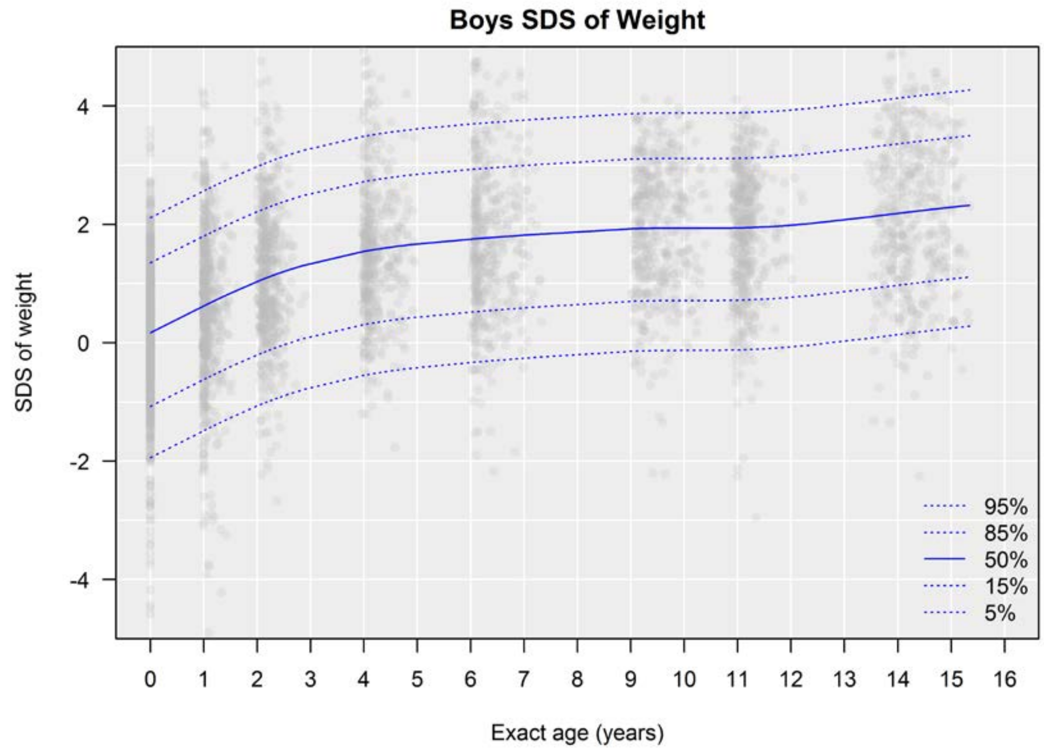

Figure 4.12 Growth curves for weight SDS of Pacific boys from birth to 14-15 y against the CDC boys SDS for weight (white horizontal lines)

BMI and BMI SDS

Body mass index and BMI SDS centile curves were also generated from age 1 y to age 14-15 y. For girls, the BMI median curve was consistent with the WHO 95th percentile curve up to age 11, which then began to accelerate rapidly to age 15 y (Figure 4.13). The PIF girls' 5th percentile curve lay just below the WHO girls' median curve right up to age 14 when the two curves converged. For PIF boys, the median curve lay above the WHO 95th percentile curve from age 4, with the gap between these two curves gradually increasing over the measurement period (Figure 4.14). By age 15, the gap between the WHO 95th and PIF boys' median was wide. The PIF boys' 5th centile was similar to the PIF girls' 5th centile, being consistent with the WHO median curve but only up to age 11. From age 11, the WHO median moved upwards from the PIF 5th percentile, lying closer to PIF 10th percentile by age 14-15 y.

Overall, the girls' and boys' BMI z-score (SDS) growth pattern was similar in that the SDS medians for both were above +1.00 SDS from age 2 and above +2.0 SDS by age 15 (Figure 4.15; Figure 4.16). However, the girls' median curve surpassed +2.0 SDS only at age 14 y, whereas the boys' median surpassed +2.0 SDS earlier at age 9. For both PIF boys and girls, approximately 40% were below +1.0 SDS at age 2 y, with this proportion reducing to 15% at age 15 y. The steepest incline in the BMI SDS median for girls was between ages 11 to age 15. For boys, the steepest inclines were observed between ages 2 to 9 y, and then between ages 11 and 15 y.

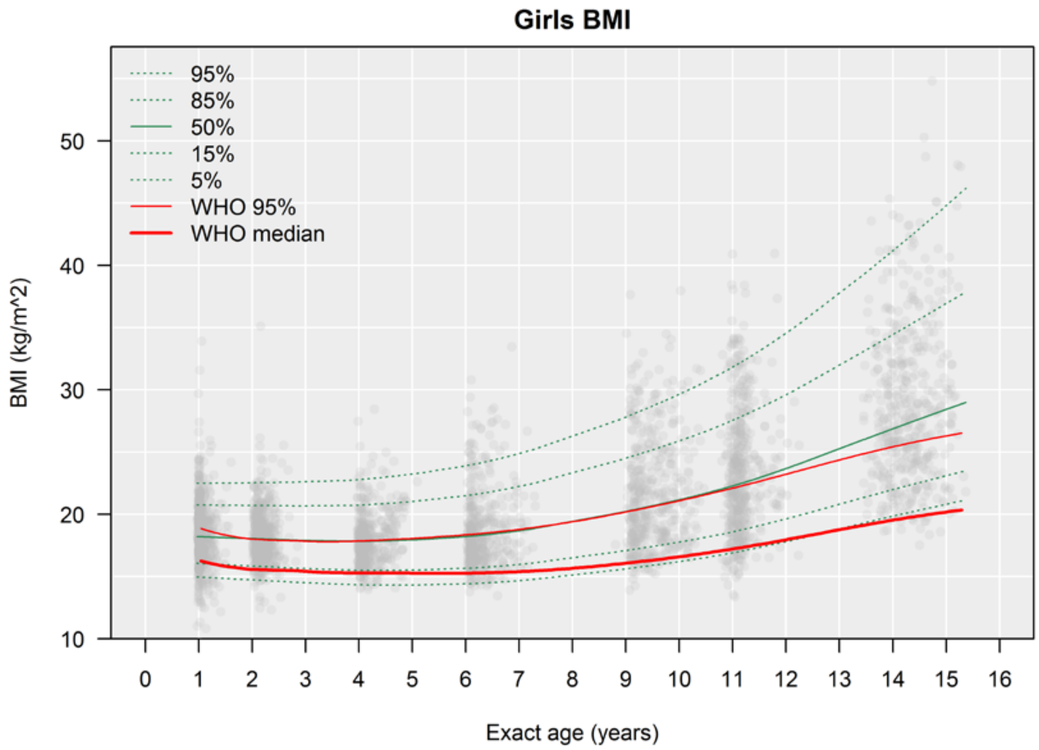

Figure 4.13 BMI growth curves for Pacific girls and the WHO girl median and 95th centile from 1 to 15 years

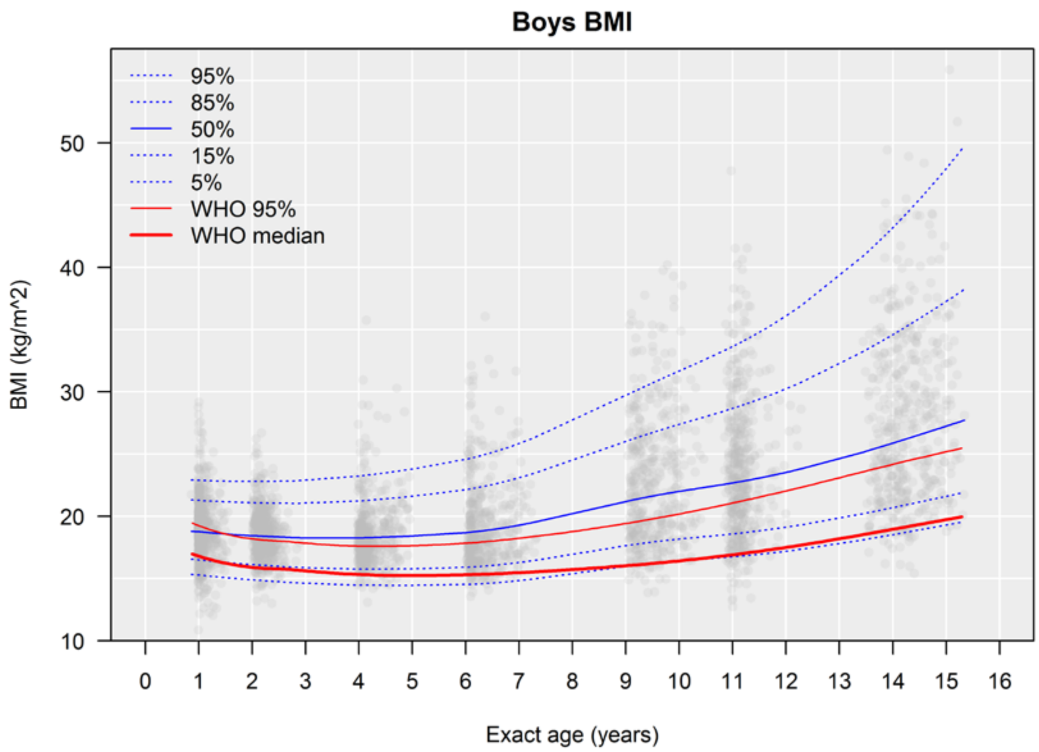

Figure 4.14 BMI growth curves for Pacific boys and WHO boys' median and 95th centile from age 1 to 15 years

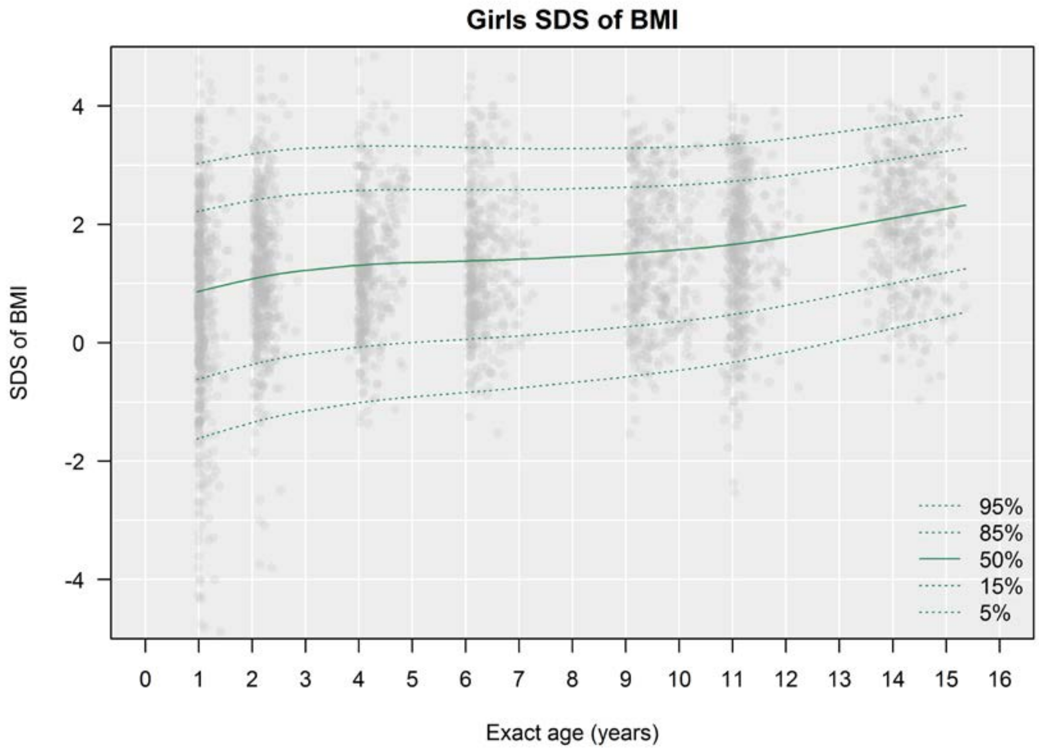

Figure 4.15 Growth curves for BMI SDS of Pacific girls from age 1 to 14 y against the CDC BMI SDS for girls

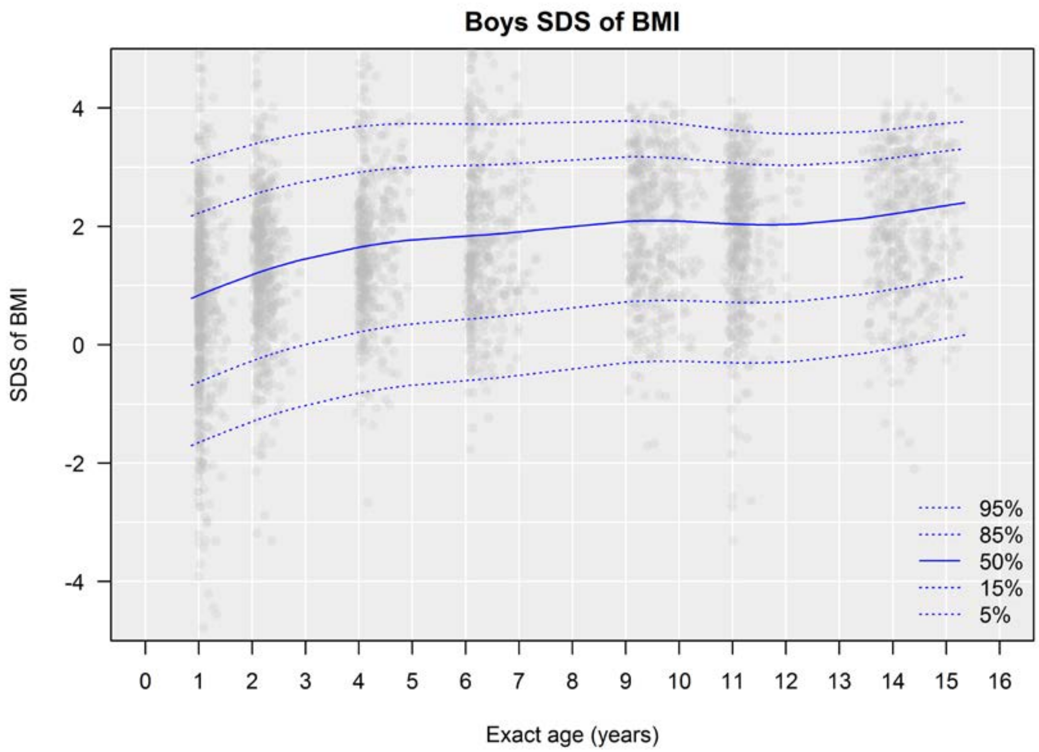

Figure 4.16 Growth curves for BMI SDS of Pacific boys from age 1 to 14 y against the CDC's boys' BMI SDS

4.4 Discussion

Relative to international standards (WHO and CDC) of ideal growth and weight, these findings confirm an accelerated growth trajectory, driven by normal linear growth but higher weight gain in New Zealand-born Pacific children to age 14 y. In the transition through childhood, an increasing magnitude in weight gain drove pronounced changes in the prevalence of overweight and obesity, with differences observed between the sexes. Mean WFA Z-scores through ages 4 to 9 y, compared with ages 11 to 14 y, increased by 31% for girls and 25% for boys. In concert, the observed IOTF grades show significantly different age effects between genders in combined prevalence of overweight and obesity, increasing less than 5% among boys but by 39% among girls from 4 to 14 y. A comprehensive search of the literature has been unable to find longitudinal or cross-sectional studies that report this high prevalence of excess weight in children who represent the "general population".

New Zealand children's mean weight and BMI from New Zealand Health Survey (NZHS) data (MoH 2015a) that were contemporaneous with the PIF cohort at age 6, 11 and 14 y were compared and presented in Table 4.4. As expected, PIF children were heavier at all ages with the mean weight and mean BMI increasing faster than the NZHS children. The comparison particularly highlights large differences in the magnitude of change between the sexes when compared with NZHS estimates. On average, from age 11 to 14 y, PIF girls gained more weight (45%) than NZHS girls compared with increases made by Pacific boys (32%) against NZHS boys. Furthermore, Pacific girls' mean BMI was more than 80% higher than NZHS girls, and Pacific boys nearly 69% higher than NZHS boys.

Table 4.4 Change in mean weight and mean BMI for PIF children[1] compared with changes in NZHS children from age 11 to 14 y[2,3] using the Cole cut-offs[4]

	Mean weight (KG) 95% CI		Increase in mean weight 11-14 y	Difference in mean weight gain between PIF & NZHS	% difference in gain between PIF & NZHS
Sample	11 y	14 y	(KG)	(KG)	(%)
PIF Boys	55.7 54.2, 57.1	82.1 79.9, 84.2	26.4	7.6	40.4
NZHS Boys	46.3 43.0, 49.7	65.1 61.9, 68.4	18.8		
PIF Girls	55.8 54.6, 57.1	78.1 76.3, 79.8	22.3	9.3	71.5
NZHS Girls	45.7 42.9, 48.5	58.7 56.4, 61.0	13.0		
	Mean BMI (KG\M^2) 95% CI		Increase in mean BMI 11-14 y	Difference in mean BMI gain between PIF & NZHS	
PIF Boys	23.7 23.2, 24.2	27.6 27.0, 28.3	3.9	1.7	77.3
NZHS Boys	20.6 19.4, 21.8	22.8 21.8, 23.8	2.2		
PIF Girls	23.4 22.9, 23.8	28.6 28.0, 29.2	5.2	2.7	108.0
NZHS Girls	20.1 19.3, 20.9	22.6 21.8, 23.5	2.5		

[1] PIF 11 y boys n=469, girls n=479; 14 y boys n=464, girls n=452
[2] NZHS 11 y sample sizes not available. For NZHS 14 y, all children age 2-14 y were pooled (n=4754) therefore sample sizes are only estimates: boys n~131 and girls n~131 (Ministry of Health, 2016c)
[3] See Appendix B for more detailed table from age 6 y
[4] (Cole et al., 2000)

Differences between the sexes in weight gain and obesity prevalence during adolescence are well known (Dietz, 1994), yet do not explain the incongruence of growth trajectories between Pacific children when compared with their respective international peers. That girls from age 11 to 14 y had a steeper trajectory of BMI compared with the WHO reference is at least partly due to early onset menarche among Pacific compared with other ethnic groups (MoH 2003). At age 9 and 11 y, mothers reported that girls had shown more characteristics of puberty and earlier than boys, and was associated with relatively greater magnitudes of weight, height and BMI when compared with girls who had not shown signs of puberty (Rush et al., 2015). In this investigation, by age 14 y Pacific girl linear growth started to plateau, converging with height of WHO girls, yet weight gain continued to increase, driving greater increases in BMI at that age.

Importantly, birthweight was positively correlated to weight and BMI in late childhood, an association reported previously for 4 & 6 y old children by Rush et al. (2010). This is well established for other populations (Danielzik, Czerwinski-Mast, Langnase, Dilba, & Muller, 2004; Gillman, Rifas-Shiman, Berkey, Field, & Colditz, 2003) and confirms a relationship between birthweight and growth trajectory among Pacific children (Rush et al., 2010; Rush, Paterson, Obolonkin, et al., 2008). The evidence supports calls for interventions that aim to slow rapid growth and later obesity to begin prior to birth to break the cycle of intergenerational obesity (Cole, Power, & Moore, 2008; Godfrey, Gluckman, & Hanson, 2010; Wells, 2017). Furthermore, because tracking of weight was not individual-specific but cross-sectional at each wave suggests that multi-level strategies designed to support healthy weight at critical stages along the age continuum may be necessary to prevent incidence of obesity in healthy-weight populations (Bogart et al., 2016).

4.4.1 The international situation

The findings of increased weight gain in later years among Pacific boys in the present thesis are aligned with findings from a large international study out of Europe and North America. However, this is true only for a small number of countries for girls. The Health Behaviour in School-aged Children (BSC) 2009/2010 was a cross-national study involving 11, 13 and 15y old children from over 40 countries and regions in Europe and North America (Currie et al., 2012). Overall results showed that “girls age 15 in a minority of countries and regions were significantly more likely than 11-year-olds to report being overweight. No clear patterns between age and overweight prevalence were seen among boys" (Currie et al., 2012, p. 90). On the other hand, "boys tended to have significantly higher prevalence in almost all countries and regions at ages 13 and 15 and in over half at 11. The gender difference however, exceeded 10% in only a few" (Currie et al., 2012, p. 90).

The prevalence of obesity among boys in the current study at 6 and 9 y was similar with boys of similar age in Southern European countries. The WHO European Childhood Obesity Surveillance Initiative of 2008 looked at 12 European countries of children aged 6 to 9y, and reported obesity from 6.0 to 26.6% among boys and 4.6 to 17.3% among girls based on WHO 2007 growth references (Wijnhoven et al., 2013). Authors observed an inter-country, north-south gradient with the highest levels of overweight in southern European countries. Contemporaneous prevalence of obesity in Pacific boys from age 6 to 9 (2006 and 2009) was 23.8 to 29.2 percent respectively (Figure 4.3). For Pacific girls at the same age, obesity prevalence ranged from 11.5 to 23.4 percentage points higher at 28.8 and 40.7 percent at 6 and 9 y respectively (Figure 4.4).

Although there is non-comparable data with their Australian counterparts, children in the PIF study were likely to have had substantially higher proportions of prevalence and greater increases in incidence of overweight/obesity. For instance, in the Australian National Health Survey (2014/15), around one in four (27.4%) children aged 5-17 years were overweight (21.9% boys; 18.2% girls) and 7.4 percent were obese (6.6% boys; 8.2% girls) (Australian Bureau of Statistics, 2016). The proportion of children who were overweight or obese in 2011-12 (25.7%) had not changed.

4.4.2 Strengths and limitations

A major strength of this project is that the data comes from repeated measures of a longitudinal birth cohort. The prospective nature of the PIF study facilitates unique opportunities to track developmental origins of health and disease (Gluckman, Hanson, & Beedle, 2007) particularly for ethnic Pacific people. Globally, Pacific populations appear to have highest prevalence of obesity but information is limited to few cross-sectional surveys and adult samples (Coyne, Hughes, & Langi, 2000). In NZ, Pacific children (age 2–14 y) were 3.6 times as likely to be obese and 3.7 times as likely to be morbidly obese compared with non-Pacific children; 29.7% of Pacific children were obese compared with 10.8% of all children (MoH 2015a, 2015d). Therefore, the information presented plays an important role in informing health services, policy and programmes about growth trajectory and weight status for a population in acute need of attention.

However, this study has its limitations. The PIF cohort was recruited from one hospital in South Auckland, a community with specific environments that may not be representative of other Pacific communities in New Zealand. However, at recruitment the sample represented between a quarter and a third of all eligible children born in the region, which has the highest density of Pacific people in New Zealand (Rush, Paterson, Obolonkin, et al., 2008). Further, among the birthing population in this region (n=8520, in 2011-12), Pacific are at high risk of gestational diabetes mellitus at 33%, compared to Māori (23%), Indian/other Asian (17%), and European/other women (27%).

Another potential limitation is that the growth curves were generated not by using continuous individual-specific data but by using cross-sectional data of the whole cohort at each wave. However, individual-specific approaches can reduce statistical power due to missing data as not all children participate at every phase and over time, which can diminish sample size. Beneficially, whole-cohort approaches allow for greater sample sizes and represent overall health status such as total prevalence of overweight and obesity. Crucially, national and international references such as WHO and CDC are constructs from cross-sectional data, meaning that the data and derived curves in this study are consistent with international standards of measuring growth trajectory.

Important factors omitted in this investigation include attention to 'critical windows' in childhood growth and the significant effects of developmental plasticity and their contributions to "age-associated variability in pediatric body composition" (Wells, 2017, p. 3). These models are the focus of much research in the foetal and infant periods of life but there is growing recognition of other potential periods of sensitivity, such as in mid-childhood and adolescence (Prentice et al., 2013). Exclusion of growth factors such as adiposity rebound, puberty, and maternal and gestational health are further limitations that where possible should be included in future analyses. Maternal and gestational health data gathered at baseline included breastfeeding and maternal smoking at 6 weeks. Rush, Paterson, Obolonkin, et al. (2008) found that the effects of smoking on low birthweight were attenuated by age 6 y. Low birthweight children grew faster than and caught up with normal birth weight babies during early childhood. The phenomenon of compensatory catch-up growth may promote body fat (adiposity rebound) and therefore understanding its timing and associations with prospective adiposity may provide crucial insights into the complex nature of somatic growth.

Further, underlying heritability of paediatric growth such as parental phenotype (Wells, 2017) and Barker's 'Thrifty Gene' are hypothesised precursors to intergenerational obesity. These developments not only strengthen the argument for continual intervention across the biological life-course until age of reproduction, but also perhaps for systematic readjustment of socioeconomic structures responsible for human nutrition and physical activity. In the unlikelihood of this occurring, the effects of pubertal development on body mass in Pacific adolescents deserved greater attention that was beyond the scope of this investigation. Coincidentally, at the time of writing, the influence of pubertal factors on growth reported at 9 and 11 y among this cohort was the subject of an impending publication (Rush et al., 2015).

Finally, the implications of utilising the WHO and CDC growth references as a model of comparison against a Pacific cohort warrants attention. Firstly, Pacific communities have environmentally unique life-courses linked to increased capacity for positive energy imbalance expressed as high body weight. Compared with other ethnic groups, these include intergenerational obesity due to high rates of obesity in the adult (parent) population, high socioeconomic deprivation influencing nutrition quality and physical activity (poverty and poor food security), and geographic/retail environments which support high intakes of energy dense food (Loring & Robertson, 2014; MoH 2012a). The WHO references have specific conditions for meeting appropriate growth such as no maternal diabetes, non-smoking home, predominantly breastfeeding for at least 4 months post-partum, and favourable socioeconomic conditions (de Onis et al., 2004). Children in this cohort meeting all of these conditions were few and where the average birthweight at 3.7kg was greater than that of the WHO child by ~0.2kg (Z +0.5 higher) (Rush, Paterson, Obolonkin, et al., 2008, p. 406). Thus, application of the international growth models may not be adequate comparisons to actual growth experienced by children of Pacific Island heritage. The growth references do however highlight the need to focus significant attention to obesity intervention to avoid later cardiometabolic and psychological disorders, and corresponding economic and social costs related to their treatment.

4.4.3 Conclusions and recommendations

This thesis is the first investigation to track growth trajectory of a birth cohort of Pacific children into adolescence. Provided here is an unprecedented and comprehensive longitudinal examination of excess body growth among children of Pacific heritage from birth to age 15 years. As a cohort nearing adulthood, these young people represent the next generation of Pacific parents. Three quarters (75%) of overweight and obesity combined signals an ominous future for Pacific peoples with weight-related chronic disease, unless effective strategies to halt and reverse the epidemic of obesity are implemented. At the time of writing, the national health strategy aimed at dealing with this crisis is focussed on screening young children prior to entering school and, where obesity is identified, referring the child on for individualised clinical, lifestyle and nutritional interventions. Unfortunately, the strategy ignores most young people who are already (overweight or) obese and are already at school, and omits screening of older children particularly those who are about to become parents. However, the screening programme will provide some protection to future generations but only if the individualised strategies are sustainable throughout the remainder of the child's growth trajectory into adolescence. Only ongoing monitoring of referred children will help determine the true effectiveness of the strategy and therefore an area for public health authorities to watch.

Notwithstanding the current strategy, it is recommended that preventing rapid growth among Pacific children be rendered a priority objective in national health strategies. As these weight related issues are more prevalent is specific communities, it is recommended that interventions focus on societal behaviour that affects child weight gain through communal nutrition and physical activity. To achieve these objectives, it is recommended that sustainable and effective opportunities that improve access to quality food and resources for exercise or bodily movement must be investigated. Finally, it is recommended that broad social, cultural and economic environmental approaches be adopted in order to realise the opportunities and behaviour changes needed to slow excessive growth among Pacific children.

Thus, one way to understand high body weight status is to investigate at the environmental contexts that might support the consumption of energy-dense foods and level of physical activity. As mentioned previously, this thesis maintains a focus on food consumption and food environments. The next two chapters examine these two factors respectfully. Chapter 5 presents an examination of the PIF children's food frequency data from age 4 and 6 y. It includes an investigation of potential associations between food and eating frequency in this period of social transition, and growth outcomes at age 14 y. Following that, Chapter 6 goes deeper to examine home and family environment variables, one of the most important micro-environmental contexts for children's food and growth.

Chapter 5 Foods and eating frequency

This chapter presents information on food frequency among children in the PIF study at age 4 and 6 years and examines potential association between food frequency and physical growth in later childhood (age 14 y). There are three objectives for this chapter. The first is to describe the characteristics of food consumption, to identify most commonly eaten foods and food groups. The second objective is to assess tracking of foods and food groups from age 4 to 6 y (the transition to school), and the third objective is to examine relationships between identified foods and frequency of consumption, and prospective measures of weight, height and BMI at age 14 y. The chapter commences with a brief review of literature summarising research on children's dietary patterns and associations with growth trajectory. This is followed by a description of the data collection and methods of analysis used to examine food frequency and associations with physical measurements. Following this are three sections of results: food frequency characteristics, tracking of foods, and foods associated with growth. The chapter continues with a discussion, situating the main findings in the context of current knowledge and concludes with a summary and some recommendations for future research.

5.1 Literature review

Optimal maternal nutrition during gestation and infant feeding contributes to positive cognitive development and healthy physiological outcomes for the child (Nyaradi, Li, Hickling, Foster, & Oddy, 2013; WHO 2003). Conversely, poor diet during the formative years can lead to excessive growth during childhood and chronic disease in later life (Barker, 1997). From the outset, children's food patterns are determined by maternal infant-feeding styles during a time when food and taste preferences are developing (S. Robinson et al., 2007; Smithers et al., 2012). Subsequently, prospective cohort studies have demonstrated how children's food patterns track throughout childhood (Northstone & Emmett, 2005; Northstone & Emmett, 2008; Smithers et al., 2011; Vilela et al., 2014). Northstone and Emmett (2008), for example, observed three predominant food patterns over ages 3, 4, 7 and 9 years (y). Patterns were identified as 'processed' (high fat and sugar content, processed and convenience foods), 'traditional' (meat, poultry, potato and vegetables), and 'health conscious' (salads, vegetables, fish, pasta and rice). Foods in the processed pattern loaded highly (appeared with high frequency) right through from age 3 to age 9 y. Similarly, foods in the traditional pattern loaded highly from age 4 to 9 y. What this study demonstrated is that foods or food patterns, once started, have a tendency to track consistently throughout early childhood.

To date there is ample research reinforcing evidence of the tracking of childhood food patterns albeit predominantly among Anglo-Saxon cohorts. There is limited data or research on minority groups in Western societies, an indication that current knowledge is not representative of other ethnic groups. Food beliefs and behaviours are structured within cultural contexts often defined by ethnicity (Kumanyika, 2008) and ethnic group research can highlight distinct sociocultural food and eating characteristics not captured in general surveys (Davidson et al., 2013). Furthermore, knowledge of food habits within ethnic groups can inform public health strategies aimed at addressing nutrition-related health status of all ethnic groups equitably (Davidson et al., 2013).

Early research on food consumption among Pacific ethnic groups in New Zealand compared the food choices of Tokelauan people (Polynesians) living in the Tokelau Islands and in New Zealand (Harding, Davidson, & van-Rij, 1974; Harding, Russell, Davidson, & Prior, 1986). These pioneering studies highlighted important changes in Tokelauan food options and choices due to migration and the number of years lived in New Zealand. Traditional wholefood staples of coconut, fish, taro and breadfruit had been replaced with processed foods – such as bread, cereals and red meat – affecting nutritive and energy intakes. A further change was the unprecedented increase in the variety of food options available to the Polynesians in New Zealand, compared with those available in the island home. Coupled with the limited access to and high cost of island foods imported to New Zealand, this represented the influential environmental determinants of a drastic nutrition transition.

The shift from traditional cultural foods was echoed in an examination of food and consumption frequency of Pacific children in the PIF study at age 4 years by Rush, Paterson, and Obolonkin (2008) where traditional foods only constituted 5% of the diet. Westernised diets were predominant, consisting of mostly of bread, milk, breakfast cereal and fruit. A low proportion of children met the recommended daily vegetable intake, indicating a nutritionally deprived dietary pattern for pre-schoolers. Dietary protein and dairy were was positively associated with weight, BMI and body fat percentage at this age, and protein was related to weight gain from birth.

More recently, the effects of nutrition variation by urbanisation and differences upon Pacific children's body weight were observed. Stewart, Reed, and Rush (2014) derived body mass index standard deviation scores (BMI SDS) in three groups of Polynesian children of Cook Islands Māori ethnicity. One group lived on the remote Northern Group of the Cook Islands, another lived on Rarotonga – the most urbanised of the Cook Islands, and a third group lived in Auckland. The study found that children living in their most traditional non-urbanised environment, eating primarily traditional foods, had the lowest mean BMI SDS (0.72) of the three groups. Cook Island children living in Auckland had the highest mean BMI SDS (1.62) while the BMI SDS of those in Rarotonga were located in between (1.29). This study shows an associated increase in BMI consistent with environmental differences in economic development, demonstrating the effects of a nutritional shifts occurring in many of the Pacific Islands today (Dancause et al., 2011; Parry, 2010).

For New Zealand children, Utter et al. (2006) and Utter et al. (2007) have investigated the characteristics of nutrition and physical activity patterns recorded in the National Children's Nutrition Survey 2002/2003 (MoH 2003). The researchers found that compared with New Zealand European and Other ethnic children, Pacific and Māori children were more likely to skip meals, buy school food from shops and were less likely to take a school lunch from home. Further, Pacific and Māori children were significantly more likely to have high consumption of foods high in fats and sugar.

Further, Utter, Scragg, Schaaf, and Mhurchu (2008) found that low frequency of at-home breakfast was associated with low consumption of fruit and vegetables, high consumption of snack foods, and higher mean BMI. The association with BMI may have been explained by the less-healthful eating behaviours, which has been associated with not eating breakfast at home.

Relationships between food frequency and body composition at age 4 y, and growth from age 6 weeks to 4 y among children from the Pacific Islands Families (PIF) study were reported by Rush and colleagues (2008). At age 4 y, bread (1.32 times/day), milk (0.86), breakfast cereal (0.83) and apples or pears (0.83) were the four most frequently consumed foods. A majority of children drank standard (full-fat) milk (85%) and ate white bread only (77%). The recommended daily intake (RDI) of fruit for healthy children and young people (MoH 2012b) was achieved by 60% of children yet only 35% consumed the RDI for vegetables. Higher frequencies of fruit, vegetables and fat foods were associated with less weight gain from 6 weeks to 4 y and a lower BMI at 4 y. In contrast, consumption of total protein and dairy foods were positively associated with BMI at 4 y.

However, longitudinal food frequency and associations with prospective anthropometric outcomes among children of Pacific Island heritage have never been reported, and this study aims to address this gap.

The aim of this investigation was to examine longitudinal food frequency among Pacific children from age 4 y to age 6 y from the PIF study and investigate relationships with later weight, BMI and weight gain at age 14 y. The first objective was to identify the most frequently eaten foods being consumed one year before school (age 4 y) and one year after starting school (age 6 y). The second objective was to estimate tracking of consumption of food items and food groups (separately), and the third objective was to quantify associations between the most frequently eaten foods and anthropometric outcomes. Weight gain, expressed as kilogram per year (kg/y), from age 6 y to age 14 y, was also an outcome variable. Based on the literature, the first hypothesis was that consumption of similar foods would track from age 4 to age 6 y. Second, due to the high prevalence of overweight it was expected that there would be, on average, a high frequency of consumption of energy-dense foods (high in sugar and fat, and/or refined carbohydrates) across the two measurement periods. Third, according to Rush, Paterson, and Obolonkin (2008), it was anticipated that there would be positive associations between frequency of fats and protein foods, such as dairy foods and meats, and BMI, and weight gain. In addition, higher consumption of fruits and vegetables will be associated with lower prospective weight and BMI at age 14 y.

5.2 Methods

5.2.1 Data collection

Descriptions of the PIF cohort are described in detail in Paterson et al. (2006) and summarised in Chapter 3 of this thesis. The food data referred to in this chapter was collected at the age 4 and 6 y measurement waves, and for anthropometry at 14 y.

At age 4 and 6 y, 1048 and 1001 caregivers – representing 1066 and 1019 children respectively – were surveyed using a food frequency questionnaire (FFQ) (Appendix C). The qualitative 111-item FFQ used in this study was the same used to collect food data in the National Children's Nutrition Survey 2002/03 (MoH 2003). In the FFQ, caregivers were asked to account for their child, the frequency of eating 111 food items "over the last 4 weeks". There were 7 possible responses that were "Never or less than once a month", "1 to 3 times a month", "1 to 2 times a week", "3 to 4 times a week", "5 to 6 times a week", "Once a day", and "2 or more times a day". Questions were accompanied with photographs that represented standard serving sizes to assist caregivers in identifying foods consumed by their child (Metcalf et al., 2003).

5.2.2 Data analysis

Data treatment was duplicated to that employed by Rush and colleagues (2008) for ease of analysis and comparison of food frequency across the two data collection phases. Thus, reporting of monthly and weekly frequencies of consumption were transformed into average daily consumption according to the weights in Table 5.1. In addition, the 111 food items were collapsed into five food groups (Table 5.2) according the New Zealand Food and Nutrition Guidelines for healthy children and young people 2-18 years (MoH 2012b). Consumption was examined by food item (foods) and food group. Food nutrient and energy density profiles were derived according to the British nutrient profiling score (Arambepola, Scarborough, & Rayner, 2008).

Data extraction and manipulation was carried out. Descriptive statistics including frequency, means and 95% confidence intervals were determined. Proportions were compared using the chi-squared statistic and associations using the Pearson correlation coefficient, r. (R v15.2; http://cran.r-project.org). Sample correlation coefficient r is an estimate of the population (population correlation coefficient) and measures the strength of the linear relationships in a sample. Levels of statistical significance were set at $p < 0.05$.

Table 5.1 Weighting chart. Food frequency and weighting factor used to standardise to daily consumption (Rush, Paterson, & Obolonkin, 2008)

Frequency	Weight
Never or less than once a month	0.005
1 to 3 times a month	0.066667
3 to 4 times a week	0.214286
5 to 6 times a week	0.785714
Once a day	1
2 or more times a day	2

Table 5.2 Food groups: Classification of the 111 foods in the food frequency questionnaire by major nutrient, according to nutrient and energy density

Class	Total	Higher nutrient, lower energy	Lower nutrient, higher energy	Example of lower nutrient, higher energy
Fruit and vegetables	27	26	1	Tomato sauce
Protein[1]	27	18	9	Sausage roll
Dairy	9	6	3	Cheese
Fat	8	1	7	Mayonnaise
Carbohydrate	40	11	29	Biscuits

[1] meat and alternates

General linear models were used to investigate associations between food frequency and physical growth outcomes weight, height and BMI at 14 y. Birthweight was accounted for in the modelling. Analyses were limited to the top 50% of most consumed foods at 4 and 6 y. Food frequency was averaged and anthropometry for weight, height and BMI were modelled as repeated measures. Only food items that had a statistically significant association with weight, height, BMI and respective standard deviation scores are reported.

5.3 Results

5.3.1 Participation in food frequency surveys

Of the total child cohort (n=1398), the caregivers of 1066 (age 4 y) and 1019 (age 6 y) children were located and asked to complete the FFQ. From these caregivers, 907 and 801 FFQ were returned, corresponding to response rates of 64.9% and 57.3% at age 4 and 6 y, respectively (Table 5.3). The caregivers of 646 children (327 girl; 319 boys) returned FFQ at both age bands and the results presented here are based on these FFQ. Analyses were confined to these FFQ so that individual (child) foods could be tracked reliably from one measurement period to the next. Probability values for bias in the distribution of respondents versus non-respondents using chi-squared tests suggested no significant differences ($p > 0.05$) between the two groups at any stage. This indicated that our sample was representative of our original baseline cohort. As mentioned earlier a decision not to carry out ethnic-specific analyses was made to maintain statistical power and because of a high number of ethnic groups, cross-ethnic identity, and a relatively small sample size.

Table 5.3 Sex of children whose parents participated at age 4 and 6 years

	Yes	**%[a]**	**No**	**%[a]**	**χ^2 p-value**
Participation at age 4 years					
Sex					0.81
Girl	444	65.2	237	34.8	
Boys	463	64.5	254	35.4	
Total	907	64.9	491	35.1	
Participation at age 6 years					
Sex					0.46
Girl	397	58.3	284	41.7	
Boys	404	56.3	313	43.7	
Total	801	57.3	597	42.7	
Participation at both age 4 and 6 years					
Sex					0.19
Girl	327	48.0	354	52.0	
Boys	319	44.5	398	55.5	
Total	646	46.2	752	53.8	

[a] row percent;

5.3.2 Frequency of food consumption

Across both waves, 12 most frequently consumed foods (the top 12 foods) were identified as being consumed ≥0.2 times per day, on average (Figure 5.1). Bread, breakfast cereal and rice represented the top three most frequently eaten foods. These were followed by apples and pears, oranges and mandarins, milk, banana, food drinks (e.g. Milo ™), chicken, (instant) noodles, crisps and powdered fruit drink (e.g. Raro™). The top 12 foods accounted for up to 25% of all food consumed on average per day across ages 4 to 6 y. Overall, frequency of consumption of the top 12 foods remained moderately stable (r^2=0.53) across the two measurement periods.

Of the top 12 foods, the average frequency of eating bread and rice was the least likely to have changed, remaining relatively consistent across the two measurement periods. On average, breakfast cereal was the only food to have increased from 0.8 to 1.0 per day by age 6 y. Overall, the intake frequency of the remaining nine of the top 12 foods decreased slightly. For example, milk and fruit (apples and pears, oranges and mandarins, bananas) decreased substantially from 0.9 and 0.8 respectively at age four to 0.3 times per day at age 6 y.

At ages 4 and 6 y, chicken was the only meat item identified in the 12 most frequently consumed foods. Snack foods, such as crisps and noodles (e.g. 2 minute), remained popular. In addition, food drinks (e.g. Milo™) and powdered fruit drinks (e.g. Raro™), which have sugar as a major component, were frequently consumed at both ages. Further, within individuals, the 12 most frequently consumed foods tracked highly and the association across the age bands was strong (r=0.72; p<0.001).

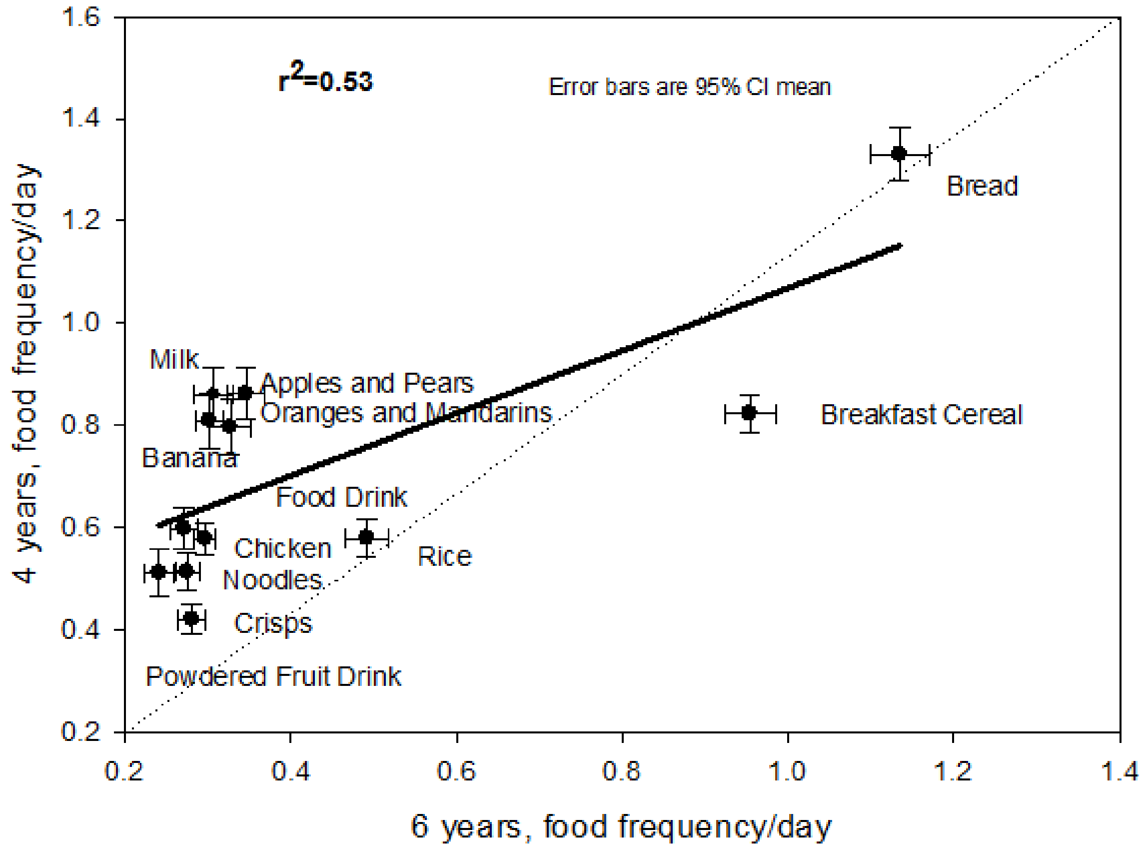

Figure 5.1 Association of average consumption per day of the top 12 most frequently consumed foods from age 4 to 6 years

5.3.3 Tracking consumption of food groups

From age 4 to age 6 y, the average daily consumption of food groups was very stable (r^2=0.96) (Figure 5.2). The food group cereals and breads (26.5%) comprised the largest percentage of daily food portions across both measurement periods. Around one fifth of daily portions consisted of the protein (meat and alternates) food group, and a quarter consisted of the vegetables (~15%) and fruit (~10%) food groups.

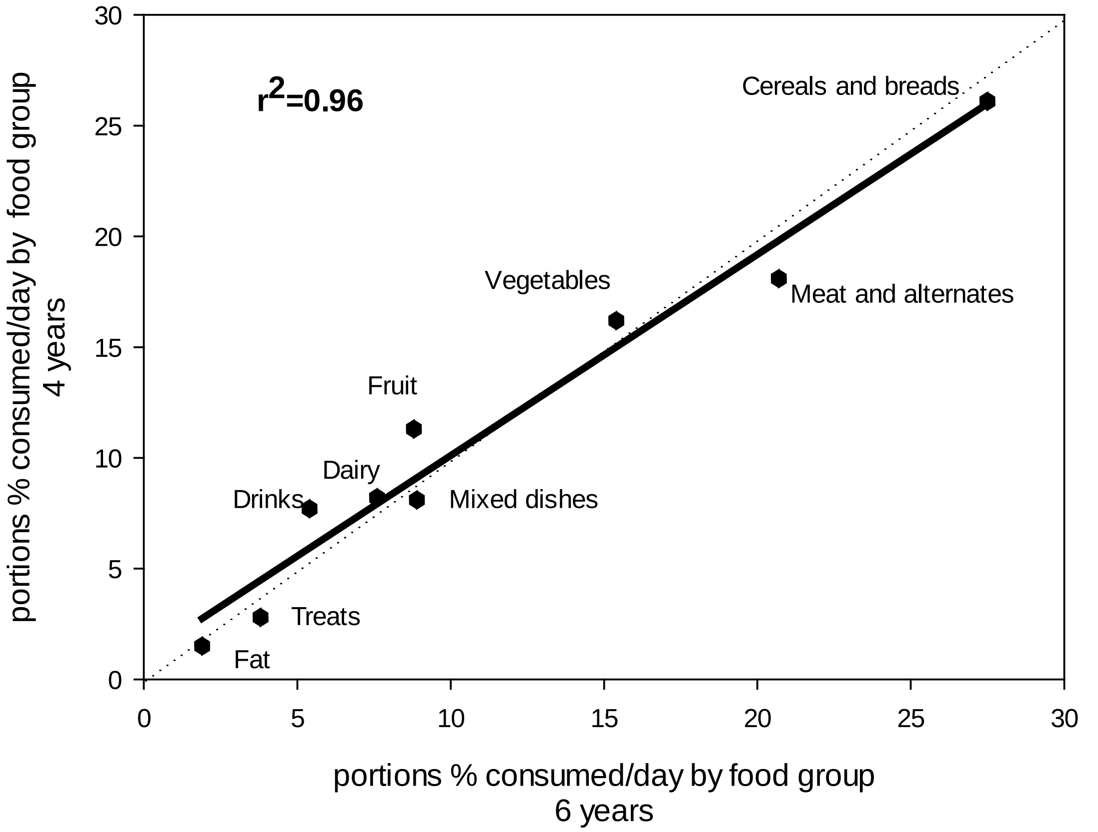

Figure 5.2 Association of average consumption per day by food group from age 4 to 6 years

5.3.4 Food frequency and prospective body weight

Foods and weight

After combining food frequency for 4 and 6 y, multivariate analyses revealed two food items that had consistent associations with weight/weight SDS and BMI/BMI SDS at age 14 y (Table 5.4). Firstly, consumption of 'cooked green bananas' was positively associated ($p<0.05$) with weight, weight SDS, BMI and BMI SDS at 14 y. Conversely, 'mixed vegetables' were found to have an inverse association with BMI and BMI SDS. Cauliflower or cabbage consumption appeared to have a negative effect on height SDS. However, the effect size was negligible when the SDS was divided by a factor of seven to derive the estimate for frequency of consumption to once per week (Cauliflower or $cabbage_x$ = -0.04 height SDS). Finally, no specific foods were found to have any significant positive associations with height.

Table 5.4 Foods of significance from the top 50% of most consumed foods[1] at age 4- and 6-year combined, modelled as repeated measures against weight, height, BMI and respective standard errors at 14 y

Measurement intercept	**coefficient β**	**Std. Error**	**t value**	**P-value**
Weight (kg) 48.92		3.87	12.64	
Cooked green banana	6.11	2.42	2.52	0.0117
BMI (kg/m²) 22.26		1.21	18.45	
Cooked green banana	2.32	0.70	3.33	0.0009
Mixed vegetables	-1.20	0.55	0.03	0.029
Weight SDS 0.35		0.23	1.52	
Cooked green banana	0.39	0.14	2.78	0.0055
Height SDS -0.12		0.16	-0.74	
Cauliflower or cabbage	-0.31	0.11	-2.81	0.005
BMI SDS 0.10		0.20	5.04	
Cooked green banana	0.36	0.12	3.01	0.0026
Mixed vegetables	-0.26	0.98	-2.70	0.0070

[1] Food frequency standardised to daily consumption

Cooked green bananas were consumed regularly at both 4 and 6 y surveys. At 4 y, cooked green bananas were consumed at least once per week by half of the cohort (n=468, 51.7%) and a further fifth (n=174, 19.2%) were consuming cooked green bananas at least once per month (1 to 3 times per month). By 6 y, weekly consumption appeared to have increased by a fifth (n=542, 71.0%) with a further 12.6% (n=96) were eating cooked green bananas at least monthly. In summary, nearly all (n=638, 98.8%) Pacific children whose mothers responded at both follow-up were consuming cooked green bananas at least monthly at age 6 y. Additionally, at 6 y, parents were asked if the cooked green bananas were eaten with coconut cream. Mothers reported about eight out of ten (78.5%; n=501) children who consumed cooked green bananas ate them with coconut cream.

5.4 Discussion

This investigation has provided an account of characteristics of food and consumption frequency for children of Pacific ethnicity at a critical stage of growth and development, and has described longitudinal associations with growth outcomes to age 14. At both ages 4 and 6 y, 12 food items represented the most frequently consumed foods comprising a quarter (25%) of food eaten every day. Across the cohort, the consumption frequency of these foods tracked moderately (r^2=0.53), a finding that is consistent with other studies that demonstrate stability in food patterns with age (Lioret et al., 2015; Patterson, Wärnberg, Kearney, & Sjöström, 2009). Further, within individuals, the 12 most frequently consumed foods tracked highly and the association across the age bands was strong (r=0.72; p<0.001).

Reported daily frequency of consumption in nine of the top 12 food items decreased; rice and bread remained stable and only breakfast cereal increased. One suggestion for this observation is that the range of children's food choices may have increased as children aged leading to a general reduction in the more frequently eaten foods.

Overall, consumption within food groups tracked strongly (r^2=0.96), with cereals, breads, and meats comprising nearly half of all daily food, followed by vegetables and fruit comprising a further quarter.

Because of a high prevalence of rapid growth and excess weight among this cohort, it was hypothesised that there would be a high frequency of energy-dense foods. Energy-dense, refined carbohydrates constituted around a quarter (26.1%; n=29) of all food in the FFQ, and cereals and breads were found to contribute around a quarter of all daily food across ages 4 to 6 years. That bread was the most frequently consumed food item in this investigation is in agreement with national estimates for NZ children, where bread was the single largest contributor of energy (MoH 2003). Further, continued consumption of white bread (85.5% at 6 y) in this investigation is consistent with national estimates. Although Pacific children (aged 5-6y) consumed less bread, on average, than other ethnic groups of the same age, they were more likely to eat white bread (boys 89% and girl 90%) compared with Māori (81% and 72%) and all other ethnic groups (70% and 72%) (MoH 2003). In addition, the high frequency of white rice, processed snacks and beverages across both age bands supports a hypothesis of energy-dense diet in the form of refined carbohydrates and added sugar.

In terms of the fats food group (e.g. mayonnaise), average daily intake was relatively low (~2%) with higher-energy fat foods comprising only 6.3% (n=7) of FFQ items. As a result, this food group alone was not likely to contribute significantly to an energy-dense food pattern. However, dietary fat may be derived from eating meats, dairy and ready-made foods, such as fried potatoes (crisps or hot chips), contributing further fat as energy intake. One third of meats (9/27) and dairy (3/9) foods were classified as lower-nutrient/higher-energy foods, equivalent to 10.8% of all FFQ items. In general, meats constituted one fifth of all daily food consumed at age six. In separate analyses (not included here) of the Economic Living Standard Index with the cohort, 41% of respondents reported buying cheaper cuts of meat with a higher fat content ‘a lot’ to keep food costs down. Dairy foods made up around 9% of daily food by age six and the overwhelming milk of choice (91.2%) was the standard full-fat variety. Overall, fats, dairy and meats constituted on average 30% of all food consumed daily, lending further support to a hypothesis of an energy-dense food pattern in terms of total fat intake.

An unexpected finding in this study was the increased frequency of breakfast cereal consumption over the two measurement periods. Research has reported that nationally Pacific and Māori children were more likely than non-Māori or Pacific children to avoid at-home breakfast and that at-home breakfast avoidance was associated with poorer nutrition choices and higher mean BMI (Utter et al., 2007; Wilson, Parnell, Wohlers, & Shirley, 2006). Thus, an increased frequency of breakfast cereal consumption would appear inconsistent with current research. There are at least two possible explanations offered for this finding. First, the FFQ does not ask how frequently the child ate breakfast per se. Instead, the question referred to the frequency of eating breakfast cereal but did not ask at what time of the day the cereal was eaten. Breakfast cereal may be consumed again later in the day, such as after school (at age 6), which might account for an average increase in frequency of breakfast cereal consumption at the 6 y follow-up. A second explanation could be that the question of frequency does not translate to prevalence of breakfast cereal consumption. The prevalence of weekly breakfast cereal consumption was not an objective of this study but is an area of further research.

However, these findings are consistent with research, around stability in dietary patterns with predominantly Anglo-Saxon children (Northstone & Emmett, 2005; Northstone & Emmett, 2008; Smithers et al., 2011; Vilela et al., 2014). These studies provide good evidence for food pattern tracking throughout early childhood. The findings from this investigation provide valuable insight about parental feeding practices, and prompts further questions around environmental factors that might contribute to food availability.

An unexpected finding was the association between ‘cooked green bananas’ and body weight/weight SDS and BMI/BMI SDS. Cooked green bananas are a staple of traditional Pacific diets, a good source of dietary fibre and nutrients, and are lower in fructose than ripe bananas (Thakorlal, Perera, Smith, Englberger, & Lorens, 2010). The association may be an indicator of other environmental factors (including dietary) at play, such as those associated with acculturation. For instance, it could be indicative of consumption of more traditional or culturally relevant foods, such as coconut cream and adopted Western foods such as tinned corned beef. Coconut cream is also a traditional food that is high in saturated fat and in this survey it was usually consumed with cooked green bananas by nearly eight out of ten children (78.5%) in the cohort at the 6 y phase (data not shown). Coconut cream is a higher-energy food with saturated fat contributing around 95% (45.8g) to total fat (48.3g) per (296g) serving. A study of dietary intake among Samoans residing in Samoa found that the highest source of energy (14%, SD ±15% of dietary energy) and fat (27%, SD ±31) was from coconut cream (Galanis, McGarvey, Quested, Sio, & Aafele-Fa'amuli, 1999).

Several introduced foods that have become valued culturally include foods that are high in saturated fat. The two most common examples of adopted foods are mutton flaps with 27.4 grams (g) of fat/100g (14.6g saturated) and tinned corned beef with 24g of fat/100g (10.6g saturated) (New Zealand Institute for Plant & Food Research Limited and Ministry of Health, 2017). Consumption of high-fat foods may be more amenable to energy balance in environments where there are naturally high levels of physical activity, such as on the traditional homelands in the Pacific Islands. However, in an environment focussed on physical inactivity and time minimisation, the facilitation of energy output is less incidental, resulting in chronic positive energy balance or excess body fat.

5.4.1 Strengths and limitations

One of the main strengths of this study is the longitudinal nature of the data allowing identification of the most frequently consumed foods from age 4 to 6 y, a critical developmental period in the transition to school. Regular measurement of consumption is necessary for reliable assessments of food and eating habits (Livingstone, Robson, & Wallace, 2004) especially when food habits are dynamic and shaped by environmental features such as the increasing availability of commercially manufactured foods (S. W. Ng & Dunford, 2013). Longitudinal food consumption data provide valuable indicators of nutrition-related chronic illnesses (e.g. obesity and diabetes) throughout the life-course (Feeley, Musenge, Pettifor, & Norris, 2013).

Another strength of this study is the comparatively high response rate, especially for an ethnic group characteristically known as ‘hard to reach’ (Finau & Finau, 2007).

Longitudinal studies are challenged by natural attrition, resulting in missing participants due to loss at follow-up. Missing participants include families who have requested withdrawal, relocated a great distance from the study location, or have become unwell or deceased at follow-up. The results reported here are unconditional response rates (Cheshire, Ofstedal, Scholes, & Schröder, 2011) where the denominator is based on the original sample of 1398, yielding response rates of 64.9 percent and 57.3 percent (age 4 and age 6, respectively). Conditional response rates—where the denominator is based on number of participants contacted at follow-up (n=1066; n=1019)—were much higher, corresponding to 85.1 percent (n=907) and 78.6 percent (n=801) at age 4 and 6 y, respectively.

A limitation of this study is that despite some evidence of a high intake of energy-dense foods, this study does not prove cause. However, the longitudinal consumption characteristics of particular foods were used in models adjusted for age and sex to predict how much explained prospective BMI within the studied cohort. However, these models did not account for other important social, cultural and economic variables that have been shown to affect significantly both food and growth outcomes. In order to address these other influential variables, the following chapter examines association of consumption of selected foods at age 9 y to explain prospective growth at age 14-15 y factoring home environment variables. At age 9 y, a measure of parenting styles was included in the maternal survey, which was not included at the 4 or 6 y measurement point. (Refer to the literature review of Chapter 6 for the important influence of parenting styles upon food and growth outcomes in offspring).

As with many nutrition surveys, another limitation of this study is that children's food patterns were reported by proxy, through parents or caregivers. In this study, 98% (4 y) and 96% (6 y) of respondents were mothers. Although FFQ have good validity and reliability for measuring children's food intake through parental reporting

(Kolodziejczyk, Merchant, & Norman, 2012), parents have limited knowledge of food consumed outside of the home (Livingstone et al., 2004). Nevertheless, most foods eaten by children in this age group are obtained from within the home and any food consumed beyond the home setting would be insignificant (Livingstone et al., 2004). The results show a reduction in nine of the top 12 foods by age six, suggesting at least two contributing factors. Firstly, as children age, food frequency may be further dispersed across foods other than those most commonly consumed at age 4. However, there was no evidence of increases in consumption of all other foods and correlation coefficients show strong tracking of frequency of all food groups.

Secondly, regardless of frequency, increases in portion size of staple foods such as bread may be underreported. The inability to accurately measure portion size is a well-known limitation of FFQs and respondents of FFQs are more likely to under-report overall food intake whereas individual food items are subject to over-reporting (Kolodziejczyk et al., 2012).

Another potential limitation of this study is the age of the FFQ and data. Parental and children's food options and choices may have changed since the time these data were collected. Therefore, these findings may not be representative of the foods that Pacific children currently consume. However, current consumption is difficult to ascertain due to a lack of comprehensive surveys of children's food intake, the most recent being in excess of 10 years ago (MoH 2003). The current national Food and Nutrition Guidelines for Children and Young People is based on the Children's Nutrition Survey 2002/03, which, as stated earlier, used the same FFQ as the one used this study. Indeed, the surveys discussed in this study are the most recent large-scale food surveys for Pacific children in New Zealand.

Finally, no adjustments were made for potential seasonal variations in food availability, socioeconomic and demographic variables. Both surveys (4 and 6 y) were carried out over a period of 18 months, meaning that any variation in seasonal foods may have had an impact. Additionally, food storage, hot-house technology, and importing allows for year round availability of most fruit and vegetables, though imported and off-season foods can be more costly. Adjustments for socioeconomic status were not undertaken because the data were clustered at the lower end of the socioeconomic strata. At baseline, only a quarter (27%) of mothers had post-school qualifications and most households (92%) had incomes lower than NZ$50,000 per annum (Cowley, Paterson, & Williams, 2004). In terms of demographic variables, there were no significant differences when adjusting for gender. However, more pertinent was understanding, for Pacific children, commonly consumed foods, and stability of foods and how these factors affected weight and growth. These factors are important for helping to explain the high prevalence of overweight and obesity across the cohort.

Despite the associations observed between consumption of some foods and growth, access to food and patterns of consumption are influenced by socioeconomic, sociocultural and physical factors within the home environment. These factors are explored in the following chapter, focussing on characteristics of the home environment that are linked to food consumption.

5.5 Conclusion

This investigation showed that, for Pacific children living in New Zealand, from before school (age 4 y) to the second year of school (age 6 y), food choices and frequency of consumption remained relatively consistent. Cross-sectionally and longitudinally, the same proportion of foods from each food group was consumed, where 12 foods accounted for one quarter of all food consumed daily. Future investigation would benefit from closer examination of the composition of these foods and how they may influence health and weight in this population. Enabling Pacific parents and children to engage in healthful food consumption will be key in ensuring nutritional intakes that are protective of health and weight in later years. Knowledge of environmental characteristics of behind what drives food and eating frequency would be an important step to understanding dietary patterns. Thus, by examining the potential links between home and family factors strategies designed to improve the drivers of food consumption may be developed.

Chapter 6 Home environment, selected food habits and body size

Home and family constitute the primary environmental context of children's food and body size. Food is a basic human need and food quantity and quality determine health and growth across the life-course. Childhood is a time of rapid physical growth and development, and nutrition status, including body size in this period, is related to future risk of disease (Hanson & Gluckman, 2011). In Chapter 4, it was shown that from birth Pacific children grow more rapidly than other reference populations, that growth trajectory through childhood was positively related to prospective body size, resulting in the prevalence of 75% of overweight and obesity by age 14 y. In Chapter 5, it was shown that the combinations of foods eaten by the PIF children track from age 4 to 6 years and that early life food is associated with prospective growth. It is important now to understand the relationship of the child's home environment as mediator of food and growth, not explored previously for these children.

This chapter examines aspects of the home environment of PIF study children at the 9-year wave and relationships with eating habits of key foods and body size. To begin, the chapter provides a review of literature examining relationships between characteristics of home environments and children's food and body weight. Particular attention is given to parenting styles as one of the most prominent features cited in research of factors affecting nutrition in the home environment. The review is followed by a description of the methods of data collection and analysis used for this investigation. The chapter then turns to the findings of relationships between household environment, selected child food habits and BMI. To finish this chapter, the findings are discussed in the context of current knowledge, especially that relevant to Pacific peoples.

6.1 Literature review

Factors of home food environments encompass features associated with patterns in children's food consumption, weight status and health. Recent literature focusses on three domains of influence within home food environments as having sociocultural (perceptions, rules, beliefs and practices), demographic (individual, family and socioeconomic characteristics), and physical characteristics as potential targets for intervention. Factors situated within these domains are not mutually exclusive and interact to moderate or mediate children's food and growth. For example, physical factors refer primarily to the availability and accessibility of core (healthful) and non-core (pleasure) foods (L. Johnson, van Jaarsveld, & Wardle, 2010) that are often determined by socioeconomic (Ding et al., 2012) and sociocultural factors (Couch, Glanz, Zhou, Sallis, & Saelens, 2014; Wyse, Campbell, Nathan, & Wolfenden, 2011). This study focusses on sociocultural and demographic factors of the home environment as the main influences on food habits and body size. Sociocultural factors include parenting and feeding styles, rules around food, meal frequency or patterns and parent/child perceptions relating to food and body size. Demographic factors refer to family and individual characteristics such as age, gender, ethnicity and, most importantly, socioeconomic position. Socioeconomic indicators such as household income, parental education and employment, have significant impacts on family financial and material deprivation. This review focusses on literature that investigates associations between the home environment, children's food and weight-related outcomes. It builds the foundation for the rationale of the proposed study and research questions at the conclusion of the literature review.

6.1.1 Sociocultural factors

Parenting and feeding styles

Sociocultural factors have been related to rules, practices and perceptions around food and its provision. Literature examining sociocultural factors has focussed on parenting and feeding styles and associations with child eating patterns, nutrition intakes and weight outcomes. Although there are various models of parenting styles employed throughout the literature, most stem from the typologies of parenting practice developed in earlier work by Baumrind (1966, 1967). Originally, Baumrind's three major typologies of parental control were categorised as permissive (high nurture/low control), authoritarian (low nurture/high control) and authoritative (high nurture/high control) parenting styles (Baumrind, 1966). Later, Maccoby and Martin (1983) merged Baumrind's typologies with other concepts of parenting, and developed linear dimensions of responsiveness (nurture) and demandingness (control), creating a fourth dimension namely, a neglectful (low nurture/low control) style of parenting (Table 6.1). Subsequent modifications, such as by Hughes, Power, Orlet Fisher, Mueller, and Nicklas (2005), adapted these parenting dimensions to contextualise feeding styles as influenced by but also distinct from general parenting practices. Various conceptualisations of parenting practices in the literature encapsulate these parenting and feeding dimensions, to examine their influences on children's eating patterns and weight-related outcomes in home environments.

Table 6.1 Four major parenting/feeding styles based on child nurture/responsiveness and control/demandingness. (Adapted from Vollmer & Mobley, 2013)

	Nurture/Responsiveness	
Control/Demandingness	Low	High
Low	Neglectful/Uninvolved	Permissive/Indulgent
High	Authoritarian	Authoritative

Thus, there have been several investigations examining the links between parenting and children's dietary intake. (Collins, Duncanson, & Burrows, 2014) recently executed a systematic review of studies (from 2004 to 2011), which examined relationships between parenting styles and child feeding behaviours. The authors observed that an authoritative style was positively associated with responsibility for and monitoring of children's diet (Hubbs-Tait, Kennedy, Page, Topham, & Harrist, 2008) and negatively associated with pressure to eat by fathers (Blissett & Haycraft, 2008). Secondly, an authoritarian style was positively associated with pressuring and restricting child food (Hubbs-Tait et al., 2008). Thirdly, a permissive parenting style was inversely associated with monitoring of child diet (Duke, Bryson, Hammer, & Agras, 2004; Hubbs-Tait et al., 2008). In their conclusions, the authors assessed that the studies reviewed reported only weak to moderate associations, and that the most consistent relationship was a negative association between permissive parenting and monitoring of children's food intake (Blissett & Haycraft, 2008; Hubbs-Tait et al., 2008). Furthermore, acknowledged limitations of the review included the low number of studies reviewed (n=7), with only one cohort study, and low response rates (in three studies). Other relevant challenges included potential confounding factors such as low representation of fathers and lack of ethnic diversity – all but one sample were predominantly Caucasian.

Despite their limitations, Collins and colleagues' (2014) review indicated that, compared with other parenting styles, an authoritative parenting style was more likely to promote positive child health outcomes especially with monitoring of diet and low pressuring to eat (Faith et al., 2004; Hubbs-Tait et al., 2008). This stance is supported in an earlier review of evidence related to general parenting, and associations with obesity-inducing behaviours and childhood overweight (Sleddens, Gerards, Thijs, de Vries, & Kremers, 2011). That review included 36 studies, where 29 studies (19 cross-sectional, 4 case-control and 6 longitudinal) reported mixed findings for relationships between parenting and children's weight status and ten studies were focussed on associations with physical in/activity). However, the overall evaluation was that *"children raised in authoritative homes ate more healthily, were more physically active and had lower BMI levels, compared to children who were raised with other styles (authoritarian, permissive/indulgent, uninvolved/neglectful)"* (Sleddens et al., 2011, p. e12).

In addition, the review also pointed out that moderation studies had revealed that general parenting can have varying effects on children's nutrition and weight outcomes, depending on child and parental (particularly maternal) characteristics (Berge, Wall, Neumark-Sztainer, Larson, & Story, 2010; Topham et al., 2010; Zeller, Boles, & Reiter-Purtill, 2008). For example, Zeller et al. (2008) revealed an interaction between child temperament, maternal warmth and BMI; Topham et al. (2010) noted how maternal depression and socioeconomic status moderated the relationship between parenting style and BMI; and Berge et al. (2010) found interactions between different paternal and maternal parenting styles, child gender and BMI outcome. In their conclusion, Sleddens et al. (2011) advocated for more longitudinal research and samples with diverse ethnic and age groups, and fathers for greater understanding of parent-child weight relationships.

A more recent review by Vollmer and Mobley (2013) reiterated further evidence for the beneficial effects of an authoritative parenting style on children's eating behaviours and body weight. The authors examined 51 studies that looked at how parenting styles and feeding styles independently influenced children's dietary patterns, obesogenic behaviours and body weight. From their investigation, Vollmer and Mobley (2013) assessed that an authoritative style of parenting was most protective of health, while an indulgent or permissive feeding style was invariably associated with poorer health outcomes. Appropriately, the authors reported on the shortcomings of the reviewed literature. For instance, studies that reported relatively consistent relationships between feeding style and childhood obesity were cross-sectional, reducing the potential to demonstrate causality and, like Sleddens (2011), highlighted a need for more longitudinal investigation. They also recommended that, in future, researchers needed to acknowledge the difference between parenting and feeding styles, and how these practices individually contributed and interacted to moderate child behaviours and weight outcomes (Hennessy, Hughes, Goldberg, Hyatt, & Economos, 2010; Hughes, Shewchuk, Baskin, Nicklas, & Qu, 2008; Mitchell, Farrow, Haycraft, & Meyer, 2013; Rhee, 2008). Finally, Vollmer and Mobley (2013) noted a lack of accounting for covariates and confounders that include parental and child characteristics such as previous BMI, maternal depression, socioeconomic status and children's dietary intake. These factors have been shown to act as important influences that interact and mediate the development of childhood obesity (Taylor, Wilson, Slater, & Mohr, 2011; Topham et al., 2010; Ventura & Birch, 2008).

Parental nutrition knowledge & modelling

In addition to parenting and feeding styles, other themes gaining attention relate to nutrition knowledge and behaviours or modelling of healthful eating by parents (Couch et al., 2014; Hendrie, Coveney, & Cox, 2012; Larson, Eisenberg, Berge, Arcan, & Neumark-Sztainer, 2015; Wyse et al., 2011). For example, parental fruit and vegetable (F&V) intake has been positively associated with child F&V intake (Wyse et al., 2011), and parental verbal encouragement and modelling have been found to have a negative association with child BMI Z (Couch et al., 2014). Hendrie et al. (2012) and Wyse et al. (2011), found that child F&V consumption was associated with parental diet quality, albeit indirectly through the creation of the home food environment—that is, the combined influence of parental nutrition knowledge and diet, general parenting and feeding styles. The strongest direct associations with child BMI Z-score was with parental BMI and nutrition knowledge. Apart from addressing the multifactorial nature of childhood obesity, a unique quality of Hendrie et al's (2012) study was in the recognition of parental knowledge as a predictor of parenting and feeding styles, a pre-existing condition not considered in other studies. Despite this, Hendrie et al. (2012) acknowledged that their study was limited by a lack of diversity in the sample and that socioeconomic factors were not accounted for.

Recent investigations have seen enhanced research designs, with greater sociodemographic diversity in study samples and increased utilisation of longitudinal cohort data and analyses (Chang & Halgunseth, 2015; Kakinami, Barnett, Séguin, & Paradis, 2015; Larson et al., 2015). Yet questions remain around the interpretation and relevance of Western theories of parenting for immigrant communities and populations of mixed and multiple ethnicity (Chang & Halgunseth, 2015). Indeed, broader sociodemographic structures, such as ethnicity and poverty, have been shown to influence family functioning and child nutrition more than parenting alone (Kakinami et al., 2015; Larson et al., 2015; Sleddens et al., 2011). The moderating effects of ethnicity and socioeconomic factors upon family context and young people's outcomes are reviewed in the following section.

6.1.2 Demographic factors: Family and socioeconomic characteristics

Family

Family is the location for learning socialisation skills (Parsons & Bales, 1956) and for many Pacific peoples it constitutes the basis of personal identity (Franklin, 2003). Family is also the environment where dietary behaviours and perceptions of body size are learned and normalised (Nepper & Chai, 2015; Patrick & Nicklas, 2005; Pearson, Biddle, & Gorely, 2009). Based on these premises, family should be a key location for social health research and intervention, especially for family-focussed communities such as Pacific (Bruss, Morris, & Dannison, 2003; Bruss et al., 2005; Kumpfer, Alvarado, Smith, & Bellamy, 2002). However, research focussing on family-specific factors – as distinct from parenting – in the context of child nutrition and weight tend to focus on factors related to family meal sharing, household composition and socioeconomics, and other demographic variables such as gender and ethnicity.

Frequency of family meals (meal sharing) has been found to be positively associated with better child food intake compared with families who do not regularly share meals (Larson et al., 2013). However, a recent review found that the current evidence linking frequency of family meals with weight outcomes is weak and inconsistent (Valdés, Rodríguez-Artalejo, Aguilar, Jaén-Casquero, & Royo-Bordonada, 2013). Frequency of family meals is beyond the scope of this study but other pathways related to child nutrition including socioeconomic and demographic factors are.

Family composition, including number of siblings, household size and adult-to-child ratio are considered influential determinants of food patterns (Northstone & Emmett, 2005). However, the relationship between household size and food may be mediated by socioeconomic and demographic factors such as income and ethnicity. For example, a larger family size among Pacific families has been associated with maternal self-reports of reduced concern for child weight despite the high level of overweight (Heimuli, Sundborn, Rush, Oliver, & Savila, 2011).

Recent literature examining the associations between family food environments and child growth emphasise the importance of demographic and socioeconomic factors for which parents are inherently linked. All of the reviews mentioned above highlighted a lack of studies with ethnically and socioeconomically diverse samples (Collins et al., 2014; Sleddens et al., 2011; Vollmer & Mobley, 2013). Only Vollmer and Mobley (2013) reported that less than one third of reviewed studies (10 of 36) included ethnically diverse samples and families from low SES areas. This is important because minority ethnic groups, such as Pacific and Māori in New Zealand, live with lower SES and have higher rates of overweight compared with the dominant and wealthier populations.

Ethnicity

Ethnicity may act as a conduit for behaviour due to differences in cultural perceptions of what is normal, acceptable and expected. Thus, ethnicity can mediate or moderate child outcomes by contributing to the sociocultural and physical environment of the child (Patrick & Nicklas, 2005). For instance, child feeding may be shaped by parental perceptions of health or acceptable body size, resulting in variations in consumption and body weight (Heimuli et al., 2011). Food availability and body weight are influenced by ethnic cultural foods and feeding/eating norms (Patrick & Nicklas, 2005). Ethnicity can be an explanatory variable when examined together with relationships in behavioural patterns and outcomes, and improve information for health advocacy and effectiveness of public health interventions. For example, Māori and Pacific ethnic children were significantly more likely to forgo home-based meals (such as breakfast) and purchase food from local stores or tuck-shops compared with New Zealand European and Other (NZEO) ethnic children (Utter et al., 2006). Some high-fat and high-sugar foods were also more likely to be consumed by Māori and Pacific compared to NZEO children. However, in separate analyses of the same sample, there were few significant ethnic differences in reported fruit and vegetable consumption (Utter et al., 2006).

Parental fruit and vegetable modelling was the most influential home environment characteristic for dietary intake, with positive associations with adolescent fruit and vegetable intake across five ethnic groups (Larson et al., 2015). Instead, 'characteristics of a supportive home/family environment were linked to indicators of better dietary intake and lower BMI z-scores in adolescents despite variation in the relevance of specific characteristics across outcomes' (Larson et al., 2015, p. 45).

A study by Rodenburg, Oenema, Kremers, and van de Mheen (2012) looked at parenting and child fruit consumption in the context of parental education and ethnic background. They found that parental fruit consumption was positively associated with child fruit consumption and the association was more pronounced among ethnic groups. The study demonstrated that ethnicity was a predictor of child fruit consumption with parental fruit consumption playing a mediating role of that consumption.

Berge et al. (2010) examined parenting characteristics and overweight among adolescents, in a sample with five major ethnic groupings (n=4,746). They found that the prevalence of parenting styles and parenting practices differed significantly not only across the different ethnic groups, but also between mothers and fathers. For instance, 44.1% of Afro-American mothers and 36.3% of Asian mothers exhibited an authoritative parenting style, whereas only 28.6% of Afro-American fathers and 27.6% of Asian fathers reported an authoritative parenting style, clearly showing a difference of parenting styles between parents. However, ethnicity did not have a moderating effect on parenting characteristics, leading to the conclusion that "the relationship between parenting style and adolescent's BMI did not vary by the adolescent's ethnicity/race" (Berge et al., 2010, p. 823).

Socioeconomic status

Socioeconomic status (SES) denotes individual, family or neighbourhood economic wellbeing. A measure of individual socioeconomic deprivation, the NZ individual deprivation index (NZiDep) was developed and validated using an ethnically representative sample of approximately 300 Māori, 300 Pacific and 300 non-Pacific NZ adults by Salmond, Crampton, King, and Waldegrave (2006). The index is an indicator of deprivation and can be used as a variable when examining relationships between socioeconomic wellbeing and health outcomes. There is convincing evidence which shows a dose response association between socioeconomic status and obesity (Hardy et al., 2017). A recent studies provide further evidence of an association of socioeconomic deprivation and quality of food in the home (Ding et al., 2012) and the wider neighbourhood environment (Sushila, Vandevijvere, Exeter, & Swinburn, 2017).

As with other countries, socioeconomic status in New Zealand is linked with ethnicity. Compared with NZEO ethnic groups, Māori and Pacific people are more likely to live in areas with higher deprivation, and have lower levels of income and educational attainment. Further, children living in poorer areas consume more fast foods and sugary soda drinks, and spend greater amounts of time watching television compared to children living with less deprivation (MoH 2016a).

Different socioeconomic variables can influence body size in various ways and may interact with other demographic factors such as gender or parenting style. For instance, in a study of children aged 9 years, researchers found that "*maternal education and household class were more consistently associated with a child being in a higher body mass index category than household income. Adjusted regression indicated that girl gender, one parent family type, lower maternal education, lower household class and a heavier parent weight status significantly increased the odds of childhood obesity*" (Keane, Layte, Harrington, Kearney, & Perry, 2012, p. e43503). This study demonstrates the variability of different socioeconomic factors and the complexity of weight and growth influences in the home environment alone.

Pacific / NZ literature

For Pacific populations, research around parenting practices and health have focussed on child rearing in general, and often with a focus on styles of disciplining. Studies that have examined nutrition-related outcomes including obesity have focussed on sociocultural factors such as perceptions, knowledge, beliefs and values related to food consumption or body size. For instance, Heimuli et al. (2011) explored Pacific mothers' level of concern for their child's future weight based on current body size. Although the concern of future weight status was related to current child weight status, the overall level of concern was low in relation to the prevalence of overweight. As a result, the authors proposed a perception of normalisation of overweight, defined as a low level of parental concern for overweight in relation to the high proportion of overweight and obesity among children (Heimuli et al., 2011). In general, the study suggests that sociocultural factors play an important role in the interpretation of body size and outcomes in body weight.

However, an investigation of perceptions of healthy weight among Pacific adolescents and their parents found that sociocultural factors might be overstated. Teevale et al. (2010) investigated sociocultural factors that may promote or prevent obesity in Pacific peoples living in New Zealand. The researcher found that other factors, such as cost and affordability of food, time constraints of parents, and poor health literacy, were more relevant to health behaviours and outcomes than sociocultural factors. This was because there was no difference in perceptions, beliefs and values regarding food and healthy/unhealthy body size between obese and non-obese participants. Instead, the key difference determining weight status was related to parental socioeconomic factors and the impact on parental presence in the home.

In summary, a large body of research exists on the relationships between sociocultural factors that are relevant to parenting practices and food behaviours, and weight-related outcomes such as obesity. Substantial research on the home environment examine demographic variables (such as ethnicity) and socioeconomic variables such as deprivation. Investigations of parenting influences on child nutrition and body weight have focussed on sociocultural factors such as perceptions, beliefs and values relating to food and body size. However, at the time of writing no studies had examined the relationships between parenting styles and other key home environment factors with food habits and body size among pre-adolescent children.

6.1.3 Aims, objectives and hypotheses

The aim of this investigation was to examine, at 9 years of age, associations between parental and home environment factors, child dietary habits and BMI Z scores among Pacific families.

The first objective was to describe sociodemographic and sociocultural characteristics observed among PIF study homes and key child dietary habits

The second objective was to examine how the various sociodemographic and sociocultural factors were related to child diet and BMI Z score.

The first hypothesis was that sociodemographic and socioeconomic factors – household size, deprivation, single parent at home, and lower education – would be positively associated with less-healthful food habits and higher child BMI Z. The assumption was that larger household sizes would be associated with an increased likelihood of parents choosing cheaper and more convenient foods (such as bread and fast food) for household members. Although chosen for taste, low-cost convenient foods tend to be energy-dense, nutritionally deficient, and not satiating thus promoting everyday consumption of excess energy, which could lead to elevated energy stores (body fat).

The second hypothesis was that an authoritative style of parenting would be positively associated with healthier food habits and, as a result, would be negatively associated with child BMI Z compared with authoritarian styles of parenting.

Cross-section and prospective BMI Z-score (WHO, 2007) was the chosen as the main outcome variable of home environment factors.

6.2 Methods

6.2.1 Data collection and measures

Data for the 9 y wave of the PIF study were collected between April 2009 to October 2010. Maternal interviews and child assessments each took approximately one hour to complete and questionnaires were administered by trained interviewers and child assessors. Maternal interviews were carried out in participant homes where consent to assess the child at school was sought. All home environment data were collected in the primary caregiver questionnaire. Child height (cm) and weight (kg) were measured at least twice and were used to derive body mass index z-scores (BMI Z) using the WHO 2007 references (World Health Organization, 2007).

Sociodemographic information

Sociodemographic data were child's age, gender, ethnicity, household size and parental status. These data also included maternal education and deprivation. Household size was defined as the total number of usual household residents, which was then collapsed into three categories of '2 to 4', '5 to 7' and '8 or more usual residents'. Parental status was a dichotomous variable indicating whether there was one or two parents at home. Maternal education was also dichotomous, indicating the presence of post-school education/qualifications or not.

Socioeconomic deprivation

Maternal socioeconomic deprivation was measured using the New Zealand Individual Deprivation (NZiDep) Index questionnaire (Salmond et al., 2006) (Appendix D). The eight questions that constitute the index are applicable to all adults (including those not economically active), have been tested with many ethnic groups and deemed appropriate for Pacific respondents. Questions are designed to identify people who have had special financial needs in the last 12 months with a binary response of either '0' No or ‘1’ Yes. Although consisting of eight questions, each worth one score, the index is designed to be a five-point individual-level index of socioeconomic deprivation. Thus, after data collection, the eight questions are collapsed to five ordinal categories of deprivation:

1. No deprivation characteristics
2. One deprivation characteristic
3. Two deprivation characteristics
4. Three or four deprivation characteristics
5. Five or more deprivation characteristics

Parenting Styles

The sociocultural environment factor for this analysis was a composite variable that measured parenting styles or parenting practices. The Parenting Practices Questionnaire (PPQ) is a list of questions (items) related to different practices that define parenting styles (C. C. Robinson, Mandleco, Olsen, & Hart, 2001) (Appendix E). The original PPQ developed by Robinson and colleagues has 62 items, but for this study, the number of items was reduced to 28. This was done because the PPQ was one questionnaire within a battery of other scales and measures compiled for the general (maternal) questionnaire which prompted lead investigators of the PIF study to reduce participant burden. (Administration of the final maternal questionnaire was approximately one hour long for participants to complete). The 28 items were chosen on the basis that they had attained the highest factor loadings >0.60 as tested earlier by C. C. Robinson, Mandleco, Olsen, and Hart (1995). Parents responded to questions by choosing an option on a 5-point Likert scale with scores ranging from ‘Never’ (score of 0) to ‘Always’ (score of 4). Subscales within the PPQ measured three dimensions or styles of parenting, authoritative (10 items), authoritarian (11 items) and permissive (7 items). Three new variables were created to represent each parenting style with values derived from composite scores of respective subscales.

Child dietary habits

Dietary outcome variables refer to the frequency of five key foods collected in a child Dietary Habits Questionnaire administered to parents (Appendix F). Questions asked about usual eating patterns over ‘the past 4 weeks’ of food eaten either at home or away from home. The five key foods selected were bread, fruit, vegetables, fast foods, and soft drinks. For bread, parents were asked to report on ‘how many slices of bread or toast, or bread rolls does your child eat per day?’ Parents could only choose one of six possible responses ranging from ‘None’ to ‘7 or more per day’. Parents were also asked how many servings of fruit (fresh, frozen, canned or stewed) and vegetables (fresh, frozen or canned) their child ate per day. For both questions, parents had to select one of six possible answers ranging from ‘Never’ to ‘4 or more servings’ per day. Lastly, in two separate questions, mothers were also asked to report how often per week their child ate ‘fast food’ and drank ‘soft drinks’ at any time of the day. They had to choose one of six possible responses ranging from ‘Never’ to ‘7 or more times per week’.

6.2.2 Data handling procedures and analysis

Independent variables were home environment factors, and outcome variables were child dietary habits and derived BMI Z collected at the 9-year (y) measurement wave. Body mass index z-score (BMI Z) was treated as a continuous variable and all home environment variables, including food habits, were ordinal. All home environment variables and BMI Z were examined for association using Spearman’s rank correlation (rho) and statistical significance (p-value) set at $p<0.05$.

One-way analysis of variance (ANOVA) tests were carried out to examine differences in mean BMI Z for all variable pairs where statistical significance was observed. All

ANOVA tests in Stata/SE v12.1, have a built-in Bartlett's test for equal variances (Snedecor & Cochran, 1989). With a significance level set at <5%, a Bartlett's p-value of <0.05 indicated that the null hypothesis of equal variances between pairs could not be assumed and was therefore rejected. All one-way ANOVAs presented below should be assumed to have not reached significance for Bartlett's test unless otherwise stated.

Total household size was also examined using simple regression for an effect on cross-sectional and prospective BMI Z (WHO, 2007) at 11 and 14 y. Household sizes were also collapsed into three categories of '2 to 4', '5 to 7' and '8 or more'.

Food habits were examined as dependent and independent variables. Food was dependent upon sociodemographic, socioeconomic and sociocultural variables and independent for association with BMI Z (WHO, 2007). Frequency of fruit, vegetables, fast food and soft drinks were dichotomised according to nutritional eating guidelines to investigate association with parenting styles using simple logistic regression. Fruit was dichotomised to 'Yes' if child had two or more (2+) servings per day and 'No' if the child had less. Vegetables into 'Yes' if the child had three or more (3+) servings per day or 'No' if the child had less (MoH 2012d). Fast food and soft drinks were dichotomised in an opposite fashion to investigate the odds of eating more non-core foods than recommended. These foods were dichotomised to 'Yes' if the child ate the food one or more (1+) times per week or 'No' if the child ate less. This was based on recommendations to limit non-core foods to less than 1/week for good health (MoH 2012).

Parenting style subscales were tested for internal consistency using Cronbach's alpha coefficient (Cronbach, 1951). Cronbach's alpha is a measure of scale reliability, indicating how closely a set of items (or questions) are as a group, representing level of internal consistency (Table 6.2).

Table 6.2 Cronbach’s alpha coefficients of internal consistency (Cronbach, 1951)

Cronbach's alpha	Internal consistency
$\alpha \geqslant 0.9$	Excellent
$0.9 > \alpha \geqslant 0.8$	Acceptable
$0.8 > \alpha \geqslant 0.7$	Good
$0.7 > \alpha \geqslant 0.6$	Questionable
$0.6 > \alpha \geqslant 0.5$	Poor
$0.5 > \alpha$	Unacceptable

Coefficients for authoritarian (0.755) and authoritative (0.785) parenting practices indicated good levels of reliability ($0.8 > \alpha \geqslant 0.7$) (Table 6.3). However, the permissive parenting coefficient indicated unacceptable internal reliability at 0.474. As a result, further examination of permissive parenting (data) was not carried out.

Table 6.3 Cronbach's alpha (α) coefficient for internal consistency of parenting styles for primary caregivers at 9 year (y) phase of the Pacific Islands Families study using a modified Parenting Practices Questionnaire (PPQ) (C. C. Robinson et al., 1995).

Parenting style	**N of items***	**9 y primary α**
Authoritative	10	0.785
Authoritarian	11	0.755
Permissive	7	0.474

*refers to number of questions measuring each respective parenting dimension.

Parenting styles (subscales) were then tested for estimation of respective medians and interquartile ranges (IQR). The IQR is a descriptive measure of statistical variation, representing the middle 50% of a rank-ordered data set, such as one created by Likert scales. In this case, the IQR describes where 50% of most of the data lie for each subscale (see Table 6.4 below).

Parenting styles and food consumption were tested for correlation using the Spearman rank-order correlation test in Stata. Food intake questions were ordinal variables requiring non-parametric testing for correlation. “The Spearman rank-order correlation coefficient is a nonparametric test which measures the strength and direction of association between two variables that are measured on an ordinal or continuous scale" (Laerd Statistics, 2017).

6.3 Results

Participants and home environment

At the 9 y wave, 995 primary caregivers (94.6% mothers; 5.4% fathers) were interviewed for 1,015 children (50.5% boys, 975 singletons, 20 pairs of twins), 72.6% of the original child cohort Table 6.4). The current descriptive report is for all parent/child participants. During this wave, over three quarters (77.6%) of children had two parents at home and median household size was 6 (SD 2.25, range 2, 21). More than eight out of 10 (83.7%) homes had five or more usual household members, including over a quarter (28.5%) that had eight or more. Most parents reported at least one deprivation (85.8%) including one third who reported three to eight deprivations (34.1%). In terms of education level, about four out of ten (39.5%) parents reported having a post-secondary school qualification.

Most parents (95%) completed all questions for subscales of authoritative and authoritarian styles in the Parenting Practices Questionnaire (PPQ). Median scores and interquartile ranges (IQR) indicated a significantly higher prevalence of authoritative parenting practices compared with authoritarian parenting (Table 6.4).

Table 6.4 Sample and home environment characteristics at the 9 year wave

Child and home environment variables	**N**	**(%)**
Child gender (n=1015) (Mean age 9.4 years)		
Boys	513	(50.5)
Girls	502	(49.5)
Ethnicity (n=1015)		
Samoan	460	(45.3)
Tongan	227	(22.4)
Cook Island Māori	176	(17.3)
Niuean	48	(4.7)
Other Pacific	104	(10.2)
Parental Status (n=1009)		
One	226	(22.4)
Two	783	(77.6)
Household size[a] (n=1015) (Mean 6.54; range 2, 21)		
2 to 4 usual residents	166	(16.4)
5 to 7 usual residents	560	(55.2)
8 or more usual residents	289	(28.5)
Individual Deprivation Index (NZiDep) (n=949)		
No deprivations	135	(14.2)
One deprivation	249	(26.2)
Two deprivations	241	(25.4)
Three to four deprivations	211	(22.2)
Five to eight deprivations	113	(11.9)
Education Level (n=1010)		
None or secondary school	610	(60.3)
Post-secondary school	400	(39.5)
Parenting style	Median score	(IQR)
Authoritative (n=959)	41	(37, 45)
Authoritarian (n=960)	22	(18, 25)

[a] actual numbers were collected and collapsed for this table; IQR: Interquartile range

Dietary habits

Bread

Bread consumption was very common among PIF children with nearly all children (98.8%) eating bread daily (Table 6.6). For all children, the most common number of slices of bread eaten per day were 3 to 4 slices per day (39.5%, n=385), followed by 5 to 6 slices (29.9%, n=291) and 7 or more slices (17.0%, n=166) per day, respectively. There were some differences by sex, in that girls were more likely to eat fewer slices daily compared with boys. For example, more girls (16.2%) ate 1 to 2 slices of bread per day compared with boys (8.9%). On the other hand, twice as many boys (23.0%) as girls (11.0%) ate 7 or more slices per day. The most common type of bread reported was white bread (73.9%) and there was no significant difference in the type of bread eaten between boys and girls (Table 6.5).

Table 6.5 Type of bread eaten by girls and boys at the 9-year wave, n=972

Type of bread	**Gender**					
	Girls		**Boys**		**Total**	
	N	**(%)**	**N**	**(%)**	**N**	**(%)**
White	362	(75.1)	355	(72.8)	717	(73.9)
High-fibre white	11	(2.3)	8	(1.6)	19	(2.0)
Light grain bread	62	(12.9)	80	(16.4)	142	(14.6)
Heavy grain bread	19	(3.9)	20	(4.1)	39	(4.0)
Other	28	(5.8)	25	(5.1)	53	(5.5)
Total	482		488		970	

Chi-squared(4) = 2.98, Pr = 0.56

Fruit

More than eight out of ten children (84.7%) ate the recommended two or more servings of fruit per day at 9 y (Table 6.6). There was little difference in daily fruit consumption between girls and boys.

Vegetables

Slightly less than half of all children at 9 y consumed the recommended 3+ servings of vegetables per day (48.8%, n=476) and daily consumption of vegetable servings between boys and girls was similar (Table 6.6).

Fast foods

For fast foods, more than half of all children at 9 y were reported to have met the recommend consumption of less than once per week (57.7%, n=563) (Table 6.6). There were no statistically significant differences in the frequency of consumption between boys and girls in terms of whether or not eating guidelines were met.

Soft drinks and energy drinks

Just over half (56.5%) of all children at 9 y were reported to have met the recommended guidelines (compliant) of consuming soft/energy drinks less than once per week (Table 6.6). This meant that more than four out of ten children were drinking soft/energy drinks one or more times per week. Around 13% were consuming these drinks approximately every second day (≥3 times per week). Boys were 1.6 times more likely than girls (49.8% versus 37.1%) to consume soft drinks more than once per week (Chi^2 (1) = 16.09, $p<0.001$).

Table 6.6 Frequency of consumption of selected foods by PIF girls and boys at the 9 y wave

Food	Girl N	Girl (column%)	Boys N	Boys (column%)	Fisher's exact p-value[a]
Slices of bread per day					
None to less than 1 per day	6	(1.2)	6	(1.2)	<0.001
1 to 2 per day	78	(16.1)	44	(8.9)	
3 to 4 per day	216	(44.6)	169	(34.4)	
5 to 6 per day	131	(27.1)	160	(32.5)	
7 or more per day	53	(11.0)	113	(23.0)	
Total	484		492		
Fruit servings per day					
None to less than one serving	11	(2.3)	24	(4.9)	0.272
1 servings	59	(12.2)	55	(11.2)	
2 servings	186	(38.4)	185	(37.6)	
3 servings	150	(31.0)	155	(31.5)	
4 or more servings	78	(16.1)	73	(14.8)	
Total	484		492		
Vegetable servings per day					
None to less than one serving	37	(7.6)	32	(6.5)	0.893
1 serving	77	(15.9)	85	(17.3)	
2 servings	131	(27.1)	138	(28.1)	
3 servings	177	(36.6)	180	(36.6)	
4 or more servings	62	(12.8)	57	(11.6)	
Total	484		492		
Fast food consumption per week					
Never	9	(1.9)	14	(2.8)	0.227
Less than once per week	272	(56.2)	268	(54.5)	
1 to 2 times per week	190	(39.3)	183	(37.2)	
3 to 4 times per week	11	(2.3)	23	(4.7)	
5 to 6 times per week	2	(.4)	3	(.6)	
7 or more times per week	0		1	(.2)	
Total	484		492		
Soft/energy drinks per week					
Never	86	(17.8)	63	(12.8)	0.001
Less than once per week	218	(45.1)	184	(37.4)	
1 to 2 times per week	133	(27.5)	163	(33.1)	
3 to 4 times per week	33	(6.8)	51	(10.4)	
5 to 6 times per week	8	(1.7)	23	(4.7)	
7 or more times per week	5	(1.0)	8	(1.6)	
Total	483		492		

[a] Chi-squared test

Household and parenting factors: Food habits and BMI Z

A Spearman's correlation test detected a weak positive correlation with household size and bread consumption which was statistically significant (rho=0.138, $p<0.001$) (Table 6.7). When stratified by gender, significance was maintained for both groups (girls rho=0.171, $p=0.0002$; boys rho=0.123, $p=0.0063$). A similar statistically significant and positive association was detected for soft drink consumption and household size among girls only (rho=0.120, $p<0.05$). There was a negative but not statistically significant association with fruit consumption and a small negative association with borderline significance detected with vegetable consumption among boys only (rho=-0.084, $p=0.058$). There was no association of household size with frequency of fast food consumption.

In terms of body size, there was a weak negative association between household size and girls' BMI Z (rho=-0.099, $p<0.05$).

No associations were detected between parental status and food habits apart from borderline significance with soft drink and fruit consumption both in the positive direction. However, there was a weak positive association across the cohort between children who had two parents at home and BMI Z (rho=0.084, $p<0.05$). This was checked in a two-sample t-test, where a borderline significant difference in mean BMI Z according to parental status was detected. Thus, mean BMI Z among boys and girls (independently) were higher in two-parent homes compared with solo parent homes (diff. 0.26, boys $p=0.047$ and girls 0.25, $p=0.049$).

In terms of education, there was a positive association of higher education with fast food consumption (rho=0.106, $p<0.05$) particularly among girls (rho=0.168, $p<0.001$) and a negative association with BMI Z (rho=-0.086, $p<0.05$) particularly among boys (rho=-0.100, $p<0.05$).

In terms of deprivation, there were positive associations, among boys, with consumption of bread (rho=0.213, p<0.001), fast food (rho=0.108, p<0.05) and soft drink (rho=0.111, p<0.05). Although the direction of association for these foods was the same for girls, they were not statistically significant. This resulted in slightly weaker though still statistically significant associations overall, with only soft drink consumption reducing to borderline significance (p<0.10). In addition, among boys, there were negative associations between deprivation and daily servings of fruit (rho=0.164, p<0.001) and vegetables (rho=-0.218, p<0.001). For girls the direction of association was the same, though only borderline significant for vegetables. There were no associations between parental deprivation and child BMI Z.

In terms of parenting styles, there were more associations linked with authoritative over authoritarian style of parenting. For authoritative parenting there was a positive association with bread (rho=0.119) and vegetable (rho=0.111) consumption among girls only (p<0.05). There was also a statistically significant positive association with fruit consumption for both boys (rho=0.138, p<0.01) and girls (rho=0.120, p<0.05). Authoritative parenting was negatively associated with fast food consumption with both gender groups (boys rho=-0.132; girls rho=-0.237) and with soft drink consumption with girls only (rho=-0.112, p<0.05). Finally, authoritative parenting had a negative association with BMI Z but only statistically significant when girls' and boys' z-scores were combined (rho=-0.079, p<0.05).

Alternatively, the authoritarian style of parenting was negatively associated with daily vegetable consumption among boys (rho=-0.170, p<0.001) and girls (rho=-184, p<0.01) but positively associated with fast food and soft drink consumption for both boys and girls combined (rho=0.096, p<0.01 and rho 0.114, p<0.001). Authoritarian parenting was positively associated with BMI Z but the relationship was not statistically significant.

In terms of food and BMI Z, there was a statistically significant positive association with bread consumption (rho=0.156, $p<0.001$), but mainly among boys (rho=0.153, $p<0.01$). There was also a weak though statistically significant positive association between soft drink consumption and BMI Z but only when the genders were combined (rho=0.084, $p<0.05$). Finally, there was a negative relationship between vegetable consumption and BMI Z, but only among girls (rho=-0.104, $p<0.05$).

Table 6.7 Spearman correlation coefficients (rho) (3 d.p) of home environment variables with selected foods and BMI Z score (WHO, 2007). (n=831; girls n=425; boys n=406)

	Bread	Fruit	Vegetables	Fast food	Soft drink	BMI Z
Household size						
Boys	**0.123****	-0.079	-0.084	-0.054	0.060	0.064
Girls	**0.171*****	-0.004	-0.010	0.059	**0.120***	**-0.099***
All	**0.138*****	-0.040	0.001	0.001	**0.088***	-0.027
Parental status[a]						
Boys	-0.036	0.096	<0.001	-0.018	0.081	0.086
Girls	0.029	0.010	0.018	-0.023	0.039	0.087
All	-0.004	0.025	0.010	-0.021	0.061	**0.084***
Education[a]						
Boys	-0.091	0.008	0.003	0.046	-0.034	**-0.100***
Girls	-0.031	0.019	0.027	**0.168*****	0.062	-0.064
All	-0.062	0.014	0.016	**0.106***	0.013	**-0.086***
NZiDep Index						
Boys	**0.213****	**-0.164*****	**-0.218*****	**0.108***	**0.111***	0.020
Girls	0.070	-0.43	-0.083	0.040	0.011	-0.031
All	**0.135****	**-0.094****	**-0.149*****	**0.076***	0.062	0.002
Authoritative style						
Boys	-0.020	**0.138****	0.051	**-0.132****	-0.078	-0.074
Girls	**0.119***	**0.120***	**0.111***	**-0.237*****	**-0.112***	-0.080
All	0.046	**0.129*****	**0.082***	**-0.186*****	**-0.094****	**-0.079***
Authoritarian style						
Boys	-0.015	0.023	**-0.170*****	0.085[b]	**0.167*****	0.033
Girls	-0.019	0.074	**-0.184****	**0.111***	0.055	0.024
All	-0.013	0.050	**-0.174*****	**0.096****	**0.114*****	0.027
9y BMI Z						
Boys	**0.153****	-0.010	0.055	-0.019	0.069	1.00
Girls	0.095	-0.028	**-0.104***	-0.024	0.074	1.00
All	**0.156*****	-0.025	-0.023	-0.013	**0.084***	1.00

[a] binary variables: Parental status 0=1 parent at home, 1=2 parents at home; Education 0=no post-school qualification and 1=post-school qualification. *p<0.05 **p<0.01 ***p<0.001

Odds of food consumption based on the New Zealand nutrition guidelines

Odds of consumption of fruit (2+ per day), vegetables (3+ per day), and fast food and soft drink (both 1+/week) based on the New Zealand nutrition guidelines were modelled on sociodemographic and home environment variables in univariate and multivariate logistic regression analyses (data in Appendix G). Variables included child gender and ethnicity, household size, parental status, parenting styles, maternal education and deprivation (NZiDep). All home environment variables were included in the model for multivariate analyses for adjusted odds ratios (AOR). The AOR estimates and 95% confidence intervals (CI) are presented in figures 6.1 to 6.4.

In terms of gender, the only statistically significant difference in food habits was detected in weekly soft drink consumption. Boys were more likely than girls to consume soft drinks at least once per week even after adjusting for home environment factors (AOR=1.68, 95% confidence interval (CI) 1.25, 2.25).

No differences were detected among household size categories or parental status in either univariate or multivariate analyses.

Compared with having only secondary school education, having post-secondary school (tertiary) education increased the odds of eating fast food (1.74, 95% CI 1.29, 2.35) and consuming soft drink (AOR=1.37, 95% CI 1.02, 1.84) one or more times per week.

According to the NZiDep Index, having two deprivations meant lower odds of meeting the guidelines for fruit and vegetables intake compared with having no deprivations but this difference was no longer significant in AORs. However, having two deprivations meant mothers were more than twice as likely to report their child eating fast food at least once a week compared with mothers reporting no deprivations (AOR 2.17, 95% CI 1.3, 3.64; $p<0.01$). Having three-to-four and five-or-more deprivations meant lower odds of eating the recommended servings of fruit and vegetables per day compared to having no deprivations in univariate analyses. However, after factoring for other variables, only having three-to-four deprivations led to lower odds of consuming the recommended daily servings of fruit compared with no deprivations (AOR=0.43, 95%

CI 0.19, 0.94; $p < 0.05$). Lower odds of eating the recommended daily serving of vegetables remained significant among mothers reporting three-to-four and five-or-more deprivations compared to those reporting no deprivations after adjustment (AOR=0.55, 95% CI 0.33, 0.91; $p < 0.05$ and 0.34, 95% CI 0.19, 0.60; $p < 0.001$, respectively).

In terms of ethnicity, Niuean children had higher odds of eating fast food compared with children identified as Samoan but this was attenuated and non-significant in the multivariate model. However, compared with Samoan, mothers of Tongan children had lower odds of consuming the recommended serves of fruit (AOR=0.48, 95% CI 0.29, 0.79) and vegetables (AOR=0.40, 95% CI 0.27, 0.59), and higher odd of consuming fast food at least once per week (AOR=1.78, 95% CI 1.23, 2.60). Although Tongan children had higher odds of drinking soft drink above the guidelines compared with Samoan children (OR=1.65, 95% CI 1.18, 2.29), this was no longer the case after multivariable adjustment (AOR=1.31, 95% CI 0.91, 1.89).

Although authoritative parenting led to greater odds of eating the recommended daily serves of fruit and vegetables, in univariate analysis, these were weakened and non-significant after accounting for home environment variables. However, authoritative parenting meant lower odds of eating fast food (AOR=0.95, 95% CI 0.92, 0.97; $p < 0.001$) and drinking soft drink (AOR=0.97, 95% CI 0.95, 1.00; $p < 0.05$) weekly even after adjusting for other home environment variables. Authoritarian parenting resulted in lower odds of consuming the daily recommended servings of vegetables (AOR=0.94, 95% CI 0.92, 0.97; $p < 0.001$), and higher odds in weekly consumption of fast food (AOR=1.04, 95% CI 1.01, 1.06; $p < 0.01$) and soft drink (AOR=1.03, 95% CI 1.01, 1.06).

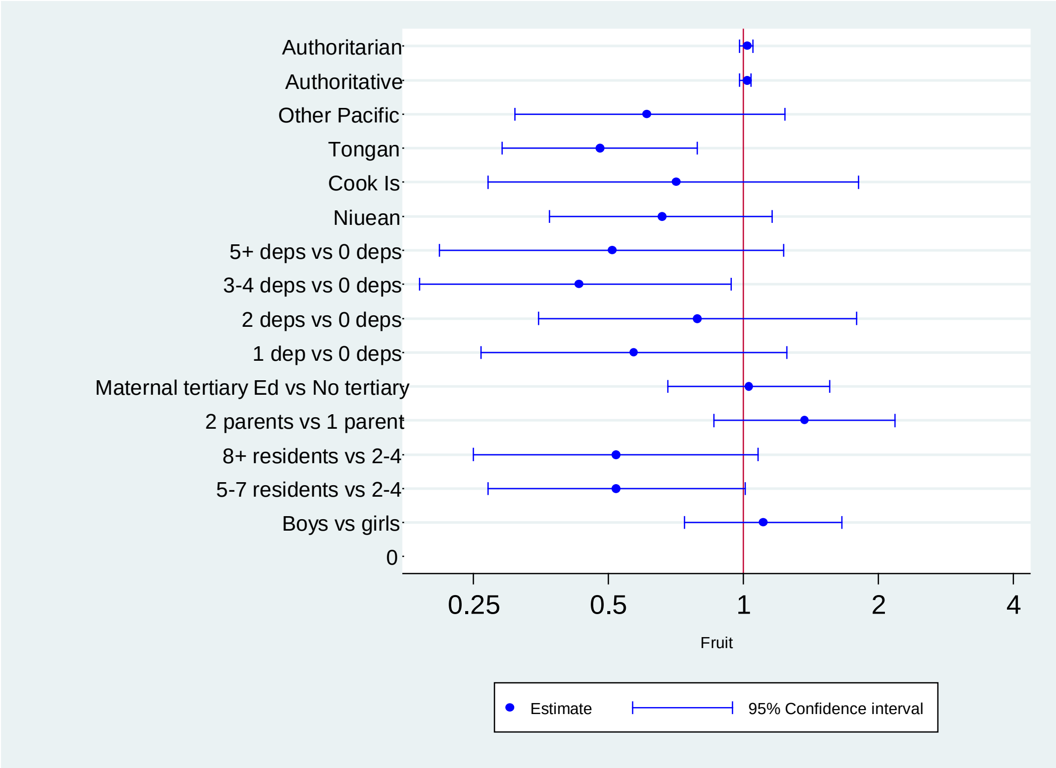

Figure 6.1 Adjusted odds ratios of home environment factors and fruit consumption 2+/day of PIF children age 9 years

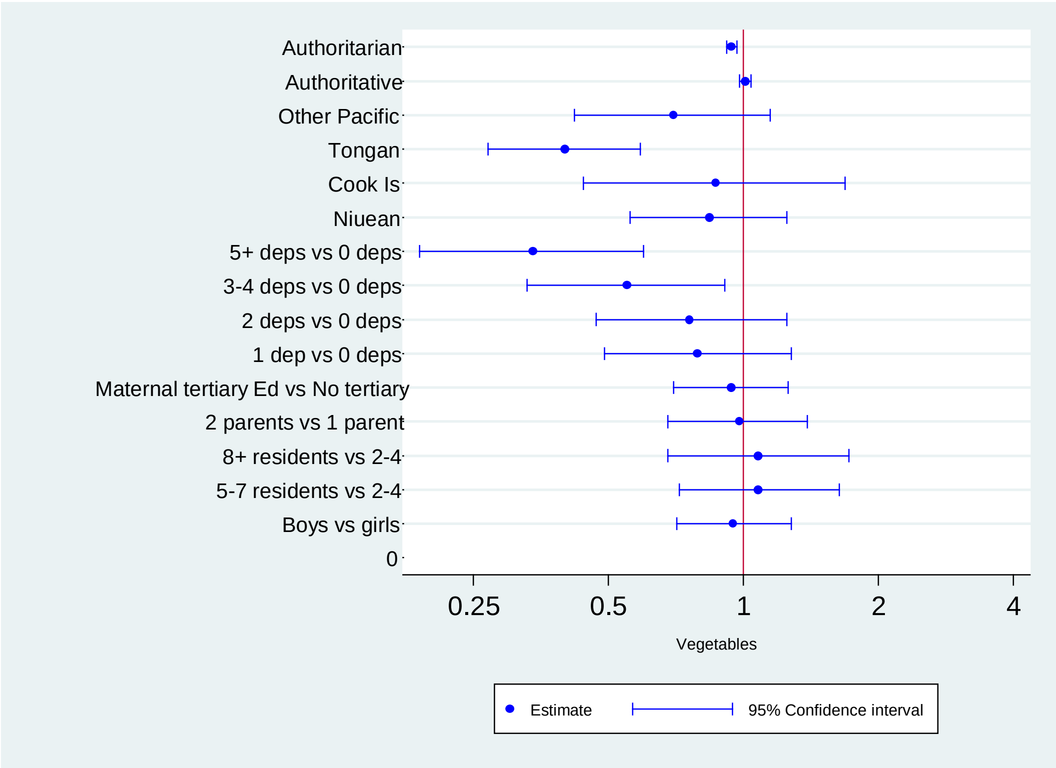

Figure 6.2 Adjusted odds ratios of home environment factors and vegetable consumption 3+/day of PIF children age 9 years

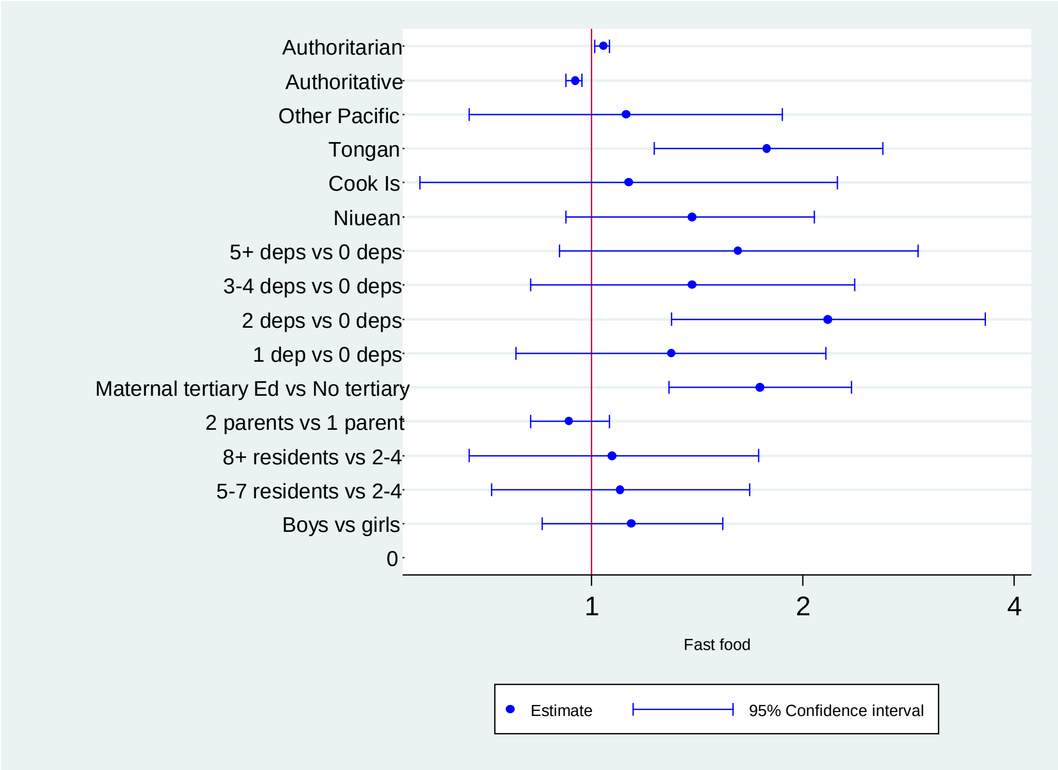

Figure 6.3 Adjusted odds ratios of home environment factors and fast food consumption of 1+/week of PIF children age 9 years

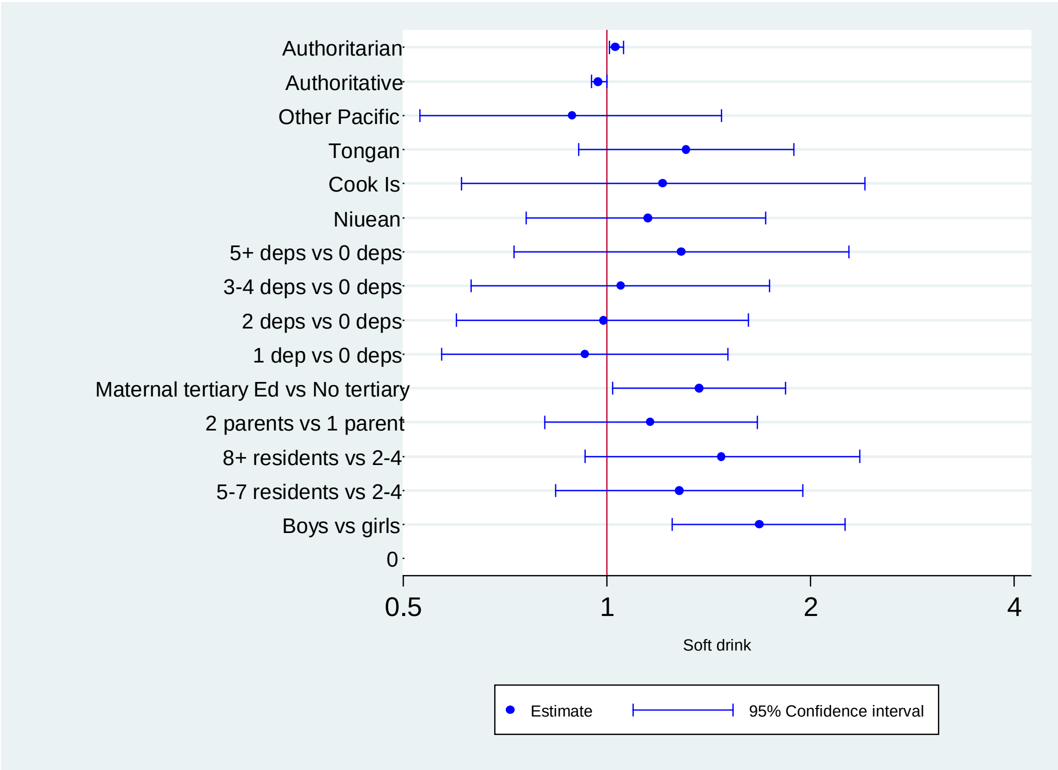

Figure 6.4 Adjusted odds ratios of home environment factors and soft drink consumption of 1+/week of PIF children age 9 years

6.4 Discussion

Crucially, this investigation of the patterns of association of home and food environments and body size found household size was linked to increased consumption of energy rich foods, bread (74% white) and soft drinks/energy drinks. The proportion of PIF children eating bread daily (boys and girls 99%) was ~25% higher than that reported for NZ children aged 7 to 10 years (boys 76%, girls 71%) (Ministry of Health, 2003). According to national nutrition surveys, Pacific children and adults are more likely to eat white bread compared with NZ European and Other ethnic peoples (Ministry of Health, 2003, 2012c). In addition, people living in socioeconomically deprived areas were more likely to both consume bread more frequently and report eating white bread more than wholemeal varieties compared with people in less socioeconomically deprived areas (Ministry of Health, 2003). This suggests that the high frequency of white bread consumption in more socioeconomically deprived groups is as likely to be driven by cost as it is by taste.

This is the first known investigation to have examined the relative influence of Pacific home environment and parenting factors associated with pre-adolescent child food habits and BMI Z at age 9-years in South Auckland, New Zealand, where the child was born. At this critical time of physical growth, Pacific children were living in households significantly larger than the average household size. According to the 2006 Census, the national average household size was 2.7 usual residents and in South Auckland, the average size was 3.8. In this cohort, the average size was 6.5 usual residents where children were 5.1 times more likely to live in households consisting of five or more usual residents than households of four or less usual residents.

Household size was linked to maternal deprivation, which had the strongest association with boys' consumption of bread compared with all other home environment factors. Furthermore, maternal deprivation had a significant inverse association with boys' consumption of fruit and vegetables, and yet an increasing influence on fast food and soft drink consumption. Although the relationship of maternal deprivation on frequency of all selected foods among girls was in the same direction as that observed among boys, none achieved statistical significance. In general, these findings are in agreement with established evidence that socioeconomic deprivation plays a key role on food security and quality of family nutrition (e.g. (Bidwell, 2009; Rush et al., 2007). Furthermore, correlations between bread, fruit and vegetables for boys suggests fruit and vegetable consumption may have been displaced by consumption of bread, especially in homes where maternal deprivation was greatest.

Increasing household size was also linked to soft drink intake, particularly among girls. Nationally, Pacific children were more likely to consume soft drinks daily (boys 60%, girls 62%) compared with NZEO children (boys 34%, girls 40%) (Ministry of Health, 2003). Among PIF children, frequency of soft drink consumption was positively associated with BMI Z. This finding is consistent with growing research on the link between sugar-added foods, weight gain and other nutrition-related outcomes such as type-2 diabetes and dental caries (Katzmarzyk et al., 2016; Malik, Pan, Willett, & Hu, 2013; Te Morenga, Mallard, & Mann, 2013). Systematic reviews and meta-analyses of random control trials and prospective cohort studies by Malik et al. (2013) and Te Morenga et al. (2013) report of significant evidence of a relationship between sugar-sweetened beverages (SSBs) and weight gain. Malik et al. (2013) found that daily serving increments of SSBs were associated with small (0.05 to 0.06) but consistent unit increases in BMI in children over a one-year period. Te Morenga et al. (2013) also reported, among child cohorts, consistent positive relationships with daily consumption of SSBs and odds of being overweight. As such, the odds ratio for being overweight or obese was 1.55 (1.32 to 1.82) among the highest consumers (at least daily) compared with the lowest consumers (less than daily). In a recent in a multi-national study among

6,162 children age 9 to 11 years, Katzmarzyk et al. (2016) reported a significant linear trend (p=0.049) in BMI z-scores in the consumption of regular (non-diet) soft drinks among boys and a in diet soft drinks among girls (p=0.0002).

The finding of greater SSB consumption in homes with more residents may indicate the quality in household food composition for Pacific families. Households that regularly purchase high-calorie sweetened drinks have been found to have poorer overall dietary patterns and greater frequency of fast food consumption (Piernas, Mendez, Ng, Gordon-Larsen, & Popkin, 2014; Pollard et al., 2016). Those reports are consistent with findings in the present study where there were statistically significant positive correlations between soft drink, bread and fast food consumption and negative correlations with fruit and vegetables. In concert, these findings support the notion that regular (weekly) consumption of SSBs within homes may predict generally poorer overall household nutrition, particularly when compared to homes with irregular (less than weekly) consumption of SSBs.

Overall, home environment sociodemographic and socioeconomic factors were associated with food habits and BMI Z in the expected direction supporting the first hypothesis of this investigation.

The second hypothesis proposed that authoritative parenting would have beneficial associations with food habits and BMI Z among children, and authoritarian parenting adverse associations. Indeed, authoritative parenting was the most influential factor compared with all other home environment factors examined. Authoritative parenting was associated with every food habit and with BMI Z. In addition, all of the associations were consistent with the literature for which strong evidence supports that this style of parenting is more likely to promote healthier dietary patterns and lower BMI among children. This includes the association of authoritative parenting with bread consumption among girls. Breads and cereals are a staple in the New Zealand diet, a primary source of energy, carbohydrate, dietary fibre (especially wholegrains), protein, and B vitamins (except B12) (Ministry of Health, 2012b). Based on nutrition guidelines that recommend children consume at least five servings of preferably whole-grain breads and cereals per day, this suggests that the influence of authoritative parenting on bread intake is encouraging.

Conversely, findings are also consistent with the literature where a large body of evidence suggests that authoritarian parenting styles have stronger associations with more deleterious dietary patterns than healthier ones. However, authoritarian parenting was not associated with increased BMI among offspring.

Only one association of a home environment factor and food habit that was unexpected was that of higher education and a greater frequency of fast food intake. Education level is used widely as an indicator of household socioeconomic wellbeing, since a greater level of education generally improves employment and income potential. Because of this, higher education usually signals improved nutrition patterns and lower likelihood of overweight. Although the effect of greater education on lower BMI Z is analogous with established evidence, the association with fast food intake is conflicting. One suggestion is possible confounding of the prevailing food environment beyond the home microenvironment in a low socioeconomic neighbourhood such as South Auckland. For instance, it has been shown that socioeconomically poorer neighbourhoods in westernised countries, such as the USA and New Zealand, have food retail environments that support better access to convenience and fast food stores in comparison with higher income neighbourhoods (Brown & Yarnell, 2013; Oreskovic, Kuhlthau, Romm, & Perrin, 2009; Pearce, Blakely, Witten, & Bartie, 2007). This supports the argument that the local retail environment for PIF families is likely to be supportive of fast food consumption regardless of family socioeconomic status. Parents of higher education residing in high-density fast food areas are more likely to utilise the low-cost convenience of regular fast foods, especially if time is constrained due to employment. This contrary finding could be examined more carefully in future investigations, as the influence of the neighbourhood food environments of Pacific families is likely to play an important role in home food environment (Rosenkranz & Dzewaltowski, 2008).

Additionally, there were two unexpected findings to do with home environment and body size, the first of which to be discussed was the relationship of increasing household size with decreasing BMI Z among girls. The direction of association of household size with BMI Z between the genders were opposing (positive, though non-significant for boys), indicating gender variations in behaviour and, therefore, perceptions regarding food and intake. Gender differences may exist in the value placed on food allocation in homes where it is likely to be scarce. For instance, a study by Beardsworth et al. (2002) of differences in gendered attitudes and choices of food and nutrition concluded that girls were generally more virtuous about food consumption. Girls were more likely than boys were to be aware and reflective of their environments, and to make nutritional alterations based on health recommendations and body size. Further, Beardsworth et al. (2002) found that boys were less inclined to restrict food intake than girls, whereas girls were more likely to make active attempts at weight-reducing diets than boys were. These findings suggest that girls in larger households may be more reflective about the scarcity of food in the home and may be inclined to forgo meals out of concern for other family members not having enough food to eat. In addition, the opportunity to initiate dieting may present itself more readily in homes were food is scarcer. However, these suggestions are only speculative, as information on perceptions, attitudes and behaviours, such as dieting, regarding Pacific children's food practices was not collected at this age.

Further to child food perceptions, are likely sociocultural differences in parental perceptions, attitudes, values and practices around parental feeding styles. For example, do Pacific parents feed children differently depending on gender, how are these feeding styles determined, and how do they affect child weight? For example, a study by Fisher and Birch (1999) found that mothers were more likely to restrict snack foods for girls than for boys. However, the same study found that maternal restriction was positively associated with greater consumption of snack foods and weight-for-height in girls, which do not align with the present findings. Another study (Pomerantz & Ruble, 1998) found that boys, more than girls, were given more freedom when it came to choosing food, suggesting that boys may be more likely to consume more often than girls. Regardless, what these studies do suggest is that there are differences in parental feeding styles depending on gender of offspring and how these practices might play out in Pacific families may be an area of import for future research.

The second unexpected finding was in the association of two-parent (versus single parent) homes with increasing BMI Z among boys and girls combined. It was expected that having two parents at home would be more advantageous nutritionally due to greater (likelihood of) parental support including increased income in the home. To examine the hypothesis, the question posed is what effect does the presence of fathers in the home have on the body size outcomes of children? In this analysis, the outcome is that the presence of Pacific fathers residing at home was positively associated with child BMI Z. As paternal data was not gathered at the 9-year wave, reports relevant to Pacific adults in general are discussed. It is proposed that there may very well be a high prevalence of obesity not only in fathers but also in mothers. This is speculated as there is currently a very high prevalence of overweight and obesity (90.1%; 95% CI 85.0–93.6) among Pacific men (age 15+ years) and Pacific women in NZ (88.6%; 95% CI 84.1–91.9) (Ministry of Health, 2016a). The combined prevalence of parental overweight has been not only suggested to be associated with intergenerational overweight but also specifically linked with child overweight at ages 5–7 years (Cole et al., 2008; Danielzik et al., 2004). In external analysis of this cohort at 14 years, maternal weight was significantly positively associated with cross-sectional child BMI Z. Based on these external findings, the author proposes that the positive relationship between having two parents at home and BMI Z is likely associated with high prevalence of overweight among Pacific adults/parents. A further speculation is that having two parents may mean higher potential income and therefore greater likelihood of access to fast foods.

6.4.1 Strengths and limitations

One of the main strengths of this investigation is that it is the largest sample of Pacific parents who have provided valuable and unique information into Pacific homes and parenting of Pacific children. Pacific parenting styles, in terms of relationships with food and growth, have not been examined before. The information obtained here will further enable investigation of how interventions related to parents or parenting might be approached in a culturally appropriate manner. This leads to another key strength of this investigation, that the home environment information provides an important context for understanding the drivers of food and growth patterns for these children. By understanding home environments, policy can be designed based on these data, to enable parents in providing appropriate nutrition for healthier childhood growth and weight. Finally, another strength to this study is that the body measurements collected are robust as they were objectively recorded at least twice by trained assessors using standardised protocols.

There are also some limitations to this study that warrant further investigation. Although the PIF study is longitudinal, this study focussed on one wave of follow-up data. The Parenting Practices Questionnaire (PPQ), used in other studies of food and growth, was administered at this follow-up wave, which was the major driver in deciding on this approach. Additionally, the dietary habits questionnaire and body measurements were also collected at this wave, allowing examination of associations between parenting styles, food consumption and BMI Z.

Information on parental feeding styles, food purchasing and the physical presence of food in the home could have provided greater insight. Questions relating to these areas of study may have helped to account for some of the unexpected findings in the analyses. However, there is a limit to participant burden in a longitudinal study such as the PIF study, which covers a number of topics and hence limiting the depth of some questions. The frequency of consumption of key foods, such as bread, fruit and vegetables, fast food and soft drink can act as indicators of the dietary options generally made available to young family members in the home. Nevertheless, as dietary habits are self-reported, participant recall error and bias are common concerns where social desirability can influence underreporting of less healthy foods and over-reporting of healthier foods. On the other hand, trust has been built with the cohort who understand the information that they provide will help inform policy, suggesting that the participants were more open to answering these questions correctly.

Another limitation was in the modification of the Parenting Practices Questionnaire by reducing the number of items used to assess the different parenting dimensions it is designed to measure. The modification possibly resulted in the inability to measure sufficiently the effect of permissive parenting dimensions on child food habits or BMI Z due to poor internal consistency detected by Cronbach's alpha in the permissive subscale. Cronbach's alpha coefficient can be affected by the number of test items as the coefficient relies on the average inter-correlation among items (UCLA Statistical Consulting Centre, 2016). The low number of items kept in the permissive subscale after modification (reduction) of the original PPQ may be responsible for low alpha for internal consistency. Alternative explanations for the poor reliability could include that permissive styles of parenting are not prevalent in Pacific families, or that interpretation of permissive practices (questions) are not consistent with dominant Western interpretation of permissiveness. However, comparable associations observed between authoritative and authoritarian parenting that are largely consistent with the literature provide valuable insight into Pacific maternal parenting and offspring food habits and body size.

Finally, not all factors can be measured or included for investigation. For instance, food preferences, meal patterns and the wider food environment were factors for which information were either not sought for or available. As with other investigations, potentially important factors arise in the attempt to understand certain phenomena or questions. The overall aim of this investigation was to provide a limited picture of the home environment by analysing important characteristics that have been shown to contribute significantly to food consumption and child body size in other non-Pacific populations.

6.5 Conclusion

Perhaps the most significant finding in this investigation is that food habits and BMI Z of Pacific children are shown to benefit from authoritative styles of parenting. This is new and encouraging information for Pacific families because Pacific children are in great need of attention to address the disparate levels of nutrition, in patterns of food consumption and weight status. Improving these outcomes would bode well for later outcomes in adult chronic disease, quality of life, and socioeconomic wellbeing. Recommendations for future research include executing robust research on parenting styles using reliable, validated scales that measure parenting practices. Further, including scales that measure feeding styles and/or measures of the physical presence of food in the home in conjunction with parenting practices measures would allow for a fuller understanding of the relationships between parenting, food habits and growth. This would strengthen evidence for recommendations around advocacy, strategies or policies that promote authoritative styles of parenting. Finally, it is recommended that it is essential to include fathers in such research, as there is scant evidence in an area for which they play a major role.

Chapter 7 Final discussion: Home and food environments and Pacific children's growth

This body of work provides new information on the very rapid physical growth trajectory in Pacific childhood, food consumption patterns that include bread but not vegetables, and family environments, such as authoritative parenting, linked to healthier food habits and body size. This chapter engages a discussion by firstly summarising questions and hypotheses proposed, and findings of the separate studies. Secondly, the significance and implications of the findings and inferences are discussed in the context of current knowledge, including the contribution of this work in the context of findings of other longitudinal studies relevant to Oceania. This is followed by a statement acknowledging weaknesses and strengths of this body of investigation, and finally concluding with some recommendations for future research.

7.1 Summary of questions, hypotheses and major findings

This thesis set out to examine the following questions

1) How can the physical growth patterns of Pacific children be defined?
2) What sorts of food combinations and patterns do Pacific children eat and are they related to body growth?
3) What is the strength of association of home environment factors with food patterns and growth?

To begin the investigation, Chapter 4 provided a unique survey of body mass, linear growth, and growth trajectory among the cohort from 1 year prior to school through to age 14 y. The primary goal was to improve understanding of the environmental drivers of rapid growth and increase in body size in mid to late childhood. Based on accelerating growth characteristics during early childhood, it was hypothesised that the relative magnitude of weight gain and increasing incidence of overweight and obesity would be greater between 11 and 14 y than that observed in earlier years. Certainly, average yearly increases in mean weight (~8.8kg), WFA Z (~0.28) (using the British 1990 reference), and BMI (~1.3kg/m^2) for boys were highest between 11 and 14 y, than any average yearly increase (between all waves) from 4 y through 11 y. However, BMI Z change between 11 and 14 y was not consistent with the hypothesis. Although the biggest increase in mean BMI Z among boys was between 6 y and 9 y, z-scores at 14 y were higher than previous ages compared to the reference population reflecting ongoing steeper inclines in age and sex-specific weight over height, equating to rapid growth.

Similar patterns of rapid growth were observed for girls. Compared with all other periods, average yearly increase in mean weight (~7.43kg), BMI (~1.73kg/m^2) and BMI Z (0.16 z) was highest between 11 and 14 y. Although the biggest increase in mean WFA Z was observed between 9 and 11 y, z-score was highest at 14 y again confirming continual faster rate of growth than the reference children (World Health Organization, 2007). Moreover, commensurate with rapidly increasing body size was the prevalence of overweight (32%) and obesity (43%), which was highest at 14 y. Although there was a slight difference in prevalence of overweight between boys (36%) and girls (28%), an additional four out of ten boys (42%) and girls (43%) were obese according to IOTF thresholds.

Chapter 5 contributes a novel examination of longitudinal food frequency patterns during a critical period in childhood development, the transition to school. Based on relevant literature, the first hypothesis tested the proposition that similar foods track. In this investigation, 12 of the most frequently eaten foods in 2004 and 2006 were identified and represent around a quarter of daily intake over this critical period of development. In addition, a strong correlation of the consumption of food groups was observed across the period, affirming that despite variation, the consumption of similar foods track through early childhood. A second hypothesis proposed that due to the high prevalence of overweight, that there would be high frequency of energy-dense foods (high carbohydrate/sugar and/or fat content). Findings confirmed that a carbohydrate-rich food profile among the 12 most commonly consumed foods, including white bread, breakfast cereal, white rice, food drinks (e.g. Milo™), noodles, crisp, and powdered fruit drinks. Standard milk (full-fat variety) and crisps (also) fell into the high-fat foods category, and although chicken is primarily a protein food, a proportion of saturated fat is present depending upon preparation. In many Pacific homes, roasted whole chicken is a traditional and, for many, weekly food item, especially for Sunday lunch, church and family functions. Nutritionally beneficial apples and pears, oranges and mandarins, and bananas featured among the top 12 foods, also contributing to daily carbohydrate intake by including fibre. Vegetables did not appear among the most frequently eaten foods.

A third hypothesis was that consumption of energy-dense nutrient-poor foods and/or discretionary foods, including refined carbohydrates, high-sugar foods, snack foods and fast foods would be associated with prospective BMI. This hypothesis was not supported in this analysis. Instead, multivariate regression found that consumption of cooked green bananas at ages 4 and 6y was positively associated with BMI, BMI Z, weight and WFA Z scores at age 14 y. At age 6, four out of five (636/799) consumed cooked green banana regularly, with 68% of the cohort eating at least once per week.

Chapter 6 was an enquiry into relationships between key home environment variables, frequency patterns of important foods and BMI Z in the Pacific child cohort at age 9 years. Pacific children lived in households that were large, nearly a quarter single-parented, with a modest proportion of post-secondary-school maternal education (40%), and a higher scores in authoritative (median 41; IQR 37, 45) over authoritarian (median 22; 18, 25) parenting styles. These home and family factors represent an imbedded micro-environmental context for prepubescent child food and body weight. Overall, food frequency habits were consistent with those seen at the national level, such as high intakes of bread and fruit and low intake of vegetables. Larger household numbers and higher deprivation was related to greater frequency of bread consumption. Higher parental education and authoritative parenting style had a small albeit statistically significant and beneficial influence on children's body size. Parenting styles were also found to be important influences in the home food environment. Parenting styles that constitute consistently high nurturing and high responsiveness had favourable associations with food practices and body size in offspring, whereas styles of parenting that constitute low nurturing, high discipline and low responsiveness had a contrasting and deleterious effect on food practices and growth.

7.2 Significance of rapid growth in the context of food and home environment

This investigation adds to the work examining growth in a unique cohort and considers factors related to the developmental trajectory of body mass and height, associated with a high and increasing prevalence of overweight and obesity with age. Birthweight and early growth have been shown to track rapidly to age 10-11 (Rush et al., 2010; Rush et al., 2013; Rush, Paterson, Obolonkin, et al., 2008) and this thesis confirms the significance of that relationship to age 14-15. Previously, maternal smoking (Carter, Percival, Paterson, & Williams, 2006), breastfeeding and smoking (Rush, Paterson, Obolonkin, et al., 2008) pre-school food consumption (Rush, Paterson, & Obolonkin, 2008), physical activity (Oliver et al., 2011), parenting perceptions (Heimuli et al., 2011), puberty (Rush et al., 2015), and acculturation (Tseng et al., 2015) have been demonstrated as important predictors of Pacific child nutrition. Now, with this thesis, home environments, parenting styles and food patterns observed in the transition to school, have been added to the micro-environmental sphere of influence. The current findings on growth are consistent with a systematic review and meta-analysis which concluded that high birthweight is positively associated with increased risk of obesity throughout childhood (Yu et al., 2011). Furthermore, although prenatal factors are associated with child obesity, a recent assessment of the evidence strongly suggests that rapid postnatal growth, without prenatal or birthweight interaction, is an added risk factor for child and adolescent obesity (Matthews, Wei, & Cunningham, 2017). This suggests that healthy-weight interventions should continue to play an important role in early childhood regardless of the presence of prenatal and gestational obesity risk factors.

Psychosocial consequences are one of the key concerns arising from obesity in children in addition to obesity and physical and metabolic comorbidities in adulthood (Dietz, 1998; Guo & Chumlea, 1999; Rankin et al., 2016). A recent review of studies concluded that "psychological comorbidities, such as depression, poorer perceived lower scores on health-related quality of life, emotional and behavioural disorders, and self-esteem during childhood" were negatively related to overweight and obesity (Rankin et al., 2016). In addition, overweight and obese children were more likely than healthy-weight children to experience 'multiple associated psychosocial problems', which the authors suggest are due to obesity related stigma, teasing and bullying (Rankin et al., 2016). In addition, obesity does not necessarily mean over nourished but can mean poorly nourished and be associated with micronutrient deficiencies, which further impact on cognition, learning and psychosocial problems (Sim, 2016)

Crucially, the enduring impact of early child overweight and obesity is related to metabolic-related disease (type-2 diabetes, hypertension, ischaemic heart disease and stroke) and premature mortality in adulthood (Reilly & Kelly, 2011). Rapid weight gain in early childhood (0-6 months and 2-3 y post-partum) has been attributed to raised systolic blood pressure in mid-childhood (6-10y) irrespective of birthweight (Perng et al., 2016). Other studies have found that overweight and obese children experience advanced bone age and increased linear growth (Hyppönen, Virtanen, Kenward, Knip,

& Akerblom, 2000; Laitinen, Power, & Järvelin, 2001; Sopher et al., 2011). This is consistent with the current thesis where height exceeded WHO (2007) references throughout most of the childhood years.

Obesity is a major driver of the growing incidence of paediatric type-2 diabetes mellitus (T2DM). A meta-analysis of cohort studies in the Asia-Pacific region found that the relative risk (RR) for T2DM incidence for obese was seven times greater (7.28, 95% CI: 6.47, 8.28) and for overweight three times (2.92, 95% CI: 2.57, 3.32) greater to that of non-overweight participants (Abdullah, Peeters, de Courten, & Stoelwinder, 2010). In New Zealand, T2DM in young people is occurring most frequently among young Pacific peoples (Craig et al., 2016). In 2014/2015 measures among the PIF cohort (mean age 14.3 y), 32/931 children were identified with glycated haemoglobin (HbA1c) >40 mmol/mol, where only four had been diagnosed previously, including one with type-1 diabetes (Rush et al., 2016). Nationally, between 2008 and 2012, 140 Pacific and 146 Non-Māori/Non-Pacific children and young people (0-24y) were hospitalised with a diagnosis of T2DM (Craig et al., 2016). Admission rates per 100,000 population were significantly higher for Pacific compared with non-Māori/non-Pacific children and young people (rate ratio=9.04, 95% CI: 7.54–10.84) (Craig et al., 2016). Further, RR for T2DM is eight times higher among obese women and six times higher among obese men compared to non-obese women and men (Abdullah et al., 2010). Thus, approaches for prevention of obesity and T2DM must consider gender differences in the development of strategies for obesity reduction.

For the present investigation, food patterns are distinct from dietary patterns. Food patterns are defined as foods or food groups identified by frequency of consumption, whereas dietary patterns are identified as clusters of foods that make up the diets of individuals. Analyses in this investigation focussed on patterns of frequency and tracking of similar foods that are eaten most often. In particular, this enquiry captured food patterns for Pacific children during a critical period of physical and cognitive development, the transition to school. The most frequently eaten foods among the cohort consist mostly of energy-dense varieties, particularly refined carbohydrates such as white bread and rice, breakfast cereal, snack foods and beverages (cordials and food drinks). Although foods remain variable, consumption of similar foods during the transition to school are significantly correlated (r^2=0.53) which is consistent with food pattern tracking in other populations. For example, Lioret et al. (2015) found similar foods tracked 'moderately' (rho=0.35, p<0.001) from infancy to early childhood (ages 3 to 5 y), and the patterns remain as children age. Using Cohen's kappa (inter-rater reliability), (Patterson et al., 2009), observed 'fair to slight' tracking of all nutrients over a six year period from childhood to adolescence (age 9 to 15 y; κ=0.30), and from adolescence to adulthood (15 to 21 y; κ=0.24). The present findings are consistent with this international evidence and translates to Pacific food tastes and preferences being developed early in life. Further inference describes Pacific children's early food patterns as representing an energy-dense intake in the pathway to body size and growth.

Previously in this cohort, frequency of specific foods (protein and dairy) were positively associated with rapid growth in children up to age 4 y (Rush, Paterson, & Obolonkin, 2008). In the analysis of food patterns and growth for this thesis, frequency of consumption of cooked green bananas at age 4 and 6 y was positively associated with 14 y weight, weight SDS, BMI, and BMI SDS, and mixed vegetables were negatively associated (Table 5.4). The association with mixed vegetables was expected but the association with cooked green bananas was not as green bananas have low-sugar and high-fibre content in the form of resistant starch (Thakorlal et al., 2010). It is suggested that the relationship might be confounded by high intake of other energy-dense foods (such as coconut cream) or by other sociocultural factors, such as acculturation, that act as markers of food patterns of people who frequently consume green bananas. It is further speculated that the association is influenced by a combination of both but with underlying sociocultural influences playing a major role in overall food consumption patterns. This is proposed as only foods in the top 50% of most frequently eaten foods were included in the model meaning other energy-dense foods were likely excluded. Further, sociocultural factors such as acculturation strongly influence lifestyle behaviours related to food consumption, physical activity and growth trajectory. In summary, this suggests that regardless of apparent associations between early childhood consumption of green banana and growth, it is likely that the association may be the result of other factors not measured or controlled for in the analysis.

Rapid growth in this cohort is uniquely linked to every day exposure to a micro-environment across the first 14 years situated within a multicultural community in challenging socioeconomic conditions. The significance of maternal factors as the primary caregiver in the child’s environment cannot be understated. The evidence in this thesis shows that a nurturing and responsive parental home environment is associated with healthier early childhood food patterns and physical development. Maternal and child support is needed in the early years to ensure optimum nutrition, appropriate combinations of foods that promote a healthy growth rate and good dental health for the growing child. Children’s food patterns are linked to food provision, which in turn is determined by sociodemographic circumstances in the home and moderated through parenting. Ethnic group differences in food consumption must be considered in the delivery of culturally appropriate and effective public health messages.

The high consumption of bread in this cohort support the argument that bread is a reliable source of low-cost energy especially for larger families. Bread is a grain product, and whole-grain and high-fibre breads are recommended foods, as they are associated with decreased risk of heart disease, type-2 diabetes, weight gain and some cancers (MoH 2015b). Alternatively, white bread has lower nutritional value but more energy (kilojoules) due to refining. Wirfält et al. (2001) found that "[f]ood patterns dominated by fibre bread provided favourable effects, while food patterns high in refined bread or in cheese, cake, and alcoholic beverages contributed adverse effects" (p1150). In this investigation, frequency of bread was negatively related to consumption of fruit and vegetables, suggesting at least two possible explanations. Firstly, socioeconomic circumstances faced by families of high consumers of bread may affect availability of fruit and vegetables and, secondly, that there is likely displacement of such highly nutritive food options with bread. However, bread is a staple food, and thus presents opportunities to develop and implement strategies aimed at increasing accessibility and desirability of whole-grain/high-fibre varieties. Provision of incentives for producers and retailers to provide nutritionally enhanced breads at lower cost may be effective. This is likely to improve nutritive intake among socioeconomically disadvantaged communities who are currently high consumers of white bread.

What can be gained in learning about home environments, parenting and the associations with food habits with physical growth in Pacific children? Harnessing the knowledge of modifiable environmental characteristics that drive outcomes for vulnerable children is relevant to understanding the developmental origins and trajectory of health and disease. Parenting that entails a high level of nurturing and control has been shown to contribute healthy food habits and growth, which is consistent with the idea of nurturing resilience in children for families who might encounter adverse nutritional environments. Timing of interventions during sensitive periods of growth and development is crucial to circumventing leptogenic barriers and prioritised in the broader scheme of optimal and equitable child rearing capacity (Kvalsvig et al., 2015). This is particularly important as it is in the early years when genetic plasticity is formative and food/taste habits are developing. Nutrition-based interventions in adolescence may be less effective than in early childhood but should nevertheless be encouraged with future generations in mind (Salam et al., 2016).

In 2013, a relatively high proportion (38.4%; n~54,569) of Pacific children and young people were living in socioeconomically deprived neighbourhoods (Simpson et al., 2016). Since market deregulation in the 1980's, Pacific have endured higher unemployment or longer work hours on lower incomes in an environment of increasing living costs (Walrond, 2014). Adequate and appropriate nutritious food is an essential part of food security that many low-income and Pacific families have found difficult to achieve and maintain (Rush et al., 2007). Thus, observed food patterns are energy-dense, defined by high consumption of low-cost carbohydrates, sugar and convenient foods, such as bread, sugary drinks, hot chips and snacks. Availability of such food is made easy by the high density of convenience and fast food outlets in socioeconomically deprived neighbourhoods and ethnic communities (Ford & Dzewaltowski, 2008; Pearce et al., 2007; Vandevijvere, Sushil, Exeter, & Swinburn, 2016). Energy-dense food is ubiquitous, and easily accessible both on the way to and within destinations such as schools, work places, church, retail and entertainment centres, sports venues, extended family and other social locations (Vandevijvere et al., 2015). Access and availability of fast food outlets and other convenience stores could increase the potential for consumption of such foods when children are travelling to school although more work is needed to provide conclusive evidence (Clark et al., 2014). Genetic contributions, such as demonstrated in Samoan cohorts (Minster et al., 2016), is also likely to contribute to Pacific children's rapid growth, compounding susceptibility to store energy and grow faster than children from other ethnic groups.

7.3 Significance in the Oceanic context

How do the findings in this thesis compare in the context of other longitudinal studies in the Oceanic region that examine micro-environmental factors associated with physical growth of children? This section provides a comparative discussion of relevant longitudinal studies in the region in relation to the topics examined in this thesis (Appendix H). The discussion focusses on contemporary studies relevant to the time-period of the Pacific Islands Families (PIF) study and this thesis. It looks at sample size, retention and sample characteristics, which lead the discussion into comparisons of study content.

Perhaps the most important highlight is that the PIF study is the only known current birth cohort study that incorporates examination of physical growth trajectory focussing specifically on children of Pacific Island heritage. There have been, and currently are, very few longitudinal studies that have consisted entirely of, or included samples of, Pacific populations. The only known example of an entirely Pacific sample is the Kauai (Hawai'i) Longitudinal Study that began in 1955. Briefly, the study was based on one island, Kauai, in the Hawai'i group and was mainly focussed on psychological risk and resilience factors in the birth cohort (Werner, 2009). As the cohort is now in their sixth decade, further insight is not relevant for comparison to the PIF cohort. Apart from that study, the only other current birth cohort that includes an identified sample of Pacific children is the Growing up in New Zealand (GUiNZ) study, beginning in 2009.

This brings us to a key element of longitudinal studies, which is sample size and retention. At the outset, the GUiNZ study recruited 6822 mothers, where 17% (n=1151) of mothers and 13% (n=580) of partners identified with at least one Pacific ethnicity (Morton et al., 2013). It is unclear how many Pacific children are identified but 1321 mothers and 617 partners identified their child as being of Pacific ethnicity (Morton et al., 2010). This is similar to the PIF study's sample of 1379 (singleton) children, all of which had at least one parent who identified with a Pacific ethnicity. Retention of the GUiNZ child cohort has only been published for the 24-months follow-up, which was 92% (n=6327) of which 20% were Pacific (n~1265) (Morton et al., 2014). This is a strength of the GUiNZ study when compared with 75% of PIF retention at 2 y. As the GUiNZ study is relatively young, current publications relating to growth outcomes only refer to outcomes at 24 months.

The Auckland Birthweight Collaborative (ABC) study (n=1714) started with a Pacific cohort (n=291; 17%) (Thompson et al., 2001). However, because retention of non-European ethnic groups was low in follow-up waves, generalisation of findings could not be applied to those population groups (Morgan et al., 2010). As a result, only the European ethnic group was included at the 11 y wave. The exclusion of other ethnic groups would at least partly explain the low retention of 32% (n=546). This is unfortunate as the detail in growth and trajectory outcomes examined in this study were similar to this thesis, and wide-ranging with the analysis of genes previously linked to obesity (Morgan et al., 2010). If the PIF study were to examine genetic markers of obesity, the ABC study could provide a good comparison study for the PIF cohort. Compared with the PIF study, the ABC study collected limited detail on environmental and dietary-related factors, although some key maternal factors were examined in relation to the child being small for gestational age (Thompson et al., 2001). Further examination of environmental factors throughout childhood could be beneficial for comparative differences of longitudinal environmental factors between Pacific and NZ European groups.

Only one of the six relevant Australian longitudinal studies identified, the Growing Up in Australia study, also known as the Longitudinal Study of Australian Children (LSAC) is likely to have a Pacific sample as it is a nationally representative sample (n=10,000). However, none of the publications or reports canvassed provided evidence or data on ethnicity in the cohort. Pacific ethnicity may not be a significant component for the LSAC study as although people identifying as Pacific in Australia are over a quarter of a million (n=279,228) they only represent 1.3% of the total Australian population (2011

Census of Population and Housing, Australian Bureau of Statistics, cited in Ravulo (2015)). The LSAC study holds a wealth of information on potential home/family environmental influences, including dietary information from two distinct cohorts, the baby (B) and kindergarten (K) cohorts (Meyerkort, Oddy, O'Sullivan, Henderson, & Pennell, 2012). There are also anthropometric measures taken at all six waves for the birth ('B') cohort at ages 0, 1, 2, 4, 6, and 8 y, allowing for potential examination of growth trajectory.

All of the remaining five longitudinal studies in Australia were unlikely to have a relevant Pacific sample as they either specifically stated the ethnic groups of the cohort and did not include Pacific (n=4), or entirely omitted description of the ethnic composition of the cohort (n=1: the WATCH study). For those that do include ethnicity describe the cohort as being indigenous (the Aboriginal Birth Cohort and Gudaga Study) or Caucasian (Generation 1 and the Tasman Infant Health study).

Referring back to sample size, after the ALSAC study, the next largest is the Tasman Infant Health (TIH) study with n=1433 singletons. The TIH study commenced in 1998, two years prior to the PIF study, and at the most recent measurement wave (age 16 y) the TIH study had retained contact with 30% (n=415) of its cohort. An investigation at age 8 y (4th wave), which examined the interaction of genes linked to lipid metabolism (APOE genotype) and cardio-respiratory fitness on adiposity, obtained complete data from 20% (n=292) of the cohort (Ellis et al., 2011). A later investigation at age 16 y (5th wave), examined the influence of maternal diet and breastfeeding on adolescent body composition, obtaining complete data for 18% of the cohort, with 264 mother-adolescent dyads (Yin, Quinn, Dwyer, Ponsonby, & Jones, 2012). These retention rates are low in comparison to the PIF cohort's 65% at 9 y and 66% at 14 y, but the investigative content of the role of genetic contributions and antenatal maternal diet on child (or adolescent) adiposity are factors the PIF study have not collected data for. For this thesis, examination of limited post-partum dietary data were beyond the scope of this enquiry. Also not known with any certainty is how many mothers had gestational diabetes. Breastfeeding was also not factored in analyses of this body of investigation, but in earlier analysis it was found that the protective role of breastfeeding in childhood weight gain observed at 4 y had disappeared by 6 y (Rush et al., 2010).

The remaining four studies had sample sizes of less than 1000 child participants at baseline. These ranged from 686 participants in the Aboriginal Birth Cohort Study (ABCS) at the higher end, to the smallest sample of 159 participants in the Gudaga Study. The ABCS and Gudaga Study are valuable in their own right as two of the few longitudinal investigations into the indigenous peoples of Australia. There is one other larger (n=1687) key indigenous study, the Longitudinal Study of Indigenous Children (LSIC), which is linked with the LSAC study and commonly known as the 'Footprints in Time' study. However, LSIC was excluded in this discussion because of low comparability as neither follow-up nor anthropometric outcomes had been published or provided in technical reports at the time of writing. This is likely influenced by the complexity in data collection (e.g. dual cohort and remote communities) and age of the study, which commenced only in 2008.

Conversely, the ABCS commenced in 1987 making it the longest running study included in this comparative discussion. The challenge faced by researchers of participants living in remote communities is common, particularly in longitudinal studies of Aboriginal peoples. At age 8-14 y (mean 11.4 y), 482 (70% of baseline) children were tracked in the ABCS to investigate differences in growth and morbidity in terms of urban versus remote residence (Mackerras et al., 2003). Findings revealed that compared with their urban counterparts, remote children in general were significantly ($p<0.001$) shorter (by 4.6 cm), lighter (by 6.8 kg in weight median) and correspondingly had lower BMI (by 2.6 kg/m^2 in BMI median). Differences in BMI attributed to level of urbanised lifestyle have also been observed between samples of children from the PIF study identified as Cook Island Māori and two separate samples of children residing in the Cook Islands (the main island of Rarotonga and a remote outer island of the Northern Cook Islands) (Stewart et al., 2014). Children from the remote island had significantly lower BMI SDS (mean 0.72; 95% CI 0.57-0.87) compared with the highly urbanised children from the PIF study (1.62; 95% CI 1.46-1.47), signalling an important macro-environmental contribution attributed to living an urban lifestyle.

Similar to the PIF study, the Gudaga Study was a birth cohort established in an urban community which, however, had a much smaller baseline (n=159) and comparably younger than the PIF study after commencing only in 2005 (Comino et al., 2010). Further, the study design and motivation were similar to PIF in that it focussed on an indigenous community in a specific urban region and it was not intentionally designed as a longitudinal study. To the best of the author’s knowledge, the Gudaga Study had only secured funding to 2012, in contrast to the PIF study that has been in operation for over 15 years at the time of writing.

A further relevant observation in longitudinal studies with Aboriginal Australians highlighted above are issues related to retention and tracking of participants in remote locations. Participants in the PIF study are both mobile (intentional) and transient (compelled), where many have the ability to return to parental homelands, some of which are on remote outer islands. However, at 14 y, more than a fifth of PIF participants had relocated either to other parts of New Zealand (4%) or to other countries (18%), particularly Australia (16%). Relocation most often occurs for educational, employment and income purposes. However, the high level of transience among Pacific families in Auckland especially is also likely related to lower rates of home ownership and low incomes, all of which can impact negatively on children’s education and on physical, emotional and mental health (A. Johnson, 2002). Thus, the

PIF study retention rate is affected by familial socioeconomic factors that can compel participants to relocate both domestically and internationally, posing time and cost challenges in cohort tracking.

The Women And Their Children's Health (WATCH) Study is also a relatively young and small study, commencing only in 2006 with n=180 mothers and n=182 babies (Hure, Collins, Giles, Wright, & Smith, 2012). However, the small sample size has enabled the WATCH study to be the most closely monitored observation of foetal and child growth at least in this comparison of birth cohorts in the Oceanic region. Beginning in the second trimester of pregnancy, with four follow-up waves before birth, then three monthly follow-ups in the first year, and then annually to age 4 y. The breadth of information is also a strength of the WATCH study, with detailed dietary data of mother and child, child and parental anthropometry, physical activity, medical history and psychosocial constructs. This study has vast potential to examine a plethora of biological and environmental influences on the growing child. However, relevance to ethnic or minority populations is unknown, as at the time of writing, publications from the WATCH study do not provide this information.

The final study in the comparison is the Generation 1 (Gen1) study, which had a Caucasian cohort of n=557 mother-child dyads (at baseline). It commenced in 1998 and has a relatively similar (post-partum) follow-up pattern as the PIF study. The most recent follow-up at 9 y reported a retention rate of 80% (n=443) compared with PIF study rate of 65% (n=885) at the same age. The difference in retention rate between PIF and Gen1 may be testament to the ethnic composition of each study, a dominant versus a minority community. When compared with the present body of work, another strength of the Gen1 study in terms of understanding growth includes the recording of pre-pregnancy BMI and relevant gestational information such as glucose tolerance and gestational weight gain. Indeed, at age 9 y pregnancy BMI appeared to have the strongest influence on child obesity (measured by BMI Z, percent body fat and waist to height ratio) over other factors (Maftei, 2011). Similar to this thesis, Maftei (2011) had available maternal education as a socioeconomic variable but this was included as a confounding rather than an explanatory variable. Further testament to a socioeconomic differentiation between the Gen1 and PIF cohort was that half (49%) of the Gen1 cohort (versus 40% PIF mothers) had had any post-secondary education. However, the use of educational attainment as a confounding variable was suitable as the relationship with physical measures was somewhat N-shaped where children of mothers who had attended TAFE or college had significantly higher BMI Z and weight-to-height ratio compared to children whose mothers had not completed high school. Interestingly, other potential (environmental) confounders, such as maternal age, smoking, parity and pregnancy-induced hypertension were not associated with child anthropometric outcomes. Finally, the main aim of the Gen1 study for Maftei (2011) was to examine the influence of pre-pregnancy factors on pre-pubertal child obesity with no attention given to dietary influences, unlike the current thesis where key micro-environmental factors in food and family were considered predictors of child growth

7.4 Limitations and strengths

There are several limitations to this body of work including the design of this thesis. Although hypotheses were informed by the literature, this thesis was opportunistic as it used secondary data. A large amount of potential explanatory data had already been collected – food frequency, home environments – but had not been examined. Research question outcomes relied on questionnaire design and data collected in the earlier waves of the PIF study (birth to age 6 y). However, the author was involved in data collection at the 9 y measurement wave and had first-hand experience of children's school and home contexts. This involvement enabled the author to be regularly immersed, for a period of around 18 months, in the environments experienced by these Pacific children on a daily basis. The author also worked on the 11 y wave as a field worker coordinator and was later involved in the PIF study development for the 14 y measurement wave, but it was not intended that data from that wave would be used in this thesis. However, inclusion of the 14 y anthropometry was justified on timing of the data, epidemiological relevance and nature of the thesis topic.

Another limitation with this body of work is that, due to the longitudinal nature of the study, participants may change from one follow-up wave to the next. There are participants for whom one reason or another are not able to participate at a certain follow-up. Thus, prevalence rates, such as in weight status, fluctuated year-on-year, potentially confusing the picture of cohort weight-change over time. Additionally, longitudinal investigations are subject to retention issues where participants may drop out due to lack of motivation or significant life events, such as changing country of residence or death. Often, in vulnerable populations, household or family members change residence due to stress resulting from family relationships or poverty. Poverty is also related to individual, family or household transience because of low home ownership, a large problem in the study location (Auckland) in recent times. These issues present complex challenges in cost, time, data analysis and interpretation in the findings, although to date there have been no major biases identified in the relation to study retention in the PIF study.

Other potential limitations of the current thesis include the lack of maternal pre-pregnancy and gestational information, parental anthropometry and food habits, and detailed child feeding practices. The provision of (healthful and discretionary) foods in the home is the domain of parents and children’s eating patterns are modelled on parental eating habits (Couch et al., 2014; Wyse et al., 2011). Children also influence the presence of foods in the home when they communicate food preferences to their parents (Holsten, Deatrick, Kumanyika, Pinto-Martin, & Compher, 2012). Family meal frequency has also been associated with child nutrition (Utter et al., 2008) and parental obesity has been shown to be associated with overweight and obesity in offspring (Danielzik et al., 2004). Parental anthropometry was not collected in the early phases of the study and therefore longitudinal association of parental body size with child body size could not be accounted for in the analysis. However, food and obesity are public health problems that are complex, with multiple layers and diversity in risk factors ranging from genetic contributions to micro- and macro-environmental factors (Signal et al., 2013). Thus, efforts to explain food consumption, rapid growth and obesity are multifarious and not all factors can be included in a single body of work.

However, there are significant strengths to this investigation. In particular, the PIF study is the only known longitudinal birth cohort of Pacific Island peoples and the family has been included at all waves. This has resulted in a trajectory of information of familial, sociocultural and environmental factors, aiding understanding in the developmental origins of health and disease. Such robust data can be used to further enquiries related to health and wellbeing in vulnerable populations and inform action that aims to support healthy development in children. Further significance is that Pacific are considered a hard to reach population (Finau & Finau, 2007) and the high retention rate across several years of investigation is testament to the relationship the study personnel have developed with the cohort. As a result, this study is sufficiently powered to provide valid longitudinal information regarding structural and cultural impacts on an ethnic minority community. The collection of data across time permits stronger causal inferences to be made between factors (e.g. food) and outcomes (e.g. physical growth) than can be achieved in cross-sectional investigations.

Further, given the growing prevalence of overweight, another key strength of this investigation is the epidemiologically relevant cohort. Pacific children are a priority demographic for public health obesity prevention and the overall findings clearly highlight the urgency for intervention. Pacific people are constantly subjected to health research particularly related to body weight issues, yet rapid weight gain continues in conjunction with disparate levels of preventable chronic illness. Compared with other ethnic groups in New Zealand, the Pacific population is young, has the highest rates of extreme obesity and remain educationally and socioeconomically deprived. This study contributes substantively to an important knowledge gap in terms of understanding the relationship between home food environments and the influences on nutritional intake and body weight among Pacific children.

7.5 Conclusions, recommendations and future research

This body of work has investigated Pacific family home environments, highlighting parenting and children's food consumption, and relationships with body mass among pre-pubertal Pacific children in Auckland, New Zealand. "The family home is one of the earliest and most influential social and environmental contexts for promoting healthy eating and physical activity habits" (Jackson et al., 2017). However, the promotion of healthy habits needs to be supported by circumstances that enable families and parents to achieve that. Pacific family homes are comprised of parents and family who provide a highly nurtured and responsive environment for their children but in an environment of relatively low education and high deprivation. Low education is linked to poor health literacy and high deprivation is associated with food insecurity both of which are associated with suboptimal food quality. Thus, food patterns among young Pacific children are persistently energy-dense and nutrient-poor, inferring susceptibility to overweight and poorer health status. This constitutes the environmental path to rapid growth, consistent with a propensity for corpulence and excess weight gain. Pacific family homes are the driving force for Pacific child nutrition, dictated by socioeconomic and sociocultural underpinnings, a locus of control for parenting and moderating the potential of future health. Preparing children for optimal health and development is important for wellbeing of individuals, families, communities, society and economy.

The United Nations Charter for the Rights of Children recognises children as important contributing members to the ongoing growth and development of society (Smith, 2007). This implies that the productivity and success of society and the wellbeing of future generations will be shaped by the health of today's Pacific children. However, the influence of wider macro-environmental factors created by a global market-driven socioeconomic environment currently dominates the food, housing, educational and political landscape. The efforts of parents to provide their children with sufficient, culturally appropriate, and safe foods depends on stability in housing and family relations, adequate education, employment, income, and the food industry: the manufacture, distribution, cost and quality of food. All of these factors come together to improve the probability of achieving a healthful home food environment.

Recommendations

Obesity and its comorbidities are avoidable and all efforts to prevent excess weight gain need to be supported. Intervention programmes need to be targeted towards environments where food is obtained or consumed, starting from the home, food services and retail, social and religious institutions and schools. Focussing on achieving a healthier food environment is more effective than focussing on treating individuals, because a supportive environment makes it easier for individuals to make healthier decisions. The calorific composition of a given environment is the determinant of calorific intake. Creation of food surroundings of reduced calorific composition should reduce the propensity for high calorific intake, positive energy balance and adiposity gain.

Growth trajectory findings in this thesis suggest that, for those children not already obese, prevention should occur in earnest in early childhood to avert obesity in adolescence. Other evidence suggests that to prevent obesity in offspring or future generations, interventions should be actioned during adolescence or prior to pregnancy. These proposals suggest the implementation of strategies throughout all stages of life and across different sectors, since people transition through multiple levels of the environment at different age stages in their lives. Global and local level programmes are particularly important in trying to counteract phenotypical susceptibility to weight gain and susceptibility to its risk factors such as those identified in the Pacific gene pool. This is further evidence that individual-level approaches are not likely to be effective in terms of prevalence because individual-level strategies are short-term and do not address the current omnipresent surroundings that display, provide and encourage consumption, and discourage physical activity, such as in time- and energy-saving devices. Individual approaches are also more costly and time intensive than environmental approaches.

Based on the above, it is recommended that governmental approaches to prevent childhood obesity prioritise wide-ranging environmental strategies beginning with reducing poverty for families and households with vulnerable people. The current childhood obesity strategy of the New Zealand government (launched July 2016) prioritises an individual treatment approach with targeted interventions for those who are obese (MoH 2016b). The Ministry of Health target is that 95% of children identified as obese by the *Before School Check* by December 2017 will be offered a referral to a health professional for clinical assessment and family-based nutrition, activity and lifestyle interventions. This priority target is likely to have limited success with vulnerable families whose parents, despite wanting good health care for their child(ren), may have unstable living arrangements, lack income, employment or transport.

Although the government's childhood obesity secondary priority includes increased support for those at risk of becoming obese, the components are health promotion messages and guidance strategies for individuals to follow. The third priority advocates for broad strategies that make healthier choices were easier for consumers, which, in theory, are environmental approaches. However, how this is being implemented is difficult to ascertain as current efforts involving the food industry include self-preservation strategies such as self-regulation and monitoring. For example, the responsibility of marketing and advertising to children is devolved from central government to the Advertising Standards Authority (ASA), who are funded by the advertising industry, which in turn is funded by private business such as those in the food industry.

7.5.1 Future directions for research

The findings of this study have a number of important implications for future research and analysis of existing PIF data. As mentioned earlier, new research has highlighted the importance of the prenatal environment on offspring adiposity, suggesting that intervention must begin prior to conception to prevent excess gestational weight gain and diabetes. All efforts to provide a supportive maternal intrauterine environment to ensure adequate nutrition and physical activity must persist throughout gestation to achieve optimal health for the mother and unborn child.

Findings of relationships between growth spurt and signs of puberty in this cohort at age 9 and 11 y, (Rush et al., 2015) are consistent with other studies that found association between early menarche and increased body fat in adulthood (Laitinen et al., 2001). Further, results from the Avon Longitudinal Study of Parents and Children found that early menarche was significantly and positively associated to greater per-annum changes in offspring weight, height, BMI, and fat mass index in infancy (Ong et al., 2007). The implication is that the pathway to intergenerational obesity is being established in this cohort prior to adolescence.

Focussing on early childhood development can significantly improve health and wellbeing in later life, and implementing policy and programmes in early childhood that supports optimal development will harbour improved social and economic return (Office of the Prime Minister's Science Advisory Committee & Gluckman, 2011). Thus further research in education settings of Pacific children may provide important evidence for developing culturally appropriate interventions, such as in nutrition policy in early childhood and primary school settings. Early childhood settings outside of homes are pathways where children learn social values and norms, and providing the conditions that teach health and food literacy and normalise the consumption of nutritious foods can lead to healthier metabolic outcomes for children as they grow and develop. Such broad-sweeping supportive, environmentally-induced behaviour can lead to other favourable outcomes such as improved child cognition, executive function, self-regulation, and positive peer relations, all of which contribute substantially to healthy child development (Kvalsvig et al., 2015). Furthermore, improved child temperament can lead to positive parent-child interaction, creating positive familial relationships in homes and in other social locations such as work, church and play, which are essential elements for improving social capital and wellbeing.

Another important area that would benefit from further research is the interaction of Pacific children and youths with online environments, especially as social media use becomes increasingly prevalent in young people’s lives. In the PIF study at age 14 y, most youths (85%) spent some of their spare time on the internet, with over a quarter (28%) spending four or more hours online on a daily basis (Pacific Islands Families Study, 2016). The online environment is a source of both negative and positive effects for children but is one in which monitoring of digital activity is difficult for caregivers.

Although social networking sites may improve social connectedness and communication there is also increased potential for exposure to marketing of unhealthy foods such as energy-dense, nutrient-poor foods, especially on children's gaming websites (Harris, Speers, Schwartz, & Brownell, 2012; Scully et al., 2012). Children's food choices and requests are strongly influenced by advertising and the extent to which online marketing of nutritionally-poor foods, such as junk and snack foods, influence Pacific children is unknown and is an area worthy of investigation.

Closing remark

Multi-sectoral involvement is likely to be the best approach to achieving healthier food profiles in the homes of the socioeconomically disadvantaged and ethnic minority communities. The food environment is beyond the control of parents but is an environment that can be regulated by governments with a leadership style that values the wellbeing of the most vulnerable in society. Parents can only meet the requirements of a healthy diet for their children when the environmental circumstances to make the healthier choices the easier choice. One strategy that is likely to improve food environments is by making healthier foods easier to access and perhaps the best way for this to happen is to remove taxes on fruit and vegetables for a cheaper price point for all families, but especially families in most need of health intervention in our communities.

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Appendix

Appendix A Growth indicator reference using standard deviation scores (SDS) or z-scores (-1 to +3 above the median only) for children age 0 to 5 years. (Adapted from (WHO 2008))

	Growth indicators			
z-score	**Length/ height-for-age**	**Weight-for-age**	**Weight-for-length /height**	**BMI-for-age**
Above 3	(See note 1)	(See note 2)	Obese	Obese
Above 2	-	-	Overweight	Overweight
Above 1	-	-	Risk of overweight (See note 3)	Risk of overweight (See note 3)
0 (median)	-	-	-	-
Below -1	-	-	-	-

Notes:

1. A child in this range is very tall. Tallness is rarely a problem, unless it is so excessive that it may indicate an endocrine disorder such as a growth-hormone-producing tumour. Refer a child in this range for assessment if you suspect an endocrine disorder (e.g. if parents of normal height have a child who is excessively tall for his or her age).

2. A child whose weight-for-age falls in this range may have a growth problem, but this is better assessed from weight-for-length/height or BMI-for-age.

3. A plotted point above 1 shows possible risk. A trend towards the 2 z-score line shows definite risk.

Appendix B Change in mean weight and mean BMI for PIF and NZHS boys and girls from age 6 to 14 y.

	Mean weight (kg) 95% CI			Increase in mean weight		Unit difference in gain between PIF & NZHS		% difference in gain between PIF & NZHS	
	6y	11y	14y	6 to 11y	11 to 14y	6 to 11y	11 to 14y	6 to 11y	11 to 14y
PIF Boys	**28.9**	**55.7**	**82.1**	26.8	26.4				
	28.3, 29.6	54.2, 57.1	79.9, 84.2			5.3	7.6	24.7	40.4
NZHS	**24.8**	**46.3**	**65.1**	21.5	18.8				
Boys	23.7, 26.0	43.0, 49.7	61.9, 68.4						
PIF Girls	**27.6**	**55.8**	**78.1**	28.2	22.3				
	27.0, 28.2	54.6, 57.1	76.3, 79.8			6.3	9.3	28.8	71.5
NZHS	**23.8**	**45.7**	**58.7**	21.9	13.0				
Girls	23.0, 24.7	42.9, 48.5	56.4, 61.0						
	Mean BMI (kg\m^2) 95% CI			Increase in mean BMI					
PIF Boys	**19.1**	**23.7**	**27.6**	4.6	3.9				
	18.8, 19.5	23.2, 24.2	27.0, 28.3			1.4	1.7	43.7	77.3
NZHS	**17.4**	**20.6**	**22.8**	3.2	2.2				
Boys	16.8, 17.9	19.4, 21.8	21.8, 23.8						
PIF Girls	**18.6**	**23.4**	**28.6**	4.8	5.2				
	18.3, 18.9	22.9, 23.8	28.0, 29.2			1.4	2.7	41.2	108.0
NZHS	**16.7**	**20.1**	**22.6**	3.4	2.5				
Girls	16.3, 17.1	19.3, 20.9	21.8, 23.5						

Notes to Appendix B

PIF boys and girls at 6 y: mean age 6.3 y (range 6.0-7.3 y).

PIF boys and girls at 11y: mean age 11.2 y (range 10.8–12.3 y).

PIF boys and girls at 14 y: mean age 14.3 y (range 13.4-15.3 y).

Source for NZ children data: Table 2 Mean weight (kg). Time trends by sex and age, 2006/07-2014/15 (unadjusted mean weight, 95% confidence intervals, adjusted p-values for differences).

The total of all children in NZHS 2006/07 was n=1983 and counts for All children aged 6 y were not available. NZHS 2006/07 reports pool all children age 5 to 9 years total n=1476 (Boys n=748 (est. pop. 145,400); Girls n=728 (est. pop. 138,600)). If recruitment/response rates were approximately equally divided by five (age groups) and gender, approximate counts at age 6 y would be Boys n~150 and Girls n~146.

Total counts for all children from NZHS 2011 were not available.

Total of all children in NZHS 2013/14 was n=4754 and counts for children age 14 were not available. Reports pool all children aged 10-14 years n=1310 (MOH 2014 Methodology Report 2013/14; Table 9: Sample sizes and population counts, by age group, 2013/14. p.25). If recruitment/response rates were approximately equally divided by five (age groups) and the two gender groups, approximate counts at age 14 y would be (n=262; Boys n~131 and Girls n~131).

Mean weight and BMI from national health survey data was extrapolated to be contemporaneous and compared with the PIF sample (Table 4.7). Pacific children were heavier at both ages and mean weight increased much faster than the total population. The comparison also demonstrated the difference in magnitude between the genders. Pacific girls gained much more weight than the total population of girls compared with increases made by Pacific boys against all boys.

Reference.

Ministry of Health. 2014. Methodology Report 2013/14: New Zealand Health Survey. Wellington: Ministry of Health.

Appendix C Food Frequency Questionnaire (administered to parents at 4 and 6 y)

Food Questionnaire

Different eating patterns may affect people's health. To help us understand these eating patterns, we would like you to **think back over the past 4 weeks** and answer the following questions about the foods your child usually eats.

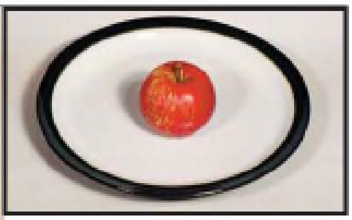
Put a tick in the box which best tells **HOW OFTEN** your child usually eats these foods.

Example

If your child eats apples on 3 or 4 days each week, put a tick in the '3-4 times a week' box.

2. Apples or pears

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☑	☐	☐	☐



If your child never or rarely eats a food, tick in the box 'never or less than once a month' and go to the next question.

It may be helpful to ask the person who does the cooking and shopping in your household to help you fill in the questions.

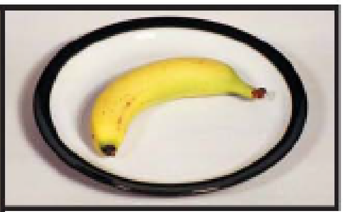
PLEASE DO NOT SKIP ANY FOODS

Put a tick ☑ in the box which best tells HOW OFTEN your child eats the food.

Fruit

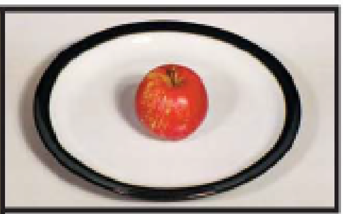
1. Banana, raw

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐



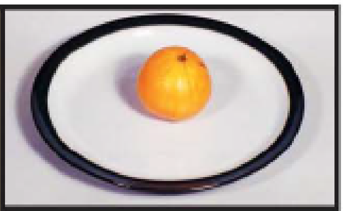
2. Apples or pears

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐



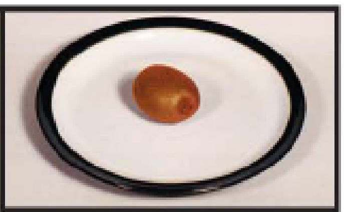
3. Oranges or mandarins

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐



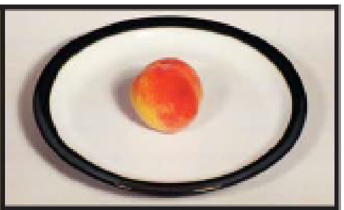
4. Kiwifruit

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐



5. Nectarines, peaches, plums or apricots

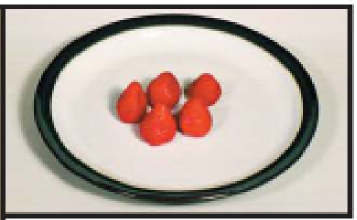
Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐



Put a tick ☑ in the box which best tells HOW OFTEN your child eats the food.

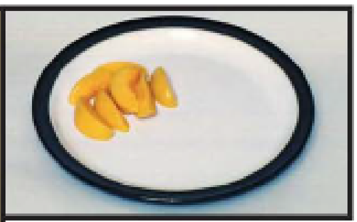
6. Strawberries or other berries

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐



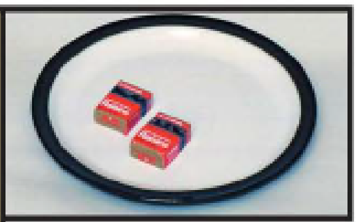
7. Canned or cooked fruit, eg. canned peaches

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐



8. Dried fruit, eg. raisins

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐



9. Other Fruit (1)

If your child often has another fruit, not listed - give the name and tick a box to show how often your child eats it ____________________

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐

10. Other Fruit (2)

If your child often has another fruit, not listed - give the name and tick a box to show how often your child eats it ____________________

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐

Put a tick ☑ in the box which best tells HOW OFTEN your child eats the food.

Vegetables

11. Fried potatoes, eg. hot potato chips, kumara chips, french fries, wedges or hash browns

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐

12. Other potatoes, eg. boiled, mashed, baked or roasted

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐

13. a.)**Taro mainly with coconut cream:** *(tick one of the two choices)*
Yes ____ *OR* **No____**

b.) Tick a box to show how often your child eats it:

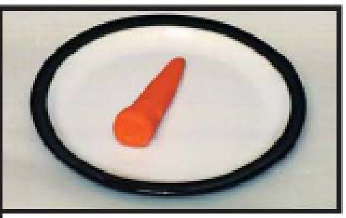
Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐

14. Kumara

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐

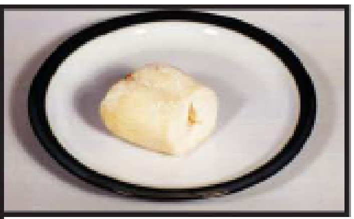
15. Carrots (raw or cooked)

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐



Put a tick ☑ in the box which best tells HOW OFTEN your child eats the food.

16. Cassava

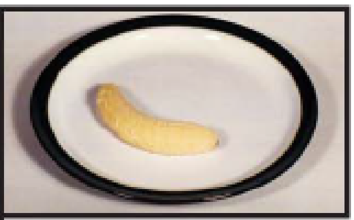


Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐

17. a.) Cooked green banana mainly with coconut cream:

Yes ____ *OR* No_____

b.) tick a box to show how often your child eats it:



Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐

18. Pumpkin

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐

19. Mixed vegetables

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐

20. Corn

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐

Put a tick ☑ in the box which best tells HOW OFTEN your child eats the food.

21. Peas

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐

22. Silverbeet, spinach, taro leaves, puha or watercress

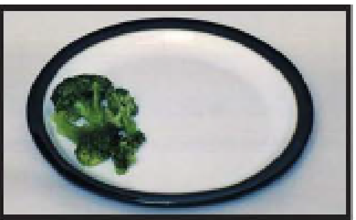
Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐

23. Green beans

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐

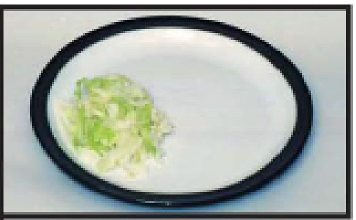
24. Broccoli

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐



25. Cauliflower or cabbage

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐



Put a tick ☑ in the box which best tells HOW OFTEN your child eats the food.

26a. Thinking about **cooked vegetables**, how often would your child have **roast vegetables?**

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐

26b. Thinking about **cooked vegetables** again, how often would your child have **butter or margarine** on them?

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐

26c. Which of these does your child usually have added to vegetables? (tick one box)

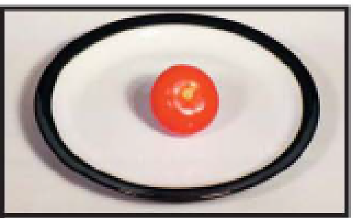
- ☐ butter
- ☐ low-fat spread
- ☐ margarine
- ☐ blend (margarine and butter)
- ☐ Don't have either
- ☐ Mayonnaise
- ☐ Coconut cream

Name of margarine or blend ______________________

27. Lettuce or green salad

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐

28. Tomatoes (raw or cooked)



Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐

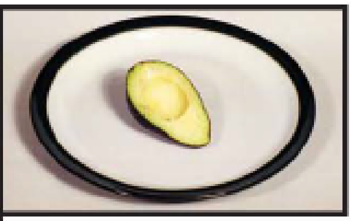
Put a tick ☑ in the box which best tells HOW OFTEN your child eats the food.

29. **Capsicum** (green, red or yellow peppers)

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐

30. **Avocado**

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐



31. **Other Vegetable (1)** If your child often has another vegetable, not listed - give the name and tick a box to show how often your child eats it

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐

32. **Other Vegetable (2)** If your child often has another vegetable, not listed-give the name and tick a box to show how often your child eats it

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐

Mixed dishes

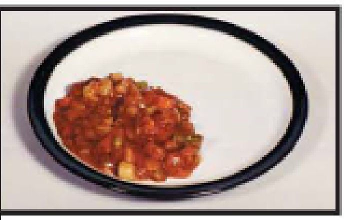
33. **Meat and vegetable 'boil-up',** eg. puha, povi masima, brisket, mutton flaps, pork bones

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐

Put a tick ☑ in the box which best tells HOW OFTEN your child eats the food.

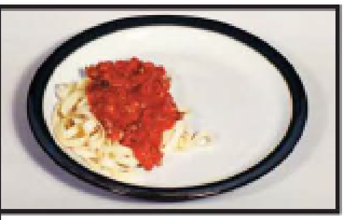
34. Meat stew or casserole with vegetables

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐



35. Pasta with meat and tomato sauce, eg. lasagne, spaghetti bolognaise

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐



36. Pasta with cream, white sauce or cheese sauce

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐

37. Chinese type dishes, stir-fry meat or chicken and vegetables includes chop suey

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐

38. Other Mixed Dish If your child often has another mixed dish, not listed - give the name and tick a box to show how often your child eats it

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐

Put a tick ☑ in the box which best tells HOW OFTEN your child eats the food.

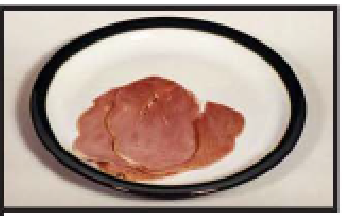
Eggs, meat, poultry and fish

39. Eggs, boiled, poached, fried or scrambled, etc

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐

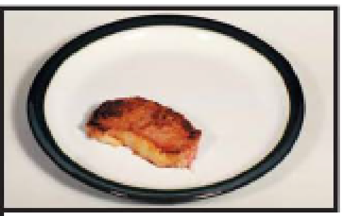
40. Roast beef, lamb or pork

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐



41. Steak

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐

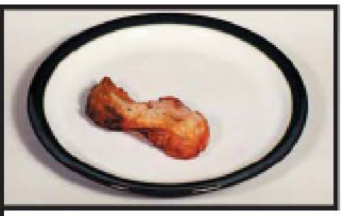


42. Lamb or mutton chops

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐

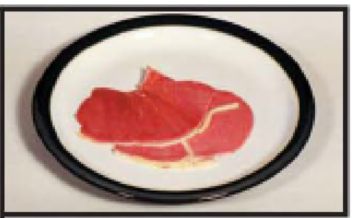
43. Pork chop (or other pork small cuts)

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐



Put a tick ☑ in the box which best tells HOW OFTEN your child eats the food.

44. **Boiled corned beef/silverside** **includes brisket**

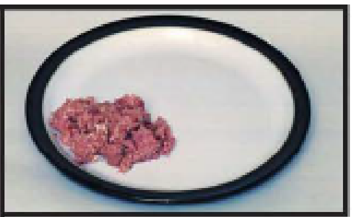


Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐

45. **a.) Canned corned beef mainly:** *(tick one of the two choices)*

full fat ___ *OR* **low fat**___

b.) Tick a box to show how often your child eats it:

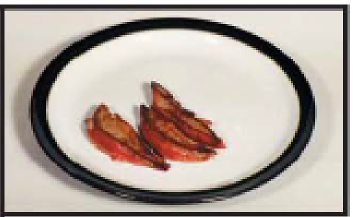


Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐

46. **Mince, including rissoles, patties, Shepherd's Pie, etc**

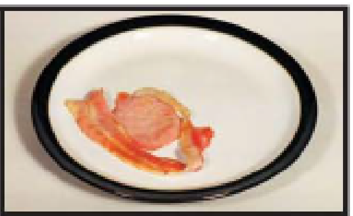
Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐

47. **Liver or liver paté**



Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐

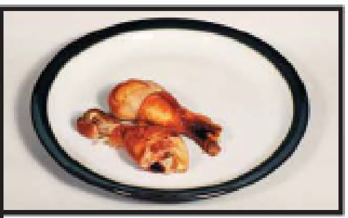
48. **Bacon or ham**



Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐

Put a tick ☑ in the box which best tells HOW OFTEN your child eats the food.

49. Chicken



Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐

49a. How often does your child ate **fried chicken or chicken nuggets?**
(tick one box)

- ☐ almost never or never
- ☐ ¼ of the time
- ☐ ½ of the time
- ☐ ¾ of the time
- ☐ almost always or always

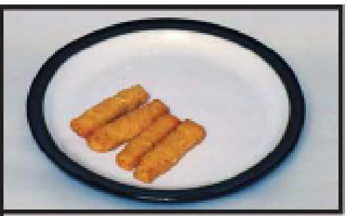
50. Fish

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐

50a. How often does your child ate **fried fish or takeaway fish or raw fish with coconut cream or milk?** (tick one box)

- ☐ almost never or never
- ☐ ¼ of the time
- ☐ ½ of the time
- ☐ ¾ of the time
- ☐ almost always or always

51. Fish cake, fish fingers or fish pie



Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐

Put a tick ☑ in the box which best tells HOW OFTEN your child eats the food.

52. **Canned fish,** eg. tuna or salmon

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐

53. **Shell fish,** eg. mussel, paua or crabmeat includes lobster

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐

54. **Other item of the 'Eggs, meat, poultry and fish' group.** If your child often have another item from this group, not listed - give the name and tick a box to show how often your child eats it ____________

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐

55. Which of the following **fats** were regularly used to cook your child's **meat, poultry or fish**? *(mark all that are used)*

- ☐ Don't know
- ☐ Margarine
- ☐ Butter
- ☐ Lard, dripping
- ☐ Kremelta type fat
- ☐ Canola oil
- ☐ Corn oil
- ☐ Olive oil
- ☐ Safflower oil
- ☐ Sunflower oil
- ☐ Other vegetable oil

Pies, burgers, sausage-meats

56. **Meat pie**

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐

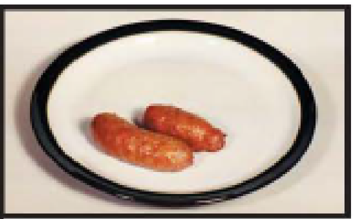
Put a tick ☑ in the box which best tells HOW OFTEN your child eats the food.

57. Burgers

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐

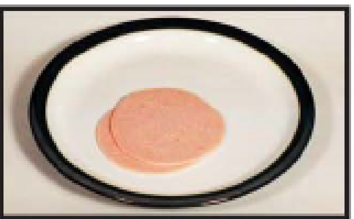
58. Sausages (all types)

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐



59. Luncheon, ham and chicken

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐



60. Sausage rolls

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐

61. Other item of the 'Pies, fast foods, sausages' group If your child often have another item from this group, not listed - give the name and tick a box to show how often your child eats it ____________________

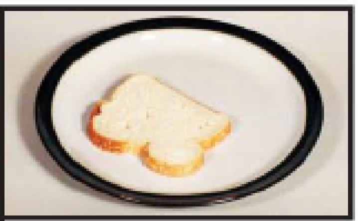
Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐

Put a tick ☑ in the box which best tells HOW OFTEN your child eats the food.

Bread and Cereals

62. **Bread, including toast and bread rolls**

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐



62a. What type of **bread** does your child usually eat? (tick one box)

- ☐ white
- ☐ wholemeal
- ☐ mixed grain

62b. How often does your child have **butter** on bread?

- ☐ rarely or never
- ☐ ¼ of the time
- ☐ ½ of the time
- ☐ most of the time

62c. How often does your child have **margarine or margarine blend** on bread?

- ☐ rarely or never
- ☐ ¼ of the time
- ☐ ½ of the time
- ☐ most of the time

62d. Which type of **margarines** does your child **usually** have?

- ☐ Polyunsaturated margarine, eg. Miracle, Meadowlea, Flora, Sunrise
- ☐ Canola margarine, eg. Gold'n Canola, Vraise Canola, Canola Harvest, Country Crock
- ☐ Olive oil, margarine, eg. Olivio, Olivani, Oliveta
- ☐ Blend of butter and margarine, eg. Countrysoft, Dairysmooth
- ☐ Don't know

Put a tick ☑ in the box which best tells HOW OFTEN your child eats the food.

62e. Is the **margarine** your child usually has, **reduced fat** or **lite**?

- ☐ Yes
- ☐ No
- ☐ Don't know

63. Breakfast cereal

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐

63a. What type of cereal does your child usually have? *(tick up to 3 boxes)*

- ☐ Weetbix type
- ☐ Cornflakes type
- ☐ Rice bubbles
- ☐ Cocopops
- ☐ Muesli
- ☐ Multi-grain type
- ☐ Porridge
- ☐ Other (Please give name) ______

63b. What **kind** of **milk** was usually added to your child's cereal?

- ☐ None
- ☐ Standard milk/dark blue
- ☐ Light blue
- ☐ Trim (green)
- ☐ Extra calcium
- ☐ Soy milk
- ☐ Other (Please give name) ______

63c. Was **sugar, honey or syrup** added to your child's cereal?

- ☐ Yes
- ☐ No

Put a tick ☑ in the box which best tells HOW OFTEN your child eats the food.

64a. Rice plain, sushi or brown

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐

64b Fried Rice

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐

65. **Other Bread and Cereals** If your child often has another item from this group, not listed - give the name and tick a box to show how often your child eats it

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐

Spreads, sauces

66. Jam or honey

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐

67. Nutella

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐

68. Marmite or Vegemite

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐

Put a tick ☑ in the box which best tells HOW OFTEN your child eats the food.

69. Peanut butter

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐

70. Mayonnaise or salad dressing, including coconut cream

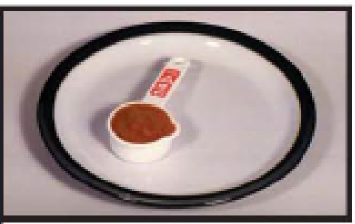
Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐

71. Tomato sauce or ketchup

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐

72. Gravy

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐



73. Other item of the 'Spreads, sauces' group If your child often has another item from this group, not listed - give the name and tick a box to show how often your child eats it ____________

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐

Put a tick ☑ in the box which best tells HOW OFTEN your child eats the food.

Convenience meals/snacks

74. Pizza

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐

75. Soup

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐

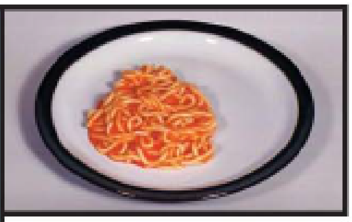
75a. What type of soup does your child usually have? *(tick one box)*

- ☐ Tomato soup
- ☐ Vegetable soup
- ☐ Cream soup
- ☐ Ham and pea soup
- ☐ Pumpkin soup
- ☐ Other soup (please name) ____________

76. Noodles

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐

77. Canned spaghetti with tomato sauce

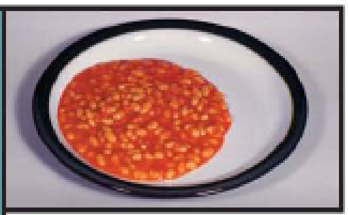


Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐

Put a tick ☑ in the box which best tells HOW OFTEN your child eats the food.

78. Baked beans

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐



79. Other item of the 'Convenience meals/snacks' group

If your child often has another item from this group, not listed - give the name and tick a box to show how often your child eats it ____________________

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐

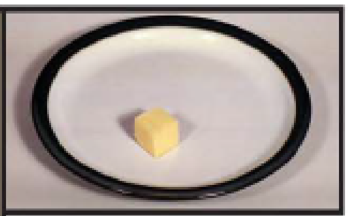
Dairy

80. Ice Cream

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐

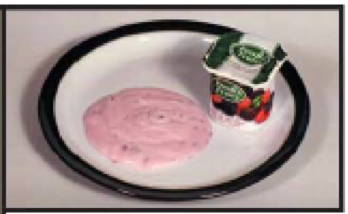
81. Cheese, eg. cheddar, colby, etc.

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐



82. Yoghurt or Dairy food (all types)

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐



Put a tick ☑ in the box which best tells HOW OFTEN your child eats the food.

83. Cream

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐

84. Other item of the 'Dairy' group (not milk drinks) If your child often has another item from this group, not listed - give the name and tick a box to show how often your child eats it ____________

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐

Biscuits/cakes

85. Chocolate coated or cream filled biscuits

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐

86. Biscuits, eg. plain, chocolate chip, semi-sweet, ginger nut, shortbread

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐

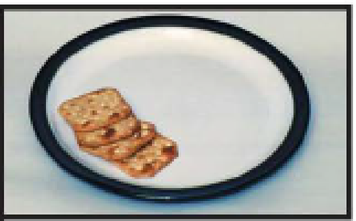
87. Bars, eg. muesli

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐

Put a tick ☑ in the box which best tells HOW OFTEN your child eats the food.

88. Crackers or crispbreads

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐



89. Cake or slice

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐

90. Doughnuts rings (deep fried) or croissants

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐

91. Scones, muffins or sweet buns

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐

92. Pancake or pikelets

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐

Put a tick ☑ in the box which best tells HOW OFTEN your child eats the food.

93. Fruit pie, fruit crumble or tart

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐

94. Pudding, eg. sponge pudding or steamed pudding

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐

95. Custard or custard puddings

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐

96. Other item of the 'Biscuits/cake' group If your child often has another item from this group, not listed - give the name and tick a box to show how often your child eats it ______________________

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐

Snacks and sweets

97. Potato crisps, corn snacks or chips, eg. burger rings, rashuns, etc

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐

Put a tick ☑ in the box which best tells HOW OFTEN your child eats the food.

98. Popcorn

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐

99. Chocolate, eg. Moro bar

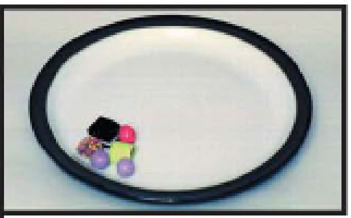
Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐

100. Candy coated chocolate, eg. pebbles

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐

101. Other sweets

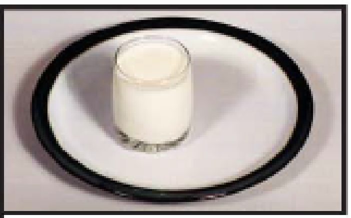
Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐



Milks

102. Milk (not flavoured)

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐

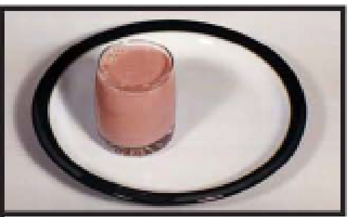


Put a tick ☑ in the box which best tells **HOW OFTEN** your child eats the food.

102a. What kind of milk does your child usually drink?

- ☐ Standard milk (dark blue)
- ☐ Trim (green)
- ☐ Soy milk
- ☐ Low fat (light blue)
- ☐ Extra calcium
- ☐ Other milk (please name) ______

103. Flavoured milk



Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐

104. Milk shake

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐

105. Food drink, eg. Milo powder, Nesquik

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐

105a. With this drink did your child use?

- ☐ All milk
- ☐ 1/2 milk
- ☐ 1/4 or less milk

Was sugar added?

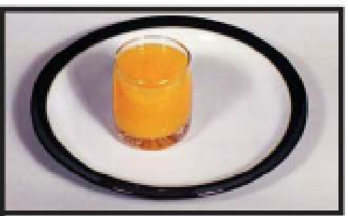
- ☐ Yes
- ☐ No

Put a tick ☑ in the box which best tells HOW OFTEN your child eats the food.

Other drinks

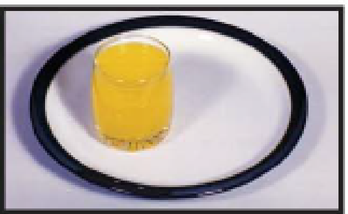
106. Juice, eg. fresh orange juice, juices such as McCoys, Robinson's, Keri

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐



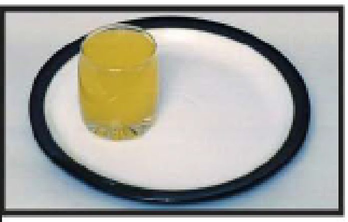
107. Powdered fruit drink, eg. Refresh, Raro

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐



108. Fruit drink from concentrate or cordial, eg. Just Juice, Ribena

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐



109. Coca cola or other cola drinks

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐

110. Mountain Dew

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐

Put a tick ☑ in the box which best tells HOW OFTEN your child eats the food.

111. 'New Age' drinks, eg. V, E_2, Red Bull

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐

111a. If you have 'New Age ' drinks, which type do you usually have? (tick one box)

- ☐ V
- ☐ E2
- ☐ Lift
- ☐ Red Bull
- ☐ Liquid B
- ☐ Ikon
- ☐ Bullrush
- ☐ Other (please name) ____________

112. Soft drinks, eg. lemonade, orange

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐

112a **Water with nothing added e.g. tap, bottle, water fountain**

Never or less than once a month	Less than 1 time/week	1-3 times a week	5-6 times a week	Once a day	2-4 times a day	More than 5 times a day
☐	☐	☐	☐	☐	☐	☐

113. Sports drinks, eg. Gatorade, Powerade

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐

114. Ice blocks

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐

Put a tick ☑ in the box which best tells HOW OFTEN your child eats the food.

115. Tea

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐

115a. Was milk added to your child's tea?

☐ Yes ☐ No

Was **sugar** added?

☐ Yes ☐ No

116. Coffee

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐

116a. Was milk added to your child's coffee?

☐ Yes ☐ No

Was **sugar** added?

☐ Yes ☐ No

117. Other item of the 'Other drinks' group. If your child often has another item from this group, not listed ***(e.g. Samoan Cocoa)*** - give the name and tick a box to show your child eats it ____________________

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐

118.

Any other foods or drinks at least once a week?
For example pacific specialities:

Poke (baked banana with coconut cream and arrowroot)

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐

Cook Island mayonnaise

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐

Takihi (taro, pawpaw and coconut cream)

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐

Other foods: please name ________________________

Never or less than once a month	1-3 times a month	1-2 times a week	3-4 times a week	5-6 times a week	Once a day	2 or more times a day
☐	☐	☐	☐	☐	☐	☐

Thank you very much for filling out this questionnaire.

Please take a moment to fill in any questions you have skipped.

Appendix D New Zealand Index of Individual Deprivation (NZiDep) 2006 (administered to parents at 9 y)

In the last *12 MONTHS*, have you *personally* been forced to buy cheaper food so that you could pay for other things you needed?

No	(0)	Yes	(1)	7

In the last *12 MONTHS*, have you been out of paid work at any time for more than one MONTH? *(**INT NOTE**: Defined as NO for those 60 and over, and for full-time care-givers/homemakers.)*

No	(0)	Yes	(1)	7

In the last *12 MONTHS*, have you *personally* put up with feeling cold to save heatin costs?

No	(0)	Yes	(1)	7

In the last *12 MONTHS*, have you *personally* made use of special food grants or food banks because you did not have enough money for food?

No	(0)	Yes	(1)	7

In the last *12 MONTHS*, have you *personally* continued wearing shoes with holes because you could not afford replacement?

No	(0)	Yes	(1)	7

In the last *12 MONTHS*, have you *personally* gone without fresh fruit and vegetables, *often*, so that you could pay for other things needed?

No	(0)	Yes	(1)	7

In the last *12 MONTHS*, have you *personally* received help in the form of food, clothes or money from a community organisation (like Salvation Army)?

No	(0)	Yes	(1)	7

The final (eighth) question of the NZiDep 2006 questionnaire which asks the participant whether in the last 12 months their partner had been on a means tested benefit was captured in an earlier question encompassing personal income (see below).

I am going to read out a list, and ask you to say "yes or no" to all the ways that YOUR PARTNER received PERSONAL INCOME in the last 12 MONTHS.

		No	Yes		
1.	Wages, salary, commissions, bonuses, redundancy	0	1	7	8
2.	Self-employment (or business you own and work in)	0	1	7	8
3.	Domestic Purposes benefit	0	1	7	8
4.	Unemployment benefit	0	1	7	8
5.	Other Government benefits (e.g. working for families, childcare/accommodation support)	0	1	7	8
6.	Interest, dividends, rent, other investments	0	1	7	8
7.	ACC regular payments	0	1	7	8
8.	NZ Superannuation (National Super)	0	1	7	8
9.	Superannuation, pensions, annuities (other than NZ Super or veteran's pension)	0	1	7	8
10.	Invalids/sickness benefit	0	1	7	8
11.	Student allowance	0	1	7	8

Appendix E Parenting Practices Questionnaire (administered to parents at 9 y)

SECTION D: RAISING CHILDREN

[PPQ Robinson 1995]

D.1. Please rate how often you exhibit or do the following behaviours with your child?
(INT: Show card 3)

Never	(0)
Once in a while	(1)
About half the time	(2)
Very often	(3)
Always	(4)
	7

1. I spoil my child...

   0 1 2 3 4 — 7 — D1

2. I yell or shout when my child misbehaves...

   0 1 2 3 4 — 7 — D2

3. I know the names of my child's friends...

   0 1 2 3 4 — 7 — D3

4. I smack when my child misbehaves...

   0 1 2 3 4 — 7 — D4

5. I punish by taking privileges away from my child with little if any explanation...

   0 1 2 3 4 — 7 — D5

6. I am easy going and relaxed with my child...

   0 1 2 3 4 — 7 — D6

7. I allow my child to annoy someone else...

   0 1 2 3 4 — 7 — D7

8. I scold (tell off) and criticise to make my child improve...

   0 1 2 3 4 — 7 — D8

9. I state punishments to my child and do not actually do them…

0 1 2 3 4 7 D9

10. I allow my child to give input into family rules…

0 1 2 3 4 7 D10

11. I argue with my child…

0 1 2 3 4 7 D11

12. I appear confident about parenting abilities…

0 1 2 3 4 7 D12

13. I give my child reasons why rules should be obeyed…

0 1 2 3 4 7 D13

14. I punish by putting my child off somewhere alone with little if any explanation…

0 1 2 3 4 7 D14

15. I help my child to understand the impact of behaviour by encouraging my child to talk about the consequences of own actions…

0 1 2 3 4 7 D15

16. I explode in anger towards my child…

0 1 2 3 4 7 D16

17. I am aware of problems or concerns about my child in school…

0 1 2 3 4 7 D17

18. I threaten my child with punishment more often than actually giving it…

0 1 2 3 4 7 D18

19. I use physical punishment as a way of disciplining my child…

0 1 2 3 4 7 D19

20. I tell my child what to do…

0 1 2 3 4 7 D20

21. I slap my child when he/she misbehaves…

0 1 2 3 4 7 D21

22. I allow my child to interrupt others…

0 1 2 3 4 7 D22

23. I explain to my child how I feel about his/her good and bad behaviour…

0 1 2 3 4 7 D23

24. I take into account my child's preferences in making plans for the family…

0 1 2 3 4 7 D24

25. I appear unsure on how to solve my child's misbehaviour…

0 1 2 3 4 7 D25

26. I explain the consequences of my child's behaviour

0 1 2 3 4 7 D26

27. I demand that my child does things…

0 1 2 3 4 7 D27

28. I emphasise the reasons for rules

0 1 2 3 4 7 D28

Appendix F Dietary Habits Questionnaire (administered to parents at 9 y)

DIETARY HABITS

I will ask you some questions about your child's usual eating patterns. When answering these questions please think back *over the PAST 4 WEEKS*. Remember to think about all meals (that is breakfast, lunch and dinner) as well as snacks, and times when you eat both at home and away from home.

On average, how many slices of bread or toast, or bread rolls does your child eat per day? *(INT: Show card 5)*

None [*INT NOTE:* Proceed to **E.4**]	(0)	3-4 per day	(3)
Less than one per day	(1)	5-6 per day	(4)
1-2 per day	(2)	7 or more per day	(5)

7

What type of bread, rolls or toast does your child eat most of?
(INT: Show card 6)

White	(1)	Heavy grain bread (e.g. Vogels and Burgen)	(4)
High fibre white	(2)	Other. *Please specify:*	(5)
Light grain bread (e.g. Molenberg, Freya's, Ploughmans, and MacKenzie High Country)	(3)	______________________ ______________________ ______________________	

7 8

On an average, how many servings of fruit (fresh, frozen, canned or stewed) does your child eat per day? Do not include fruit juice or dried fruit.

A serving is the same as a medium piece of fruit such as an apple or two small pieces of fruit such as two apricots, or half a cup of stewed fruit.

(INT: Show card 10)

Never, my child doesn't eat fruit	(0)	2 servings	(3)
Less than one serving per day	(1)	3 servings	(4)
1 serving	(2)	4 or more servings	(5)

7 8

On an average, how many servings of vegetables (fresh, frozen or canned) does your child eat per day? Do not include vegetable juices.

A serving is the same as one potato/kumara, half a cup of peas or a cup of salad. For example, 2 medium potatoes + ½ cup of peas = 3 servings

(INT: Show card 11)

Never, my child doesn't eat vegetables	(0)	2 servings	(3)
Less than one serving per day	(1)	3 servings	(4)
1 serving	(2)	4 or more servings	(5)

7 8

How often does your child eat fast food or takeaways from places like McDonalds, KFC, Burger King, Pizza shops or Fish 'n' Chip shops? Think about breakfast, lunch, dinner and snacks. *(INT: Show card 8)*

Never	(0)	3-4 times per WEEK	(3)
Less than once per WEEK	(1)	5-6 times per WEEK	(4)
1-2 times per WEEK	(2)	7 or more times per WEEK	(5)

7 8

How often does your child drink soft drinks or energy drinks? Do not include diet varieties.

Soft drinks are often carbonated or 'fizzy' and includes Coca-cola, Pepsi, Lemonade, Ginger beer, Energy drinks (e.g. 'V', Red Bull, Lift plus), Powerade, E2 and G-force.

[*INT NOTE:*: Excludes – 'diet varieties', fruit juices and drinks, flavoured waters (e.g. H2Go), and sports waters (e.g. Charlies Sports water, Mizone and Aqua-shot).]

(INT: Show card 8)

Never	(0)	3-4 times per WEEK	(3)
Less than once per WEEK	(1)	5-6 times per WEEK	(4)
1-2 times per WEEK	(2)	7 or more times per WEEK	(5)

7 8

Appendix G Univariate and multivariate odds ratios for consumption of dichotomised food habits based on NZ nutrition guidelines[ab]

	Fruit 2+/day OR (95% CI)		Veg 3+/day OR (95% CI)		Fast food 1+/week OR (95% CI)		Soft drink 1+/week OR (95% CI)	
	Univariate	**Multivariate**	**Univariate**	**Multivariate**	**Univariate**	**Multivariate**	**Univariate**	**Multivariate**
Gender Boys vs. girls	0.89 (0.62, 1.25)	1.11 (0.74, 1.66)	0.97 (0.75, 1.25)	0.95 (0.71, 1.28)	1.01 (0.78, 1.31)	1.14 (0.85, 1.54)	**1.66 (1.29, 2.16)**[***]	**1.68 (1.25, 2.25)**[***]
Household size (reference 2-4 residents)								
5-7 resident	0.65 (0.37, 1.14)	0.52 (0.27, 1.01)	0.97 (0.68, 1.39)	1.08 (0.72, 1.64)	1.13 (0.79, 1.63)	1.10 (0.72, 1.68)	1.24 (0.89, 1.78)	1.28 (0.84, 1.95)
8+ resident	0.63 (0.35, 1.14)	0.52 (0.25, 1.08)	0.85 (0.58, 1.26)	1.08 (0.68, 1.72)	1.18 0.79, 1.76)	1.07 (0.67, 1.73)	1.42 (0.96, 2.13)	1.48 (0.93, 2.37)
Parental status 2 parents vs 1	1.28 (0.89, 1.93)	1.37 (0.86, 2.18)	1.06 (0.78, 1.43)	0.98 (0.68, 1.39)	0.93 (0.68, 1.26)	0.93 (0.82, 1.06)	1.12 (0.82, 1.52)	1.16 (0.81, 1.67)
Education[c] Post-Secondary	1.19 (0.85, 1.66)	1.03 (0.68, 1.56)	0.99 (0.79, 1.23)	0.94 (0.70, 1.26)	**1.37 (1.09, 1.74)**[**]	**1.74 (1.29, 2.35)**[***]	1.12 (0.90, 1.40)	**1.37 (1.02, 1.84)**[*]
NZiDep Index[d] (reference 0 deprivations)								
1 dep	0.78 (0.51, 1.21)	0.57 (0.26, 1.25)	0.78 (0.51, 1.21)	0.79 (0.49, 1.28)	1.14 (0.73, 1.79)	1.30 (0.78, 2.16)	1.03 (0.67, 1.59)	0.93 (0.57, 1.51)
2 deps	**0.58 (0.38, 0.90)**[*]	0.79 (0.35, 1.79)	**0.58 (0.38, 0.90)**[*]	0.76 (0.47, 1.25)	**2.37 (1.51, 3.69)**[***]	**2.17 (1.30, 3.64)**[**]	1.29 (0.83, 1.99)	0.99 (0.60, 1.62)
3-4 deps	**0.44 (0.28, 0.69)**[***]	**0.43 (0.19, 0.94)***	**0.44 (0.28, 0.69)**[***]	**0.55 (0.33, 0.91)***	1.43 (0.91, 2.26)	1.39 (0.82, 2.37)	1.33 (0.85, 2.08)	1.05 (0.63, 1.74)

	Fruit 2+/day OR (95% CI)		Veg 3+/day OR (95% CI)		Fast food 1+/week OR (95% CI)		Soft drink 1+/week OR (95% CI)	
	Univariate	**Multivariate**	**Univariate**	**Multivariate**	**Univariate**	**Multivariate**	**Univariate**	**Multivariate**
5+ deps	**0.33 (0.19, 0.55)*** **	0.51 (0.21, 1.23)	**0.33 (0.19, 0.55)*** **	**0.34 (0.19, 0.60)*** **	1.46 (0.86, 2.46)	1.62 (0.90, 2.92)	1.39 (0.83, 2.31)	1.29 (0.73, 2.28)
Ethnicity (reference group Samoan)								
Niuean	0.66 (0.40, 1.08)	0.66 (0.37, 1.16)	0.76 (0.53, 1.09)	0.84 (0.56, 1.25)	**1.50 (1.05, 2.15)***	1.39 (0.92, 2.08)	1.36 (0.95, 1.94)	1.15 (0.76, 1.72)
Cook Island	0.72 (0.31, 1.70)	0.71 (0.27, 1.81)	0.76 (0.41, 1.40)	0.87 (0.44, 1.69)	1.70 (0.92, 3.13)	1.13 (0.57, 2.24)	1.46 (0.79, 2.70)	1.21 (0.61, 2.41)
Tongan	**0.49 (0.32, 0.77)** **	**0.48 (0.29, 0.79)** **	**0.33 (0.23, 0.47)*** **	**0.40 (0.27, 0.59)*** **	**2.29 (1.64, 3.19)*** **	**1.78 (1.23, 2.60)** **	**1.65 (1.18, 2.29)** **	1.31 (0.91, 1.89)
Other Pacific	0.62 (0.34, 1.15)	0.61 (0.31, 1.24)	0.68 (0.44, 1.07)	0.70 (0.42, 1.15)	1.40 (0.89, 2.21)	1.12 (0.67, 1.87)	0.88 (0.55, 1.40)	0.89 (0.53, 1.48)
Parenting style[e]								
Authoritative	**1.04 (1.01, 1.07)** *	1.02 (0.98, 1.04)	**1.04 (1.02, 1.06)** **	1.01 (0.98, 1.04)	**0.94 (0.92, 0.96)** ***	**0.95 (0.92, 0.97)** ***	**0.96 (0.94, 0.99)** **	**0.97 (0.95, 1.00)** *
Authoritarian	0.99 (0.96, 1.03)	1.02 (0.98, 1.05)	**0.93 (0.91, 0.95)** ***	**0.94 (0.92, 0.97)** ***	**1.05 (1.02, 1.07)** ***	**1.04 (1.01, 1.06)** **	**1.04 (1.02, 1.06)** ***	**1.03 (1.01, 1.06)** **

*p<0.05 **p<0.01 ***p<0.001; [a] NZ nutrition guidelines recommend that two servings of fruit and three servings of vegetables are consumed each day and that fast foods and sugar-sweetened beverages are consumed less than once each week; [b] 1 twin sibling removed; [c] Reference is no post-secondary school education; [d] New Zealand individual deprivation index; [e] odds ratios relate to a unit increase in the parenting style subscales.

Appendix H Selected contemporary birth cohort studies in New Zealand (NZ) and Australia with physical growth outcomes and/or trajectories

Study name, Country (Reference)	**Aim(s)**	**Cohort ethnic representation**	**Baseline year; Age waves**	**Baseline n, Retention% (age)**	**Home/Family environment, maternal predictors**	**Food/ nutrition predictors**	**Child growth outcomes/ trajectories**
Auckland Birthweight Collaborative study NZ (Morgan et al., 2010)	To test association of SGA and polymorphism in genes linked with obesity/T2DM	Caucasian	1995-96 birth,1,3,5,7, 11y	Mothers/ children 1714 32% (11y)[b]	Maternal smoking, stature, diet, ethnicity, hypertension	[Maternal diet]	11y height/Z, weight/Z, BMI/Z, obesity/T2DM risk allele genotype
Pacific Islands Families study NZ (This thesis)	Investigate relationships between physical growth, food and home environment factors Pacific children	NZ-born children of Pacific Island ethnicity	2000; 6w 4,6,9,11 & 14y	Mothers 1376 Children 1398 66.6% (14y)	BW, 9y Maternal NZiDep, education, household size, parenting style	4 and 6y FFQ, 9y selected foods – bread, fruit, vegetables, fast food, soft drink	4-14y height/Z weight/Z BMI/Z
Growing up in New Zealand (GUiNZ) NZ (Morton et al., 2012; 2010; 2013) (GUiNZ 2014)	Study outcomes and developmental trajectories; identify casual pathways across political, social, cultural, intergenerational, familial and individual levels of influence	Ethnically representative of births in NZ	2009; 28w gest. 6w 9, 24 & 54m	Mothers 6822 Babies 6846 95% (9m)	BW Parental education, smoking, SES, hardship	Maternal 4 item FFQ: 3rd trimester Child breast feeding, solid foods	4.5y height, weight
Aboriginal Birth Cohort Study Australia (Mackerras et al., 2003; 2010)	Investigate effects of foetal growth restriction on later growth and health	Children born to Aboriginal mothers	1987; Birth 11,18,25y	Mothers 686 Babies 686 68% (18y)	Maternal smoking Child BW, length. urban/rural residence, smoking (18y)	[Not reported]	Height, weight, skinfolds, waist

Study name, Country (Reference)	Aim(s)	Cohort ethnic representation	Baseline year; Age waves	Baseline n, Retention% (age)	Home/Family environment, maternal predictors	Food/ nutrition predictors	Child growth outcomes/ trajectories
Generation 1 Australia (Conn, Davies, Walker, & Moore, 2009; Maftei, 2011)	Study early life influences on obesity and fat patterning in children: critical periods, environmental, sociocultural context	Caucasian	1998; Antenatal 6,9,12m 2,3,5,9y	Mothers 557 Babies 557 80% (9y)	PP BMI, glucose tolerance, GWG	Food/nutrient intake (9m)	9-10y Child BMI Z, %BF, WHtR, insulin resistance
Tasman Infant Health study Australia (Ellis et al., 2011; Tikellis et al., 2012; Yin et al., 2012)	Study cause of SIDS. Study links between early life exposures and later disease	Caucasian Tasmanian infants at high risk of SIDS	1998; Birth,5,10w 7.5,16y	Mothers 1433 Babies 1433 30% (16y)	Maternal PP BMI, Ed, Parental status, employment, Child BW, PA,	Breast feeding Maternal FFQ 3rd tri. Child FFQ 5 & 10w Adolescent FFQ 16y	weight, height, BMI, OW, OB, Tanner stage, DEXA FM, LM, %BF truncal fat mass, waist,
Growing Up in Australia Australia (Gasser, Kerr, Mensah, & Wake, 2017)	Investigating the contribution of children's social, economic and cultural environments to their adjustment and wellbeing	Nationally representative samples of 0-1y and 4-5y olds[a]	2004 2 cohorts[a] **B 0-1y**: 2,4,6,8y **K 4-5y**: 6,8,10,12,14y	Families/ Children 10,000 B cohort 5107 K cohort 4983	Household structure, SES, parental style language, country of birth, employment,	Added sugar, food security,	B: 0-8y; K: 4-12y height, weight, BMI
Gudaga Study Australia (Comino et al., 2010)	To study the health, development and service usage of Aboriginal infants and their mothers	(Mothers of) Aboriginal infants	2005; Birth, 2.5w 1,3,5y	Mothers 159 Babies 159 86% (12m)	Maternal smoking, health, social support, food security, family functioning, racism, forced removal	Short quest food intake NSW Health survey	Height, weight, BMI

Study name, Country (Reference)	Aim(s)	Cohort ethnic representation	Baseline year; Age waves	Baseline n, Retention% (age)	Home/Family environment, maternal predictors	Food/ nutrition predictors	Child growth outcomes/ trajectories
WATCH Study Australia (Hure et al., 2012)	How maternal nutrition and hormonal factors predict of offspring growth, body composition, cognition	Not stated	2006; 11,19,24,30,36w G. 3,6,9,12m 2,3,4y	Mothers 180 Babies 182 74% (2y)	Foetal growth, Parental anthrop. BP, PA, SES, medical history, family lifestyle	Maternal/ child feeding/diet	weight, height, skinfold, girth, BP

Notes: [a] two cohorts: 'B' Babies; 'K' Kindergarten, [b] due to low retention in non-Caucasian participants, only Caucasian ethnic group were included at 11 y BMI-body mass index, [c] Sample size depends on reference. BW=Birthweight, DEXA=dual-energy X-ray absorptiometry, Ed=level of education, FFQ=food frequency questionnaire, G=gestation, GWG=gestational weight gain, LM=lean mass, m=months, N/A=Not Available, NZ=New Zealand, NZiDep=NZ individual deprivation, OW=overweight, OB=obesity, PA=physical activity, PP=pre-pregnancy, SES=socioeconomic status (often includes multiple measures), SIDS=sudden infant death syndrome, w=weeks, WHtR=weight-to-height ratio, y=years, Z=zero score, %BF=per cent body fat