# The link between Dietary Diversity and Body Composition in New Zealand European, Māori and Pacific women – the women's EXPLORE study

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# Abstract

Eating a diverse diet improves diet quality and nutritional adequacy, but may be higher in energy and discretionary foods, which are associated with obesity. We aimed to utilise a newly validated dietary diversity questionnaire (DDQ) to explore the dietary diversity and food variety of New Zealand European, Māori and Pacific women and how dietary diversity and food variety may link to different body composition profiles (BCPs).

Women's (n=235) waist circumference, body mass index and body fat percentage (BF%) was used to categorise them into one of three BCP groups (normal-fat, hidden-fat, apparent-fat). Dietary intake was assessed using a Food Frequency Questionnaire (energy and nutrients), alongside a validated DDQ, which assessed participants dietary diversity and food variety scores (DDS and FVS).

Dietary diversity was high (88%, 22/25) whilst food variety was comparatively low (31%, 78/237), especially within carbohydrates, fruits, vegetables and seafood. Overall, DDS and nutritious-DDS was lower for Pacific participants ($P$<0.005), whilst discretionary-FVS was higher for Māori and Pacific participants (both $P$<0.001). Regarding obesity, nutritious-DDS was higher in participants with a non-obese BMI ($P$=0.024) and BF% ($P$=0.029), compared to obese participants. Both DDS and N-DDS negatively correlated to WC and BF% ($P$<0.005). Participants in the highest tertile of DDS and nutritious-DDS had a lower WC ($P$=0.015, P<0.001), BMI ($P$=0.048, $P$=0.004), and BF% ($P$=0.002, $P$=0.011), despite consuming more energy ($P$=0.016). We were unable to demonstrate any significant anthropometric differences between tertiles of discretionary DDS nor discretionary FVS.

Our results support previous prospective studies, showing that consuming an increased variety of nutritious foods may be associated with reduced female obesity, possibly more so than omitting discretionary foods. Health promotion should encourage exchanging rather than excluding, discretionary foods.



Key words: *Dietary diversity, food variety, diet quality, New Zealand women*

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# List of Abbreviations

| | |
|---|---|
| AMDR | Acceptable macronutrient distribution range |
| BCP | Body composition profile |
| BCPG | Body composition profile group |
| BF | Body fat |
| BF% | Body fat percentage |
| BIA | Bioelectrical impedance analysis |
| BMI | Body mass index |
| CHO | Carbohydrate |
| DD | Dietary diversity |
| DDS | Dietary diversity score |
| D-DDS | Discretionary dietary diversity score |
| D-FVS | Discretionary food variety score |
| D-FR | Discretionary food ratio |
| DXA | Duel x-ray absorptiometry |
| EXPLORE | Examining predictors linking obesity related elements |
| FV | Food variety |
| FVS | Food variety score |
| FFQ | Food frequency questionnaire |
| F&V | Fruit and vegetables |
| G | Gram |
| IQR | Interquartile range |
| KG | Kilogram |
| M | Metre |
| MUFA | Monounsaturated fat |
| N | Number |
| N-DDS | Nutritious dietary diversity score |
| N-FVS | Nutritious food variety score |
| NZE | New Zealand European |
| NZWFFQ | New Zealand women's food frequency questionnaire |
| PUFA | Polyunsaturated fat |
| RDI | Recommended daily intake |
| SFA | Saturated fat |
| U.S | United States |
| WC | Waist circumference |
| %E | Percentage of daily energy intake |

# Chapter One:
# Justification

## 1.1 Background

Experts estimate that one in every five deaths globally can be attributed to a poor quality diet (Gakidou et al., 2017), thus researchers often define diet quality by the ability of the diet to prevent chronic disease (Kant, 2004; Wirt & Collins, 2009). As the research field evolves, experts now recommend that measurements of diet quality do not focus on single foods and nutrients, but instead consider the quality of the 'whole diet' (Asghari, Mirmiran, Yuzbashian, & Azizi, 2017; Freeland-Graves & Nitzke, 2013; Nitzke, Freeland-Graves, Olendzki, & Association, 2007). Factors such as portion sizes, proportionality, moderation, and dietary diversity each play a unique role in diet quality. However, it is currently undecided whether dietary diversity is a help or hindrance in the battle against one of the most lethal and perpetuating lifestyle diseases; obesity. Obesity is defined as the extreme excess accumulation of body fat (World Health Organisation, 2018b), and in 2015, more than 600 million people were obese - a statistic that has nearly doubled in the past 35 years alone (World Health Organisation, 2018b). Obesity has detrimental health complications such as heart disease, stroke, arthritis, type two diabetes, and certain cancers (Ministry of Health, 2015b) and has well-established links to psychological conditions such as depression and anxiety (Ministry of Health, 2008). Obesity also has an economic impact, costing New Zealand $722 million per year in lost productivity, and health care (Lal, Moodie, Ashton, Siahpush, & Swinburn, 2012). In New Zealand's fight against obesity, women of childbearing age are a particularly important consideration, as they are significantly more likely to be obese than men of the same age (Ministry of Health, 2017). Female obesity poses unique risks to both mother and baby during pregnancies (Ministry of Health, 2018b). Given the impact of female obesity on our nation's social, physical and economic wellbeing, it has become increasingly critical that we can assess and understand which factors of diet quality, such as dietary diversity, may be causing one third of New Zealand's women of childbearing age to live in a state of obesity (Ministry of Health, 2017).

To understand the quality of an individual's diet, and how this may link to obesity, the diet of an individual must first be assessed. Dietary assessment is defined as the gathering of dietary information to assess food intake (Biro, Hulshof, Ovesen, & Cruz, 2002). Most dietary assessment techniques fall under one of two types; quantitative dietary assessment and qualitative assessment, each with unique strengths and shortfalls. Quantitative dietary assessment attempts to precisely enumerate dietary intakes, and considers factors such as the frequency and quantity of consumed food items and nutrients (Harris et al., 2009; Thompson et al., 2015). Commonly used quantitative methods of dietary assessment include food frequency questionnaires (FFQ's), weighed or estimated food records, and 24-hour diet recalls (Thompson et al., 2015). However, quantitative techniques are often criticised for being time consuming, inducing behavioural changes, under-reporting and bias, as well as having low validity to true intakes (Mahan & Raymond, 2016; Willett, 2001). In addition, quantitative techniques require a high level of participant literacy and compliance, and often involve extensive and expensive analysis by specifically trained people (FAO, 2011; Mahan & Raymond, 2016). Because of the limitations of quantitative assessment, qualitative dietary assessment is becoming increasingly common (Oldewage-Theron & Kruger, 2011). Qualitative techniques include focus groups, in depth interviewing, participant observations and qualitative surveys (Harris et al., 2009). Qualitative techniques are not concerned with the exact quantities of intake, instead, they consider the whole diet, in regards to the individual's dietary patterns, behaviours, habits, attitudes, and perceptions (Biro et al., 2002; Harris et al., 2009).

Dietary diversity is a qualitative approach to measuring diet quality that considers two main factors; dietary diversity (the number of food groups eaten from) and food variety (the number of food items eaten) (Ruel, 2003b). The concept of assessing dietary diversity was developed after noticing that dietary intakes in underdeveloped countries were limited to a small range of starchy staple foods, leading to a poor quality diet and dangerous vitamin and mineral deficiencies (FAO, 2011; Hatløy, Torheim, & Oshaug, 1998). In order to assess the dietary diversity of individuals in resource poor settings, the dietary diversity questionnaire (DDQ) was created (Hatløy et al., 1998). The new DDQ was a list of food items that provided a simplified way to assess the diet, as participants were only required to tick if they did or did not consume a certain food over the past seven days, regardless of quantity or frequency (FAO, 2011). It was found that an individual's combined dietary diversity score (DDS) and food variety score (FVS) correlated well to the nutritional adequacy of their diet, thus were indices of diet quality that did not require quantitative assessment, high participant literacy, or extensive staff training (Hatløy et al., 1998). Since its initial success, further studies have demonstrated the ability of increased DDS and FVS to reliably correlate to a reduced risk of energy and nutrient deficiencies and thus lower rates of preventable disease across a range of population groups, such as children (Steyn, Nel, Nantel, Kennedy, & Labadarios, 2006), adolescents (Mirmiran, Azadbakht, Esmaillzadeh, & Azizi, 2004) adults (Arimond et al., 2010; Ogle, Hung, & Tuyet, 2001; Oldewage-Theron & Egal, 2013; Oldewage-Theron & Kruger, 2011; Torheim et al., 2004; Vandevijvere, De Vriese, Huybrechts, Moreau, & Van Oyen, 2010) and older people (Rathnayake, Madushani, & Silva, 2012). However, despite dietary diversity being considered vital for nutritional adequacy and diet quality, research surrounding the link between dietary diversity and obesity is conflicting.

In a third world setting, it is unclear whether dietary diversity is most reliably linked to increased or decreased body mass index (BMI; kg/m$^2$); it may depend on the population of interest, as dietary diversity appears to protect individuals from being dangerously underweight in rural third world poverty (Savy, Martin-Prével, Sawadogo, Kameli, & Delpeuch, 2005), but also protects individuals from being dangerously overweight in urban third world poverty (Azadbakht & Esmaillzadeh, 2011; Oldewage-Theron & Egal, 2013). However, dietary diversity has also been associated with increased BMIs and obesity in many third world nations, such as Sri Lanka (Jayawardena et al., 2013), Brazil (Bezerra & Sichieri, 2011) Bolivia (Bénéfice, Lopez, Monroy, & Rodríguez, 2007), and Mexico (Ponce, Ramirez, & Delisle, 2006), whilst other third world investigations found no obesity-dietary-diversity (obesity-DD) link at all (Ajani, 2010; Gregory, McCullough, Ramirez-Zea, & Stein, 2008; Hasan-Ghomi et al., 2012; Kimura et al., 2009; Lee, Huang, Su, Lee, & Wahlqvist, 2011; Mayega et al., 2012; Savy et al., 2008).

In New Zealand and other first world countries, current dietary guidelines suggest consuming a varied diet for health, as dietary diversity has been linked to a reduced risk of deficiencies (Foote, Murphy, Wilkens, Basiotis, & Carlson, 2004; Vandevijvere et al., 2010), cancer (Fernandez, D'Avanzo, Negri, Franceschi, & La Vecchia, 1996; Health & Services, 2017; Ministry of Health, 2015a; World Health Organisation, 2018a), and early mortality

(Kant, Schatzkin, Harris, Ziegler, & Block, 1993). However the relationship between dietary diversity and obesity again remains undecided, as although some authors have found dietary diversity to correlate positively with obesity (Bernstein et al., 2002; Foote et al., 2004; Tian, Wu, Zang, Zhu, & Wang, 2017), others describe an inverse relationship (Abris et al., 2018; Kant, 2004; Kant & Graubard, 2005; Kant et al., 1993), whilst a recent meta-analysis finds no relationship at all (Salehi-Abargouei, Akbari, Bellissimo, & Azadbakht, 2016). Authors who have concluded that the there was a concerning obesity-DD link, do so most often on the grounds of two conclusions. The first is what the current study will call the DD-energy hypothesis, where authors conclude that a diverse diet is higher in energy, thus has obesity as a consequence (Azadbakht & Esmaillzadeh, 2012; Bernstein et al., 2002; Foote et al., 2004; McCrory et al., 1999). However, the obesity-DD link has also recently been established even when energy intakes are controlled for (Tian et al., 2017). The second hypothesis is that a diverse diet is also diverse in discretionary foods (Azadbakht & Esmaillzadeh, 2011; Azadbakht, Mirmiran, Esmaillzadeh, & Azizi, 2006; Ponce et al., 2006). Discretionary foods are foods and drinks that do not fit into the five food groups (fruits, vegetables, dairy, whole grains and protein foods) such as cakes, biscuits, chips and chocolate (Australian Government, 2013). Like all foods, discretionary foods provide nutrients and consuming a wide range of discretionary foods means the diet is technically more diverse. However, the consumption of discretionary foods, especially when they displace nutritious foods in the diet, has been repeatedly linked to obesity (Aburto, Pedraza, Sánchez-Pimienta, Batis, & Rivera, 2016; Cohen, Sturm, Scott, Farley, & Bluthenthal, 2010; Guenther, Reedy, & Krebs-Smith, 2008; Johnson, Bell, Zarnowiecki, Rangan, & Golley, 2017; Nitzke et al., 2007).

There are many possible explanations for the conflicting results of dietary diversity studies in developed countries. The first is that outcomes may be affected by discretionary food diversity, and whilst some authors consider discretionary foods in their dietary diversity analysis (de Oliveira Otto, Padhye, Bertoni, Jacobs Jr, & Mozaffarian, 2015; McCrory et al., 1999), others do not (Abris et al., 2018; Bernstein et al., 2002; Foote et al., 2004; Kant & Graubard, 2005; Kant et al., 1993; Tian et al., 2017). Secondly, it could be that DDQ's are not able to reflect the enormous variety of foods available in culturally diverse developed countries such as New Zealand. For example, original DDQ's consisted of nine food groups only: starchy staples; dark green leafy vegetables; other vitamin A rich fruits and vegetables; other fruits and vegetables; organ meat; meat and fish; eggs; legumes, nuts and seeds; milk and milk products (FAO, 2011). However, in a developed country most individuals have access to an abundance of different foods, thus as many as 21 food groups may be required to better understand dietary diversity (FAO, 2011; Salehi-Abargouei et al., 2016). Finally, obesity-DD research outcomes may differ depending on how each author measures obesity, whether by body fat percentage (Abris et al., 2018; McCrory et al., 1999), waist circumference measurements (de Oliveira Otto et al., 2015), or, as most frequently, BMI (Bernstein et al., 2002; Kant, 2004; Kant & Graubard, 2005; Tian et al., 2017).

Māori and Pacific women are twice as likely to have an obese BMI (>30kg/m$^2$) compared to New Zealand European (NZE) women (Ministry of Health, 2012a). However, BMI measurements do not consider ethnic differences in frame and weight (Huxley, Mendis, Zheleznyakov, Reddy, & Chan, 2010; World Health, 2000) and thus some authors argue that BMI overestimates the body fat of some ethnic groups such as Māori and Pacifica (Rush, Plank, Laulu, & Robinson, 1997; Rush, Puniani, Valencia, Davies, & Plank, 2003; Swinburn, Craig, Daniel, Dent, & Strauss, 1996). However, recent research suggests that using higher BMI cut off for Māori and Pacifica is not appropriate, and reduces the sensitivity of the measure (Taylor et al., 2010). Using BMI may also be inappropriate for NZE women, as many as 21% of NZE women with normal BMI's hold excessive abdominal fat, which is 'hidden' by smaller frames (Kruger et al., 2015). Literature suggests that as per high BMI's, hidden fat correlates to obesity related health outcomes such as cardiovascular disease, cancers (Zhang, Rexrode, Van Dam, Li, & Hu, 2008) hypercholesterolemia (He, Liu, Chen, He, & Dong), and all-cause mortality (Padwal, Leslie, Lix, & Majumdar, 2016; Pischon et al., 2008; Sahakyan et al., 2015), thus BMI may overestimate or underestimate obesity and its related risks in some populations.

## 1.2 Justification and statement of research problem

Amid an obesity epidemic, it has become increasingly critical to understand the relationship between diet quality and obesity in New Zealand women. Because a diet that is excessive in energy and discretionary foods can be diverse and varied, there is no current consensus as to whether dietary diversity and food variety is beneficial, detrimental or irrelevant in the battle against obesity. Once the role dietary diversity plays in obesity is better understood, DDQ's could provide a cost and time effective way to understand diet quality, from a qualitative perspective that is becoming increasingly popular with respected health agencies. No current research considers how dietary diversity, as a factor of diet quality, may be influencing the body composition of childbearing aged NZE, Māori and Pacific women in New Zealand. However, this is now possible as a DDQ has been newly validated for use with New Zealand women of childbearing age, as part of the EXPLORE (Examining Predictors Linking Obesity Related Elements) sub-study (Hepburn, 2014; Kruger et al., 2015). Results from the DDQ will allow the opportunity to grasp which food groups and food items are compromised or preferred by women of different ethnicities and body composition profiles (BCPs), and how this affects the diversity, variety and quality of their diet. The current study will go beyond analysing BMI, and also consider body fat percentage (BF%) and waist circumference (WC) to better understand obesity in NZE women where obesity may be hidden, and Māori and Pacific women where BMI may overestimate BF%. The current research will allow for tailored public health tools, that utilise dietary diversity to correct the 'whole diet' instead of focusing on single foods - a critical step for effective health intervention (Freeland-Graves & Nitzke, 2013; Nitzke et al., 2007) and thus a critical step to prevent the growing economic, physical, social costs of obesity.

Therefore, this research aims to utilise a newly validated DDQ in order to explore the dietary diversity and food variety of NZE, Māori and Pacific women living in New Zealand, and how dietary diversity and food variety may link to different body composition profiles.

## 1.3 Objectives

Objective 1 - To explore the dietary diversity and food variety of NZE, Māori and Pacific women

Objective 2 - To examine the relationship between dietary diversity and different body composition profiles in New Zealand women

Objective 3 – To examine the relationship between dietary diversity and obesity

Sub-objective 3.1 - To examine the relationship between dietary diversity, increased energy intake and obesity

Sub-objective 3.2 - To examine the relationship between dietary diversity and increased discretionary food and nutrient intake, and obesity

## 1.4 Structure of the thesis

This thesis comprises of four parts. Chapter 1 outlines the relevant background information, as well as providing the justification for the current study. Chapter 2 contains an extensive review of the relevant literature regarding diet quality, the state of obesity in New Zealand, dietary diversity and food variety as qualitative indices of diet quality, and the link between these measures of obesity. Chapter 3 contains the research manuscript, in accordance with the British Journal of Nutrition. The research manuscript contains an abstract (a brief summary of the study), introduction (scope of the topic), methods section (our processes and tools) results section (our findings) and discussion section (our findings in comparison to previous relevant research). Finally, the conclusions, strength and limitations of our study is outlined in Chapter 4. Appendices contain the questionnaires used (appendix A and B) and supplementary results (appendix C1, C2 and C3).

## 1.5 Researchers contribution

The role of each researcher as well as their contributions to the current study are outlined in table 1.1. Each author and contributor has declared no conflict of interest.

Table 1.1: Contribution of researchers to current study

| Researcher | Contribution to Thesis |
| --- | --- |
| Catherine Bell | Author of thesis, literature research and review and manuscript. Statistical data analysis and interpretation of results. |
| Associate Professor Rozanne Kruger – Supervisor | Main academic supervisor, primary investigator and designer of the EXPLORE study, developed and designed DDQ, interpretation of results, thesis review and approval. |
| Dr Marilize Richter - Supervisor | Academic co-supervisor. Support with interpretation of statistical methods and results. Statistical data analysis support, thesis review and approval. |
| Rozanne Kruger, Sarah McNaughton, Sarah Shultz, Aaron Russell, Ridvan Firestone, Welma Stonehouse and Lily George | Designed protocol for women's EXPLORE study. |
| Adrianna Hepburn | DDQ development and validation |
| Wendy O'Brien and Shakeela Jayasinghe | Organisation of participant recruitment, screening and testing |
| Rozanne Kruger, Wendy O'Brien, Shakeela Jayasinghe, Zara Houston, Jenna Schrijvers, Maria Casale, Sarah Philipsen, Adrianna Hepburn and Sara Bodel | Participant recruitment and screening, data collection. |
| Rozanne Kruger, Wendy O'Brien, Shakeela Jayasinghe, Pamela Von Hurst, Cathryn Conlon, Kathryn Beck, Adrianna Hepburn, Zara Houston, Richard Swift, Owen Mugridge, PC Tong, Sarah Philipsen, Jenna Schrijvers, Maria Casale, Alexandra Lawn | Participant testing across eight stations: general health screening questionnaire, blood pressure, blood testing, body composition measurements, BIA, DXA scan, dietary questionnaires including DDQ. |
| Jenna Schrijvers, Maria Casale, Alexandra Lawn, Sarah Philipsen, Zara Houston, Adrianna Hepburn and Chelsea Symons, Wendy O'Brien, Shakeela Jayasinghe | Data entry. |
| PC Tong | Equipment assistance for data collection. |

# Chapter Two:
# Literature Review

## 2.1 A high quality diet

### 2.1.1 What defines a high quality diet

In a developing country, where food access is limited, diet quality is defined by the diet's nutritional adequacy and ability to provide all of the nutrients needed for daily functioning (Ruel, Harris, & Cunningham, 2013). In a developed country, the context of health is obesity, and nutrient containing high energy convenience foods are over consumed (Asghari et al., 2017). Thus, nutrient deficiencies are less common, however, diet quality remains poor (Asghari et al., 2017). Authors therefore often define developed world diet quality by the extent to which the diet prevents diet-related chronic diseases (Asghari et al., 2017; Kant, 2004; Wirt & Collins, 2009)**.** Improving diet quality and preventing obesity is a priority for health researchers, and there has been increasing interest in correcting the whole diet, rather than focusing on the intake of single nutrients (i.e. saturated fat) or foods (i.e. fast foods) (Asghari et al., 2017; Freeland-Graves & Nitzke, 2013). Research suggests that optimal diet quality relies on the interplay between many indicators of diet quality (including those outlined in **table 2.1**), as together they synergistically prevent disease of lifestyle, such as obesity, type two diabetes, cancers and even premature death (Asghari et al., 2017; Guo, Warden, Paeratakul, & Bray, 2004; Kant, 2004; Kennedy, Ohls, Carlson, & Fleming, 1995b; Torheim et al., 2004)**.**

Table 2.1. Commonly explored indicators of diet quality (Asghari et al., 2017; Guo, Warden, Paeratakul, & Bray, 2004)

| Dietary Quality indicators | Definition |
|---|---|
| Portion sizes | The amount of food eaten during eating occasions |
| Proportionality | Consuming more of some food groups whilst less of others across a day's eating |
| Moderation | Limiting the intake of discretionary foods and nutrients that pose a risk to health outcomes and ensuring that the majority of dietary intake is nutritious foods |
| Dietary diversity (DD) | Consuming foods from a diverse range of food groups to ensure all nutrients are consumed daily |
| Food variety (FV) | A factor of dietary diversity; defined as consuming a varied range of foods within each food group and across the whole diet |

There are numerous ways in which a person's health may benefit from optimising each indicator of diet quality. One such way is that consuming a diet with optimal portion sizes, proportionality, and moderation inherently results in a reduced intake of discretionary foods. Discretionary foods are foods and beverages that do not fit into the main five nutritious food groups (fruits and vegetables, dairy, whole grains, protein foods and healthy fats), such as cakes, biscuits, chips and chocolate (Australian Government, 2013). Discretionary foods, like all foods, can provide nutrients that are vital for human health (for example, ice-cream provides calcium), however they are high in discretionary nutrients such as saturated fat, added sugars and salt (Australian Government, 2013). The New Zealand Ministry of Health (2013) recommends that we limit our intake of saturated fat, sugar and salt as their overconsumption is linked to obesity, cardiovascular disease and hypertension (Ministry of Health, 2013a). A diet high in discretionary foods does have the ability to be nutritionally adequate, however discretionary foods can displace the consumption of nutritious foods within healthy food groups. When discretionary foods displace nutritious foods in the diet, the overall quality of the diet reduces, and the risk of lifestyle diseases increases (Aburto et al., 2016; Johnson et al., 2017). Because of their negative consequences, dietary guidelines from the United States (U.S) (Department of Agriculture (US), 2005) and Australia (Australian Government, 2013) have suggested that no more than 14% of energy intake (or ~260 calories of a 2000 calorie diet) should be consumed in the form of discretionary food.

As a public health strategy to improve diet quality, expert health authorities have created a variety of tools that promote the aforementioned indicators of diet quality and encourage limiting discretionary foods. For example, the traditional plate model demonstrates what constitutes an appropriate portion size and does not include discretionary items, whilst the food pyramid has promoted proportionality and moderation and includes only a small fraction for discretionary foods at its peak (Nitzke et al., 2007). However, there is no widely accepted measurement or tool that helps us to understand and promote dietary diversity and food variety, despite its links to improved health outcomes (Ministry of Health, 2018a; World Health Organisation, 2018a), nutritional adequacy (Foote et al., 2004; Vandevijvere et al., 2010), reduced risk of cancer (Fernandez et al., 1996; Health & Services, 2017), and reduced risk of early mortality (Kant, Schatzkin, Graubard, & Schairer, 2000; Kant et al., 1993; Michels & Wolk, 2002).

### 2.1.1 Obesity as a penalty of a poor quality diet

One of the most researched consequences of a poor quality diet is obesity, which has detrimental health, social and economic consequences. Obesity is defined as the excessive accumulation of body fat that places a significant risk on an individual's health (World Health Organisation, 2017). In a comparable way to smoking, obesity accounts for more than 9% of all premature mortality in New Zealand (Ministry of Social Development, 2016) and can shorten an individual's life by a decade (Prospective Studies, 2009). The poor health outcomes linked to obesity include dysfunctional respiratory function, bone health, and reproductive capabilities, as well as significantly increasing the risk of life threatening conditions such as stroke, heart disease, type two diabetes, and cancers of the bowel and stomach (World Health Organisation, 2018a).

Beyond its physical effects, obesity has detrimental social consequences. Research in New Zealand has demonstrated a link between obesity and psychological conditions such as depression and anxiety (Ministry of Health, 2008). The relationship between obesity and mental health is also found internationally in multiple meta-analyses, which link obesity to depression in both adults and teenagers, especially women (De Wit et al., 2010; Quek, Tam, Zhang, & Ho, 2017). It has been demonstrated that obese individuals face discrimination across multiple settings such as health care, the workplace and within interpersonal relationships, again, particularly so in women (Spahlholz, Baer, König, Riedel-Heller, & Luck-Sikorski, 2016).

Because of its physical and social consequences, obesity results in lost productivity and health care costs. In the United States, an obese person is predicted to cost their nation upwards of $1700 U.S dollars ($2700 New Zealand dollars) per year, thus, a national cost of $95 billion U.S dollars ($149 billion New Zealand dollars) per year in 2014 (Kim & Basu, 2016). In New Zealand, it is predicted that obesity has a national cost of $722 million New Zealand dollars ($468 million U.S dollars) per year (Lal et al., 2012).

### 2.1.2 The measurement and classification of obesity

In a clinical setting, BMI (kg/m$^2$) is most commonly used to diagnose obesity. Scientific consensus has determined a BMI of more than (or equal to) 30kg/m$^2$) to be indicative of obesity (Ministry of Health, 2015b; World Health Organisation, 2018b). However, as BMI is a continuous variable, the cut-offs differentiating between healthy or unhealthy BMI, are merely predictive. **Table 2.2** demonstrates each BMI category alongside its predicted level of health risk as used by both New Zealand's Ministry of Health (2015) and the World Health Organisation (2018b).

Table 2.2. Adult BMI scores with its consequential health risks (Ministry of Health, 2015b; World Health Organisation, 2018b)

| **BMI Categories (kg/m$^2$)** | **Weight Classification** | **Risk of Negative Health Outcomes** |
|---|---|---|
| <18.5 | Underweight | |
| 18.5-24.9 | Healthy Weight | Average |
| 25-29.9 | Overweight | Increased |
| >30 | Obese | Substantially increased |
| • 30-34.9 | Obese (Class 1) | Moderate |
| • 35-39.9 | Obese (Class 2) | Severe |
| • >40 | Obese (Class 3) | Very severe |

BMI, body mass index

As a measurement of body fatness in women, BMI is a powerful tool as it considers not just body weight, but an individual's weight in relation to their height (Garrow & Webster, 1985). However, as per any predictive measure, BMI holds limitations, one such limitation being the reliance on body weight. An individual's body weight is the combined weight of their bone, lean muscle, organ tissue and fluid mass, thus some individuals may have a higher body weight without necessarily having higher body fat (Ministry of Health, 2015b).

Therefore, other anthropometric indicators are often used alongside BMI to determine whether an individual holds excess body fat, and if so, to what extent.

One such additional method is waist circumference (WC), a measurement of length taken around the midsection of the torso (Ministry of Health, 2015b). Unlike BMI, WC allows us to distinguish between those who have more body weight due to extra lean muscle, fluid or bone mass, versus those have excess body fat around their midsection. A WC of more than 80cm (for women) has a well-supported association to increased truncal adiposity and negative health outcomes (He et al.; Padwal et al., 2016; Pischon et al., 2008; Sahakyan et al., 2015; Zhang et al., 2008). Alternative obesity measurements such as WC may be crucial in New Zealand, as some authors argue that BMI measurements tend to overestimate the body fat of Pacific and Māori people (Rush et al., 1997; Rush et al., 2003; Swinburn et al., 1996). However, more recent research has demonstrated that increased BMI cut off points for Māori people (i.e. $32kg/m^2$) reduces the sensitivity of the measure and is not appropriate (Taylor et al., 2010). Therefore, using a BMI cut off of $30kg/m^2$ across all ethnic groups alongside other anthropometric measures, such as body fat percentage (BF%) may provide a more comprehensive approach to measuring body composition.

### 2.1.3 The demographics of obesity in New Zealand

New Zealand is currently the world's third most obese country – with more than one in every three New Zealand adults classified as obese (Organisation of Economic Co-operation and Development, 2017). **Table 2.3** demonstrates the most current national obesity trends within different demographic factors (Ministry of Health, 2017).

Table 2.3. Current New Zealand obesity trends segregated by demographic factor (Ministry of Health, 2017)

| Demographic factor | New Zealand obesity trends |
|---|---|
| Gender | Women were not significantly more likely to be obese than men (29.1% versus 28.3%). However, when looking only at the rates of obesity within the 24-35 years age range, when women often bear children, women were significantly more likely to be obese than men (31.6% versus 24.3%) |
| Age | The risk of obesity increases with age, peaking within those between 55-64 years, and then declining within older adults. |
| Ethnicity | Māori and Pacific people were more likely to be obese than New Zealand European people (1.8 and 2.5 times more likely respectively) |
| Socioeconomic status | Living within New Zealand's most deprived quintile was a significant predictor of obesity, with 44% being obese, compared to 22% of those living within the least deprived quantile |

### 2.1.4 Diet, obesity and women

The diet of women of childbearing age is often the focal point of diet and health researchers due to their increased nutritional requirements for menarche and pregnancy (Arimond et al., 2010; Blumfield, Hure, Macdonald-Wicks, Smith, & Collins, 2013). As a result of increased needs, women routinely suffer from nutritional deficiencies of nutrients such as calcium, iron, folate, iodine, zinc, vitamin A and selenium (Kennedy & Meyers, 2005).

Obesity in women of child-bearing age creates dangerous health risks for both the mother and child during pregnancy (Ministry of Health, 2018b). Poor pregnancy outcomes are exacerbated in the presence of nutritional deficiencies. Recent meta-analyses have found that despite increased energy consumption, common nutritional shortfalls are often more common in obese versus non-obese women, for both iron (Zhao et al., 2015) and vitamin D (Pereira-Santos, Costa, Assis, Santos, & Santos, 2015), which are critical in pregnancy for foetal neural and bone development (Blumfield et al., 2013). Furthermore, research continues to demonstrate a link between obese mothers and childhood obesity in their offspring, with obesity in mothers more than doubling the risk of an obese child (Gibson et al., 2007; Whitaker, 2004). Childhood obesity is linked to childhood depression, anxiety, conduct disorders, developmental delays, social ostracism and adult obesity, thus obesity is further perpetuated (Halfon, Larson, & Slusser, 2013; Nader et al., 2006; Pizzi & Vroman, 2013; Russell-Mayhew, McVey, Bardick, & Ireland, 2012).

Despite lower obesity rates, New Zealand Europeans (NZE) still contribute significantly, to negative obesity-related health outcomes, such as cardiovascular disease and arthritis (Ministry of Health, 2017). The New Zealand Examining Predictors Linking Obesity Related Elements (EXPLORE) (Kruger et al., 2015) study investigated the BCPs of New Zealand women and found that 30% of NZE participants, but only 21% of Māori and 11% of Pacific participants had normal BMIs (BMI <25kg/$m^2$). Māori and Pacific women were more likely to be classified as having 'apparent fat', with a high BMI (BMI >30kg/$m^2$) and a high BF% (BF% >30%) (Kruger et al., 2015). However, the EXPLORE study (Kruger et al., 2015) demonstrated that despite lower BMI's, 28% of NZE women still hold excessive abdominal fat, which is 'hidden' by lower body weights. Only 13% of Māori and 2% of Pacific participants demonstrated this same 'hidden' fat profile (Kruger et al., 2015). Hidden abdominal fat correlates to cardiovascular disease, cancers, type two diabetes (Zhang et al., 2008), hypercholesterolemia (He et al.), and all-cause mortality (Padwal et al., 2016; Pischon et al., 2008; Sahakyan et al., 2015). Given the detrimental effects of obesity on our health, economic and social systems, we must find a method to assess diet quality that can demonstrate the patterns of eating that contribute to both obesity and hidden fat.

## 2.2 Dietary assessment

### 2.2.1 The purpose of assessing diet quality

Dietary assessment refers to the gathering of dietary information to assess the intake of an individual (Biro et al., 2002). Dietary assessment methods are the types of techniques used to explore the dietary intake and patterns and thus diet quality, usually to establish an individual's nutritional status (Thompson et al., 2015). Styles of dietary assessment differ between the length of time they will be conducted over, whether they will be looking into past or future eating patterns and whether they will be exploring quantitative or qualitative data (Biro et al., 2002).

### 2.2.2 Quantitative dietary assessments

When attempting to understand the exact nutritional intake of an individual, quantitative methods of dietary assessment are often said to be the gold standard, as they provide measured (or predicted) quantities of foods consumed (Harris et al., 2009). With enumerated intakes, assessors can quantify the amount of nutrients within an individual's diet, and then use this information to assess where nutritional shortfalls within the diet may occur. However, despite the presumed precision of quantitative dietary assessment tools, each tool has strengths and limitations, as described in **table 2.4**.

Table 2.4. The strengths and weaknesses of different retrospective and prospective quantitative dietary assessment methods (Biro et al., 2002; Mahan & Raymond, 2016; Thompson et al., 2015; Willett, 2001)

| **Quantitative Tool** | **Explanation** | **Strengths** | **Weaknesses** |
|---|---|---|---|
| Food Frequency Questionnaires (retrospective) | Using a survey with lists of foods, participants report their predicted frequency of consuming a specific food over a specific time period (i.e. a week, a month, a year). Can include quantities (QFFQ) or not (more qualitative) (FFQ) | - Not affected by day to day variability in the diet<br>- Does not elicit changes to dietary intake<br>- Captures foods not frequently consumed or consumed in small amounts<br>- Relatively small time burden to participant<br>- Relatively simple data handling, no nutrition professional needed to analyse results | - Relies on long term memory recall which may be inaccurate<br>- Relies on estimations of portion sizes so gives imprecise quantifications of intake<br>- Underestimation of energy and protein intakes more common<br>- May have low validity to true intakes if not well validated<br>- Requires high participant literacy<br>- Participants may eat foods not included in the FFQ<br>- Must be culturally specific or it cannot encompass all potential foods of participants' diets |
| Weighed Food Record (prospective) | Participants record everything they consume over a certain time period (i.e. 1+ days, ideally 5-6 days). Recorded quantities are weighed (i.e. 43g of chicken) | - Provides an accurate quantity of each food consumed, providing that information is recorded correctly<br>- Omission of food items from record is said to be minimal compared to other methods<br>- If recorded over the course of five to six days, controls for day to day variability in dietary intakes unlike 24 hour food recall<br>- No reliance on participant memory and no opportunity for recall bias<br>- Open ended, meaning even uncommon food items can be recorded | - Writing a record of food intake can elicit changes to dietary intake<br>- Time consuming and fatiguing for the participant<br>- Low compliance and under-reporting common because of high participant burden<br>- Requires high level of participant literacy and compliance<br>- Condiments and cooking oils often omitted<br>- Requires time consuming analysis by trained professional |

| Quantitative Tool | Explanation | Strengths | Weaknesses |
|---|---|---|---|
| Estimated Food Record (prospective) | Participants record everything they consume over a certain time period (i.e. one day or several weeks) – recorded quantities are estimated using household/familiar quantities (i.e. ~1/2 a cup of chicken) | - Self-reported<br>Provides an accurate estimation quantity of each food consumed, providing that information is recorded correctly<br>Less of a time burden than a weighed food record<br>- No reliance on participant memory and no opportunity for recall bias<br>- Open ended, meaning even uncommon food items can be recorded | - Writing a record of food intake can elicit changes to dietary intake<br>- Subject to estimation error by both participant and recorder<br>- Commonly, condiments and cooking oils are not recorded by participants |
| 24 Hour Diet Recalls (retrospective) | Interviewer asks participants to recall everything they consumed over the past 24 hours. Participants are probed by the interviewer for extra details or forgotten foods | - Interviewer-based<br>- Quick for participant to complete thus small time burden for participant<br>- No literacy required because participant can speak aloud what they ate to recorder<br>- A face to face interview between recorder and participant increases the likelihood of reliable data<br>- Open ended questioning means food intake patterns are not changed | - Subject to memory errors<br>- Subject to recall bias and misreporting, especially in obese participants<br>- Possibility for interviewer bias and leading questions<br>- Underestimation of energy intakes is common as portion sizes are difficult to recall and report<br>- Requires trained interviewer<br>- Affected by day to day variability and may not represent participants overall diet |

FFQ, food frequency questionnaire; QFFQ, quantitative food frequency questionnaire.

### 2.2.3 A quantitative examination of the diets of New Zealand European, Māori and Pacific women

Quantitative research has demonstrated that the majority (>68%) of New Zealand women do not consume the recommended daily intake (RDI) of monounsaturated fat or carbohydrate, and approximately 16% of nutrient RDI's are not being achieved. (Hepburn, 2014). New Zealand's Ministry of Health has completed two reports that consider the nutritional adequacy of Māori versus non-Māori women (Ministry of Health, 2012a) and Pacific versus non-Pacific women (Ministry of Health, 2012b). The key findings of these studies are presented in **table 2.5**.

Table 2.5. Differences between intakes of key macro and micro nutrients of Māori versus non-Māori, and Pacific versus non-Pacific women (Ministry of Health, 2012a, 2012b)

| **Nutrient** | **Māori women versus non-Māori women#** | **Prevalence of inadequate intakes in Māori women** | **Pacific versus non-Pacific women$** | **Prevalence of inadequate intakes in Pacific women** |
|---|---|---|---|---|
| Energy | No statistical difference | N/A | **More (543kcal)** | N/A |
| Protein (% of energy) | No statistical difference | N/A | No statistical difference | N/A |
| Fat (% of energy) | **More of saturated (1.2%) and monounsaturated (0.7%)** | N/A | **More of monounsaturated (0.7%)** | N/A |
| Carbohydrate (% of energy) | No statistical difference | N/A | No statistical difference | N/A |
| Dietary Fibre | No statistical difference | N/A | No statistical difference | N/A |
| Vitamin A | No statistical difference | 16.6% | No statistical difference | 37.1% |
| Riboflavin | No statistical difference | 5.4% | No statistical difference | 13.1% |
| Vitamin B12 | No statistical difference | 12.4% | No statistical difference | 20% |
| Calcium | No statistical difference | 71.4% | **Less (-152mg)** | 92.3% |
| Zinc | No statistical difference | 14.7% | No statistical difference | 10.5% |
| Selenium | No statistical difference | 53.3% | No statistical difference | 54.4% |
| Iron | No statistical difference | 4.8% had anaemia | No statistical difference | 6.9% had anaemia |

# Compared to non-Māori women, Māori women consumed:
$ Compared to non-Pacific women, Pacific women consumed:
% of energy, the percentage of daily energy that is contributed by that macronutrient; Kcal, kilo calories; mg, milligrams.

Although New Zealand's Ministry of Health has not published results of NZE women in isolation, as they have for Māori and Pacific women, they do report that Māori and Pacific people are more prone to deficiencies (Ministry of Health, 2009).

Differences between the nutrient intakes of Māori, Pacific and NZE women is likely due to different foods favoured by each ethnicity, resulting from differences in social, cultural, economic and physical food access (Ministry of Health, 2017). For example, Māori and Pacific women consume more traditional foods (i.e. puha and watercress), have reduced financial access to expensive food items, and tend to live in more deprived food environments with increased exposure to discretionary convenience foods compared to NZE people (Metcalf et al., 2008). According to New Zealand survey results (Ministry of Health, 2012a, 2012b), fewer Māori and Pacific women consumed the recommended number of servings of vegetables (11% and 22% less), choose low fat milk and milk alternatives (17% and 17% less), trim the fat from their meats (16% and 15% less) and choose whole grain carbohydrates (17% and 19% less). However, Māori and Pacific women more often consumed the discretionary versions of these foods such as hot chips (10% and 8% more), full cream milk and butter (20% and 22% more), refined carbohydrates (21% and 20% more) and ate fast food and takeaways more than three times per week (7% and 8% more) (Ministry of Health, 2012a, 2012b). Independent authors have concluded that Māori and Pacific women have diets higher in energy and saturated fat (Metcalf, Scragg, Tukuitonga, & Dryson, 1998), and lower in fibre and calcium (Metcalf et al., 2008; Metcalf, Scragg, Sundborn, & Jackson, 2014). However, not all of these findings are supported by the results of national health surveys as demonstrated in **table 2.5** (Ministry of Health, 2012a, 2012b). Although quantitative evidence exists as to which foods and nutrients are favoured by NZE, Māori and Pacific women, qualitative research regarding the diet quality of these ethnic groups is scarce.

### 2.2.4 Qualitative dietary assessments

Qualitative methods include any dietary assessment that does not focus on quantities or frequency of food and energy intake, nor attempts to quantify exact nutrient profiles of the diet. Qualitative methods look at overall diet quality indicators, patterns and trends that may underlie unhealthy or obesogenic eating patterns (Harris et al., 2009). For example, proportionality, moderation of discretionary foods, dietary diversity and food variety (Freeland-Graves & Nitzke, 2013). Understanding these dietary patterns is critical, as nutritional information can be communicated to the public using a 'whole diet' approach, shown to be more effective than advocating for the removal of single 'bad' foods or nutrients from the diet (Freeland-Graves & Nitzke, 2013; Nitzke et al., 2007). Methods of qualitative dietary assessment include focus group discussions, meal time observations or in depth interviewing or qualitative surveys (Harris et al., 2009). A qualitative approach is used to determine a number of quality based objective scoring techniques that are commonly used in developed countries (**table 2.6**). With each scoring technique in **table 2.6**, an individual can improve their score by consuming less discretionary foods. However, traditional DDS and FVS scoring systems are counts of the number of nutritious food groups and food items consumed, therefore consuming an abundance of discretionary foods would typically not change an individual's DDS or FVS.

Table 2.6. Description of dietary quality scoring techniques (Asghari et al., 2017; Wirt & Collins, 2009)

| Qualitative dietary pattern scoring technique | Country of development and intended use | Score objective | Description | Alternative versions |
|---|---|---|---|---|
| Healthy Eating Index (HEI) (Kennedy, Ohls, Carlson, & Fleming, 1995) | Developed in the U.S for international use in developed countries | Single diet quality score from zero (poor) to 100 (excellent) that indicates adherence to the U.S dietary guidelines and food pyramid | Comprises of ten components required for a healthy diet based on the U.S dietary guidelines. For each component participants can score from zero (poor) to ten (excellent). Components include appropriate energy intake, adequacy moderation and variety within the five major food groups of grains, dairy, protein foods, fruits and vegetables, as well as moderating discretionary nutrients | Alternative Healthy Eating Index: Acknowledges healthy benefits of unsaturated fats and includes alcohol (McCullough & Willett, 2006) |
| Diet Quality Index (DQI) (Patterson, Haines, & Popkin, 1994) | Developed in the U.S for international use in developed countries | Single score from zero (excellent) to 16 (poor) consequential risk of diet related disease | Comprises of eight components based on the U.S dietary guidelines, with scores of zero for meets recommendation or two, does not meet recommendation. Includes six nutrient based scores, including saturated fat, cholesterol, protein salt and calcium as well as two food groups, grains, and fruits and vegetables | Diet Quality Index-International: Uses international dietary guidelines (Kim, Haines, Siega-Riz, & Popkin, 2003) Diet Quality Index Revised: revised to reflect new guidelines regarding moderation of sugar and uses improved methods to estimate servings (Haines, Siega-Riz, & Popkin, 1999) |
| Dietary Guidelines adherance Index (DGAI) (Fogli-Cawley et al., 2006) | Developed in the U.S for international use in developed countries | Single score from zero (not compliant) to 150 (full compliance) that measures compliance to U.S dietary guidelines | Comprises of 15 components from diet and non-diet related guidelines i.e. exercise, sleep. Diet components include vegetables, fruit, grains, cereals, meats, meat alternatives, lean protein, and reduced fat dairy as well as discretionary nutrients such as salt, saturated fat, alcohol and sugar | None |
| Recommended Food Score (RFS) (Collins et al., 2015) | Developed in Australia for international use in developed countries | Sum of recommended food items eaten in a week, from 0-23 | Comprises of count of 23 recommended foods including fruits, beans, specific leafy greens, starchy and non- starchy vegetables, lean proteins, whole grains, cereals, and reduced fat dairy | 'Good' Recommended Food Score: Score of 0-17, excludes poultry, potato and juices and uses 3 month FFQ. (Collins et al., 2015) Not Recommended Food Score: Count of 0-21, includes only discretionary foods and uses three month FFQ. (Collins et al., 2015) |

| **Qualitative dietary pattern scoring technique** | **Country of development and intended use** | **Score objective** | **Description** | **Alternative versions** |
|---|---|---|---|---|
| Dietary Diversity Score (DDS) (Hatløy et al., 1998) | Developed using participants in Mali, Africa. Intended for use in resource poor settings such as developing countries | Sum of food groups which are eaten from in the past 1-7 days with scores ranging from one (poor diversity) to nine (excellent diversity) | Comprises of a count of nine food groups; staples, vegetables, milk, meat, poultry, fish, egg, fruits and green leaves | Household Dietary Diverstiy Score: A score that reflects the diversity of foods available to each member of a household (FAO, 2011) Disaggregated Dietary Diversity Scores: Many variations exist (**table 2.8**) in developed countries. Scores comprise of a count of as many as 5-23 different food groups, and contain culturally specific and discretionary food groups |
| Food Variety Score (FVS) (Hatløy et al., 1998) | Developed using participants in Mali, Africa. Intended for use in resource poor settings | Sum of food items consumed in past 1-7 days | Comprises of food item count, where no maximum value exists | None |

## 2.3 Dietary diversity

### 2.3.1 Dietary diversity as a diet quality assessment tool

In a research setting, dietary diversity has recently been defined as a qualitative measure that reflects an individual's or group's access to food, and works as a proxy measure of nutritional adequacy (FAO, 2011). The concept of dietary diversity stems from the idea that eating a wide range of foods is preferable, as no single food item has all the nutrients needed to meet an individual's nutritional requirements, nor prevent deficiencies (FAO, 2011). Eating a large range of foods has been said to be especially beneficial in developing countries, where diets consist of a narrow range of starchy staples and limited amounts of fruits, vegetables, and high quality animal proteins (Ruel et al., 2013). Because dietary diversity is often inadequate in developing countries, explorations into dietary diversity as a measure of diet quality began in Mali (Hatløy et al., 1998).

Hatløy et al. (1998) were the first to investigate if dietary diversity and food variety are associated with nutritional adequacy. In their foundation study, participant's three day food records were used to assess the Nutritional Adequacy Ratio (NAR) for energy (kcal) and ten dietary components they defined as essential within the population group; protein, fat, vitamin A, vitamin C, thiamine, riboflavin, niacin, folic acid, iron and calcium (Hatløy et al., 1998). A NAR compares the recommended daily intake of a nutrient, versus actual intake (FAO, 2011). A NAR of one would mean a participant had consumed the exact amount of the nutrient recommended, whereas a NAR of 1.1 would imply a slight over-consumption, and 0.9 a slight under-consumption. Once NAR scores are established, the average of these can be used to calculate each participant's Mean Adequacy Ratio (MAR). Mean adequacy ratios can be defined as the ability of an individual's diet to meet their nutritional requirements and are quantified by using a combination of different 'essential nutrients' (FAO, 2011; Hatløy et al., 1998; Mirmiran et al., 2004; Rathnayake et al., 2012; Steyn et al., 2006).

$$MAR = \frac{Sum\ of\ NAR}{Number\ of\ nutrients} \times 100$$

Hatloy et al., (1998) found that MAR scores improved with higher food variety scores (FVS) and especially improved with higher dietary diversity scores (DDS). Therefore, people were more likely to meet their nutritional requirements if they ate a wider range of foods and ate from a wider range of food groups. A FVS counts the number of food items eaten overall, whereas DDS counts the number of food groups, eaten within a predetermined period of time (i.e. seven days). Neither FVS nor DDS are concerned with the quantity or frequency in which a food is eaten. Hatløy et al. (1998) concluded that a higher DDS is more preferable than a higher FVS for nutritional adequacy, highlighting the importance of consuming from all food groups. Therefore, an individual first needs to consume from all the food groups, and thereafter diversity/variety within the groups may become important. Since then, many authors have explored the ability of DDS and FVS to predict nutritional adequacy in a range of population groups from both developing and developed countries, such as children (Steyn et al., 2006), adolescents (Mirmiran et al., 2004) adults (Arimond et al., 2010; Ogle et al., 2001; Oldewage-Theron & Egal, 2013; Oldewage-Theron & Kruger, 2011; Torheim et al., 2004; Vandevijvere et al., 2010) and older people (Rathnayake et al., 2012). Studies that have investigated the relationship between dietary diversity, food variety and nutritional adequacy are summarised in **table 2.7**. **Table 2.7** demonstrates that despite differing populations of interest, food groups, techniques, and surveys, most studies supported the findings of Hatløy et al (1998), as higher DDS and FVS correlate to improved MAR and thus improved nutritional adequacy.

Table 2.7. Summary of different populations of interest, methodology and results of studies investigating the relationship between food variety and dietary diversity on nutritional adequacy

| Author and Country | Participant profile | Method of dietary assessment | Number of food items included overall | Number of food groups included | Results |
|---|---|---|---|---|---|
| Hatloy et al. (1998)<br>Mali | Children (0-5 years)<br>n=77 | Three day weighed food record | 75 | Eight (staples, vegetables, milk, meat, fish, egg, fruits, green leaves) | Mean FVS was 20.8, mean DDS was 5.8. An increased FVS correlated to increased MAR and thus nutritional adequacy ($r_s$=0.33, *P*<0.001) as did an increased DDS ($r_s$=0.39, *P*<0.001) |
| Steyn et al., 2006<br>South Africa | Children (1-8 years)<br>n=2200 | 24 hour recall | 45 | Nine (cereals, roots and tubers, vitamin A rich fruits and vegetables, other fruits, other vegetables, legumes and nuts, meat, poultry and fish, fats and oils, dairy, and egg) | Mean FVS was 5.5, mean DDS was 3.6. Mean MAR was 50%. An increased FVS correlated to increased MAR ($r_s$=0.73, *P*<0.001) as did an increased DDS ($r_s$=0.66, *P*<0.001). Therefore both FVS and DDS can be used as proxy measures of nutritional adequacy |
| Mirmiran et al 2004<br>Iran | Adolescents (10-14 years)<br>n=304 | 2 x 24 hour food recall | Used 23 subgroups instead of individual food items | Five (grain, vegetables, fruit, meat and dairy) | Mean DDS was 6.3. An increased DDS correlated to increased MAR ($r_s$=0.42, *P*<0.001) |
| Arimond et al., 2010.<br>Burkina Faso, Mali, Mozambique, Bangladesh, Philipines | Men and women (15-49 years)<br>n=500<br>(from 5 existing data sets) | 2 x 24 hour food recall | Used 21 subgroups instead of individual food items | 9-21 (grains, starchy staples, legumes, soy, milk/yoghurt, cheese, organ meats, eggs, small fish, large fish, red meat, poultry, insects/rodents, vitamin A rich green vegetables, vitamin A rich yellow/orange vegetables, vitamin A rich fruits, vitamin C rich vegetables, vitamin C rich fruits and all other vegetables) | Each food group diversity measure (defined in eight different ways) correlated to probability of nutritional adequacy ($r_s$=0.20-0.53, *P*<0.001) even when controlling for energy intake |

| Author and Country | Participant profile | Method of dietary assessment | Number of food items included overall | Number of food groups included | Results |
|---|---|---|---|---|---|
| Torheim 2004. Mali | Men and women (15-45 years) n=502 | QFFQ (7 day) | 76 | Ten (cereals, legumes, oil and sugar fruit, vegetables, meal, milk, fish, eggs and green leaves | An increased FVS correlated to increased MAR ($r_s$=0.34, *P*<0.001) as did an increased DDS ($r_s$=0.30, *P*<0.001). The correlations between MAR and food group variety were the strongest for vegetables and milk ($r_s$=0.31 and $r_s$=0.30 *P*<0.001). BMI was not associated with FVS nor DDS |
| Oldewage-Theron and Kruger (2011). South Africa | Women from 357 households n=426 | QFFQ (7 day) | 40 | Nine (cereals, legumes, flesh products, eggs, dairy, vegetables, fruits, vitamin A rich foods, fats) | Mean FVS was 3.2, mean DDS was 2.8. An increased FVS correlated to increased MAR ($r_s$=0.22, *P*<0.001) as did an increased DDS ($r_s$=0.22, *P*<0.001) |
| Ogle et al., 2001 Vietnam | Women (19-60 years) n=196 | FFQ (7 day) | 120 | 12 including discretionary (cereals, starchy roots, green leafy vegetables, other vegetable, fish and seafood, nuts and legumes, fruit and fruit juice, oils and fats, sauces). | Mean FVS was 14.2, mean DDS was 9. Participants with high FVS (FVS >21) and DDS (DDS >8) had higher overall nutrient intakes compared to participants with low FVS and DDS (FVS <15, DDS < 5 *P*<0.01) |
| Rathnayake et al (2012) Sri Lanka | Older men and Women (>60 years) n=200 | 24 hour recall | 15 | Six (cereals/roots, vegetables, fruits, legumes/lentils, meat/fish/egg & milk/dairy products) | Mean FVS was 8.4, mean DDS was 4.4. An increased FVS correlated to increased MAR ($r_s$=0.45, *P*<0.001) as did an increased DDS ($r_s$=0.48, *P*<0.001) |

n=, number of participants; FFQ, food frequency questionnaire; QFFQ, quantitative food frequency questionnaire; MAR, mean adequacy ratio; FVS, food variety score; DDS, dietary diversity score.

### 2.3.2 Dietary diversity and its link to anthropometric measures

Interest in the relationship between dietary diversity and anthropometric measures (such as BMI, WC and BF%), largely stem from explorations into dietary diversity and children's growth in developing countries. Authors found that children grew more consistently along predicted growth charts when dietary diversity scores were higher, even when controlling for economic status, maternal and paternal height and paternal education (Arimond & Ruel, 2004; Steyn et al., 2006). However, despite its links to child growth, there is a conflicting body of evidence as to whether having a varied and diverse diet protects an individual from, or contributes to, obesity.

Increased dietary diversity has been associated with an increased BMI within settings where individuals are often dangerously underweight, such as rural poverty in developing countries (Mirmiran et al., 2004; Savy et al., 2005). For example, Tehran adolescents in the highest DDS tertile had a BMI of 19.8kg/m$^2$ (normal) compared to 17.2kg/m$^2$ (underweight) as demonstrated by those in the lowest (Mirmiran et al., 2004). Women in the highest DDS tertile demonstrated 9.8% prevalence of underweight, compared to 22.8% in the lowest DDS tertile in rural Brazil (Savy et al., 2005). However, in settings where individuals tend to be obese (such as in urban poverty), increased dietary diversity has instead been associated with reduced BMIs (FAO, 2018). For example, women within the highest DDS quartile demonstrated a lower BMI in South Africa (29.3 vs. 30.7 $P<0.001$) (Oldewage-Theron & Egal, 2013) and a reduced risk of obesity in Iran (OR 0.21, $P=0.03$) (Azadbakht & Esmaillzadeh, 2011). These studies indicate that increased dietary diversity is associated with preferable BMIs (i.e. neither underweight nor overweight), in developing countries.

Evidence also exists to suggest that dietary diversity may be a risk factor for obesity in developing counties. Authors have demonstrated that those who consume a larger variety of healthy foods are more likely to be obese due to either a higher daily energy consumption (aka; the DD-energy hypothesis) seen in Sri Lankan (Jayawardena et al., 2013), Brazilian (Bezerra & Sichieri, 2011) and Bolivian adults (Bénéfice et al., 2007), or the tendency to consume an equally varied intake of discretionary foods (aka; the DD-discretionary hypothesis) seen in Mexican adults (Ponce et al., 2006).

Despite a growing body of evidence, many authors debate the existence of an obesity-DD link. For example, there was no significant difference in BMI between participants with the highest and lowest DDS in poverty stricken South America, (Savy et al., 2008) Asia (Gregory et al., 2008; Kimura et al., 2009; Lee et al., 2011) nor Africa (Ajani, 2010; Hasan-Ghomi et al., 2012; Mayega et al., 2012). However, authors who are unable to find an association between DDS and BMI, WC or BF%, did not include discretionary food items or groups in their analyses. By not including discretionary foods, authors exclude a wide range of foods that have been demonstrated to contribute to 27% of energy intakes in developing countries such as Mexico (Aburto et al., 2016) and 40% of the diet in developed countries such as Australia (Johnson et al., 2017), therefore ignoring a significant portion of the dietary intake which may influence body composition.

Studies that investigate an obesity-DD link within developed countries are scarce, however as per the findings of developing countries, results are conflicting. Authors have found that compared to participants in the lowest tertile of DDS, participants within the highest DDS quartile were less likely to have an obese BMI by 55% ($P$=0.009) (Vadiveloo, Dixon, Mijanovich, Elbel, & Parekh, 2014), 51% ($P$=0.009) (Abris et al., 2018), or had a significantly lower average BMI (24.8 vs. 26.0, $P$<0.001) (Kant & Graubard, 2005), indicating that higher DDS is associated with reduced obesity. Despite these findings, some of the earliest cross sectional investigations on the topic concluded increasing diversity was associated with an increased risk of obesity (Rolls & Hetherington, 1989). Since then, further authors have demonstrated that having a higher DDS is associated with increased energy intakes and thus the risk of being overweight in urban Chinese men (OR 1.09, $P$<0.05) (Tian et al., 2017) and adults in the U.S (Foote et al., 2004; McCrory et al., 1999), therefore supporting the DD-energy hypothesis of obesity. It is notable that the correlation between a higher DDS and a higher BMI ($P$<0.001) has also been established when energy intake is controlled for (Bernstein et al., 2002; Tian et al., 2017).

Evidently, there is a lack of consensus as to whether DDS is positively or negatively associated with BMI and obesity. It may be that the anthropometric effect of a diverse diet depends on the types of foods being eaten, and whether it is nutritious or instead discretionary (Abris et al., 2018; Aburto et al., 2016; de Oliveira Otto et al., 2015; Foote et al., 2004; McCrory et al., 1999). For example, vegetable and legume intakes contribute to only 5.7% and 3.8% of energy intake in Mexico (controlling for socio-economic status), even when dietary targets of five servings a day are achieved (Aburto et al., 2016). Perhaps unsurprisingly, consuming an increased variety of vegetables correlates significantly to a lower BMI (Abris et al., 2018; Aburto et al., 2016; McCrory et al., 1999) and a 49% lower risk of an obese BMI (OR 0.61, *P*=0.03) (Azadbakht et al., 2006). The same can be said for consuming a wide variety of legumes (OR 0.67, *P*<0.001) (Aburto et al., 2016). Conversely, consuming a variety of discretionary foods such as sweets and low quality carbohydrates was associated with an increased BMI (de Oliveira Otto et al., 2015; McCrory et al., 1999) and increased energy and saturated fat intake (Ponce et al., 2006) thus supporting the DD-discretionary hypothesis of obesity. However, discretionary foods cannot be the only contributing factor within a possible obesity-DD link as many authors who do not include discretionary foods in their analysis have still found dietary diversity to be associated to a higher BMI or BF% (Bernstein et al., 2002; Foote et al., 2004; Tian et al., 2017). The results of studies that consider the obesity-DD link in developed countries are further summarised in **table 2.8**.

Table 2.8. Summary of different populations of interest, methodology and results of studies investigating the relationship between dietary diversity and food variety on obesity and weight outcomes in developed countries

| Author (controls used) | Participant profile | Method of D.A | # of food groups | Disc- food groups included | Indices of DD or FV used | Results | Conclusions |
|---|---|---|---|---|---|---|---|
| Kant et al., 1993. (Age) | Men and women (<20 years) in the U.S n=10,406 | 24 hour recall | Five (dairy, meat, grains, fruits, vegetables) | ✕ | DDS as a count of food groups consumed | Women in the highest quintile of DDS (DDS = 5) were 21% more likely to demonstrate a normal BMI, compared to the lowest who were more 8% more likely to have an obese BMI (*P*=0.003). No significant results were demonstrated for men. | Increased DDS within nutritious food groups is associated with a reduced risk of obesity in women. |
| Kant et al., 2005 (Age, ethnicity, smoking, alcohol, energy intake, exercise, dieting status, education) | Men and women (>20 years) in the U.S n=8719 | 24 hour recall | Five (dairy, meat, grains, fruits, vegetables | ✕ | DDS as a count of food groups consumed | Participants within the highest quartile of DDS (DDS=4-5) demonstrated a significantly lower average BMI (24.8kg/m$^2$) compared to the lowest quartile of DDS (DDS=0-1, 26.0kg/m$^2$, *P*<0.001). | A higher DDS is associated with a healthier BMI (i.e. not overweight or obese) more so than a lower DDS. Therefore consuming from a wider range of healthy food groups is protective of obesity. |
| Abris et al. 2018 (Energy intake, age, place of residence, employment, parity, breastfeeding) | Women (>19 years) in urban South Korea n=402 | 24 hour recall | 11 (grains/ tubers, red meat, poultry, fish, other seafood, legumes/seeds/nuts, egg, dairy, leafy vegetable, other vegetables, fruits) | ✕ | DDS and FVS (called variety count) as a count of food groups and consumed | A higher DDS was inversely associated with the risk of abdominal obesity measured by WC (OR 0.49, *P*=0.009) and general obesity measured by BMI (OR 0.47, *P*=0.008). A higher FVS within vegetable and poultry groups was associated with a 49% (*P*=0.005) and 50% (*P*=0.003) lower risk of general obesity respectively. | Increased DDS within nutritious food groups (in particular vegetables and poultry) is protective of general and abdominal obesity even when controlling for energy intake. |

| Author (controls used) | Participant profile | Method of D.A | # of food groups | Disc- food groups included | Indices of DD or FV used | Results | Conclusions |
|---|---|---|---|---|---|---|---|
| Vadiveloo et al. 2015 (Energy intake) | Men and women (>20 years) in the U.S n=7470 | Two x 24 hour recall | 17 (whole grains, trim milk, vegetables (green, red/orange, starchy, legumes, other), fruits, nuts/seeds, seafood, oil, meat, poultry, eggs, refined grain, solid fat, added sugar) | ✓ | FVS measured using the U.S HFD index. Participants are given a score between zero and one. One = consumes a higher # of healthful foods | Among women, the odds of having an obese range BMI and android-to-gynoid fat ratio and fat mass index were 35-55% lower in the highest quintile of FVS score compared to the lowest (*P*<0.001) | Higher FVS was inversely associated with a range of anthropometric measures, which indicates that consuming a wider range of healthy foods protects against obesity |
| Foote et al., 2004 (Energy intake, age, education, BMI, ethnicity) | Men and women (>19 years) in the U.S n=9769 | 24 hour recall | Five (dairy, fruit, vegetables, grains, meat/protein) | ✕ | DDS (called food group intakes) and FVS (called dietary variety count) as counts of food groups and items eaten | Increased DDS and FVS positively correlated to energy intake (both *P*<0.001) | Increased DDS and FVS predicts higher energy intakes and thus predicts obesity |
| Tian et al. 2018 (Energy intake, income, exercise, marital status, age, education, smoking, alcohol, urban/rural) | Men and women (18-65 years) in urban China n=17825 | 24 hour recall x three days | Six (grains, dairy, vegetables, fruit, meat and beans) | ✕ | DDS as a count of food groups consumed | There was a positive association between higher DDS and the likelihood of a participant having an overweight (but not obese) BMI (OR 1.09, *P*<0.05) in men but not women | An increased DDS increases the likelihood for an overweight (but not obese) BMI in men, even when controlling for energy intake |

| Author (controls used) | Participant profile | Method of D.A | # of food groups | Disc- food groups included | Indices of DD or FV used | Results | Conclusions |
|---|---|---|---|---|---|---|---|
| Bernstein et al. 2002 (Age, BMI, energy intake) | Elderly men and women (72-98 years) in the U.S n=98 | Three day weighed food diary | Two (fruits and vegetables, other) | ✕ | FVS as count of food items consumed (called dietary variety scores) | There was a significant positive correlation between a higher DDS and a higher energy intake ($r_s$=0.44, *P*<0.001) and BMI ($r_s$=0.34, *P*<0.001) and thus reduced frailty in women. There was no significant correlation between FVS, energy intake and BMI in men | Increased FVS predicts higher energy intake and BMIs in frail older women, thus increased DDS is associated with a reduced risk of all-cause mortality in older adults |
| McCrory et al., 1999 (Age and sex) | Men and women (20-80 years) in the U.S n=71 | FFQ (six months) | Ten (breakfast, lunch, dinner, entrees, sweets snacks, condiments, fruit, vegetables, energy containing beverages, dairy) | ✓ | FVS (called dietary variety) calculated as a percentage of food items consumed within each food group | There was a significant positive correlation between FVS and energy intake both overall ($r_s$=0.32, *P* <0.05) and within each individual food group ($r_s$=0.27–0.56, *P*< 0.05). Discretionary food FVS (namely; sweets, snacks, sauces, entrées) demonstrated a positive correlation to BF% ($r_s$=0.38, *P*<0.001). Vegetable FVS demonstrated a negative correlation to BF% ($r_s$=0.31, *P*<0.001) | Higher FVS predicts an increased energy intake, within both nutritious and discretionary food groups. Increased FVS within groups only predicts increased BF% when food variety is within discretionary food groups |
| De Oliveira otto et al., 2015 (Age, sex, ethnicity, education, physical activity, BMI, cholesterol, T2DM) | Men and women (45-84 years) in the U.S n=5160 | FFQ (one year) | N/A | ✓ | FVS as a count of food items, 'dissimilarity' of food items and 'evenness' of food items spread between food groups | Participants in the highest quintile of overall food dissimilarity demonstrated a 120% higher risk of a WC >80cm (i.e. obese) compared to the lowest quintile (*P*<0.01). There was no significant difference in WC between the highest and lowest quintiles o FVS, evenness or dissimilarity when considering only healthy foods | Increased food dissimilarity across the diet (i.e. consuming a wider variety of foods) is positively associated with an obese WC, as the result of an associated increase in discretionary food intake |

n=, number of participants; D.A, dietary assessment; #, number; disc-, discretionary; DD, dietary diversity; FV, food variety; DDS, dietary diversity score; FVS, food variety score; FFQ, food frequency questionnaire; BMI, body mass index; WC, waist circumference; N/A, not applicable; T2DM, type two diabetes mellitus. All studies are cross-sectional. Green = study concluded that increased dietary diversity and/or food variety negatively associated with obesity. Red = study concluded that increased dietary diversity and/or food variety positively associated with obesity. Orange = study concluded that the direction of the association between dietary diversity, food variety and obesity depends on the types of foods consumed (i.e. nutritious or discretionary).

### 2.3.3 Measuring dietary diversity

As discussed, original explorations into dietary diversity commonly relied on collecting food records, food frequency questionnaires and 24 hour dietary recalls (**table 2.6**), and then using these to determine an individual's DDS and FVS. In an attempt to standardise and simplify the process of measuring DD, dietary diversity questionnaires (DDQ) have been developed (FAO, 2011). A DDQ has a list of foods and asks participants (with the help of an assessor in the case of illiteracy), to tick whether they have or have not consumed a food over a certain reference period (i.e. previous 24 hours) (FAO, 2011). By not requiring exact proportions or measurements, the DDQ is not as strongly subjected to recall bias and memory error as assessment methods such as the FFQ or 24 hour food recall (Thompson et al., 2015). Due to differences in cultural food practices and scientific opinion, many versions of the DDQ exist. What is most critical is that each DDQ is first validated in the population of interest (Ruel, 2003a). To validate a DDQ, it must be tested against multiple participant food records and dietary analysis to ensure it contains all of the foods commonly consumed within a population group, and that a higher DDQ score reliably predicts higher nutritional adequacy (FAO, 2011). Alongside proper validation, the FAO (2011) advocates for better standardisation of DDQs, in order for the DDS and FVS to provide a comparable, valid and reliable reflection of nutritional adequacy across multiple settings.

The measurement of dietary diversity can differ between developing and developed countries. When exploring dietary diversity in a developing country, where diverse intakes are uncommon, a typical DDQ contains foods sorted into nine nutritious food groups, namely; starchy staples, dark leafy green vegetables, other vitamin A-rich fruits and vegetables, other fruits and vegetables, organ meat, meat and fish, eggs, legumes nuts and seeds, and milk and milk products (**table 2.7**). However, within a developed country, the food environment contains an abundant and highly accessible range of both nutritious and discretionary foods, thus eating at least one food from all main food groups is common. Therefore, when using a typical DDQ in developed nations, most people would achieve a very high DDS, regardless of their nutritional status. Developed world DDQ's require further disaggregation of the original nine food groups, and a deeper exploration into the number of food items consumed within each group to truly capture the diversity and variety of the diet. Authors of recent meta-analysis have recommended that future authors consider disaggregating food groups (to as many as 25, outlined in their article), and consider overall FVS and within food group FVS, to better understand the vast range of food items consumed (Salehi-Abargouei et al., 2016). Furthermore, it is recommended that discretionary food groups are included in the analysis, as they comprise a significant portion of the developed world diet (Arimond et al., 2010; Salehi-Abargouei et al., 2016). For example, using these suggestions, a group such as (a) milk and milk products used in a developing world DDQ, may be disaggregated to (a) milk (b) cheese, (c) yoghurt and (d) discretionary dairy in a developed world DDQ.

Even when considerations are made to ensure that a DDQ is appropriate for a developed setting, challenges arise. For example, in a country where multiple cultures and food practices exist, a single standardised survey may be able to capture most, but possibly not all, of the food items consumed (Metcalf et al., 2008). If participants are consuming items outside of the DDQ, their calculated FVS score may underestimate the food variety in their diet, which weakens the relevance of their FVS (FAO, 2011). Therefore, DDQs in developed settings may benefit from an “other” section where participants can add foods that were not captured in the survey, and may require continuous reassessment to adapt the survey in line with changing food trends. Next, the results of DDQs become increasingly challenging to interpret when the original nine food groups used to calculate DDS are disaggregated further. For example, each original food group provides a rich source of an essential nutrient (i.e. milk and milk products provides calcium), thus omitting the food group negatively impacts your nutritional status (Hatløy, Hallund, Diarra, & Oshaug, 2000; Torheim et al., 2004). However, when food groups are further disaggregated excluding some food groups (i.e. discretionary food groups) may be beneficial for health and must be considered separately to nutritious groups, and omitting calcium rich groups such as ‘cheese’, may not be detrimental to nutrition status if still consuming from groups such as ‘milk’. Finally, comparing the results of different studies within this field of research is challenging, as classifying foods (especially discretionary foods) is subjective and differs between authors, as some foods (for example; nuts), can be considered both nutritious and discretionary depending on preparation method (Salehi-Abargouei et al., 2016).

In New Zealand, a DDQ has recently been developed and validated within a subgroup of NZE, Māori and Pacific women of childbearing age (Hepburn, 2014). In accordance with the recommendations of Arimond et al. (2010) and Salehi-Abargouei et al. (2016) this DDQ was disaggregated to 26 groups. The groups include discretionary food groups that are high in saturated fats, sugars and energy - such as; discretionary cereals, breads, starchy vegetables (i.e. fries), dairy (i.e. ice cream) and flesh foods (i.e. bacon), as well as sweet and savoury snack groups, takeaways, sauces, spreads, flavourings and alcohol. Much like the original investigations into dietary diversity, food variety and nutritional adequacy, Hepburn (2014) found significant positive correlations between the women's MAR and their DDS – however, the same strength correlation was not seen with an increasing FVS. Similar to Hatløy et al., (1998), Hepburn (2014) concluded that in New Zealand women, omitting food groups was more detrimental to nutritional status than low food variety overall.

## 2.4 Gap in the research

In New Zealand, obesity has become an epidemic, and most dietary research focuses on quantitative assessment methods that do not consider the 'whole diet' nor explore overall diet quality. Historically, explorations into dietary diversity (as a diet quality measure) mostly take place in developing nations, where intakes are limited to starchy staples and dietary deficiencies are common. Because of the link between dietary diversity and nutritional adequacy, consuming a diverse diet can help an individual avoid dietary deficiencies, however the relationship between dietary diversity and chronic lifestyle diseases such as obesity is not well established. There are multiple barriers to investigating the obesity-DD link in a developed setting, such as the enormous variety of foods available, and the abundance of discretionary foods. Thus, investigations into the consequences of dietary diversity on obesity in developed nations are scarce, and are in disagreement as to whether dietary diversity is positively or negatively associated with obesity. Exploring new ways to assess the dietary quality of reproductive age women is critical, as they are more likely to be obese than men of the same age, often bear children, and appear to suffer more so from the poor psychological and social outcomes related to obesity (i.e. anxiety, depression, discrimination, ostracism). There is currently no research that explores dietary diversity or food variety as a risk factor for obesity in New Zealand women, or how this might differ between ethnicities.

# Chapter Three:
# Research study manuscript
## 3.1 Abstract

Eating a diverse diet improves diet quality and nutritional adequacy, but may be higher in energy and discretionary foods, which are associated with obesity. We aimed to utilise a newly validated dietary diversity questionnaire (DDQ) to explore the dietary diversity and food variety of New Zealand European, Māori and Pacific women and how dietary diversity and food variety may link to different body composition profiles (BCPs).

Women's (n=235) waist circumference, body mass index and body fat percentage (BF%) was used to categorise them into one of three BCP groups (normal-fat, hidden-fat, apparent-fat). Dietary intake was assessed using a Food Frequency Questionnaire (energy and nutrients), alongside a validated DDQ, which assessed participants' dietary diversity and food variety scores (DDS and FVS).

Dietary diversity was high (88%, 22/25) whilst food variety was comparatively low (31%, 78/237), especially within carbohydrates, fruits, vegetables and seafood. Overall, DDS and nutritious-DDS was lower for Pacific participants (*P*<0.005), whilst discretionary-FVS was higher for Māori and Pacific participants (both *P*<0.001). Regarding obesity, nutritious-DDS was higher in participants with a non-obese BMI (*P*=0.024) and BF% (*P*=0.029), compared to obese participants. Both DDS and N-DDS negatively correlated to WC and BF% (*P*<0.005). Participants in the highest tertile of DDS and nutritious-DDS had a lower WC (*P*=0.015, P<0.001), BMI (*P*=0.048, *P*=0.004), and BF% (*P*=0.002, *P*=0.011), despite consuming more energy (*P*=0.016). We were unable to demonstrate any significant anthropometric differences between tertiles of discretionary DDS nor discretionary FVS.

Our results support previous prospective studies, showing that consuming an increased variety of nutritious foods is associated with a reduction in female obesity, possibly more so than omitting discretionary foods. Health promotion should encourage exchanging rather than excluding, discretionary foods.

Key words: *Dietary diversity, food variety, diet quality, New Zealand women*

## 3.2 Introduction

Globally, one in every five deaths can be attributed to a poor quality diet (Gakidou et al., 2017). For the best health outcomes, emerging research encourages us to focus on the quality of the 'whole diet', instead of excluding or including single foods (Asghari et al., 2017; Freeland-Graves & Nitzke, 2013; Nitzke et al., 2007). Eating a diverse diet is an important factor of diet quality and is recommended by respected health agencies (Ministry of Health, 2015a; World Health Organisation, 2018a), however there is no consensus as to whether dietary diversity is detrimental, beneficial or irrelevant in the battle against obesity. The prevalence of obesity has reached epidemic levels, with 600 million people obese globally, 390 million of which are women (World Health Organisation, 2017, 2018b). Obesity has detrimental physical and mental health repercussions such as heart disease, stroke, arthritis, type two diabetes, cancers, depression and anxiety (Ministry of Health, 2008, 2015b). In New Zealand more than half of child-bearing aged women are classified as overweight or obese, which is significantly more than men of the same age (Ministry of Social Development, 2016). Furthermore, a recent pilot study has suggested that as many as 21% of New Zealand women are not recognised as obese, but have hidden fat, which holds metabolic risks comparable to apparent obesity (He et al.; Padwal et al., 2016; Pischon et al., 2008; Sahakyan et al., 2015; Zhang et al., 2008). To date, no studies have considered the role dietary diversity, as an uncomprehend factor of diet quality, may play in New Zealand's female obesity crisis.

Dietary diversity is a qualitative measure of diet quality that considers two factors; dietary diversity (the count of food groups eaten, termed the dietary diversity score [DDS]) and food variety (the count of food items eaten, termed the food variety score [FVS]) (Ruel, 2003b). Dietary diversity was first explored in the developing world, where intakes are limited to a narrow range of starchy staples (Hatløy et al., 1998). Using the results from a dietary diversity questionnaire (DDQ), researchers demonstrated that combined DDS and FVS predicted nutritional adequacy as accurately as a weighed food record (Hatløy et al., 1998), without the need for high participant literacy, trained researchers and quantitative assessment (which is commonly influenced by bias and misreporting (Biro et al., 2002; Harris et al., 2009). Since, increased DDS and FVS scores have been linked to improved nutritional adequacy and lower rates of preventable disease across a range of population groups, such as children (Steyn et al., 2006), adolescents (Mirmiran et al., 2004) adults (Arimond et al., 2010; Fernandez et al., 1996; Foote et al., 2004; Kant, 2004; Kant & Graubard, 2005; Kant et al., 1993; Nicklas, Baranowski, Cullen, & Berenson, 2001; Ogle et al., 2001; Oldewage-Theron & Egal, 2013; Oldewage-Theron & Kruger, 2011; Torheim et al., 2004; Vandevijvere et al., 2010) and older people (Rathnayake et al., 2012).

The role that dietary diversity plays in obesity is uncertain. In developing countries, dietary diversity is linked to reduced body mass index (BMI) (Azadbakht & Esmaillzadeh, 2011; Oldewage-Theron & Egal, 2013), increased BMI (Bénéfice et al., 2007; Bezerra & Sichieri, 2011; Jayawardena et al., 2013; Ponce et al., 2006), or no change in BMI (Ajani, 2010; Gregory et al., 2008; Hasan-Ghomi et al., 2012; Kimura et al., 2009; Lee et al., 2011; Mayega et al., 2012; Savy et al., 2008). In developed countries, the concept of an obesity-dietary-diversity (obesity-DD) link is again not robust, as research demonstrates that in regards to obesity, dietary diversity can be positive (Bernstein et al., 2002; Foote et al., 2004; Tian et al., 2017), detrimental (Abris et al., 2018; Kant, 2004; Kant & Graubard, 2005; Kant et al., 1993), or irrelevant (Salehi-Abargouei et al., 2016). Authors who find a link between increased dietary diversity and obesity, often attribute it to either an accompanying increase in energy intake (hereby termed the DD-energy hypothesis) (Azadbakht & Esmaillzadeh, 2012; Bernstein et al., 2002; Foote et al., 2004; McCrory et al., 1999) or an accompanying increase in discretionary food intake (hereby termed the DD-discretionary hypothesis) (Azadbakht & Esmaillzadeh, 2011; Azadbakht et al., 2006; Ponce et al., 2006). Discretionary foods (i.e. biscuits, chips and chocolate), do not fit into the five healthy food groups (fruits, vegetables, dairy, whole grains and protein foods) (Australian Government, 2013). Consuming a wide range of discretionary foods means the diet is more diverse, however, it is also high in discretionary nutrients (i.e. saturated fat, and added sugars) and is associated with obesity (Aburto et al., 2016; Cohen et al., 2010; Guenther et al., 2008; Johnson et al., 2017; McCrory et al., 1999; Nitzke et al., 2007).

The findings of previous obesity-DD research are difficult to interpret and compare. Firstly, there is no consensus as to whether discretionary foods should be included within dietary diversity studies, as some authors do (de Oliveira Otto et al., 2015; McCrory et al., 1999) whilst others do not (Abris et al., 2018; Bernstein et al., 2002; Foote et al., 2004; Kant & Graubard, 2005; Kant et al., 1993; Tian et al., 2017). Secondly, it is challenging for a DDQ to validly capture the enormous variety of foods available in a first world setting, as experts suggest as many as

21 food groups (compared to the original nine) may be required (FAO, 2011; Salehi-Abargouei et al., 2016). Finally, each study measures obesity differently, whether by body fat percentage (BF%) (Abris et al., 2018; McCrory et al., 1999), waist circumference measurements (WC) (de Oliveira Otto et al., 2015), or, most frequently using BMI (Bernstein et al., 2002; Kant, 2004; Kant & Graubard, 2005; Tian et al., 2017). Though the most commonly relied on obesity measure, BMI has limitations when used in a multicultural setting such as New Zealand. For example, BMI does not consider ethnic differences in frame and weight (Huxley et al., 2010; World Health, 2000) thus BMI may overestimate the BF% in Māori and Pacific individuals (Rush et al., 1997; Rush et al., 2003; Swinburn et al., 1996), however altering the Māori and Pacific BMI cut-off points may reduce the sensitivity of the measure and is not appropriate either (Taylor et al., 2010). Furthermore, BMI is unable to detect hidden obesity (normal BMI but high BF%), seen most frequently in New Zealand European (NZE) women (Kruger et al., 2015).

The current study had three main objectives, (1) to investigate dietary diversity and food variety of childbearing aged New Zealand NZE, Māori and Pacific women, (2) to explore the relationship between dietary diversity and different body composition profiles within these same women and (3) to examine the relationship between dietary diversity and obesity, all using a newly validated DDQ, which includes discretionary food items (Hepburn, 2014).

## 3.3 Methods

### 3.3.1 Study design

The current investigation is a sub-study using anthropometric, food frequency questionnaire (FFQ) and DDQ data collected during the Women's Examining Predictors Linking Obesity Related Elements (EXPLORE) study (Kruger et al., 2015). The EXPLORE study investigated the relationship between different body composition profiles (BCPs) and chronic diseases of metabolic dysregulation of women in Auckland, New Zealand. Recruitment took place between August 2013 and December 2014, at Massey University's Albany Campus.

### 3.3.2 Ethical approval

Ethical approval was obtained from the Massey University Ethics Committee in 2013: Southern A, Application 13/13 (Kruger et al., 2015). All participants were required to complete a written informed consent before participating.

### 3.3.3 Participants and Recruitment

To participate in the EXPLORE study (Kruger et al., 2015), participants needed to be female, identify ethnically as NZE, Māori or Pacific, be post menarche (for one year) and pre-menopausal, not pregnant, breastfeeding or dieting and have no chronic diseases. The EXPLORE study aimed to recruit 225 women per ethnic group, to provide 80% power at a significant level $P<0.05$ to detect a medium effect size $f$ of 0.25. Participants were recruited in Auckland, New Zealand using advertising via media sources such as Facebook, Twitter, newspapers, magazines, websites and radio. Posters were placed in locations such as kindergartens, schools, gyms and libraries. Details of the study were also emailed to those on the Massey University staff and student email list. Recruitment methods were also adapted to be culturally appropriate for Māori and Pacific participants within their respective communities. For the subsample used in the current study, participants needed to have completed both an FFQ and DDQ.

### 3.3.4 Data collection

The EXPLORE study (Kruger et al., 2015) required eligible and willing participants to visit Massey University's Albany campus, fasted for at least two and a half hours. Participants underwent a series of tests, performed by trained research assistants. Waist circumference was measured according to the International Society for the Advancement of

Kinathropometry protocol (Marfell-Jones, Stewart, & De Ridder, 2012). Air Displacement Plethsmography was used to measure fat mass (BF%) and lean mass (BodPod Life Measurement Inc, Concord CA, with software V4.2+). Duel X-ray absorptiometry (DXA) was used to measure regional adiposity (Hologic QDR Discovery A, Hologic Inc, Bedford, MA with software APEX V.3.2)

On site, participants completed a 220 item semi quantitative FFQ validated in New Zealand women (New Zealand Women's FFQ [NZWFFQ]) (Beck et al., 2018). Participants were asked to tick the option which best described their usual intake of the food item over the previous month (see appendix A for full NZWFFQ). The survey was completed on SurveyMonkey.

Six days after their testing session, participants were emailed a SurveyMonkey link to complete the validated DDQ (Hepburn, 2014) at home. Those without reliable internet access received a printed copy of the DDQ, along with a return postage-paid envelope. The DDQ is a list of 237 food items (143 nutritious, 94 discretionary). Participants were asked to tick if they had consumed (or not) each food over the past seven days (see appendix B for full DDQ). Each food item belonged to a food group that was based on its main ingredient, for example, fruit yoghurt was considered a dairy product. The survey contained all commonly eaten foods in New Zealand, including traditional Māori and Pacific foods.

### 3.3.5 Data processing and analysis

*Participant information*

To evaluate misreporting within the NZWFFQ, we compared reported energy intake to estimated energy expenditure using the Goldberg method. In accordance with the revised Goldberg cut offs outlined by Black (2000), we utilised $SD_{min}$ and $SD_{max}$ values of -2 and +2 for 95% lower and upper confidence intervals respectively, with an S factor of 17.24, and a *d* of infinity. Energy expenditure was estimated using the Schofield equation, with a physical activity level (PAL) of 1.55 (the World Health Organisation (1985) value for 'light activity'). A PAL of 1.55 is commonly used in the Goldberg method when physical activity levels are unknown within disease free adults (Black, 2000; Goldberg et al., 1991) and was used during the validation of our DDQ (Hepburn, 2014). Participants who were highlighted as possible misreporters were not removed from the current study, as it has been previously demonstrated that this is not imperative when examining diet quality and obesity (Malinowska, Mlodzik-Czyzewska, & Chmurzynska, 2019).

Participant socioeconomic status (SES) was calculated by checking participants' address using the New Zealand Index of Deprivation (NZDEP) (Ministry of Health, 2013b). The NZDEP scores allocate each suburb from one (least deprived) to ten (most deprived), based off factors such as average income and employment rates.

*Anthropometry*

Participants were categorised into three different BCP groups (BCPGs) as per EXPLORE protocol: normal-fat (BMI <25kg/m$^2$ and BF% <30%); hidden-fat (BMI <25kg/m$^2$ and BF%>30%); apparent-fat (BMI >25kg/m$^2$ and BF% >30%) (Kruger et al., 2015). Four participants had BF% <30%, but BMIs >25, indicating a heavy bone or lean muscle mass. These participants were categorised as normal. Participants were also categorised into obese and non-obese groups based on World Health Organisation (1995) cut off points for obese BF% and BMI (>35% and >30kg/m$^2$ respectively).

*NZWFFQ*

The data from the NZWFFQ was entered manually into FoodWorks version 7 (Xyris Software, 2012) by trained professionals. FoodWorks utilises the New Zealand Food Composition Database (NZ, FOODfiles 2010) developed by New Zealand Plant and Food Research to determine energy and nutrient intakes.

*DDQ*

The results of the nutritional analysis (as gathered from FoodWorks) and DDQ (scores) were imported into Microsoft Excel. Using the results of the DDQ, the following scores were calculated for each participant; dietary diversity score (DDS) (count of overall food groups consumed), nutritious dietary diversity score (N-DDS) (count of nutritious food groups consumed), discretionary dietary diversity score (D-DDS) (count of discretionary food groups consumed), food variety score (FVS), (count of overall food items consumed), nutritious food variety score (N-FVS) (count of nutritious food items consumed) and discretionary food variety score (D-FVS) (count of discretionary food items consumed), as well as the discretionary food ratio (D-FR) (the percentage of food items consumed that is discretionary compared to overall FVS).

From the original nine food groups, food groups were disaggregated to a final 25 (16 nutritious, nine discretionary). Food groups were meat; poultry; fish and seafood; eggs; nutritious dairy products; cheese; breads; cereal; starchy vegetables; vitamin A rich fruit and vegetables (F&V); vitamin C rich F&V; other vegetables; other fruits; legumes; nuts and seeds; oils and fats; discretionary meat; discretionary dairy products; discretionary breads cereals and starchy vegetables; drinks; alcohol; sauce, spreads and flavourings; savoury snacks; sweet snacks; and takeaways and fast food. An additional group was created called sugar-sweetened beverages, where non caloric drinks were removed from the drinks group (diet soft drinks, black tea, black coffee, herbal tea). Vitamin A rich F&V are produce with more the 100ug of vitamin A equivalents per cup, vitamin C rich F&V have more than 30mg of ascorbic per cup. Fruits and vegetables that were rich in both vitamin A and C were considered vitamin A rich.

### 3.3.6 Statistical analysis

All data was imported into IBM SPSS 24 (SPSS Inc., Chicago, IL, USA). All variables were tested for normality, both overall and segregated by ethnicity and BCPG, using Kolmogorov-Smirnov, Shapiro-Wilk tests and normality plots. The Levene's test was used to examine the homogeneity of variance. Data that was not normally distributed was log transformed, and retested for normality. Data that remained not normal, was reported as medians with 25$^{th}$ and 75$^{th}$ centiles. Normally distributed data (height) was presented as means ± standard deviation. The Kruskal-Wallis tests were used to examine differences between non-parametric medians between ethnicities and BCPG and tertile of diversity and variety scores, with the exception of height, which was explored using a two tailed independent *t*-test. Significant Kruskal-Wallis *P* values were followed up with Mann-Whitney tests, with a Bonferroni correction of $P<0.0167$, to examine differences between groups. Frequency measures were used to determine the most popular twenty foods of each subgroup. Of the anthropometric data collected by EXPLORE (Kruger et al., 2015), WC ($r_s$=0.895) BF% ($r_s$=0.912) and BMI ($r_s$=0.786) demonstrated the strongest correlations to truncal fat measured by DXA (all $P<0.001$), thus were the focus of the analysis. Spearman's two tailed partial correlation coefficients were used to examine relationships between variables, controlling for age, ethnicity and SES.

## 3.4 Results

### 3.4.1 Participant profile

Despite all three BCPG groups (BCPGs) in all ethnicities being actively recruited, most of the final participant sample were NZE (n=141) (**figure 3.1**). More NZE participants were within the normal-fat BCPG, followed by apparent-fat, and hidden-fat, while more Māori and Pacific participants were in the apparent-fat BCPG, followed by the normal-fat, and hidden-fat BCPG.

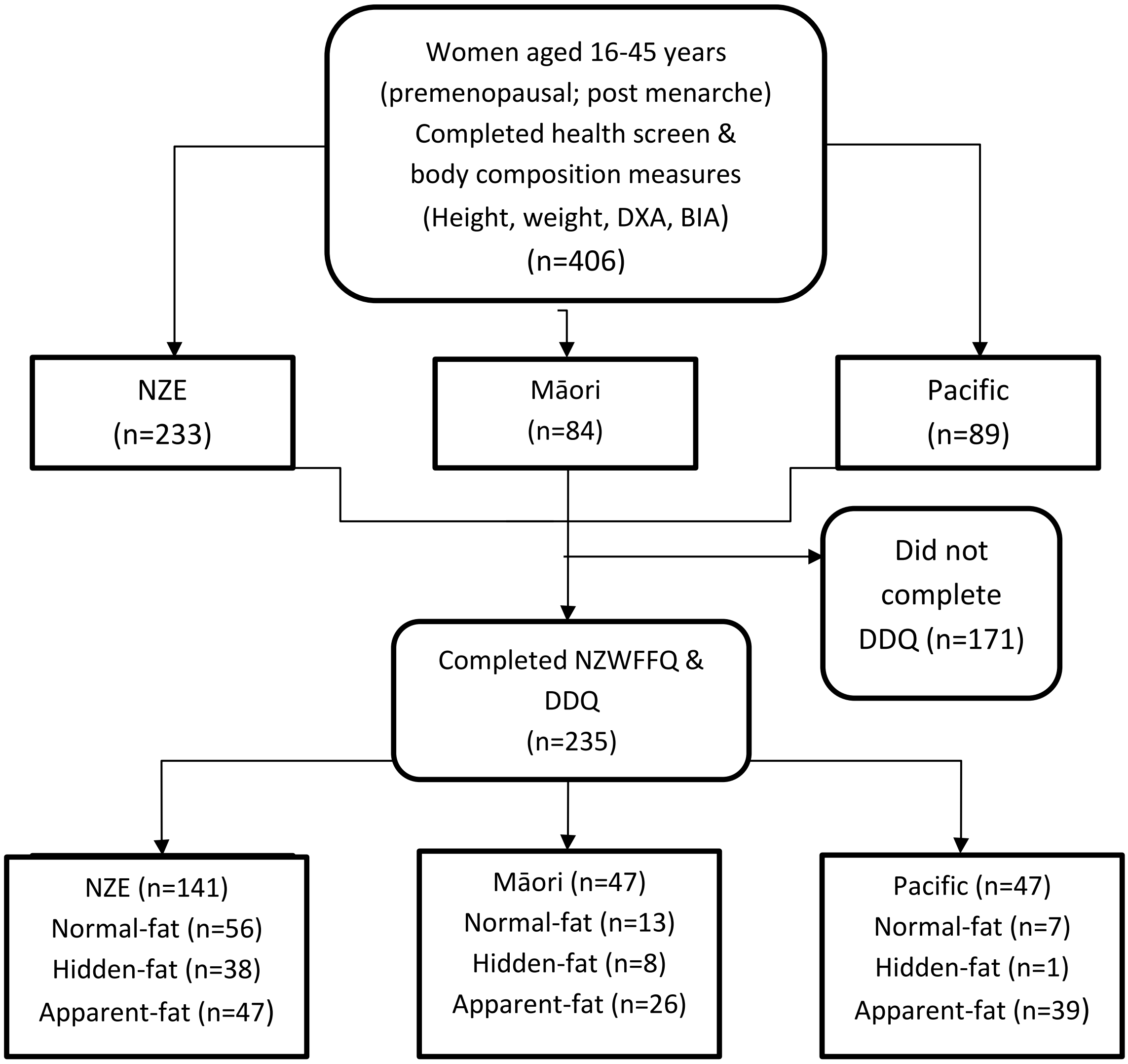


Figure 3.1. Stratification of EXPLORE sub-study participants (Kruger et al., 2015).

We identified 23 NZE (16.3%), 11 Māori (23.4%) and 13 Pacific (27.6%), eight normal-fat (10.5%), eight hidden-fat (17.0%) and 31 apparent-fat (27.7%) participants as possible under-reporters (results not shown). These women were not excluded from our analysis. Overall the most common BCPG was apparent-fat (n=112, 47% of participants), followed by normal-fat

(32.3%), then the hidden-fat (20.0%) BCPG (table 1). Participants' median(IQR) WC was in the normal category 78.5cm (72.3, 89.2), whilst both the median BMI and BF% were in the overweight category (25.1kg/m$^2$ [22.5, 30.2] and 33.4% [27.8, 39.2], respectively) (**table 3.1**).

Table 3.1. Participant profile characteristics

| Characteristic [cut off for obesity and increased metabolic risk]# | | Median (IQR 25th, 75th percentiles) (n=235) | Range |
|---|---|---|---|
| Age (years) | | 30.6 (23.6,38.5) | 16.3 - 45.2 |
| Height (cm) | | 167 ± 6.4 | 149 - 184 |
| Weight (kg) | | 70.4 (63.7, 82.9) | 43.7 - 142 |
| WC (cm) [>80cm]# | | 78.5 (72.3, 89.2) | 59.2 - 135 |
| BMI (kg/m$^2$) [>30%]# | | 25.1 (22.5,30.2) | 19.2 - 54.5 |
| Body Fat (%) [>35%]# | | 33.4 (27.8, 39.2) | 17.7 - 61.8 |
| SES 1= least deprived, 10 = most deprived | | 4 (2,7) | 1-10 |
| **Ethnicity of Participants** | **Count n (%)** | | |
| NZE | 141 (60) | | |
| Māori | 47 (20) | | |
| Pacific | 47 (20) | | |
| **BCPG of Participants** | **Count n (%)** | | |
| Normal-fat (*BMI <25kg/m$^2$, BF% <30%) | 76 (32.3) | | |
| NZE | 56 (39.7) | | |
| Māori | 13 (27.7) | | |
| Pacific | 7 (14.9) | | |
| Hidden-fat (BMI <25kg/m$^2$, BF% >30%) | 47 (20.0) | | |
| NZE | 38 (26.9) | | |
| Māori | 8 (17.0) | | |
| Pacific | 1 (2.13) | | |
| Apparent-fat (BMI >25kg/m$^2$, BF% >30%) | 112 (47.7) | | |
| NZE | 47 (33.3) | | |
| Māori | 26 (76.6) | | |
| Pacific | 39 (82.9) | | |

#, cut off for obesity and increased metabolic risk, NZE, New Zealand European; WC waist circumference; BMI, body mass index; SES, socioeconomic status as determined by NZ Deprivation Index (2013), BCPG; body composition profile group. *Participants were still characterised as having normal-fat if their BMI exceeded 25kg/m$^2$ but their WC and body fat measurements were below 80cm and 30% respectively. Presented as median (IQR 25th, 75th percentiles) or mean ± SD for normally distributed data. Ranges are presented as minimum-maximum. Three participants were excluded from our SES analysis due to missing data.

When comparing participant characteristics between ethnicities, weight, BF%, BMI and WC were highest in Pacific, and were higher for both Pacific and Māori, compared to NZE participants (**table 3.2**). Within BCPGs, the apparent-fat BCPG had the highest median BF%, BMI and WC. There was no significant difference in weight nor BMI between the normal-fat and hidden-fat BCPG, however, the latter had a higher BF% (by 4.4%, $P$=0.012) and WC (by

8.1cm *P*=0.008). The apparent-fat BCPG had significantly higher weights (*P*<0.001) and BMIs (*P*<0.001) than the hidden-fat BCPG. However, both the hidden-fat and apparent-fat BCPG had BF% within the obese range whereas the normal-fat BCPG did not. Based on SES scores, deprivation was significantly higher in Pacific compared with NZE and Māori participants (*P*<0.001), and the apparent-fat BCPG compared with the hidden fat BCPG.

Table 3.2. Differences in participant characteristics, by ethnicity and body composition profile group

| **Characteristic** | **Ethnicity** NZE (n=141) | Māori (n=47) | Pacific (n=47) | ***P*-value** |
|---|---|---|---|---|
| Age (years) | 31.4 (24.7, 39.0)[a] [16.58-45.17] | 33.8 (26.0, 38.2)[b] [16.8-45.1] | 25.8 (19.8, 34.3)[a,b] [16.3-44.8] | <0.001 |
| Height (cm) | 167 ± 6.7 [148-184] | 167 ± 5.8 [154-180] | 167 ± 5.50 [154-181] | 0.803 |
| Weight (kg) | 66.9 (61.5, 74.6)[a,b] [43.7-142] | 73.6 (65.8, 88.5)[a,c] [52.7-136] | 89.4 (73.3, 103.8)[b,c] [53.7-134] | <0.001 |
| WC (cm) [>80cm]# | 74.5 (70.2,81.3)[a,b] [59.2-135] | 82.6 (73.9, 92.4)[a,c] [63.7-121] | 92.3 (80.7, 99.7)[b,c] [66.8-111] | <0.001 |
| BMI (kg/m$^2$) [>30kg/m$^2$]# | 23.7 (21.7, 26.3)[a,b] [19.2-54.6] | 26.1 (23.9, 32.3)[a,c] [19.1-45.3] | 31.3 (26.9,38.9)[b,c] [20.4-48.1] | <0.001 |
| Body Fat (%) [>35%]# | 31.4 (26,35.2)[a,b] [17.7-61.8] | 35.8 (27.8, 41.4)[a,c] [17.9-52.9] | 37.6 (33.3,43.2)[b,c] [26.2-53.0] | <0.001 |
| SES 1= least deprived 10 = most deprived | 3 (2,4)[a,b] [1-10] | 4 (3-7)[a,c] [1-10) | 8 (4,8)[b,c] [1-10] | <0.001 |
| | **Body Composition Profile Groups** Normal (n=76) | Hidden (n=47) | Apparent (n=112) | *P*-value |
| Age (years) | 29.8(23.6, 37.2) [16.4-45.2] | 32.6 (25.2,39.5) [16.8-45.1] | 31.3 (23.1,39.3) [16.3-45.2] | 0.635 |
| Height (cm) | 168 ± 6.49 [149-182] | 168 ± 5.55 [153-184] | 168 ± 5.55 [148-181] | 0.189 |
| Weight (kg) | 63.6 (57.0,67.3)[a] [43.7-80.3] | 65.2 (62.4,68.4)[b] [58.2-80.3] | 83.7 (74.4,99.8)[a,b] [62.0 -142] | <0.001 |
| WC (cm) [>80cm]# | 70.5(67.5,75.2)[a,b] [59.2-87.3] | 73.5(72.2,78.2)[a,c] [66.6-85.3] | 90.3(82.8,98.5)[b,c] [71.2-135] | <0.001 |
| BMI (kg/m$^2$) [>30kg/m$^2$]# | 22.0 (20.6, 23.8)[a] [19.0-28.8]* | 23.2 (22.3, 24.3)[b] [20.4-25.0] | 30.5 (26.9,35.1)[a,b] [25.1-54.5] | <0.001 |
| Body Fat (%) [>35%]# | 25.6(22.2,27.6)[a,b] [17.7-29.8] | 32.4(31.4,35.2)[a,c] [30.0-38.8] | 39.5(34.9,44.0)[b,c] [30.2-61.8] | <0.001 |
| SES 1= least deprived 10 = most deprived | 3 (2,5) [1-10] | 3 (2,4)[a] [1-10] | 4 (2,7)[a] [1-10] | <0.001 |

#, cut off for obesity and increased metabolic risk; NZE, New Zealand European; WC, waist circumference; BMI, body mass index; SES, socioeconomic status Normal, normal-fat; Hidden, hidden-fat; Apparent, apparent-fat. *Participants were still characterised as having normal-fat if their BMI exceeded 25kg/m$^2$ but their WC and body fat measurements were below 80cm and 30% respectively. Presented as Median (IQR 25$^{th}$, 75$^{th}$ percentiles) for non-parametric data or mean ± SD for parametric data. Ranges are presented as [min-max]. Maximum cut off points for increased metabolic risk are presented as []#. *P*-values determined by Kruskal-Wallis for non-parametric data, and one way ANOVA for parametric data. Following Mann-Whitney post hoc test and Bonferroni correction with a *P*-value of 0.0167, matching alphabetical subscripts ([a-c]) indicate that two medians differ significantly. Red = Statistical significant at *P*<0.01. Four (one NZE, one Māori and two Pacific) participants had missing anthropometric data so were excluded from anthropometric analysis.

### 3.4.2 Dietary diversity and food variety

The overall dietary diversity and food variety of our participants, as well as of each ethnic and BCPG was investigated (**table 3.3**).

Overall, participants median DDS was 22 (IQR 21, 23) from 25 food groups, N-DDS was 15 (IQR 14, 16) from 16 food groups and D-DDS was 8 (IQR 7, 8) from nine food groups (table 3). Dietary diversity score was significantly lower in Pacific participants than Māori (*P*=0.012). Nutritious-DDS was significantly lower in Pacific participants than both NZE and Māori (Both *P*<0.005). However, there was no significant difference in D-DDS between ethnic groups, and also no significant difference in DDS, N-DDS nor D-DDS between BCPGs.

Overall, the median FVS was 73 (IQR 57, 88) from a total of 237 foods (30.8%), N-FVS was 47 (IQR 36, 57) from 143 foods, (32.8%) and D-FVS was 27 (IQR 20, 34) from 94 foods (28.7%). Therefore, on average, 10.4 different foods (6.7 nutritious and 3.8 discretionary) were consumed each day over the seven days. Discretionary-FVS was significantly higher in Māori and Pacific participants compared to NZE (*P*<0.001). There was no significant difference between BCPGs for FVS following post-hoc adjustments. Discretionary-FVS was significantly higher in normal-fat compared to the hidden-fat BCPG *(P*=0.015).

Overall, 37.4% (IQR 32.0, 41.8) of food items (D-FR) consumed were discretionary. Discretionary-FR was significantly lower for NZE than both Māori and Pacific (both *P*<0.001) participants, and for normal-fat and hidden-fat compared to the apparent-fat BCPG (both *P*<0.001).

| Score | Max score possible | Overall | Ethnicity | | | | | | *P*-value | Body Composition Profile Groups | | | | | | *P*-value |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | NZE (n=141) | | Māori (n=47) | | Pacific (n=47) | | | Normal (n=76) | | Hidden (n=47) | | Apparent (n=112) | | |
| | | | Median | Max | Median | Max | Median | Max | | Median | Max | Median | Max | Median | Max | |
| DDS | 25 | 22 (21,23) | 22 (20,23) | 25 | 22 (21,24)[a] | 25 | 22 (20,23)[a] | 25 | 0.028 | 23 (21,24) | 25 | 22 (20,23) | 25 | 22 (21,23) | 25 | 0.065 |
| N-DDS | 16 | 15 (14,16) | 15 (14,16)[a] | 16 | 15 (14,16)[b] | 16 | 14 (12,15)[a,b] | 16 | 0.008 | 15 (14,16) | 16 | 15 (13,16) | 16 | 14 (14,15) | 16 | 0.091 |
| D-DDS | 9 | 8 (7,8) | 8 (7,8) | 9 | 8 (7,9) | 9 | 8 (7,8) | 9 | 0.037 | 8 (7,8) | 9 | 7 (6,8) | 9 | 8 (7,8) | 9 | 0.117 |
| FVS | 237 | 73 (57,88) | 70 (56,86) | 154 | 80 (63,105) | 184 | 74 (55,107) | 192 | 0.018 | 78 (66,94) | 144 | 72 (52,86) | 184 | 70 (54,91) | 192 | 0.032 |
| N-FVS | 143 | 47 (36,57) | 46 (37,55) | 96 | 50 (40,63) | 107 | 45 (32,67) | 113 | 0.247 | 49 (43,60) | 92 | 48 (36,55) | 107 | 43 (34,56) | 113 | 0.061 |
| D-FVS | 94 | 27 (20,34) | 24 (19,31)[a,b] | 58 | 30 (23,42)[a] | 77 | 29 (23,40)[b] | 79 | <0.001 | 29 (23,34)[a] | 52 | 24 (16,31)[a] | 77 | 27 (20,35) | 79 | 0.032 |
| D-FR (%) | 100 | 37.4 (32.0,41.8) | 36.4 (31.1, 40.7)[a,b] | 69.4 | 38.5 (34.4,43.3)[a] | 57.9 | 40.4 (35.1, 44.2)[b] | 59.2 | <0.001 | 35.4 (30.6,40.9)[a] | 69.4 | 34.0 (27.3,40.6)[b] | 50.99 | 39.3 (35.0,43.2)[a,b] | 59.2 | <0.001 |

Table 3.3. Participant dietary diversity scores over a seven day period overall and segregated by ethnicity and body composition profile groups

NZE, New Zealand European; Normal, normal fat (BMI<25kg/m$^2$ and body fat %<30%); Hidden, hidden fat (BMI<25kg/m$^2$ and body fat %>30%); apparent fat (BMI>25kg/m$^2$ and body fat %>30%); DDS, dietary diversity score; N-DDS, nutritious dietary diversity score; D-DDS, discretionary dietary diversity score; FVS, food variety score; N-FVS, nutritious food variety score; D-FVS, discretionary food variety; D-GR, discretionary group ratio (the % of overall food groups consumed that were discretionary); D-FR, discretionary food ratio (the % of food items consumed that were discretionary); Max, maximum score achieved by group. Means presented as Median (IQR 25$^{th}$, 75$^{th}$ percentiles). Max indicates the maximum score achieved by a participant. *P*-values determined by Kruskal-Wallis. Following Mann-Whitney post hoc test and Bonferroni correction with a *P*-value of 0.0167, matching alphabetical subscripts indicate that two medians differ significantly. Orange = statistical significant at $P$ <0.05, red = Statistical significant at $P$ <0.01

Median and mode within-group FVS's from each of the nutritious and discretionary food groups were calculated overall, as well as for each ethnicity (**supplementary table 1 in appendix C.1**). Overall, the combined flesh foods (meat, poultry and fish and seafood) FVS was four (2, 8), the combined vegetarian proteins FVS (eggs, nutritious dairy, cheese, nuts and seeds and legumes) was seven (6, 11), the combined carbohydrate FVS (breads, cereals, starchy vegetables) was eight (5, 11), and the combined F&V FVS (vitamin A rich F&V, vitamin C rich F&V, other vegetables, other fruits) was 24 (16, 31). The most commonly excluded food group was legumes (42.4% of participants with FVS of zero).

For flesh foods, NZE participants had a significantly lower median poultry FVS, 1 (1, 1) than Pacific, 1 (1, 2; $P<0.001$), and Māori, 1 (1, 2; $P=0.032$) participants. Mode score analysis indicated that a FVS of zero (thus no item from the food group was eaten) was most common for meat, scored by 13% of NZE, Māori and Pacific participants.

For vegetarian proteins, Pacific participants had a significantly lower FVS for egg, 1 (1, 1), cheese, 1 (0, 2) and legumes, 0 (0, 1) than NZE participants (all $P<0.01$) and a significantly lower median egg and cheese FVS than Māori participants (both $P<0.01$). A mode FVS of zero was most common for legumes, scored by 38%, 36% and 62% NZE, Māori and Pacific participants respectively.

For the nine discretionary food groups, the FVS of NZE participants were significantly lower than Māori participants for discretionary meat and drinks ($P=0.012$), discretionary breads cereals and starchy vegetables ($P=0.015$), and takeaways and fast food ($P<0.001$), and lower than Pacific participants for savoury snacks ($P<0.001$), sweet snacks ($P<0.001$), discretionary breads cereals and starchy vegetables ($P<0.001$), and takeaways and fast food ($P<0.001$)

For flesh foods, the apparent-fat BCPG had the highest poultry (but not meat) FVS of any BCPG, 1 (1, 2; $P<0.001$) (**supplementary table 2 in appendix C.2**). Mode scores demonstrated that the normal-fat BCPG were the highest non consumers of meat and poultry (20% and 11% did not consume meat and poultry respectively).

For vegetarian proteins, compared to the apparent-fat BCPG, the normal-fat BCPG had a higher FVS for eggs ($P=0.014$), cheese ($P=0.003$), and legumes ($P<0.001$). The apparent-fat

BCPG were the highest non-consumers of eggs, cheese and legumes (17%, 18% and 57% respectively).

For carbohydrates, the normal-fat BCPG had a significantly higher cereals FVS, 5 (4, 6) compared to the apparent-fat BCPG, 4 (3, 5; $P$=0.012). The apparent-fat BCPG were the highest non-consumers of cereals (7%).

For discretionary foods, the normal-fat BCPG had the highest drinks FVS, 6 (4, 8) of any BCPG ($P$=0.008). Takeaways and fast foods FVS was significantly higher in the apparent-fat BCPG, 4 (3, 6) compared to the normal-fat BCPG, 3 (2, 5; $P$<0.001).

The 20 most commonly consumed food items over the seven day period (T20), features 18 nutritious foods, and two discretionary foods (**table 3.4**).

Pacific participants had only one vegetarian protein in their T20 (eggs), whereas Māori had two (eggs, hard cheese), and NZE participants had three (eggs, hard cheese, nuts). Pacific and NZE participants both had three carbohydrates in their T20 (potatoes, white bread, whole grain bread versus rice, whole grain bread, potatoes, respectively), whereas Māori had two (potatoes, whole grain bread). Pacific participants had six discretionary foods (sauce, butter, mayonnaise, chewing gum, chocolate, chips) in their T20, versus four (chocolate, sauce, mayonnaise, salt) for Māori, and two (chocolate, sauce) for NZE participants.

Table 3.4. The 20 most popular foods for participants overall and for each ethnicity

| | Overall | | Ethnicity | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | NZE (n=141) | | Māori (n=47) | | Pacific (n=47) | |
| **Rank** | **Food item/drink** | **%** | **Food item/drink** | **%** | **Food item/drink** | **%** | **Food item/drink** | **%** |
| 1 | Water | 97 | Water | 96 | Carrots | 98 | Water | 100 |
| 2 | Carrots | 91 | Oil (e.g. canola) | 94 | Water | 96 | Onions | 96 |
| 3 | Onions | 90 | Carrots | 92 | Eggs | 94 | Lettuce, all varieties | 91 |
| 4 | Chicken (e.g. thighs) | 89 | Eggs | 91 | Chicken (e.g. thighs) | 91 | Chicken (e.g. thighs) | 89 |
| 5 | Eggs | 89 | Tomatoes | 88 | Onions | 91 | Sauce (e.g. tomato or BBQ) | 87 |
| 6 | Oil (e.g. canola) | 88 | Chicken (e.g. thighs) | 87 | Apple | 89 | Banana | 83 |
| 7 | Lettuce, all varieties | 87 | Onions | 87 | Hard cheese | 87 | Butter | 83 |
| 8 | Tomatoes | 85 | Hard cheese | 86 | Lettuce, all varieties | 87 | Mayonnaise or creamy dressings | 83 |
| 9 | Banana | 84 | Lettuce, all varieties | 86 | Banana | 87 | Beef (e.g. steak) | 81 |
| 10 | Chocolates | 83 | Chocolates | 84 | Broccoli | 85 | Tomatoes | 81 |
| 11 | Sauce (e.g. tomato or BBQ) | 82 | Banana | 84 | Chocolates | 85 | Carrots | 79 |
| 12 | Beef (e.g. steak) | 81 | Beef (e.g. steak) | 82 | Garlic | 83 | Apple | 79 |
| 13 | Hard Cheese | 80 | Broccoli | 82 | Sauce (e.g. tomato or BBQ) | 83 | Oil (e.g. canola) | 79 |
| 14 | Broccoli | 80 | Garlic | 80 | Beef (e.g. steak) | 81 | Eggs | 77 |
| 15 | Garlic | 79 | Sauce (e.g. tomato or BBQ) | 80 | Potatoes | 81 | Chewing gum | 77 |
| 16 | Potatoes | 75 | Rice, all varieties | 77 | Tomatoes | 79 | Chocolates | 77 |
| 17 | Bread or rolls, whole-wheat/grain | 74 | Nuts (e.g. almond) | 75 | Oil (e.g. canola) | 79 | Chips/crisps | 77 |
| 18 | Apple | 74 | Bread or rolls, whole-wheat/grain | 74 | Mayonnaise or creamy dressings | 79 | Potatoes | 74 |
| 19 | Rice, all varieties | 74 | Potatoes | 74 | Salt, added to food or drink | 79 | Bread or rolls, white | 72 |
| 20 | Nuts (e.g. almond) | 71 | Spinach, silverbeet | 99 | Bread or rolls, whole-wheat/grain | 77 | Bread or rolls, whole-wheat/grain | 71 |

NZE, New Zealand European; %, percentage of participants within the subgroup that consumed that food item or drink rounded to the nearest whole number. . Food items are ranked in order of popularity (based on % of participants who ate it) from 1st to 20th most popular. Colour codes; Green = fruit or vegetable, red = discretionary food, orange = meat, cream = vegetarian protein source, darker blue = carbohydrates, breads, cereals and starchy vegetables, pale blue = oil.

Within their T20, each BCPG (**table 3.5**) had two flesh foods (chicken, beef). The normal-fat and hidden-fat BCPG had three vegetarian proteins in their T20 (eggs, cheese, nuts) whereas the apparent-fat BCPG has two (eggs, cheese). The apparent-fat BCPG demonstrated four discretionary foods in their T20 (sauce, chocolate, butter, mayonnaise) compared to two for normal-fat (chocolate, sauce) and hidden-fat BCPGs (chocolate, salt).

Table 3.5. The 20 most popular foods for each body composition profile group

| Rank | **Body Composition Profile Group** | | | | | |
|---|---|---|---|---|---|---|
| | **Normal (n=76)** | | **Hidden (n=47)** | | **Apparent (n=112)** | |
| | **Food item/drink** | **%** | **Food item/drink** | **%** | **Food item/drink** | **%** |
| 1 | Water | 97 | Water | 96 | Water | 97 |
| 2 | Eggs | 96 | Carrots | 91 | Chicken (e.g. thighs) | 95 |
| 3 | Oil (e.g. canola) | 95 | Banana | 91 | Onions | 90 |
| 4 | Tomatoes | 93 | Eggs | 89 | Carrots | 89 |
| 5 | Carrots | 92 | Oil (e.g. canola) | 89 | Beef (e.g. steak) | 88 |
| 6 | Onions | 91 | Onions | 87 | Lettuce, all varieties | 87 |
| 7 | Chocolates | 91 | Lettuce, all varieties | 85 | Sauce (e.g. tomato or BBQ) | 86 |
| 8 | Chicken (e.g. thigh) | 89 | Garlic | 83 | Eggs | 83 |
| 9 | Lettuce, all varieties | 89 | Hard cheese | 81 | Oil (e.g. canola) | 82 |
| 10 | Hard cheese | 88 | Bread or rolls, whole-wheat/grain | 81 | Tomatoes | 81 |
| 11 | Broccoli | 88 | Rice, all varieties | 79 | Chocolates | 79 |
| 12 | Banana | 88 | Tomatoes | 79 | Potatoes | 79 |
| 13 | Sauce (e.g. tomato or BBQ) | 86 | Broccoli | 79 | Banana | 79 |
| 14 | Rice, all varieties | 82 | Chocolates | 79 | Garlic | 77 |
| 15 | Garlic | 80 | Nuts (e.g. almonds) | 77 | Broccoli | 76 |
| 16 | Apple | 80 | Potatoes | 74 | Apple | 76 |
| 17 | Beef (e.g. steak) | 79 | Salt, added to food or drink | 74 | Butter | 76 |
| 18 | Green beans | 78 | Chicken (e.g. thighs) | 72 | Hard cheese | 75 |
| 19 | Nuts (e.g. almond) | 78 | Capsicum red | 72 | Mayonnaise or creamy dressings | 73 |
| 20 | Bread or rolls, whole-wheat/grain | 74 | Beef (e.g. steak) | 70 | Bread or rolls, whole-wheat/grain | 72 |

Normal, normal-fat; Hidden, hidden-fat; Apparent, apparent-fat; BF%, Body Fat Percentage; BMI, Body Mass Index, %, percentage of participants within the subgroup that consumed that food item or drink rounded to the nearest whole number. Food items are ranked in order of popularity (based on % of participants who ate it) from 1st to 20th most popular. Colour codes; Green = fruit or vegetable, red = discretionary food, orange = meat, cream = vegetarian protein source, darker blue = carbohydrates, breads, cereals and starchy vegetables, pale blue = oil.

When assessing the distribution of energy intake in the participants' diets, the percentage of energy (%E) contribution from protein intake was within the acceptable macronutrient distribution range (AMDR), %E from carbohydrate was below, and %E from fat above the AMDRs respectively. Only NZE and the normal-fat BCPG consumed %E from fat within the AMDR (**table 3.6**). Furthermore, E% from PUFA intake was below recommendations whilst the %E from SFA and sugar both exceeded recommendations.

There were no significant differences in energy (kcal) intake between ethnic groups nor BCPGs (**table 3.6**). Māori participants consumed the lowest %E from carbohydrate of any ethnicity ($P<0.001$). Within BCPGs, the apparent-fat BCPG had a higher fat (g), %E from fat, %E from SFA ($P=0.015$) and %E from MUFA than the normal-fat BCPG. The normal-fat BCPG consumed a higher %E from sugar and lactose (g) than the apparent-fat BCPG.

Table 3.6. Participants' average daily dietary composition overall and segregated by ethnicity and body composition profile group

| Energy and Nutrients | AMDR/EAR | Overall (n=235) | Ethnicity | | | *P*-value | Body Composition Profile | | | *P*-value |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | NZE (n=141) | Māori (n=47) | Pacific (n=47) | | Normal (n=76) | Hidden (n=47) | Apparent (n=112) | |
| Energy (kcal) | 1800-2300[+#] | 2130 (1751,2655) | 2115 (1805,2487) | 2130 (1716,2772) | 2215 (1679,3233) | 0.536 | 2220 (1819,2533) | 2105 (1843,2457) | 2095 (1679,2792) | 0.938 |
| %E Protein | 15-25%[+] | 17.9 (15.9,19.9) | 17.3 (15.8,19.8) | 18.4 (16.7,20.2) | 17.9 (15.6,19.5) | 0.354 | 17.3 (16.0,20.4) | 17.2 (14.6,19.4) | 18.0 (16.3,19.8) | 0.383 |
| Protein (g) | 37g[+] | 95.2 (76.9,118.7) | 92.9 (75.0,113) | 99.8 (82.4,129) | 102 (86.0,131) | 0.145 | 97.4 (78.3,114) | 91.9 (71.5,109) | 95.5 (78.8,129) | 0.315 |
| %E Fat | 20-35%[+] | 35.4 (32.1,39.5) | 34.6 (32.0,39.0) | 37.8 (32.9,41.5) | 35.7 (30.7,39.4) | 0.086 | 33.7[a] (31.0,37.5) | 35.2 (32.0,39.5) | 37.7[a] (32.7,39.9) | 0.018 |
| Total fat (g) | | 85.3 (65.2,106) | 83.3 (65.2,102) | 91.7 (68.5,111) | 83.3 (62.2,131) | 0.279 | 83.3 (62.2,100) | 89.2 (70.2,104) | 87.8 (65.2,114) | 0.546 |
| SFA (g) | | 34.8 (24.9,45.9) | 32.1 (23.8,41.1) | 37.1 (25.4,42.3) | 37.0 (24.1,49.5) | 0.453 | 31.6 (23.5,38.2) | 32.1 (23.7,41.2) | 35.4 (24.8,43.5) | 0.327 |
| %E SFA | <10%[+] | 13.7 (11.9,16.2) | 13.6 (11.6,15.9) | 14.5 (12.7,17.6) | 14.4 (12, 16.7) | 0.088 | 13.4[a] (11.2,16.3) | 13.9[b] (11.7,15.9) | 15.6[a,b] (12.9,20.2) | 0.015 |
| PUFA (g) | | 13.5 (9.94,17.5) | 12.7 (9.68,16.1) | 11.9 (9.10,16.6) | 12.9 (8.91,15.4) | 0.994 | 13.3 (10.0,15.2) | 12.3 (8.92,16.2) | 11.7 (9.01,16.8) | 0.780 |
| %E PUFA | 6-11%[^] | 5.2 (4.54,6.17) | 5.21 (4.47,6.45) | 5.06 (4.69,5.95) | 5.23 (4.67,5.63) | 0.731 | 5.46 (4.74,6.55) | 5.29 (4.76,6.48) | 5.36 (4.61,6.98) | 0.939 |
| MUFA (g) | | 30.7 (23.1,39.0) | 28.1 (21.9,34.4) | 31.4 (22.4,37.6) | 31.3 (22.2,38.3) | 0.507 | 28.1 (20.8,32.9) | 30.7 (21.9,35.5) | 29.4 (22.4,38.4) | 0.397 |
| %E MUFA | 10-20%[^] By difference[#] | 12.2 (10.7, 13.9) | 12.3 (10.5, 13.7) | 12.7 (11, 15.2) | 12.4 (10.4, 14.3) | 0.081 | 11.8[a] (10.2,13.5) | 12.6 (10.8,14.2) | 13.6[a] (11.4,15.9) | 0.001 |
| %E CHO | 45-65%[+] | 41.5 (35.9,46.5) | 42.5[a] (38.9,47.0) | 31.6[a,b] (10.1,41.1) | 43.3[b] (37.1,47.8) | <0.001 | 42.5 (39.2,47.0) | 39.6 (33.8,45.1) | 41.1 (34.8,46.0) | 0.116 |
| CHO (g) | | 225 (178,291) | 226 (181,288) | 213 (145,285) | 253 (190,340) | 0.094 | 231 (189,291) | 227 (182,261) | 224 (165,301) | 0.756 |

| Nutrient | AMDR | Overall n=235 | Ethnicity | | | *P*-value | Body Composition Profile Group | | | *P*-value |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | NZE (n=141) | Māori (n=47) | Pacific (n=47) | | Normal (n=76) | Hidden (n=47) | Apparent (n=112) | |
| Starch (g) | | 111 (75.1,142) | 110 (84.8,136) | 89.3 (67.7,135) | 135 (81.9,171) | 0.036 | 109 (72.8,138) | 105 (89.0,139) | 113 (74.1,145) | 0.874 |
| Sugar (g) | | 121 (87.2,146) | 122 (90.5,145) | 119 (77.9,139) | 124 (83.5,158) | 0.393 | 130.5 [a] (94.0,157) | 116 (95.1,135) | 116 [a] (78.0,140) | 0.130 |
| %E Sugar | <10%^ | 21.4 (17.9,25.1) | 22.0 (18.3,25.7) | 20.1 (17.2,23.1) | 20.8 (26.5,25.75) | 0.058 | 23.0[a] (19.1,26.4) | 20.5 (18.0,24.8) | 20.1[a] (16.9,24.1) | 0.005 |
| Glucose (g) | | 22.3 (15.5,30.8) | 22.2 (16.1,30.7) | 22.2 (13.3,32.8) | 24.4 (15.1,31.4) | 0.878 | 26.5 (19.0,33.4) | 22.3 (16.0,30.8) | 20.0 (14.1,27.5) | 0.033 |
| Fructose (g) | | 22.5 (15.9,32.6) | 21.3 (16.1,32.6) | 22.0 (15.2,31.6) | 23.5 (16.7,33.3) | 0.751 | 24.71 (17.9,33.3) | 23.8 (15.1,30.8) | 20.3 (14.5,32.1) | 0.197 |
| Sucrose (g) | | 45.4 (29.8,61.1) | 42.9 (29.8,62,0) | 41.8 (24.7,54.9) | 50.4 (31.5,68.1) | 0.247 | 47.2 (34.7,59.4) | 45.4 (33.8,60.3) | 42.9 (25.7,62.2) | 0.771 |
| Lactose (g) | | 17.5 (9.2,28.0) | 18.3 (10.1,28.9) | 11.7 (7.6,26.6) | 16.9 (5.58,28.2) | 0.307 | 21.2[a] (11.6,33.3) | 16.5 (9.31,26.0) | 14.9[a] (7.55,26.7) | 0.041 |

Kcal, kilo calories; SFA, saturated fatty acids; PUFA, polyunsaturated fatty acids; MUFA, monounsaturated fatty acids, CHO, carbohydrate; AMDR, acceptable macronutrient distribution range, EAR, estimated average requirements for women between 19-70 years old, %E; percentage of energy from protein, fat, carbohydrate, saturated fat, polyunsaturated fat, monounsaturated fat, or sugars respectively. Normal, normal-fat; Hidden, hidden-fat; Apparent, apparent-fat. Presented as Median (IQR 25$^{th}$, 75$^{th}$ percentiles). *P*-values determined by Kruskal-Wallis. Following Mann-Whitney post hoc test and Bonferroni correction with a *p*-value of 0.0167, matching alphabetical subscripts indicate that two medians differ significantly. [#] Recommended daily energy intake differs varies between individuals based on their metabolism and physical activity levels, [+] AMDR's based on Ministry of Health (2013), [^] Recommendation based on World Health Organisation (2010) [#]%E MUFA recommendation by difference (%E MUFA = %E fat – %E PUFA – %E SFA). Orange = statistical significant at *P* <0.05, red = Statistical significant at *P* <0.01. Five Pacific participants had missing data regarding fat intake (total fat (g), SFA (g), %E from fat, MUFA, %E from MUFA, PUFA, %E from PUFA) so were excluded from fat intakes analysis.

### 3.4.3 Dietary diversity, food variety and Obesity

To investigate a obesity-DD link, we explored the relationship between dietary diversity, anthropometric outcomes (namely WC, BMI and BF%) and diet composition. When comparing the dietary diversity and food variety of obese and non-obese participants (**table 3.7**), DDS was significantly higher for non-obese than obese participants, but only when obesity was defined by BF% (*P*=0.029), not BMI. Nutritious-DDS was significantly higher in non-obese participants than obese participants, classified by either BMI (*P=0.*024) or BF% (*P=0.*029), with a median N-DDS of 15 (14, 16) versus 14 (14, 16) in each instance. There was no significant difference in FVS, N-FVS nor D-FVS between obese and non-obese participants. Compared to normal-fat and non-obese participants, D-FR was significantly higher for obese participants (*P*=0.015 for BMI and *P*<0.001 for BF%).

Table 3.7. Comparison between median dietary scores for different categories of obese versus non obese participants

| | | **BMI (kg/m²)** | | | **BF%** | | |
|---|---|---|---|---|---|---|---|
| | | **<30 (not obese) (n=174)** | **≥30 (obese) (n=61)** | ***P*-value** | **<35% (not obese) (n=139)** | **≥35% (obese) (n=96)** | ***P*-value** |
| | **Max Score Possible** | **Median** | **Median** | | **Median** | **Median** | |
| DDS | 25 | 23 (21,23) | 22 (21,23) | 0.124 | 23 (21,24) | 22 (20,23) | 0.012 |
| N-DDS | 16 | 15 (14,16) | 14 (14,15) | 0.024 | 15 (14,16) | 14 (13,15) | 0.029 |
| D-DDS | 9 | 8 (7,8) | 8 (7,8) | 0.778 | 8 (7,8) | 8 (7,8) | 0.151 |
| FVS | 237 | 74 (59,87) | 70 (55,98) | 0.781 | 74 (60,87) | 70 (53,92) | 0.414 |
| N-FVS | 143 | 48 (39,56) | 41 (33,58) | 0.244 | 48 (39,56) | 44 (33,59) | 0.274 |
| D-FVS | 94 | 26 (20,33) | 29 (20,39) | 0.136 | 27 (21,34) | 27 (20,35) | 0.898 |
| D-FR (%) | 100 | 36.5 (30.7,40.9) | 39.7 (35.6,43.4) | 0.001 | 36.4 (30.7,40.9) | 38.7 (34.6,43.2) | 0.015 |

DDS, dietary diversity score; N-DDS, nutritious dietary diversity score; D-DDS, discretionary dietary diversity score; FVS, food variety score; N-FVS, nutritious food variety score; D-FVS, discretionary food variety; D-FR, discretionary food ratio; max, maximum score achieved by sub group. Medians presented as Median (25, 75 percentiles).Within body composition profile groups *P*-values were determined by Kruskal-Wallis, *Statistical significant at *P* <0.05, **Statistical significant at *P*<0.01. Following Mann-Whitney post hoc test and Bonferroni correction with a *P*-value of 0.0167, matching alphabetical subscripts indicate that two medians differ significantly. Within BF% and BMI obesity, *P*-values were determined by Mann-Whitney, Orange = statistical significant at *P* <0.05, red = Statistical significant at *P* <0.01.

When comparing the anthropometry of participants within the highest and lowest quartiles of dietary diversity, results demonstrated that the highest tertile of DDS, N-DDS and D-FR had a significantly higher WC, BMI and BF% than the lowest tertile of each (**table 3.8**). The highest tertile of N-FVS has a significantly higher BF% than the lowest N-FVS tertile.

Table 3.8. Comparison of WC, BMI and BF% for the highest and lowest tertiles of each dietary score

| Score | T | WC (cm) >80 = increased metabolic risk | | BMI (kg/m²) >30 = increased metabolic risk | | BF% >35 = increased metabolic risk | |
|---|---|---|---|---|---|---|---|
| | | Median | P-value | Median | P-value | Median | P-value |
| DDS | 3 | 80.1 | 0.015 | 26.2 | 0.048 | 35.2 | 0.002 |
| | 1 | 75.7 | | 24.4 | | 31.5 | |
| N-DDS | 3 | 80.6 | <0.001 | 26.1 | 0.004 | 34.8 | 0.011 |
| | 1 | 73.7 | | 23.9 | | 31.7 | |
| D-DDS | 3 | 78.0 | 0.886 | 25.0 | 0.838 | 34.4 | 0.214 |
| | 1 | 77.8 | | 25.1 | | 32.1 | |
| FVS | 3 | 82.3 | 0.141 | 26.3 | 0.413 | 35.7 | 0.072 |
| | 1 | 77.3 | | 25.1 | | 32.9 | |
| N-FVS | 3 | 82.0 | 0.075 | 26.4 | 0.293 | 35.2 | 0.048 |
| | 1 | 76.8 | | 24.5 | | 32.6 | |
| D-FVS | 3 | 80.3 | 0.922 | 25.6 | 0.396 | 35.0 | 0.358 |
| | 1 | 78.4 | | 26.4 | | 33.1 | |
| D-FR (%) | 3 | 75.5 | 0.003 | 23.7 | 0.000 | 30.9 | 0.000 |
| | 1 | 81.0 | | 27.6 | | 35.1 | |

T; tertile; Tertile 1 = highest tertile, 3 = lowest tertile; DDS, dietary diversity score; N-DDS, nutritious dietary diversity score; D-DDS, discretionary dietary diversity score; FVS, food variety score; N-FVS, nutritious food variety score; D-FVS, discretionary food variety; D-FR, discretionary food ratio (the % of food items consumed that were discretionary); WC, waist circumference (cm); BMI, body mass index ($kg/m^2$); BF%, body fat percentage. *P*-values determined by Mann-Whittney U, orange = statistical significant at *P*<0.05, red = Statistical significant at *P*<0.01.

Correlations between dietary diversity scores and anthropometric measures demonstrates that both DDS and N-DDS were negatively correlated to WC and BF% (all *P*<0.005) (**table 3.9**). Nutritious-DDS negatively correlated to all three anthropometric measures (BMI, *P*=0.043). Similarly, FVS and N-FVS were negatively correlated to WC (both *P*<0.001), BF% (both *P*<0.001) and BMI (both *P*<0.005). Neither discretionary scores (D-DDS nor D-FVS) were significantly correlated to WC, BMI nor BF%. Discretionary-FR had a positive correlation to WC (*P*=0.029), BMI (*P*=0.034) and BF% (*P*=0.014).

Table 3.9. Spearman's correlation coefficients between anthropometric measures and dietary diversity and variety scores

| Anthropometric measure | Dietary Diversity Scores | | | Food Variety Scores | | | Discretionary Ratio |
|---|---|---|---|---|---|---|---|
| | **DDS** | **N-DDS** | **D-DDS** | **FVS** | **N-FVS** | **D-FVS** | **D-FR (%)** |
| | **r value** | **r value** | **r value** | **r value** | **r value** | **r value** | **r value** |
| WC | -0.187** | -0.207** | -0.076 | -0.246** | -0.256** | -0.146 | 0.200** |
| BMI | -0.129 | -0.137* | -0.075 | -0.188** | -0.209** | 0.011 | 0.219** |
| BF% | -0.168** | -0.168* | -0.071 | -0.137* | -0.154* | -0.332 | 0.187** |

DDS, dietary diversity score; N-DDS, nutritious dietary diversity score; D-DDS, discretionary dietary diversity score; FVS, food variety score; N-FVS, nutritious food variety score; D-FVS, discretionary food variety score; D-GR, discretionary group ratio (the % of overall food groups consumed that were discretionary); D-FR, discretionary food ratio (the % of food items consumed that were discretionary); BF%, body fat percentage; BMI, body mass index; WC, waist circumference; BF%, body fat percentage. *P*-values calculated using spearman's two-tailed bivariate correlations, correlations were controlled for age, ethnicity and socioeconomic status. * unreported *P* value statistical significant at *P* <0.05, ** unreported *P* value has statistical significant at *P* <0.01.

Correlations between WC, BMI and BF% and within-group FVS's demonstrates that the nutritious food groups which negatively correlated to BF% were fish and seafood (*P*<0.001), eggs (*P*=0.049), nutritious dairy (*P*=0.01), cheese (*P*=0.004), cereals (*P*=0.004), vitamin A rich F&V (*P*<0.001), vitamin C rich F&V (*P*=0.049), other vegetables (*P*=0.033), other fruits (*P*=0.016), overall vegetables (*P*=0.021), overall fruits (*P*=0.045) legumes (*P*<0.001) and nuts and seeds (*P*=0.019) (**table 3.10**). The aforementioned food groups also negatively correlated to WC and BMI (all *P*<0.05) except for other fruits.

The discretionary food groups which negatively correlated to BF% were drinks (*P*=0.032), alcohol (*P*=0.025), and sauces, spreads and flavourings (both *P*=0.022). The aforementioned food groups also negatively correlated to WC and BMI (all *P*<0.01) except for sauces, spreads and flavourings. There was no significant correlation between sugar-sweetened beverages and WC nor BF%. Takeaways and fast food was the only discretionary food group to have a positive correlation to an anthropometric measure (BMI, *P*=0.016).

Table 3.10**.** Spearman's correlation coefficients between anthropometric measures and food variety scores from each food group

| | Anthropometric Measures | | |
|---|---|---|---|
| | **WC** | **BMI** | **BF%** |
| | **r value** | **r value** | **r value** |
| Meat | 0.002 | 0.112 | 0.054 |
| Poultry | 0.016 | 0.106 | -0.011 |
| Fish and seafood | -0.245** | -0.184** | -0.151* |
| Eggs | -0.131* | -0.148* | -0.164* |
| Nutritious dairy products | -0.172* | -0.188** | -0.204** |
| Cheese | -0.188** | -0.131* | -0.165* |
| Breads | -0.054 | -0.049 | -0.062 |
| Cereals | -0.254** | -0.255** | -0.198** |
| Starchy vegetables | -0.052 | -0.040 | -0.054 |
| Vitamin A-rich fruit and vegetables | -0.204** | -0.177** | -0.189** |
| Vitamin C-rich fruit and vegetables | -0.130* | -0.092 | -0.099 |
| Other vegetables | -0.142* | -0.100 | -0.115 |
| Other fruits | -0.162* | -0.121 | -0.153* |
| Overall vegetables | -0.141* | -0.188** | -0.162* |
| Overall Fruits | -0.112* | -0.151* | -0.139* |
| Legumes | -0.302** | -0.289** | -0.177** |
| Nuts and seeds | -0.156* | -0.146* | -0.104 |
| Oils and fats | -0.062 | -0.064 | -0.101 |
| Discretionary meat | 0.069 | 0.124 | 0.001 |
| Discretionary dairy products | -0.146* | -0.115 | -0.099 |
| Discretionary breads cereals and starchy vegetables | 0.035 | 0.002 | -0.003 |
| Drinks | -0.149* | -0.112* | -0.202** |
| Alcohol | -0.169* | -0.137* | -0.19** |
| Sauce, spreads and flavourings | -0.167* | -0.122 | -0.158* |
| Savoury snacks | -0.094 | -0.078 | -0.059 |
| Sweet snacks | -0.091 | -0.072 | -0.101 |
| Takeaways and fast food | 0.103 | 0.159* | 0.079 |
| Sugar-sweetened beverages | -0.090 | -0.043 | -0.054 |

BF%, body fat percentage; BMI, body mass index; WC, waist circumference. Nutritious food groups are shaded green, discretionary food groups are shaded red. *P*-values calculated using spearman's two-tailed bivariate correlations and indicated using * unreported *P* value has statistical significant at *P*< 0.05 and ** unreported *P* value has statistical significant at *P*< 0.01. Correlations are partial correlations, controlling for age, ethnicity and socioeconomic status.

When considering the variety of food items consumed within food groups that negatively correlated to BF%, compared to the apparent-fat BCPG, the normal-fat BCPG consumes a significantly wider variety of cheese, cereals, legumes, drinks and alcohol (all *P*<0.005, visually demonstrated in **figure 3.2**).

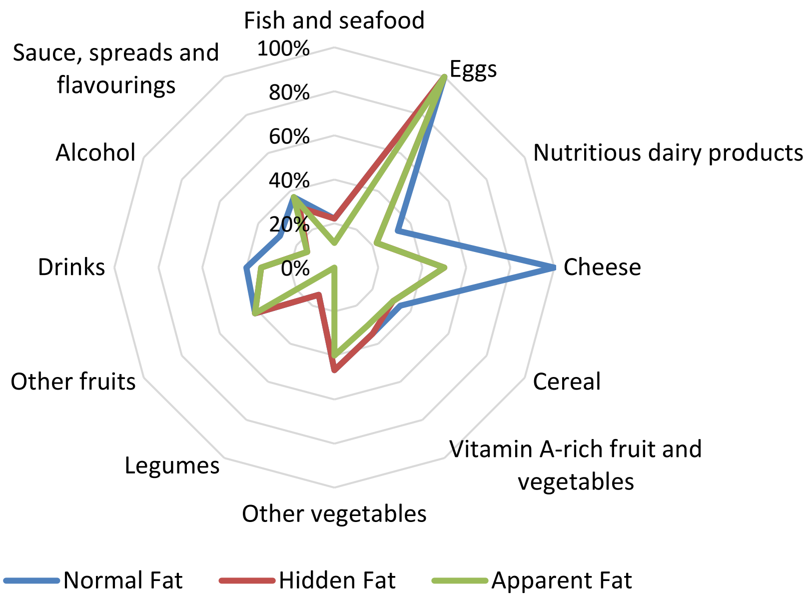


Figure 3.2. Radar chart of % food group food variety scores segregated by body composition profile groups

When comparing the distribution of energy intake (%E) and macronutrient intakes (g) between the highest and lowest tertiles of dietary diversity and food variety scores (**table 3.11**), the highest DDS tertile consumed significantly more energy (kcal) ($P$=0.016), %E from carbohydrate, and lactose (g). The highest tertile N-DDS consumed significantly higher %E from protein, and lactose (g), but a lower %E from carbohydrate.

The highest FVS, N-FVS and D-FVS tertiles consumed significantly more energy (kcal) than the lower tertiles of each (all $P$<0.005). The highest N-FVS tertile consumed more glucose (g) fructose (g) and lactose (g) compared to the lowest. There was no significant difference in %E from SFA nor sucrose (g) between the highest and lowest tertile of N-FVS. The highest tertile of D-FVS consumed more energy (kcal), %E from SFA ($P$=0.003), starch (g) and sugars (g) (including glucose, fructose and sucrose [$P$=0.002], but not lactose). Participants in the highest D-FR tertile consumed significantly more energy (kcal) ($P$=0.020), %E from SFA ($P$<0.001) and starch (g) ($P$=0.031) than those in the lowest D-FR tertile.

Table 3.11. Comparison of nutrient intake for the highest and lowest tertiles of each dietary score

| Score | | Energy (kcal) | | %E Protein | | %E Fat | | %E SFA | | %E CHO | | Starch | | Sugar | | Glucose | | Fructose | | Sucrose | | Lactose | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | T | Med | P | Med | P | Med | P | Med | P | Med | P | Med | P | Med | P | Med | P | Med | P | Med | P | Med | p |
| DDS | 3 | 2044 | 0.016 | 17.2 | 0.072 | 33.8 | 0.205 | 13.2 | 0.054 | 43.8 | 0.011 | 104 | 0.318 | 117 | 0.374 | 21.8 | 0.457 | 23.2 | 0.576 | 43.6 | 0.633 | 13.8 | 0.011 |
| | 1 | 2201 | | 17.9 | | 35.7 | | 13.9 | | 40.9 | | 113 | | 121 | | 22.4 | | 21.3 | | 44.7 | | 20.7 | |
| N-DDS | 3 | 2074 | 0.051 | 17.5 | 0.028 | 34.7 | 0.328 | 13.7 | 0.612 | 42.6 | 0.027 | 110 | 0.873 | 118 | 0.359 | 22.4 | 0.557 | 23.2 | 0.964 | 46.7 | 0.649 | 13.7 | 0.002 |
| | 1 | 2198 | | 18 | | 36.5 | | 13.7 | | 41.1 | | 102 | | 121 | | 22.6 | | 22.5 | | 42.7 | | 21.4 | |
| D-DDS | 3 | 2081 | 0.055 | 17.7 | 0.941 | 34.9 | 0.876 | 13.6 | 0.097 | 42.3 | 0.218 | 110 | 0.364 | 120 | 0.316 | 22.2 | 0.174 | 22.5 | 0.229 | 44.5 | 0.589 | 17.2 | 0.355 |
| | 1 | 2236 | | 17.6 | | 36.4 | | 13.9 | | 41.1 | | 113 | | 122 | | 23.2 | | 21.6 | | 47.0 | | 18.3 | |
| FVS | 3 | 1903 | 0.001 | 17.1 | 0.438 | 35.3 | 0.512 | 13.4 | 0.266 | 43.2 | 0.040 | 102 | 0.054 | 104 | 0.024 | 19.3 | 0.006 | 20.1 | 0.016 | 38.7 | 0.081 | 12.4 | 0.055 |
| | 1 | 2271 | | 17.5 | | 37.1 | | 13.8 | | 40.3 | | 123 | | 130 | | 26.3 | | 27.4 | | 47.2 | | 18.4 | |
| N-FVS | 3 | 2056 | 0.018 | 17.2 | 0.326 | 36.1 | 0.931 | 13.8 | 0.823 | 42.1 | 0.210 | 106 | 0.411 | 110 | 0.041 | 18.8 | 0.002 | 18 | 0.004 | 38.9 | 0.100 | 13.7 | 0.041 |
| | 1 | 2267 | | 17.5 | | 36.5 | | 13.8 | | 41.1 | | 113 | | 124 | | 26.2 | | 26.8 | | 45.3 | | 19.7 | |
| D-FVS | 3 | 1845 | <0.001 | 18.3 | 0.086 | 35.2 | 0.407 | 13.3 | 0.003 | 40.8 | 0.575 | 93.2 | 0.003 | 99.3 | 0.003 | 18.4 | 0.014 | 18.1 | 0.010 | 32.7 | 0.002 | 13.7 | 0.133 |
| | 1 | 2287 | | 17.0 | | 37.2 | | 14.5 | | 41.4 | | 118 | | 128 | | 25.8 | | 25.4 | | 48.9 | | 17.5 | |
| D-GR (%) | 3 | 2056 | 0.203 | 18 | 0.083 | 34.1 | 0.680 | 13.1 | 0.125 | 41.4 | 0.450 | 98.8 | 0.057 | 113 | 0.667 | 21 | 0.891 | 21.1 | 0.714 | 42.7 | 0.994 | 18.2 | 0.598 |
| | 1 | 2162 | | 17.5 | | 34.3 | | 13.7 | | 42.5 | | 117 | | 118 | | 22.4 | | 20.5 | | 45.4 | | 14.3 | |
| D-FR (%) | 3 | 2060 | 0.020 | 18.1 | 0.087 | 34.3 | 0.115 | 12.7 | <0.001 | 42.2 | 0.583 | 96.5 | 0.013 | 108 | 0.483 | 23.1 | 0.096 | 23.5 | 0.194 | 40.1 | 0.166 | 17.6 | 0.741 |
| | 1 | 2305 | | 17.5 | | 37.7 | | 15.0 | | 41.5 | | 119 | | 117 | | 20.1 | | 19.9 | | 51.2 | | 14.9 | |

T; tertile; Tertile 1 = highest tertile, 3 = lowest tertile; DDS, dietary diversity score; N-DDS, nutritious dietary diversity score; D-DDS, discretionary dietary diversity score; FVS, food variety score; N-FVS, nutritious food variety score; D-FVS, discretionary food variety; D-GR, discretionary group ratio (the % of overall food groups consumed that were discretionary); D-FR, discretionary food ratio (the % of food items consumed that were discretionary); %E; percentage of energy from protein, fat, carbohydrate or saturated fat; Med, median. *P*-values determined by Mann-Whittney U, Orange = statistical significant at $P<0.05$, red = Statistical significant at $P<0.01$. Five Pacific participants had missing data regarding fat intake (total fat (g), SFA (g), %E from fat, MUFA, %E from MUFA, PUFA, %E from PUFA) so were excluded from fat intakes analysis.

Correlations between dietary diversity and dietary intake results demonstrate that all DD scores (DDS, N-DDS and D-DDS) were positively correlated with energy, protein, total fat, SFA (g), PUFA (g), MUFA (g), %E from carbohydrate, and lactose (g) (all *P*<0.005) (**table 3.12**). The only exceptions were for D-DDS which did not significantly correlate to PUFA (g), %E from carbohydrate nor lactose (g). The D-DDS score was the only dietary diversity score that was significantly positively correlated to %E from SFA (*P*<0.001).

Food variety analyses showed that FVS, N-FVS and D-FVS positively correlated to energy (kcal) intake. Nutritious-FVS positively correlated to PUFA (g) (*P*<0.001), MUFA (g) (*P*=0.05), sugar (g) (*P*=0.02), glucose (g) (*P*<0.001), fructose (g) (*P*<0.001) and lactose (g) (*P*<0.05). Discretionary-FVS also positively correlated to PUFA (g) (*P*=0.01,) and MUFA (g) (*P*<0.001) but also SFA (g) (*P*<0.001) and %E from SFA (*P*=0.014) as well as carbohydrate (g), starch (g), sugar (g) and sucrose (g) (all *P*<0.001).

D-FR positively correlated to energy (*P*=0.023), fat (g) (*P*<0.001), SFA (g) (*P*<0.001), %E from SFA (*P*<0.001) MUFA (g) (*P*=0.012) carbohydrate (g) (*P*<0.001), starch (g) (*P*=0.01), and %E from sugar (*P*=0.01).

Table 3.12. Spearman's correlation coefficients between macronutrients and dietary scores

| Nutrients | Dietary Diversity Scores | | | Food Variety Scores | | | Discretionary ratio |
|---|---|---|---|---|---|---|---|
| | DDS | N-DDS | D-DDS | FVS | N-FVS | D-FVS | D-FR (%) |
| | r value | r value | r value | r value | r value | r value | r value |
| Energy (kcal) | 0.229** | 0.180** | 0.172* | 0.243** | 0.173* | 0.287** | 0.165* |
| Protein (g) | 0.282** | 0.261** | 0.168* | 0.235** | 0.208** | 0.216** | 0.050 |
| %E Protein | 0.147* | 0.162* | 0.017* | -0.021 | 0.061 | -0.144 | -0.198** |
| Total fat (g) | 0.232** | 0.200** | 0.168* | 0.218** | 0.146* | 0.272** | 0.192** |
| %E Fat | 0.053 | 0.049 | 0.008 | 0.015 | -0.013 | 0.046 | 0.107 |
| SFA (g) | 0.263** | 0.161* | 0.264** | 0.214** | 0.101 | 0.353** | 0.325** |
| %E SFA | 0.118 | 0.022 | 0.171** | 0.059 | -0.043 | 0.223** | 0.345** |
| PUFA (g) | 0.153* | 0.161* | 0.074 | 0.220** | 0.208** | 0.179** | -0.009 |
| %E PUFA | -0.057 | 0.032 | -0.138 | 0.036 | 0.105 | -0.094 | -0.208** |
| MUFA (g) | 0.250** | 0.203** | 0.181** | 0.203** | 0.137* | 0.253** | 0.185** |
| %E MUFA | 0.067 | 0.065 | 0.006 | 0.001 | -0.031 | 0.054 | 0.487 |
| CHO (g) | 0.120 | 0.091 | 0.115 | 0.193** | 0.124 | 0.248** | 0.158* |
| %E CHO | -0.175* | -0.158* | -0.097 | -0.052 | 0.073 | -0.003 | -0.039 |
| Starch (g) | 0.130 | 0.072 | 0.147* | 0.162** | 0.087 | 0.225** | 0.177** |
| Sugars (g) | 0.091 | 0.090 | 0.063 | 0.200** | 0.159* | 0.212** | 0.076 |
| %E Sugar | -0.111 | -0.056 | -0.125 | 0.013 | 0.055 | -0.046 | 0.144* |
| Glucose (g) | 0.100 | 0.096 | 0.070 | 0.234** | 0.250** | 0.126 | 0.133 |
| Fructose (g) | 0.084 | 0.069 | 0.066 | 0.231** | 0.240** | 0.132 | 0.102 |
| Sucrose (g) | 0.052 | 0.062 | 0.039 | 0.164* | 0.199 | 0.222** | 0.157* |
| Lactose (g) | 0.171* | 0.184** | 0.085 | 0.146* | 0.150* | 0.135 | -0.024 |

DDS, dietary diversity score; N-DDS, nutritious dietary diversity score; D-DDS, discretionary dietary diversity score; FVS, food variety score; N-FVS, nutritious food variety score; D-GR, discretionary group ratio (the % of overall food groups consumed that were discretionary); D-FR, discretionary food ratio (the % of food items consumed that were discretionary); SFA, saturated fatty acid; PUFA, polyunsaturated fat; MUFA, monounsaturated fat; CHO, carbohydrates, %E, percentage of daily energy intake from . *P*-values calculated using spearman's two-tailed bivariate correlations, * unreported *P* value has statistical significance at *P*<0.05, ** unreported *P* value has statistical significance at *P*<0.01. All correlations are partial correlations, controlling for age, ethnicity and socioeconomic status.

The significant positive correlation between N-FVS and D-FVS (**supplementary figure 3.3 in appendix C.3)** ($r_s$=0.614, *P*<0.001), indicates that nutritious and discretionary food intake increased concurrently.

## 3.5 Discussion

### 3.5.1 Participant Profile

The EXPLORE study (Kruger et al., 2015) aimed to recruit an equal number of NZE, Māori and Pacific participants, from each BCPG (225 per ethnic group with 75 per BCPG). However, despite utilising culturally sensitive recruitment strategies, aims were not achieved as NZE participants were more responsive to recruitment strategies, and obesity was more prevalent in all ethnic groups. Although NZE participants were unintentionally the ethnic majority in the current study (60%), they were, as intended, spread fairly evenly between the normal, hidden and apparent-fat BCPGs (39.7%, 26.9%, 33.3% respectively). However, most Māori and Pacific participants able to be recruited (76.6% and 82.9%) were classified into the apparent-fat BCPG. Our findings therefore do not support previous research, which argues that Māori and Pacific individuals have a higher BMI due exclusively to increased muscle and bone mass (Rush et al., 1997; Rush et al., 2003; Swinburn et al., 1996), as our study demonstrated they also possessed excess body fat. In our study the hidden-fat BCPG was more prevalent in NZE (26.9%) than Māori (17%) or Pacific (2%) participants. Interestingly, national statistics state that only 13.3% of Pacific women and 24.2% of Māori women in New Zealand have healthy BMIs, compared to 37.3% of NZE women (Ministry of Health, 2018a). However it is important to consider that these national statistics do not recognise that NZE women may have hidden obesity, therefore more NZE women may be at risk of poor metabolic outcomes than expected.

### 3.5.2 Overall dietary diversity and food variety

Median dietary diversity scores and IQRs reveal that 75% of our participants consumed from at least 84% of food groups (21/25). In the current study, DDS was profoundly higher than DDS in the developing world, where participants consume from as few as 50% (Savy et al., 2005), 36% (Steyn et al., 2006) or 26% (Azadbakht et al., 2006) of food groups. High DDS was demonstrated across all ethnicities and BCPGs, despite Pacific participants' significantly higher deprivation score. Higher deprivation has previously been associated with a reduced DDS (Hasan-Ghomi et al., 2012; Hoddinott & Yohannes, 2002; Jayawardena et al., 2013; Ruel, 2003a). However, our results reflect the conclusions of recent meta-analysis, which state most western individuals eat from most food groups regardless of SES and body composition

(Salehi-Abargouei et al., 2016). To explore dietary diversity more thoroughly, our investigation segregated scores into nutritious and discretionary versions (i.e. N-DDS, D-DDS) as recommended in a recent meta-analysis (Salehi-Abargouei et al., 2016). Our N-DDS scores demonstrate that NZE and Māori participants consume an additional nutritious food group to Pacific participants. Our N-DDS's align with national surveys, which state that more deprived individuals (Pacific participants) consume a less diverse range of nutritious foods (Ministry of Health, 2018a). As per DDS, D-DDS was also high (88%), but did not differ between ethnicities nor BCPG's, demonstrating the extraordinary prevalence of discretionary food intake in New Zealand.

Compared to DDS, overall FVS was lower for our participants. Over the seven days, participants consumed only 31% of the food items within our DDQ (78 of 237), thus only 10.4 different foods each day, 6.7 being nutritious. Our results are concerning, given that previous research has found women consuming fewer than eight healthy foods per day have a 42% increased risk of all-cause mortality compared to those consuming between sixteen and seventeen (Michels & Wolk, 2002). Further prospective studies have also noted that poor food variety is prevalent in the western diet, and predictive of mortality in women (Kant, 2004; Kant & Graubard, 2005; Kant et al., 2000; Kant et al., 1993). Our results confirm the importance of food counts remain a commonplace feature of overall diet quality indices (i.e the Healthy Eating Index), as poor food variety is evidently a common shortfall in the western diet (Asghari et al., 2017; Nicklas et al., 2001; Wirt & Collins, 2009).

Within our study, overall FVS and N-FVS did not differ between ethnic groups. However, Pacific and Māori participants consumed significantly more discretionary food items (D-FVS) than NZE participants. National survey data concurs (Ministry of Health, 2012a, 2012b) stating Pacific and Māori women are three and two times as likely to consume discretionary foods (five times per week) than non-Pacific and non-Māori women. It is also notable that participants in the normal-fat BCPG had a higher D-FVS than participants in the hidden-fat BCPG, despite their significantly lower BF%. This directly contradicts previous literature where increased discretionary food intake was associated with increased BF% (Aburto et al., 2016; McCrory et al., 1999; Michels & Wolk, 2002). It is possible that participants in our hidden-fat BCPG have higher BF% unrelated to discretionary food intake (i.e. lack of physical activity). It is also important to consider that 17.0% of participants in the hidden-fat BCPG underreported their intakes, compared to 10.5% of participants in the normal-fat BCGP according to the Goldberg method (Black, 2000). New Zealand research has also found that obese women are significantly (14.6%) more likely to underreport their food intake compared to non-obese women (Gemming, Jiang, Swinburn, Utter, & Mhurchu, 2014), and similar findings have been reported internationally (Hebert et al., 1997; King et al., 2016; Scagliusi et al., 2009; Schoeller, 1990; Taylor et al., 2019).

Overall, participants' within-group FVS's indicated that participants consumed only one or two food items from 60% (15/25) of food groups. Hence, despite DDS being high, overall FVS was low. Within-group FVS's demonstrate that each day participants consumed (to the nearest whole number) one variety of flesh food, one variety of vegetarian protein, one variety of carbohydrate food, three varieties of fruits and vegetables and four varieties of discretionary foods. On the basis of these scores, it is unlikely that participants are achieving national dietary recommendations of six daily servings of carbohydrate, five daily servings of fruits and vegetables and consuming discretionary foods only occasionally (Ministry of Health, 2018a). Participants also consumed one variety of fish and seafood over the week, which again unlikely meets the recommendation of two servings of fish a week. The poorly varied intakes of carbohydrate, fruits and vegetables, and fish were reflected in participants' low %E from carbohydrate (3.5% below minimum AMDR) and %E from PUFA (0.8% below minimum AMDR, rich in grains and seafood). Furthermore, excessive discretionary food intake, was reflected in participants' excessive fat (0.4% above maximum AMDR) and discretionary nutrients intake (%E from SFA and sugar 3.7% and 11.4% above maximum recommendations respectively). Our findings were unlike the most recent national survey which found women to consume carbohydrate (46.7 %E) and fat (33.8 %E) within AMDR's. Differences between our results and national data may be due to their inclusion of demographics beyond our cohort, such as additional age groups and ethnic groups (i.e. Asian and Indian women). However, similar to our findings, the survey found %E from SFA was excessive (13.1%), and %E from PUFA insufficient (4.9%) (Ministry of Health, 2009). Our participants' diets reflect the typical patterns of the western diet reported in observational studies internationally; low in nutritious carbohydrate and excessive in %E from fat, SFA and sugar (Kaidar-Person, Person, Szomstein, & Rosenthal, 2008; Sánchez et al., 2016; Schweiger, Weiss, Berry, & Keidar, 2010).

Within-group FVS's also elucidate the different %E and macronutrient intakes of each ethnicity and BCPG. Māori had a combined carbohydrate FVS of seven, compared to eight and 10 for NZE and Pacific participants respectively. Nutritional analysis reflected the lower carbohydrate variety of Māori, as they consumed significantly lower %E from carbohydrate (31.6%) compared to NZE (42.5%) and Pacific (43.3%) participants. Interestingly, past research has not demonstrated a significant difference between the carbohydrate intake of Māori versus non-Māori (Metcalf et al., 2008; Metcalf et al., 1998; Ministry of Health, 2012a, 2012b). Our results may have been affected to some extent by the popularisation of low carbohydrate diets. For example, more than 75% of Americans reported to be actively reducing their carbohydrate intake in 2018 (International Food Information Council, 2019), thus usual participant carbohydrate intakes may be reduced, perhaps more so for Māori. Māori and Pacific participants had higher within-group FVS's for discretionary dairy, carbohydrates, takeaways and snacks (Pacific only), however they did not consume more fat, SFA or sugar which are commonly found within these discretionary foods. Our contradictory finding may be the result of 27.6% of Pacific and 23.4% of Māori participants underreporting their sources of dietary fat in our FFQ compared to 16.3% of NZE participants. Further New Zealand studies have also demonstrated that underreporting is 10.7% and 8.2% greater in Pacific and Māori women than NZE women (Gemming et al., 2014).

For BCPGs, within-group FVS's demonstrated that the apparent-fat BCPG consumed the widest variety of poultry, as well as fast food and takeaways. Additionally the T20 of the apparent-fat BCPG had beef ranked 5$^{th}$ (17$^{th}$ normal-fat, 20$^{th}$ hidden-fat), and more discretionary foods (four) than other BCPGs. These findings provide an explanation as to why the apparent-fat BGPC consume significantly more total fat, %E from SFA (common in flesh foods and discretionary foods) and %E from MUFA (present in nutritious foods (nuts [28g/100g], avocado [10g/100g]), but more abundant in deep-frying oils such as canola [61g/100g] vegetable [48g/100g] and sunflower oil [46g/100g]). The apparent-fat BCPG also consumed a reduced variety of cheese, whilst consuming perhaps not coincidentally, less sugar in the form of lactose. Along with cheese, participants in the apparent-fat BCPG consumed a lower variety of other vegetarian proteins (eggs, legumes) and cereals. Our results reflect the outcomes of a recent meta-analysis, which found dietary patterns significantly higher in red meat and poultry, and lower in vegetarian proteins and grains are more common in obese individuals (Soltani, Shirani, Chitsazi, & Salehi-Abargouei, 2016).

### 3.5.3 Dietary diversity, food variety and obesity

In the current study, non-obese participants demonstrated a significantly higher DDS than obese participants (as defined by BF%, not BMI). Furthermore, participants in the highest tertile of DDS had a WC (75.7cm), BMI (24.4kg/m$^2$), and BF% (31.5%) that was non-obese, and significantly lower than participants in the lowest DDS tertile (WC [*P*=0.015], BMI [*P*=0.048] and BF% [*P*=0.002]). Previous research has also found that DDS is negatively associated with obesity, as women with the highest DDS demonstrated a significantly lower BMI (24.8kg/ m$^2$ ) (Kant & Graubard, 2005), or the lowest probability of obesity (OR 0.21 (Azadbakht & Esmaillzadeh, 2011), OR 0.49 (Abris et al., 2018). In our study, participants in the lowest DDS tertile demonstrated an obese WC (80.1cm) and BF% (35.2%) alongside an overweight BMI (26.2kg/m$^2$). Similarly, past cross sectional studies have demonstrated that participants within the lowest DDS tertile have an overweight BMI (26.0kg/m$^2$) (Kant & Graubard, 2005). Therefore, our results and others suggest an increased DDS may be be associated with reduced obesity, however it is important to consider that conflicting research exists. For example individuals in the highest DDS tertiles have also previously demonstrated an obese WC (80.4cm) (Jayawardena et al., 2013) an overweight BMI (26.9kg/m$^2$), and a higher probability of obesity (OR 1.45) (Azadbakht et al., 2006).

In the current study, the highest N-DDS tertile had a WC, BMI and BF% that was significantly lower than the WC (*P*<0.001), BF% (*P*=0.011) and BMI (*P*=0.004) of the lowest N-DDS tertile. An American study found comparable results, as participants who consumed from all six nutritious food groups had a significantly lower BF% and BMI than those who consumed from less than three (Kant & Graubard, 2005). In the current study, participants in the highest N-FVS tertile also had a significantly lower BF% (32.6%) versus the BF% of the lowest N-FVS tertile (35.2%). A recent study has also found increased nutritious food counts to be associated with reduced BMI and BF% (Abris et al., 2018; Foote et al., 2004). Regarding discretionary food intake, the current study was unable to demonstrate any significant difference in anthropometry between tertiles of D-DDS or D-FVS. Therefore, contrary to expectation, participants who consumed more discretionary foods were not significantly more obese. We propose that the significant relationship between increased DDS and reduced anthropometry was thus more attributable to the possible benefits of increased nutritious food intake than to any impact of discretionary food intake. Our proposal is further supported by the way in which DDS, FVS, N-DDS and N-FVS correlated significantly to a reduction in WC, BMI and BF%, whilst D-DDS and D-FVS did not. Previous prospective studies have also suggested that consuming more nutritious foods may be more important for women's metabolic health than omitting discretionary foods (Abris et al., 2018; Kant, 2004; Kant et al., 2000; Michels & Wolk, 2002)

Of our 25 disaggregated food groups, 11 (fish and seafood, eggs, dairy, cheese, cereals, vitamin A-rich F&V, overall vegetables, fruits, legumes, drinks and alcohol) demonstrated a significant negative correlation to each of WC, BMI and BF%, even when controlling for age, SES and ethnicity. Previous research has demonstrated similar findings, with body fatness inversely correlating to dairy FVS (McCrory et al., 1999; Tian et al., 2017) fruit and vegetable FVS (Abris et al., 2018; Aburto et al., 2016; McCrory et al., 1999) and legume FVS (Aburto et al., 2016). We propose that the inverse correlation between drinks and anthropometry in the current study was because many drinks in our DDQ were not necessarily high in energy, SFA nor sugar (i.e. water, black coffee and tea). We further supported this proposal by creating a sugar-sweetened beverages (SBBs) group, and demonstrating that it did not demonstrate this same negative (or any) correlation to WC, BMI and BF%. Our results therefore directly contrast meta-analysis which suggest SSB consumption positively correlates positively to body fatness (Malik, Schulze, & Hu, 2006). It was also unexpected that meat, poultry and most discretionary food groups did not demonstrate a consistent positive correlation to increased anthropometry, as has been previously demonstrated with both meat FVS (McCrory et al., 1999; Michels & Wolk, 2002) and discretionary FVS (Aburto et al., 2016; McCrory et al., 1999; Michels & Wolk, 2002).

Our remaining findings will be discussed in relation to the two main hypotheses in the literature; the DD-energy hypothesis, and the DD-Discretionary hypothesis.

### 3.5.4 The DD-energy hypothesis

To support the well described DD-energy hypothesis we would first expect that higher dietary diversity would associate with an increase in energy intake (Azadbakht & Esmaillzadeh, 2012) (Azadbakht & Esmaillzadeh, 2011; Azadbakht et al., 2006; Bénéfice et al., 2007; Bezerra & Sichieri, 2011; Foote et al., 2004; Jayawardena et al., 2013; Ponce et al., 2006; Rolls &

Hetherington, 1989). We found that participants in the highest tertile of DDS and FVS consumed significantly more energy per day than those in the lowest tertiles of each, therefore supporting the DD-energy hypothesis. In addition, both DDS and FVS positively correlated to an increase in energy intake, thus supporting the hypothesis further. However, in previous research, this increase in energy intake has then been associated with consequential obesity (Foote et al., 2004; Jayawardena et al., 2013; Ponce et al., 2006; Rolls & Hetherington, 1989), whereas, as discussed, our study suggests DDS is associated with reduced obesity. We propose that improved nutritious DDS and FVS may not be associated with poor anthropometric outcomes, despite a corresponding increase in energy intake. Similar to our findings, other studies have also demonstrated that those with the highest DDS and FVS consume more energy, but also demonstrate preferable BMIs and BF% in women (Abris et al., 2018; Azadbakht & Esmaillzadeh, 2011, 2012; Kant et al., 1993) and men (Kant & Graubard, 2005).

### 3.5.5. The DD-discretionary hypothesis

Based on the DD-discretionary hypothesis, we would expect that obese participants would consume a wider variety of discretionary foods (de Oliveira Otto et al., 2015; Ponce et al., 2006). In the current study, this was not true, as obese participants (based on BMI, BF% and BCPG) demonstrate neither a higher D-DDS nor a D-FVS. Furthermore, there was no correlation between a higher D.DDS nor D.FVS and an increase in WC, BMI nor BF%, which directly contrasts past literature (Foote et al., 2004; McCrory et al., 1999). The DD-discretionary hypothesis also suggests that consuming a wider variety of discretionary foods is associated with an increased intake of discretionary nutrients (de Oliveira Otto et al., 2015; Ponce et al., 2006). Tertile analysis revealed that participants with a higher D.FVS (but not D.DDS) did have a higher intake of SFA and sucrose (a surrogate measure of added sugar used previously in New Zealand (Kibblewhite et al., 2017), thus supporting this portion of the hypothesis. Furthermore, discretionary-FVS positively correlated to %E from SFA and sucrose, whilst N-FVS did not.

Interestingly, as well as discretionary nutrients participants in the highest tertile of D-FVS consumed more nutritious nutrients, such as glucose and fructose and D-FVS positively correlated to %E from protein and PUFA – two nutrients which have been associated with improved anthropometric outcomes in multiple meta-analysis (Bender et al., 2014; Clifton, Condo, & Keogh, 2014; Du, Jin, Fang, & Su, 2015; Wycherley, Moran, Clifton, Noakes, & Brinkworth, 2012; Zhang, Liu, Zhao, & Tian, 2017). A possible cause for this finding is how D-FVS positively correlates to N-DDS ($r_s$=0.614, *P*<0.001) in our study, and others (Bénéfice et al., 2007; Bezerra & Sichieri, 2011; de Oliveira Otto et al., 2015; Jayawardena et al., 2013; Ponce et al., 2006). Therefore, participants who consume more discretionary foods, also consumed a wider range of nutritious foods and thus nutritious nutrients. Metabolic and mortality risk in women drops by 5% with each additional healthy food consumed (Michels & Wolk, 2002), thus is possible that nutritious food intake may be mitigating the obesogenic effects of increased discretionary food intake in our study, as proposed by authors previously (de Oliveira Otto et al., 2015; Michels & Wolk, 2002). This could explain why we were unable to find a clear relationship between body fatness, D-DDS and D-FVS.

### 3.5.6 A possible new diversity score

The discretionary food ratio is the percentage of the total food items a participant consumes that are discretionary. Therefore, it considers D-FVS whilst taking overall FVS and N-FVS into account. Overall, 37.4% of the food items consumed by participants were discretionary, which is excessive given that both the U.S and Australian guidelines suggest no more than 14% of energy intake should be from discretionary foods (Australian Government, 2013; Department of Agriculture (US), 2005). Discretionary food has also been demonstrated to be excessive (30-40% of daily energy) in Australian and American children (Johnson et al., 2017; Keast, Fulgoni, Nicklas, & O'Neil, 2013), and Mexican adults (Aburto et al., 2016), however these studies quantified energy intakes, instead of using simple food counts as per the current study. In our study, D-FR was significantly higher in all obese groups versus non-obese groups (defined by BCPG, BF% and BMI) and correlated significantly to an increase in WC, BMI and BF%. Additionally, participants in the highest D-FR tertile had an obese WC, BMI and BF% which was significantly higher than the WC, BMI and BF% of the lowest D-FR tertile. Therefore, D-FR may provide a more comprehensive way to measure dietary diversity, which considers the detriment of discretionary food variety and the benefits of nutritious food variety concurrently.

The current study had many strengths, the first being the rigorous exclusion criteria of the EXPLORE study, outlined in Kruger et al. (2015), which controlled for typical female hormone and adiposity fluctuations. Our study also utilised WC and BF%, thus overcoming any possible limitations of BMI. Finally, by using a qualitative survey (DDQ), we believe our FVS's may be less subject to under-reporting and behavioural change, than FVS's collected using food records and FFQs. Our study also had limitations, firstly, as we utilised a data set from the EXPLORE study (Kruger et al., 2015), our study had a cross-sectional design, which limits the causality and reproducibility of our results. Additionally, we were unable to meet requirements of our power calculation, thus increasing the likelihood that significant results were undetected. We asked participants to complete their DDQ at home, however despite several attempts to retrieve the data, participant drop out was high. Due to poor participant response, we utilised a relatively small sample size (n=235), which under represented Māori (n=47) and Pacific participants (n=47), and does not reflect the cultural diversity of New Zealand, thus limiting the applicability of our findings. It is also possible that dietary under-reporting occurred in our FFQ which may have impacted our nutritional analysis. Finally, as the data was not available we did not control for physical activity, which impacts body composition as per diet.

### 3.5.7 Conclusions and recommendations

We found that NZE women more commonly had hidden body fat than Māori and Pacific women. Therefore, BF% should be used whenever feasible when screening for NZE obesity in particular. Our study was the first to describe the high dietary diversity, but comparatively lower food variety of New Zealand women, across ethnicities and BCPs in the women's EXPLORE study (Kruger et al., 2015). Food variety was especially poor within carbohydrate, fruit and vegetable groups and high within discretionary food groups, which was reflected in the women's low carbohydrate, low PUFA, high SFA diets. Increased DDS and N-DDS was associated with reduced measures of obesity, despite an associated increase in energy intake. Surprisingly, discretionary food intake did not demonstrate clear links to either discretionary nutrient intake or poor anthropometry, thus we suggest that increased nutritious food intake may mitigate the well reported obesogenic effects of discretionary food intake. Our new D-FR requires further validation, but could provide a new way to measure dietary diversity that considers the synergies between nutritious and discretionary food intake. Overall, our study adds to a body of research that suggests increased dietary diversity, especially within nutritious foods, may be associated with reduced obesity. Health promotion in New Zealand should focus on promoting the consumption of a wide and diverse variety of nutritious foods across all ethnic groups, rather than solely the omission of discretionary food items, as per other effective health campaigns internationally (Grieger, Johnson, Wycherley, & Golley, 2017; O'Hara et al., 2016).

# Chapter Four:
# Conclusions and recommendations

## 4.1 Overview

The aim of the current study was to utilise a newly validated DDQ to explore the dietary diversity and food variety of NZE, Māori and Pacific women and how dietary diversity and food variety may link to different BCPs and obesity. To do this, the current study calculated the nutritious and discretionary dietary diversity and food variety scores of each woman, and utilised BCPGs to measure obesity, alongside BF%, WC and BMI. Body composition profiles consider BMI and BF% concurrently to capture the dangerous hidden-fat BCP (BMI <30kg/m$^2$ with BF% >30%), which is more common in NZE women, as well as the apparent-fat BCP (BMI >30kg/m$^2$ with BF% >30%). To date, there is no study which examines how dietary diversity, as an index of diet quality, differs between ethnicities and BCPGs in New Zealand. If the role dietary diversity plays in obesity is better understood, it would allow dietary diversity to be incorporated into public health interventions that focus on optimising the quality of the diet, which experts believe is critical to prevent the growing economic, physical, social costs of obesity (Freeland-Graves & Nitzke, 2013; Nitzke et al., 2007).

The aim of this study was met through several objectives:

## 4.2 Aims and objectives

*Objective 1 - To explore the dietary diversity and food variety of New Zealand NZE, Māori and Pacific women*

Overall DDS was high, 22 (21, 23), as participants (all ethnic groups and BCPGs) ate from most (88%) of the food groups. Overall food variety 73 (57, 88), was much lower, as participants ate only 30.8% of food items included in the DDQ over the seven day period. The daily FVS indicated that participants ate 10.4 foods daily, of which 6.7 were nutritious. We propose that food variety in our participants is very low, a concerning result, given that previous authors have suggested consuming fewer than eight healthy foods each day increases mortality risk (Michels & Wolk, 2002). To explore food variety further, we also considered within-group FVSs. Participants consumed two or fewer food items from most food groups (15/25, 60%), explaining why participants' DDS was high whilst FVS was low. Within-group FVSs demonstrated that each day, participants ate only one variety of carbohydrate food, three varieties of fruits and vegetables, four varieties of discretionary foods, as well as one variety of seafood across the week. Therefore, participants are unlikely to be adhering to national dietary guidelines outlined by the Ministry of Health (2015). Our within-group FVSs provide an explanation as to why participants ate a diet that was (compared to national guidelines) low in %E from carbohydrate (i.e. cereals) and PUFA (i.e. grains and seafood), whilst excessive in fat and %E from SFA and sugar (i.e. discretionary foods).

Our study also highlighted the differences and similarities in dietary diversity and food variety for NZE, Māori and Pacific women. Despite lifestyle differences (evidenced by the significantly increased SES score, BMI and BF% of Pacific participants in particular) neither overall median DDS nor D-DDS differed between ethnicities. However, based on median N-DDS, Pacific participants consumed from fewer nutritious food groups (14/16) than Māori and NZE participants (15/16) (both $P<0.01$). We propose that regardless of SES and body composition, the diets of New Zealand women are diverse, however the nutritious diversity consumed by Pacific participants is significantly lower than other ethnic groups.

When considering food variety, NZE had a lower D-FVS (24/94) than both Māori (30/94) and Pacific (29/94) participants (all $P<0.001$). Our results indicate that Māori and Pacific women did not consume a wider variety of overall food items, but did consume a wider variety of discretionary food items. The Ministry of Health (2012a, 2012b) have previously found that Māori and Pacific women consume pre-packaged convenience foods more frequently, however, it is new knowledge that Māori and Pacific women also consume a wider variety of discretionary food items.

*Objective 2 - To examine the relationship between dietary diversity and different body composition profiles in New Zealand women*

After post-hoc adjustments there were no significant differences between BCPGs in DDS, D-DDS, FVS nor N-FVS. We did however highlight that participants within the normal-fat BCPG had a higher D-FVS (indicating they consumed a wider variety of discretionary food items) than participants in the hidden-fat BCPG (*P*=0.012). This was a surprising result, given that numerous previous studies have instead found a positive association between discretionary food intake and body fatness (Aburto et al., 2016; Cohen et al., 2010; Guenther et al., 2008; Johnson et al., 2017; Nitzke et al., 2007). We propose that the hidden-fat BCPG may have higher BF% for reasons other than discretionary food intake (i.e. lack of physical activity, which we did not measure) or, by using the Goldberg method (Black, 2000), we suggest that 17.0% of the hidden-fat BCPG may have under-reported their dietary intakes.

We found that participants in the apparent-fat BCPG consumed a wider variety of poultry and fast food and takeaways, and had more discretionary foods in their T20. They also consumed a lower variety of vegetarian proteins such as cheese, eggs, legumes and cereals. Our results reflect the outcomes of a recent meta-analysis, which suggests that dietary patterns significantly higher in red meat and poultry, and lower in vegetarian proteins and grains may be more common in obese individuals (Soltani et al., 2016).

*Objective 3 - To examine the relationship between dietary diversity and obesity*

To investigate dietary diversity and obesity, we regrouped participants based on obese cut-offs (determined by the World Health Organisation (2018b), for BF% (below and above 30%) and BMI (below and above 30kg/m$^2$). We propose that consuming more nutritious food groups is negatively associated with obesity, as the highest tertile of N-DDS had a significantly lower WC (*P*=0.015, *P*<0.001), BMI (*P*=0.048, *P*=0.004) and BF% (*P*=0.002, *P*=0.011) than the lowest. The highest tertile of N-FVS also had a significantly lower BF% than the lowest. Correlational analysis concurred as N-DDS, and N-FVS inversely correlated to WC, BF% and BMI. Surprisingly, we were unable to find a clear link between discretionary food intake and obesity. Our results advocate for the importance of consuming a wide range of nutritious foods, as it may be more important for preventing female obesity than reducing discretionary food intake. The same has been suggested previously (Michels & Wolk, 2002).

*Sub-objective 3.1 - To examine the relationship between dietary diversity, increased energy intake and obesity*

The highest tertiles of DDS and FVS both consumed significantly more energy than the lowest tertiles of DDS (*P*=0.016) and FVS (*P*=0.001). However, despite this associated increase in energy intake, increased dietary diversity and food variety was not associated with obesity as noted by objective 3. Our findings therefore suggest that DDS especially within nutritious food groups, is associated with reduced obesity, despite a corresponding increase in energy intake.

*Sub-objective 3.2 - To examine the relationship between dietary diversity and increased discretionary food and nutrient intake, and obesity*

Our tertile analysis demonstrated that participants in the highest tertile of D-FVS consumed more energy, SFA and sucrose than the lowest, indicating that consuming more discretionary foods is associated with an increased intake of discretionary nutrients. However, our analysis demonstrated that participants who consumed a wider range of discretionary foods did not have a higher WC, BMI or BF%. There was also no correlation between a higher D-DDS or D-FVS and an increase in WC, BMI nor BF%. Therefore, there may be a relationship between increased discretionary variety and increased discretionary nutrient intake, however we were not able to say that discretionary food intake was associated with obesity. Our findings may be due to the positive correlation between D-FVS and N-FVS, thus increased nutritious food intake may be mitigating the possible detrimental effects of increased discretionary food. We propose it may be preferable to consider N-FVS and D-FVS in relation to each other (possibly using our suggestion of a D-FR score), to fully understand the impact of discretionary variety on obesity. The D-FR score has benefits as unlike other diet quality scores, it can be calculated using DDQs, (a relatively simple non-quantitative dietary assessment technique) and may provide a method of examining the whole diet, more comprehensively than N-FVS and D-FVS alone.

So therefore our overall objectives were met as follows – dietary diversity was high across all ethnic and BCPGs, however food variety was profoundly lower. Food variety was particularly poor within certain food groups such as carbohydrates, fruits and vegetables, legumes and seafood whilst discretionary food variety was high. Discretionary food variety was particularly high within Māori and Pacific participants. We do not support the DD-energy hypothesis nor the DD-discretionary hypothesis. Instead, we propose that consuming from a wide range of nutritious food groups may be associated with reduced obesity in women, and that nutritious and discretionary food intake should be considered in tandem.

### 4.3 Strengths and weaknesses of the study

The current study finds strength in the rigorous exclusion criteria of the EXPLORE study (Kruger et al., 2015), which controlled for all fluctuations of hormones, adiposity and food choices between participants, as well as rigorous anthropometric measures. Whilst many previous dietary diversity studies rely solely on either BMI, or BF%, or WC, the current study utilised all three measurements, both separately and concurrently in the form of BCPGs. By using multiple definitions of obesity, we controlled for any possible limitations of BMI. Additionally, by exploring BMI and WC, which are easily measured in a clinical setting, our study's findings are relevant to public health, as measuring BF% with DXA is rarely feasible. Finally, our study has strength by examining dietary intake following a qualitative approach. By retrospectively measuring food intakes with our DDQ, and not relying on food records and exact quantities, our study may have overcome the limitations of quantitative studies, such as behavioural change.

The most pressing limitation of this study is its cross-sectional design which means our results are limited in respect to causality and reproducibility. The current study relied on participants returning their completed DDQ's which they were asked to complete at home. Despite several attempts to retrieve the survey results, participant drop out was high. As a results, we utilised a relatively small sample size (n=235), which under represented Māori (n=47) and Pacific participants (n=47) due to reduced participant response from these ethnic groups. We also did not include ethnic groups such as Asian and Indian within our study. Therefore, our study does not match the true ethnic distribution of New Zealand and our results may not be a true reflection of the dietary diversity and food variety of New Zealand women. In addition, we were unable to meet the requirements of our power calculation, therefore increasing the likelihood of not detecting significant results within our data. The current study also relies on correlational analysis in several instances, which may be weakened by not controlling for important factors that affect body composition such as physical activity. There were also weaknesses in the nutritional analysis of this study, as it relied on results from an FFQ, which is a retrospective dietary assessment method that is not able to enumerate exact intakes as per a weighed food record. A FFQ is however useful when ranking individuals in regards to their dietary intakes as per the current study. Next, our study relied on SFA and sucrose as they are commonly used proxy measures of discretionary nutrient intake, however these measures have been said to overestimate discretionary nutrient intake (Kibblewhite et al., 2017). In addition, the current study relied on correlational analysis between FFQ and DDQ data as part of our nutritional analysis, however, these surveys covered different time periods (the previous month, versus the previous week). Therefore it is possible that participants consumed different foods over these time periods, thus limiting the validity of our results. Finally, it is important to consider that the food groups in our DDQ were disaggregated into more nutritious foods (143), than discretionary foods (94), therefore our results may underestimate the proportion of the diet made up by discretionary foods.

## 4.4 Recommendations

### 4.4.1 Recommendations for dietary diversity focused health promotion

Based on our results, to encourage a healthy body composition, we recommend that overall nutritious dietary diversity and food variety should be endorsed by health promotion across all ethnicities and socio-economic groups. Health promotion programmes should especially focus on the consumption of a wide range of carbohydrates, fruits, vegetables, seafood and vegetarian proteins (i.e. legumes) to best mend the possible dietary gaps highlighted by our study. A focus on carbohydrates and cereals may be of particular importance to Māori, whilst a focus on increasing the consumption of vegetarian proteins (with a reduced reliance on poultry) may be important for those with apparent-fat.

We believe that DDQ surveys can provide a new method to compare nutritious food intake to discretionary food intake at both an individual and group level, by using simple food counts that do not require high health literacy or numeracy skills. Given that nutritious food variety especially lacked within our study, and when increased had a strong association to reduced obesity markers, health promotion should consider educating the public on how to improve their ratio of nutritious to discretionary food intake by promoting the substitution, rather than omission, of discretionary food items. This type of health promotion has proven to be especially beneficial for obesity prevention internationally (Grieger et al., 2017; O'Hara et al., 2016). It is also critical that this approach is culturally tailored to Māori and Pacific who routinely suffer from health and wellness disadvantageous such as increased rates of obesity (Ministry of Health, 2018a), and according to our results also consume a wider variety of discretionary food items.

### 4.4.2 Recommendations for future research

- Similar future investigations should always consider and include discretionary food items as they constitute a significant portion of the first world diet.
- Further consider the impact of dietary diversity and food variety of New Zealanders by:
    - Using a larger number of participants, a cross-sectional group outside of Auckland, or other ethnicities (i.e. Asian) or male participants
    - Conducting a longitudinal study to better understand the change in dietary diversity and food variety over time, in different age groups
    - Comparing other biomarkers beyond anthropometric measures dietary diversity and food variety (i.e. blood pressure, blood lipids, fasting glucose)
    - Investigating the obesogenic impact of food variety within each nutritious and discretionary food group individually
- Further consider the impact of discretionary food variety in relation to nutritious food variety by:
    - Validating D-FR scores and investigating insightful cut offs that we can recommend for improved anthropometry

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# Appendices

## Appendix A – New Zealand women's food frequency questionnaire

### EXPLORE Food Frequency Questionnaire

#### 1. Please read carefully before you begin:

Please make sure when filling out this questionnaire that you:

• Tell us what YOU usually eat (not someone else in your household!).
• Fill in the form YOURSELF.
• Are correct, but don't spend too much time on each food.
• Answer EVERY question; the asterisk symbol (*) at the beginning of each question means that you must answer before moving onto the next question.

This will help us to get the most accurate information about your usual food intake.

Please answer by ticking the box which best describes HOW OFTEN you ate or drank a particular food or drink in the LAST MONTH and HOW MUCH you would usually have.

For example:

**1. EXAMPLE: How often do you usually have sugar? (Please do not fill out)**

| | Never | <1x / month | 1-3x / month | 1x / week | 2-3x / week | 4-6x / week | Once / day | 2-3x / day | 4+ x / day |
|---|---|---|---|---|---|---|---|---|---|
| Sugar - 1 tsp | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |

If every day you have 2 cups of coffee with 1 tsp sugar, 4 cups of tea with 1 tsp sugar, one bowl of cereal with 1 tsp sugar and sugar on pancakes at dinner, you would choose four or more times per day = '4+ x / day'.

Adjust your portion size and frequency of intake to suit your eating habits.

**2. EXAMPLE: How often do you usually eat bread? (Please do not fill out)**

| | Never | <1x / month | 1-3x / month | 1x / week | 2-3x / week | 4-6x / week | Once / day | 2-3x / day | 4+ x / day |
|---|---|---|---|---|---|---|---|---|---|
| Bread - 1 slice | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |

If every day you have two slices of toast for breakfast, and you have a sandwich for lunch three times per week, you would choose two - three times per day = '2-3x / day'.

Adjust your portion size and frequency of intake to suit your eating habits.

## EXPLORE Food Frequency Questionnaire

### 2. EXPLORE Study Food Frequency Questionnaire

***1. Please enter your study ID (if you are unsure or don't know please ask the researcher)**

# EXPLORE Food Frequency Questionnaire

## 3. Eating Pattern

***1. How would you describe your eating pattern? (Please choose one only)**

- ◯ Eat a variety of all foods, including animal products
- ◯ Eat eggs, dairy products, fish and chicken but avoid other meats
- ◯ Eat eggs, dairy products and fish, but avoid chicken and other red meats
- ◯ Eat eggs and dairy products, but avoid all meats, chicken and fish
- ◯ Eat eggs, but avoid dairy products, all meats and fish
- ◯ Eat dairy products, but avoid eggs, all meats and fish
- ◯ Eat no animal products
- ◯ None of the above

Other (please state)

# EXPLORE Food Frequency Questionnaire

## 4. Dairy

***1. Do you use milk? (e.g. fresh, UHT, powdered)**

◯ Yes

◯ No

**2. What type(s) of milk do you have most often? (You can choose up to 3 options, but please only choose the ones you usually have)**

☐ Not applicable

☐ Full cream milk (purple top)

☐ Standard milk (blue top)

☐ Skim milk (light blue top)

☐ Trim milk (green top)

☐ Super trim milk (light green top)

☐ Calcium enriched milk (yellow top) e.g. Xtra, Calci-Trim

☐ Calcium and vitamin enriched milk e.g. Mega, Anlene

☐ Calcium and protein enriched milk e.g. Sun Latte

☐ Standard soy milk (blue)

☐ Light soy milk (light blue)

☐ Calcium enriched soy milk (purple) e.g. Calci-Forte, Calci-Plus

☐ Calcium, vitamin and omega 3 enriched soy milk e.g. Essential

☐ Calcium and high fibre enriched soy milk e.g. Calci-Plus High Fibre

☐ Rice milk

Other (please state)

____________________

***3. On average, how many servings of milk do you have per day? (Please choose one only)**
**(A 'serving' = 250 mL or 1 cup/glass)**
**e.g. 5 cups of coffee/tea using 50 mL of milk + ½ cup of milk on cereal = 1 ½ servings per day**

◯ Not applicable

◯ Less than 1 serving

◯ 1-2 servings

◯ 3-4 servings

◯ 5 or more servings

# EXPLORE Food Frequency Questionnaire

***4. How often do you usually have milk?**

| | Never | <1x / month | 1-3x / month | 1x / week | 2-3x / week | 4-6x / week | Once / day | 2-3x / day | 4+ x / day |
|---|---|---|---|---|---|---|---|---|---|
| Flavoured milk (milkshake, iced coffee, Primo, Nesquik) - 250 mL/ 1 cup | | | | | | | | | |
| Milk as a drink - 250 mL / 1 cup | | | | | | | | | |
| Milk on breakfast cereals or porridge - 125 mL/ 1/2 cup | | | | | | | | | |
| Milk added to water-based hot drinks (coffee, tea) - 50 mL / 1/5 cup | | | | | | | | | |
| Milk-based hot drinks (Latte, Milo) - 250 mL / 1 cup | | | | | | | | | |

***5. How often do you usually eat cheese?**

| | Never | <1x / month | 1-3x / month | 1x / week | 2-3x / week | 4-6x / week | Once / day | 2-3x / day | 4+ x / day | 4+ x / day |
|---|---|---|---|---|---|---|---|---|---|---|
| Cheddar (tasty, mild, colby) - 2 heaped Tbsp / matchbox cube | | | | | | | | | | |
| Edam, Gouda, Swiss - 2 heaped Tbsp / matchbox cube | | | | | | | | | | |
| Feta, Mozarella, Camembert - 1 heaped Tbsp / 1 med wedge | | | | | | | | | | |
| Brie, blue and other specialty cheese - 1 heaped Tbsp / 1 med wedge | | | | | | | | | | |
| Processed cheese slices - 1 slice | | | | | | | | | | |
| Cream cheese - 2 heaped Tbsp | | | | | | | | | | |
| Cottage or ricotta cheese - 2 heaped Tbsp | | | | | | | | | | |

***6. How often do you usually eat these dairy based foods?**

| | Never | <1x / month | 1-3x / month | 1x / week | 2-3x / week | 4-6x / week | Once / day | 2-3x / day | 4+ x / day |
|---|---|---|---|---|---|---|---|---|---|
| Ice cream - 2 scoops | | | | | | | | | |
| Custard or dairy food - 1 pottle / ½ cup | | | | | | | | | |
| Yoghurt, plain or flavour - 1 pottle / ½ cup | | | | | | | | | |
| Milk puddings (semolina, instant) - ½ cup | | | | | | | | | |
| Fermented or evaporated milk (buttermilk) - ½ cup | | | | | | | | | |

## EXPLORE Food Frequency Questionnaire

### 5. Bread

***1. Do you eat bread?**

◯ No

◯ Yes

**2. What type(s) of bread, rolls or toast do you eat most often? (You can choose up to 3 options, but please only choose the ones you usually have)**

☐ Not applicable

☐ White

☐ White – high fibre

☐ Wholemeal or wheat meal

☐ Wholegrain

Other (please state)

____________________

***3. What type of bread slice do you usually have? (Please choose one only)**

◯ Not applicable

◯ Sandwich slice

◯ Toast slice

◯ Mixture of both sandwich and toast slices

***4. On average, how many servings of bread do eat per day? (Please choose one only)**
**(A 'serving' = 1 slice of bread or 1 small roll)**

◯ Not applicable

◯ Less than 1 serving

◯ 1–2 servings

◯ 3–4 servings

◯ 5–6 servings

◯ 7 or more servings

## EXPLORE Food Frequency Questionnaire

### *5. How often do you usually eat these bread based foods?

| | Never | <1x / month | 1-3x / month | 1x / week | 2-3x / week | 4-6x / week | Once / day | 2-3x / day | 4+ x / day |
|---|---|---|---|---|---|---|---|---|---|
| Plain white bread - 1 slice | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| High fibre white bread - 1 slice | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Wholemeal or wheat meal - 1 slice | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Wholegrain bread - 1 slice | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Fruit bread or fruit bun - 1 slice | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Wrap - 1 medium | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Focaccia, bagel, pita, panini or other speciality breads - 1 medium | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Paraoa Parai (fry bread) - 1 slice | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Rewena bread - 1 slice | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Doughboys or Maori bread - 1 slice | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |

### *6. How often do you usually eat these other bread based foods?

| | Never | <1x / month | 1-3x / month | 1x / week | 2-3x / week | 4-6x / week | Once / day | 2-3x / day | 4+ x / day |
|---|---|---|---|---|---|---|---|---|---|
| Crumpet or muffin split - 1 crumpet / 1 whole muffin split | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Scone - 1 medium | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Bran muffin or savoury muffin - 1 medium | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Croissant - 1 medium | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Waffle, pancakes or pikelets - 1 medium / 2 small | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Iced buns - 1 medium | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Crackers (cream crackers, cruskits, corn / rice crackers, vitawheat) - 2 medium | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |

### *7. Do you have butter, margarine or spreads on bread or crackers?

◯ No

◯ Yes

## EXPLORE Food Frequency Questionnaire

**8. What type(s) do you have most often? (You can choose up to 3 options, but please only choose the ones you usually have)**

- ☐ Not applicable
- ☐ Butter (all varieties)
- ☐ Monounsaturated fat margarine e.g. Olive, Rice Bran, Canola Oil Spreads
- ☐ Polyunsaturated fat margarine e.g. Sunflower Oil Spreads
- ☐ Light monounsaturated fat margarine e.g. Olivio Spread Light
- ☐ Light polyunsaturated fat margarine e.g. Flora Spread Light
- ☐ Plant sterol enriched margarine e.g. Pro Active, Logical Spreads
- ☐ Light plant sterol enriched margarine e.g. Pro Active Spread Light
- ☐ Butter and margarine blend e.g. Country Soft, Butter Lea

Other (please state)

***9. On average, how many servings of butter, margarine or spreads do you have per day? (Please choose one only)**
**(A 'serving' = 1 level teaspoon or 5 mL)**
**e.g. 1 sandwich with butter thinly spread on two pieces of bread = 2 servings**

- ◯ Not applicable
- ◯ Less than 1 serving
- ◯ 1–2 servings
- ◯ 3–4 servings
- ◯ 5–6 servings
- ◯ 7 or more servings

## EXPLORE Food Frequency Questionnaire

### 6. Breakfast Cereals and Porridge

***1. Do you usually eat breakfast cereal and/or porridge?**

- ◯ No
- ◯ Yes

**2. What breakfast cereal(s) do you eat most often? (You can choose up to 3 options, but please only choose the ones you usually have)**

- ☐ Not applicable
- ☐ Weetbix
- ☐ Refined cereals e.g. Cornflakes or Rice Bubbles
- ☐ Bran based cereals including fruity varieties e.g. Special K, Muesli, All Bran
- ☐ Sweetened e.g. Nutrigrain, Cocoa Pops
- ☐ Porridge

Other (please state)

***3. On average, how many servings of breakfast cereal or porridge do you have per week? (Please choose one only)**
**(A 'serving' = ½ cup porridge, muesli, cornflakes or 2 weetbix)**
**e.g. ½ cup of porridge 3 times per week + 2 weetbix 4 times a week = 7 servings per week**

- ◯ Not applicable
- ◯ Less than 4 servings
- ◯ 4–6 servings
- ◯ 7–9 servings
- ◯ 10–12 servings
- ◯ 13–15 servings
- ◯ 16 or more servings

# EXPLORE Food Frequency Questionnaire

***4. How often do you usually eat porridge or these cereal foods?**

| | Never | <1x / month | 1-3x / month | 1x / week | 2-3x / week | 4-6x / week | Once / day | 2-3x / day | 4+ x / day |
|---|---|---|---|---|---|---|---|---|---|
| Porridge, rolled oats, oat bran, oat meal - ½ cup | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Muesli (all varieties) - ½ cup | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Weetbix (all varieties) - 2 weetbix | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Cornflakes or rice bubbles - ½ cup | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Bran cereals (All Bran, Bran Flakes) - ½ cup | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Bran based cereals (Sultana Bran, Sultana Bran Extra) - ½ cup | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Light and fruity cereals (Special K, Light and Tasty) - ½ cup | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Chocolate based cereals (Milo cereal, Coco Pops) - ½ cup | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Sweetened cereals (Nutrigrain, Fruit Loops, Honey Puffs, Frosties) - ½ cup | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Breakfast drinks (Up and Go) - Small carton / 250 mL | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |

## EXPLORE Food Frequency Questionnaire

### 7. Starchy Foods

***1. Do you eat any type of starchy foods such as rice, pasta, noodles and couscous?**

- No
- Yes

***2. On average, how many servings of starchy foods such as rice, pasta, noodles and couscous do you eat per week? (Please choose one only)**
**(A 'serving' = 1 cup cooked rice / pasta)**
**e.g. 1 cup of rice + ½ cup of pasta included in a lasagne pasta dish + 1 cup of spaghetti = 2.5 servings**

- Not applicable
- Less than 4 servings
- 4–6 servings
- 7–9 servings
- 10–12 servings
- 13–15 servings
- 16 or more servings

***3. How often do you usually eat these starchy foods?**

| | Never | <1x / month | 1-3x / month | 1x / week | 2-3x / week | 4-6x / week | Once / day | 2-3x / day | 4+ x / day |
|---|---|---|---|---|---|---|---|---|---|
| Rice, white - 1 cup | | | | | | | | | |
| Rice, brown or wild - 1 cup | | | | | | | | | |
| Pasta, white or wholegrain (spaghetti, vermicelli) - 1 cup | | | | | | | | | |
| Canned spaghetti (Watties) - 1 cup | | | | | | | | | |
| Instant noodles (2 minute noodles) - 1 packet | | | | | | | | | |
| Egg and rice noodles (hokkien noodles, udon) - 1 cup | | | | | | | | | |
| Other grain (quinoa, couscous, bulgar wheat) - 1 cup | | | | | | | | | |

## EXPLORE Food Frequency Questionnaire

### 8. Meat

***1. Do you eat beef, mutton, hogget, lamb, or pork**

- ◯ No
- ◯ Yes

***2. Do you trim any excess fat (fat you can see) off these meats? (Please choose one only)**

- ◯ Not applicable
- ◯ Always
- ◯ Often
- ◯ Occasionally
- ◯ Never cut the fat off meat

***3. On average, how many servings of meat e.g. beef, mutton, hogget, lamb or pork do you eat per week? (Please choose one only)**
**(A 'serving' = palm size or ½ a cup of meat without bone)**
**e.g. ½ cup of savoury mince + 2 small lamb chops = 2 servings**

- ◯ Not applicable
- ◯ Less than 1 serving
- ◯ 1-3 servings
- ◯ 4-6 servings
- ◯ 7 or more servings

***4. How often do you usually eat meat?**

| | Never | <1x / month | 1-3x / month | 1x / week | 2-3x / week | 4-6x / week | Once / day | 2-3x / day | 4+ x / day |
|---|---|---|---|---|---|---|---|---|---|
| Beef mince dishes (rissoles, meatloaf, hamburger pattie) - 1 slice / patty / ½ cup | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Beef or veal mixed dishes (casserole, stir-fry) - ½ cup | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Beef or veal (roast, chop, steak, schnitzel, corned beef) - palm size / ½ cup | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Lamb, hogget or mutton mixed dishes (stews, casserole, stir-fry) - ½ cup | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Lamb, hogget or mutton (roast, chops, steak) - palm size / ½ cup | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Pork (roast, chop, steak) - palm size / ½ cup | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Canned corned beef - 1 medium slice | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |

## EXPLORE Food Frequency Questionnaire

***5. How often do you usually eat these other meats?**

| | Never | <1x / month | 1-3x / month | 1x / week | 2-3x / week | 4-6x / week | Once / day | 2-3x / day | 4+ x / day |
|---|---|---|---|---|---|---|---|---|---|
| Sausage, frankfurter or saveloy - 1 sausage / frankfurter/ 2 saveloys | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Bacon - 2 rashers | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Ham - 1 medium slice | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Luncheon meats or brawn - 1 slice | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Salami or chorizo - 1 slice / cube | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Offal (liver, kidneys, pate) - palm size / ½ cup | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Venison/game - palm size / ½ cup | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |

## EXPLORE Food Frequency Questionnaire

### 9. Poultry

***1. Do you eat poultry e.g. chicken, turkey or duck?**

- ◯ No
- ◯ Yes

***2. Do you remove the skin from chicken? (Please choose one only)**

- ◯ Not applicable
- ◯ Always
- ◯ Often
- ◯ Occasionally
- ◯ Never remove the skin from chicken

***3. On average, how many servings of chicken do you eat per week? (Please choose one only)**
**(A 'serving' = palm size of chicken or ½ cup)**
**e.g. 1 chicken breast + 2 chicken drumsticks + 1 chicken thigh = 4 servings per week**

- ◯ Not applicable
- ◯ Less than1 serving
- ◯ 1-3 servings
- ◯ 4-6 servings
- ◯ 7 or more servings

***4. How often do you usually eat poultry?**

| | Never | <1x / month | 1-3x / month | 1x / week | 2-3x / week | 4-6x / week | Once / day | 2-3x / day | 4+ x / day |
|---|---|---|---|---|---|---|---|---|---|
| Chicken legs or wings - palm size / ½ cup / 1 unit (wing, drumstick) | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Chicken breast - palm size / ½ cup / ½ breast | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Chicken mixed dishes (casserole, stir-fry) - palm size / ½ cup | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Crumbed chicken (nuggets, patties, schnitzel) - 1 medium / 4 nuggets | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Turkey or quail - palm size / ½ cup | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Mutton bird or duck - palm size / ½ cup | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |

EXPLORE Food Frequency Questionnaire

## 10. Fish and Seafood

***1. Do you eat any type of fish or seafood?**

- ◯ No
- ◯ Yes

***2. On average, how many servings of fish and seafood (all types; fresh, frozen, tinned) do you eat per week? (Please choose one only)**
**(A 'serving' = 80 - 120g or palm size or small tin (85g))**
**e.g. 1 fish fillet and 1 small tin of tuna = 2 servings per week.**

- ◯ Not applicable
- ◯ Less than 1 serving
- ◯ 1-3 servings
- ◯ 4-6 servings
- ◯ 7 or more servings

**3. How do you normally cook / eat fish? (You can choose up to 3 options, but please only choose the ones you usually have)**

- ☐ Not applicable
- ☐ Raw / I don't cook it
- ☐ Oven baked / Grilled
- ☐ Deep fried
- ☐ Shallow fry
- ☐ Micro waved
- ☐ Steamed
- ☐ Poached
- ☐ Smoked

## EXPLORE Food Frequency Questionnaire

### *4. How often do you usually eat seafood?

| | Never | <1x / month | 1-3x / month | 1x / week | 2-3x / week | 4-6x / week | Once / day | 2-3x / day | 4+ x / day |
|---|---|---|---|---|---|---|---|---|---|
| Canned Salmon - 1 small can (85-95g) | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Canned Tuna - 1 small can (85-95g) | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Canned Mackerel, sardines, anchovies, herring - 1 small can (85-95g) | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Frozen crumbed fish (patties, fillets, cakes, fingers, nuggets) - 1 medium / 4 nuggets | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Snapper, Tarakihi, Hoki, Cod, Flounder - palm size / ½ cup | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Gurnard, Kahawai or Trevally - palm size / ½ cup | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Lemon fish or Shark - palm size / ½ cup | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Tuna - palm size / ½ cup | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Salmon, trout or eel - palm size / ½ cup | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |

### *5. How often do you usually eat seafood?

| | Never | <1x / month | 1-3x / month | 1x / week | 2-3x / week | 4-6x / week | Once / day | 2-3x / day | 4+ x / day |
|---|---|---|---|---|---|---|---|---|---|
| Shrimp, prawn, lobster or crayfish - ½ cup | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Crab or surumi - ½ cup | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Scallops, mussels, oysters, paua or clams - ½ cup | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Pipi or cockle - ½ cup | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Kina - ½ cup | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Whitebait - ¼ cup | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Roe - ¼ cup | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Squid, octopus, calamari, cuttlefish - ½ cup | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |

## EXPLORE Food Frequency Questionnaire

### 11. Fats and Oils

***1. Do you cook meat, chicken, fish, eggs and/or vegetables with fat or oil?**

- ○ No
- ○ Yes

**2. What type(s) do you use most often? (You can choose up to 3 options, but please only choose the ones you usually have)**

- ☐ Not applicable
- ☐ Butter (all varieties)
- ☐ Margarines (all varieties)
- ☐ Cooking oils (all varieties)
- ☐ Lard, Dripping, Coconut oil, Ghee (clarified butter)
- ☐ Cooking spray

Other (please state)

***3. When you use fat or oil to cook, how many servings of fat or oil do you use per dish? (Please choose one only)**
**(A 'serving' = 1 level teaspoon or 5 mL)**

- ○ Not applicable
- ○ Less than 1 serving
- ○ 1 serving
- ○ 2 servings
- ○ 3 servings
- ○ 4 servings
- ○ 5 or more servings

***4. On average, how many servings of fat or oil do you use to cook per week? (Please choose one only)**

- ○ Not applicable
- ○ Less than 1 serving
- ○ 1-3 servings
- ○ 4-7 servings
- ○ 8-10 servings
- ○ 11-14 servings
- ○ 15 or more servings

## EXPLORE Food Frequency Questionnaire

### 12. Eggs

***1. Do you eat eggs?**

- ◯ No
- ◯ Yes

***2. On average, not counting eggs used in baking / cooking, how many eggs do you usually eat per week? (Please choose one only)**

- ◯ Not applicable
- ◯ Less than 1 egg
- ◯ 1 egg
- ◯ 2 eggs
- ◯ 3 eggs
- ◯ 4 eggs
- ◯ 5 or more eggs

***3. How often do you usually eat eggs?**

| | Never | <1x / month | 1-3x / month | 1x / week | 2-3x / week | 4-6x / week | Once / day | 2-3x / day | 4+ x / day |
|---|---|---|---|---|---|---|---|---|---|
| Whole eggs (hard-boiled, poached, fried, mashed, omelette, scrambled) - 1 egg | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Mixed egg dish (quiche, frittata, other baked egg) - 1 slice | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |

## EXPLORE Food Frequency Questionnaire

### 13. Legumes

***1. Do you eat legumes e.g. chickpeas/dried peas, soybeans, dried/canned beans, baked beans, lentils or Dahl?**

- ◯ No
- ◯ Yes

***2. On average, how many servings of legumes (fresh, frozen, canned, dried) do you eat per week? (Please choose one only)**
**(A 'serving' = ½ cup or 125g of cooked legumes)**

- ◯ Not applicable
- ◯ Less than 1 serving
- ◯ 1 serving
- ◯ 2 servings
- ◯ 3 servings
- ◯ 4-5 servings
- ◯ 6-7 servings
- ◯ 8 or more servings

***3. How often do you usually eat these legumes?**

| | Never | <1x / month | 1-3x / month | 1x / week | 2-3x / week | 4-6x / week | Once / day | 2-3x / day | 4+ x / day |
|---|---|---|---|---|---|---|---|---|---|
| Soybeans - ½ cup | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Tofu - ½ cup | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Dahl - ½ cup | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Canned or dried legumes, beans (baked beans, chickpeas, lentils, peas, beans) - ½ cup | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Hummus - 2 Tbsp | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |

## EXPLORE Food Frequency Questionnaire

### 14. Vegetables

***1. Do you eat vegetables?**

◯ No

◯ Yes

***2. On average, how many servings of vegetables (fresh, frozen, canned) do you eat per day? Do NOT include vegetable juices. (Please choose one only)**
**(A 'serving' = 1 medium potato / kumara or ½ cup cooked vegetables or 1/2 cup of lettuce)**
**e.g. 2 medium potatoes + ½ cup of peas = 3 servings**

◯ Not applicable

◯ Less than 1 serving

◯ 1 serving

◯ 2 servings

◯ 3 servings

◯ 4 or more servings

***3. How often do you usually eat these vegetables?**

| | Never | <1x / month | 1-3x / month | 1x / week | 2-3x / week | 4-6x / week | Once / day | 2-3x / day | 4+ x / day |
|---|---|---|---|---|---|---|---|---|---|
| Potato (boiled, mashed, baked, roasted) - 1 medium / ½ cup | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Pumpkin (boiled, mashed, baked, roasted) - ½ cup | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Kumara (boiled, mashed, baked, roasted) - 1 medium / ½ cup | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Mixed frozen vegetables - ½ cup | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Green beans - ½ cup | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Silver beet, spinach - ½ cup | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Carrots - 1 medium / ½ cup | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Sweet corn - 1 medium cob / ½ cup | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Mushrooms - ½ cup | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Tomatoes - 1 medium / ½ cup | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Beetroot - 1 medium / ½ cup | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Taro, cassava or breadfruit - 1 medium / ½ cup | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |

## EXPLORE Food Frequency Questionnaire

***4. How often do you usually eat these vegetables?**

| | Never | <1x / month | 1-3x / month | 1x / week | 2-3x / week | 4-6x / week | Once / day | 2-3x / day | 4+ x / day |
|---|---|---|---|---|---|---|---|---|---|
| Green bananas (plantain) - 1 medium / ½ cup | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Sprouts (alfalfa, mung) - ½ cup | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Pacific Island yams - 1 medium / ½ cup | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Turnips, swedes, parsnip or yams - ½ cup | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Onions, celery or leeks - ¼ cup | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Cauliflower, broccoli or broccoflower - ½ cup | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Brussel sprouts, cabbage, red cabbage or kale - ½ cup | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Courgette/zucchini, marrow, eggplant, squash, kamo kamo, asparagus, cucumber - ½ cup | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Capsicum (peppers) - ½ medium / ¼ cup | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Avocado - ¼ avocado | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Lettuce greens (mesculin, cos, iceberg) - ½ cup | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Other green leafy vegetables (whitloof, watercress, taro leaves, puha) - ½ cup | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |

## EXPLORE Food Frequency Questionnaire

### 15. Fruit

***1. Do you eat fruit?**

- ◯ No
- ◯ Yes

***2. On average, how many servings of fruit (fresh, frozen, canned or stewed) do you eat per day? Do NOT include fruit juice. (Please choose one only)**
**(A 'serving' = 1 medium or 2 small pieces of fruit or 1/2 cup of chopped fruit)**
**e.g. 1 apple + 2 small apricots = 2 servings)**

- ◯ Not applicable
- ◯ Less than one serving
- ◯ 1 serving
- ◯ 2 servings
- ◯ 3 or more servings

***3. How often do you usually eat these fruits?**

| | Never | <1x / month | 1-3x / month | 1x / week | 2-3x / week | 4-6x / week | Once / day | 2-3x / day | 4+ x / day |
|---|---|---|---|---|---|---|---|---|---|
| Apple - 1 medium / ½ cup | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Pear - 1 medium / ½ cup | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Banana - 1 medium / ½ cup | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Orange, mandarin, tangelo, grapefruit - 1 medium / 2 small | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Peach, nectarine, plum or apricot - 1 medium / ½ cup / 2 small | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Mango, paw-paw or persimmons / ½ cup | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Pineapple - ½ cup | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Grapes - ½ cup / 8-10 grapes | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Strawberries, other berries, cherries - ½ cup | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Melon (watermelon, rockmelon) - ½ cup | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Kiwifruit - 1 medium / 2 small | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Feijoas - 1 medium / 2 small | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Tamarillos - 1 medium / ½ cup | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Sultanas, raisins or currants - 1 small box | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Other dried fruit (apricots, prunes, dates) - 4 pieces | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |

# EXPLORE Food Frequency Questionnaire

## 16. Drinks

***1. On average, how many drinks do you have per day? (Please choose one only) (A 'serving' = 250 mL or one cup/glass)**

- ◯ Less than 1 serving
- ◯ 1-3 servings
- ◯ 4-5 servings
- ◯ 6-8 servings
- ◯ 9-10 servings
- ◯ 11 or more servings

***2. How often do you usually have these drinks?**

| | Never | <1x / month | 1-3x / month | 1x / week | 2-3x / week | 4-6x / week | Once / day | 2-3x / day | 4+ x / day |
|---|---|---|---|---|---|---|---|---|---|
| Instant soup (Cup of soup) - 250 mL / 1 cup | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Fruit juice (Just Juice, Fresh-up, Charlie's, Rio Gold) - 250 mL / 1 cup/glass | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Fruit drink (Choice, Rio Splice) - 250 mL / 1 cup/glass | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Vegetable juice (tomato juice, V8 juice) - 250 mL / 1 cup/glass | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Iced Tea (Lipton ice tea) - 250 mL / 1 cup/glass | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Cordial or Powdered drinks (Thriftee, Raro, Vita-fresh) - 250 mL / 1 cup/glass | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Low-calorie cordial - 250 mL / 1 cup/glass | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Energy drinks small-medium can (V, Red Bull) - 250-350 mL | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Energy drinks large can (Monster, Mother, Demon, large V) - 450-550 mL | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Sugar-free Energy drinks (sugar-free V, Monster, Red Bull) - 1 small can | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Diet soft/fizzy/carbonated drink (diet sprite) - 250 mL / 1 cup/glass | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Soft/fizzy/carbonated drinks (Coke, Sprite) - 250 mL / 1 cup/glass | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Sport's drinks (Gatorade, Powerade) - 1 bottle | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Flavoured water (Mizone, H2Go flavoured) - 1 bottle | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Water (unflavoured mineral water, soda water, tap water) - 250 mL / 1 cup/glass | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |

## EXPLORE Food Frequency Questionnaire

### *3. How often do you usually have these drinks?

| | Never | <1x / month | 1-3x / month | 1x / week | 2-3x / week | 4-6x / week | Once / day | 2-3x / day | 4+ x / day |
|---|---|---|---|---|---|---|---|---|---|
| Coffee instant or brewed with or without milk (Nescafe, expresso) - 1 cup | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Specialty coffees (flat white, cappuccino, lattes) - 1 small cup | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Coffee decaffeinated or substitute (Inka) - 1 cup | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Hot chocolate drinks (drinking chocolate, hot chocolate, Koko) - 1 cup | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Milo - 1 tsp | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Tea (English breakfast tea, Earl Grey) - 1 cup | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Herbal tea or Green tea - 1 cup | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Soy drinks - 1 cup | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |

### *4. How often do you usually have these alcoholic drinks?

| | Never | <1x / month | 1-3x / month | 1x / week | 2-3x / week | 4-6x / week | Once / day | 2-3x / day | 4+ x / day |
|---|---|---|---|---|---|---|---|---|---|
| Beer – low alcohol - 1 can or bottle | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Beer – ordinary - 1 can or bottle | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Red wine - 1 small glass | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| White wine, champagne, sparkling wine - 1 small glass | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Wine cooler - 1 small glass / bottle | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Sparkling grape juice - 1 glass / cup | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Sherry or port - 100 mL | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Spirits, liqueurs - 1 shot or 30 mL | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| RTD (KGB, Vodka Cruiser, Woodstock bourbon) - 1 bottle / can | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Cider - 1 glass / cup / bottle | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Kava - 1 glass / cup | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |

# EXPLORE Food Frequency Questionnaire

## 17. Dressings and Sauces

***1. How often do you usually have these dressings or sauces?**

| | Never | <1x / month | 1-3x / month | 1x / week | 2-3x / week | 4-6x / week | Once / day | 2-3x / day | 4+ x / day |
|---|---|---|---|---|---|---|---|---|---|
| Butter (all varieties) - 1 tsp | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Margarine (all varieties) - 1 tsp | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Oil (all varieties) - 1 tsp | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Cream or sour cream - 1 Tbsp | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Mayonnaise or creamy dressings (aioli, tartae sauce) - 1 Tbsp | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Low fat/calorie dressing (reduced fat mayonnaise) - 1 Tbsp | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Salad dressing (french, italian) - 1 Tbsp | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Sauces (tomato, BBQ, sweet chilli, mint) - 1 Tbsp | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Mustard - 1 Tbsp | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Soy sauce - 1 Tbsp | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Chutney or relish - 1 Tbsp | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Gravy homemade - ¼ cup | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Instant Gravy (e.g. Maggi) - ¼ cup | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| White sauce/cheese sauce - ¼ cup | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |

## EXPLORE Food Frequency Questionnaire

### 18. Miscellaneous - Cakes, Biscuits and Puddings

***1. How often do you usually eat these baked products?**

| | Never | <1x / month | 1-3x / month | 1x / week | 2-3x / week | 4-6x / week | Once / day | 2-3x / day | 4+ x / day |
|---|---|---|---|---|---|---|---|---|---|
| Cakes, loaves, sweet muffins - 1 slice / 1 muffin | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Sweet pies or pastries, tarts, doughnuts - 1 medium | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Other puddings or desserts - not including milk-based puddings (sticky date pudding, pavlova) - ½ cup | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Plain biscuits, cookies (Round wine, Ginger nut) - 2 biscuits | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Fancy biscuits (chocolate, cream) - 2 biscuits | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |

## EXPLORE Food Frequency Questionnaire

### 19. Miscellaneous

***1. How often do you usually eat these other foods?**

| | Never | <1x / month | 1-3x / month | 1x / week | 2-3x / week | 4-6x / week | Once / day | 2-3x / day | 4+ x / day |
|---|---|---|---|---|---|---|---|---|---|
| Jelly - ½ cup | | | | | | | | | |
| Ice blocks - 1 ice block | | | | | | | | | |
| Lollies - 2 lollies | | | | | | | | | |
| Chocolate - including chocolate bars (Moro bars) - 1 small bar | | | | | | | | | |
| Sugar added to food and drinks - 1 level tsp | | | | | | | | | |
| Jam, honey, marmalade or syrup - 1 level tsp | | | | | | | | | |
| Vegemite or marmite - 1 level tsp | | | | | | | | | |
| Peanut butter or other nut spreads - 1 level Tbsp | | | | | | | | | |
| Brazil nuts or walnuts - 2 | | | | | | | | | |
| Peanuts - 10 | | | | | | | | | |
| Other nuts (almonds, cashew, pistachio, macadamia) - 10 | | | | | | | | | |
| Seeds (pumpkin, sunflower) | | | | | | | | | |
| Muesli bars - 1 bar | | | | | | | | | |
| Coconut cream - ¼ cup | | | | | | | | | |
| Coconut milk - ¼ cup | | | | | | | | | |
| Lite coconut milk - ¼ cup | | | | | | | | | |
| Potato crisps, corn chips, Twisties - ½ cup / handful | | | | | | | | | |

***2. Do you use salt in cooking?**

- Never
- Rarely
- Sometimes
- Usually
- Always

***3. Do you use salt at the table?**

- Never
- Rarely
- Sometimes
- Usually
- Always

## EXPLORE Food Frequency Questionnaire

### 20. Miscellaneous - Takeaways

***1. On average, how often do you eat takeaways per week? (Please choose one only)**

- ◯ Never
- ◯ Less than 1 times
- ◯ 1-2 times
- ◯ 3-4 times
- ◯ 4-6 times
- ◯ More than 7 times

***2. How often do you usually eat these takeaway foods?**

| | Never | <1x / month | 1-3x / month | 1x / week | 2-3x / week | 4-6x / week | Once / day | 2-3x / day | 4+ x / day |
|---|---|---|---|---|---|---|---|---|---|
| Meat pie, sausage roll, other savouries - 1 pie / 2 small sausage rolls or savouries | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Hot potato chips, kumara chips, french fries, wedges - ½ cup | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Chinese - 1 serve | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Indian - 1 serve | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Thai - 1 serve | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Pizza - 1 medium slice | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Burgers - 1 medium burger | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Battered fish - 1 piece | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Fried chicken (KFC, Country fried chicken) - 1 medium piece | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Bread based (Kebab, sandwiches, wraps, Pita Pit, Subway) - 1 medium | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |

## EXPLORE Food Frequency Questionnaire

### 21. Other

*1. Are there any other foods or drinks that you can think of that you have on a regular basis that was not covered by this questionnaire?**

- ◯ No
- ◯ Yes

## EXPLORE Food Frequency Questionnaire

### 22. Other

**1. Please list these foods and drinks including; the serving size, and how many times per week you eat or drink these items (e.g. Pizza, 4 slices, one time per week)**

Appendix B – Dietary diversity questionnaire

MASSEY UNIVERSITY
COLLEGE OF HEALTH
TE KURA HAUORA TANGATA

# Women's EXPLORE Study

## Dietary Diversity Questionnaire

*Thank you very much for taking part in the EXPLORE Study. We are extremely grateful for your time, effort and commitment!*

*If you have any questions, please contact EXPLORE staff on: 414 0800 (extn 41189) email: explore@massey.ac.nz or AJ Hepburn 027 404 5351*

Either fill out the paper questionnaire after the 7-day period and return it to us in the envelope provided

OR

Fill it out online after the 7-day period at: http://www.surveymonkey.com/s/W5TYNTW

Subject ID______________

## DIETARY DIVERSITY QUESTIONNAIRE

*Please tick the foods you consumed during the past 7 days. You only need to tick a food once even if it was consumed several times.*
*For foods that require preparation (e.g. meat) consider all types of preparation and cooking methods.*
*Also consider foods that can be eaten in fresh, frozen, dried or canned versions.*

| 1. FLESH FOODS (MEAT, POULTRY, FISH) | YES | NO |
|---|---|---|
| Lamb or mutton (e.g. chops, leg, stewing meat, flaps, etc.) | | |
| Beef (e.g. steak, mince, stewing meat, etc.) | | |
| Pork (e.g. chops, fillet, leg, etc.) | | |
| Hocks, pork bones, pig's head | | |
| Other meats (e.g. venison, etc.) | | |
| Offal, (liver, kidneys, heart etc.) | | |
| Goat (meat) | | |
| Chicken (e.g. whole, thighs, drumsticks, etc.) | | |
| Chicken wings, nibbles | | |
| Chicken offal (e.g. livers, hearts, giblets, chicken frames, etc.) | | |
| Crumbed, battered chicken (e.g. chicken schnitzel, nuggets, etc.) | | |
| Other poultry (e.g. turkey, duck, muttonbird, etc.) | | |
| Cured meat (e.g. ham, bacon, salami, etc.) | | |
| Luncheon meats, all varieties | | |
| Tinned meat (e.g. corned beef, etc.) | | |
| Sausage, all varieties | | |
| Meat patties | | |
| Fish, fresh, white (e.g. hoki, snapper, flounder, etc.) | | |
| Fish, fresh, brown or pink (e.g. salmon, trout, eel, etc.) | | |
| Crumbed, battered fish (e.g. fish fingers, fish cakes, etc.) | | |
| Tinned tuna, salmon | | |
| Other tinned fish (e.g. sardines, mackerel, herring, etc.) | | |
| Roe (e.g. caviar, fish eggs, etc.) | | |
| Shell fish (e.g. mussels, oysters, scallops, clams, pipis, cockles, paua, kina, etc.) | | |
| Crayfish, shrimp, prawns, crab | | |
| Squid, calamari, octopus | | |
| Whitebait | | |
| Other | | |

| 2. EGGS | YES | NO |
|---|---|---|
| Eggs | | |

| 3. DAIRY PRODUCTS | YES | NO |
|---|---|---|
| Full cream milk (dark blue) | | |
| Low-fat milk (light blue) | | |
| Skim milk (green) | | |
| Milk with calcium added (yellow top) | | |
| Evaporated milk, tinned, (unsweetened) | | |
| Fermented milk (Buttermilk, etc.) | | |
| Sweetened condensed milk | | |
| Cream or sour cream | | |
| Hard cheese (e.g. edam, tasty, etc.) | | |
| Soft cheese (e.g. cottage, ricotta, camembert, etc) | | |
| Processed cheese (slices or spread) | | |
| Custard | | |
| Ice cream | | |
| Yoghurt, full fat | | |
| Yoghurt, low fat | | |
| Yoghurt drink | | |
| Dairyfood | | |
| Other milks (e.g. soy milk, rice milk, almond milk, etc.) | | |
| Other | | |

| 4. BREADS, CEREALS AND STARCHY VEGETABLES | YES | NO |
|---|---|---|
| Rice, all varieties (e.g. long grain, white, brown Basmati, Jasmine, etc.) | | |
| Bread or rolls, white | | |
| Bread or rolls, whole-wheat, whole-grain, wheat-meal, multi-grain, etc. | | |
| Fruit bread or buns | | |
| Specialty breads (e.g. croissant, panini, focaccia, pita, muffin splits, crumpets, etc.) | | |
| Wraps | | |
| Maori bread (rewena), doughboys | | |
| Pasta (e.g. macaroni, spaghetti, penne, etc.) | | |
| Rice vermicelli (rice noodles) | | |
| Instant noodles (two-minute noodles, all varieties, e.g. Maggi, Fantastic, etc.) | | |

| | | |
|---|---|---|
| Instant flavoured pasta packets (e.g. macaroni and cheese, chicken and mushroom, etc.) | | |
| Quinoa | | |
| Couscous | | |
| Dumpling (e.g. pork dumpling, red bean dumpling, etc.) | | |
| Large savoury muffins (e.g. cheese etc.) | | |
| Scones | | |
| Crackers (e.g. cream crackers, vita wheat, etc.) | | |
| Porridge (e.g. rolled oats, oat meal, etc.) | | |
| Sweetened breakfast cereals (e.g. Coco Pops, Fruit Loops, Nutri-Grain, etc.) | | |
| Unsweetened breakfast cereals (e.g. Cornflakes, Rice Bubbles, etc.) | | |
| Bran flakes (e.g. All Bran, Special K Advantage, etc.) | | |
| Wheat biscuits (e.g. Weet-Bix, etc.) | | |
| Muesli, all varieties | | |
| Liquid meal (e.g. Up and Go liquid breakfast, etc.) | | |
| Potatoes | | |
| Kumara (sweet potato) | | |
| Taro | | |
| Cassava | | |
| Corn | | |
| Green banana, plantain | | |
| Swedes | | |
| Yams | | |
| Turnip | | |
| Parsnip | | |
| Other | | |

| 5. LEGUMES AND NUTS | YES | NO |
|---|---|---|
| Dried beans (e.g. kidney, sugar, red, butter, garbanzo, etc.) | | |
| Canned beans (e.g. kidney, sugar, red, butter, garbanzo, etc.) | | |
| Dried peas (green) | | |
| Dried lentils (brown, red) | | |
| Canned lentils (brown, red) | | |
| Chick peas (e.g. in hummus, in falafels, etc) | | |
| Tofu, tempeh | | |
| Salted, flavoured nuts | | |
| Nuts (e.g. pecan, walnut, almond, cashew, etc.) | | |
| Peanuts | | |
| Seeds (e.g. sunflower, sesame, poppy, pumpkin, etc.) | | |
| Coconut flesh | | |
| Other | | |

| 6. FRUITS (AND JUICES) | YES | NO |
|---|---|---|
| Apple | | |
| Peaches, white | | |
| Peaches, yellow | | |
| Apricots | | |
| Mango | | |
| Pears | | |
| Grapes | | |
| Plum | | |
| Lemon, lime | | |
| Orange | | |
| Mandarin | | |
| Banana | | |
| Pineapple | | |
| Avocado | | |
| Berries (e.g. blueberry, boysenberry, etc.) and cherries | | |
| Strawberry | | |
| Feijoa | | |
| Kiwifruit | | |
| Gooseberry | | |

| | | |
|---|---|---|
| Watermelon | | |
| Melon, green or yellow | | |
| Persimmon | | |
| Guava | | |
| Lychees | | |
| Papaya/pawpaw | | |
| Tamarilo/tree tomato | | |
| Passion fruit | | |
| Prunes, dates | | |
| Raisins, sultanas, currants | | |
| Other | | |

| 7. VEGETABLES | YES | NO |
|---|---|---|
| Onions | | |
| Spring onions | | |
| Leeks | | |
| Cabbage | | |
| Red cabbage | | |
| Spinach, silverbeet | | |
| Puha | | |
| Watercress | | |
| Rhubarb | | |
| Chinese greens (e.g. bok choy, pak choi, etc.) | | |
| Brussel sprouts | | |
| Taro leaves | | |
| Carrots | | |
| Beetroot | | |
| Radishes | | |
| Asparagus | | |
| Celery | | |
| Cucumber | | |
| Squash (e.g. gem, butternut, etc.) | | |
| Pumpkin | | |
| Tomatoes | | |
| Green beans | | |
| Peas | | |
| Cauliflower | | |

| | | |
|---|---|---|
| Broccoli | | |
| Chili (red/green) | | |
| Lettuce, all varieties | | |
| Mushroom | | |
| Courgette/zucchini | | |
| Capsicum (green, yellow, orange, black) | | |
| Capsicum, red | | |
| Eggplant/aubergine | | |
| Garlic | | |
| Artichoke | | |
| Other | | |

| 8. OILS AND FATS | YES | NO |
|---|---|---|
| Butter | | |
| Clarified butter (e.g. ghee, etc.) | | |
| Margarine, all varieties | | |
| Margarine, all varieties, low fat or lite | | |
| Lard (e.g. dripping, animal fat, etc.) | | |
| Oil (e.g. olive, sunflower, canola, rice bran, etc.) | | |
| Coconut cream (e.g. Kara, Fia Fia, etc.) | | |
| Coconut milk (e.g. Kara, Ayam, Tropical, etc.) | | |
| Other | | |

| 9. DRINKS | YES | NO |
|---|---|---|
| Juice (100% pure juice e.g. Ceres, Arano, etc.) | | |
| Juice (<100% pure / imitation juice, e.g. Just Juice, McCoy, etc.) | | |
| Imitation drinks (e.g. cordial, Raro, etc.) | | |
| Soft drinks (e.g. Coke, Fanta, etc.) | | |
| Diet soft drinks (e.g. Coke Zero, etc.) | | |
| Flavoured milk (e.g. Milo, Nesquik, Primo, hot chocolate, milkshakes, Koko, etc.) | | |
| Tea (e.g. Dilma, Twining's, etc.) | | |
| Herbal tea (e.g. green tea, chamomile, etc.) | | |
| Coffee, instant or brewed, with or without milk (e.g. flat white, espresso, etc.) | | |
| Coffee-based drinks (e.g. latte, cappuccino, mochaccino etc.) | | |
| Soups, instant, powdered (e.g. Cup a Soup, etc.) | | |

| | | |
|---|---|---|
| Energy drinks (e.g. Red Bull, Mother, etc.) | | |
| Sports drinks (e.g. Powerade, Gatorade, etc.) | | |
| Flavoured water (e.g. Mizone, h2go flavoured water, etc.) | | |
| Water | | |
| Other | | |

| 10. ALCOHOL | YES | NO |
|---|---|---|
| Beer, all varieties, commercial | | |
| Home brewed beer (e.g. hop beer, aaleve, etc.) | | |
| Cider (e.g. Monteith's crushed apple, Magners, etc.) | | |
| Wine (red or white) | | |
| Spirits (e.g. rum, brandy, whiskey, etc.) | | |
| Kava | | |
| RTDs (ready-to-drinks) (e.g. Vodka Cruisers, Archers, etc.) | | |
| Other | | |

| 11. SAUCES, SPREADS AND FLAVOURINGS | YES | NO |
|---|---|---|
| Tomato, BBQ, sweet chilli, mustard sauce, etc. | | |
| Mayonnaise, salad cream or creamy dressings (e.g. aioli, tartare, etc.) | | |
| Salad dressing (French, Italian, etc.) | | |
| Chutney, relish | | |
| White sauce, cheese sauce | | |
| Gravy, homemade | | |
| Gravy, packet (e.g. Maggi roast chicken gravy, Royal brown gravy, pepper sauce, etc.) | | |
| Soy sauce | | |
| Fish sauce/paste | | |
| Salt, added to food or drink | | |
| Sugar, white or brown, added to food or drink (e.g. on cereal, in drinks, etc.) | | |
| Jam, marmalade | | |
| Peanut butter | | |
| Honey | | |
| Chocolate spread (e.g. Nutella, etc.) | | |
| Syrup (e.g. golden, maple, etc.) | | |

| | | |
|---|---|---|
| Yeast spreads (e.g. Marmite, Vegemite, etc.) | | |
| Dips (e.g. cheese and onion dip, chunky basil pesto dip, etc.) | | |
| Pate | | |
| Other | | |

| 12. SWEET SNACKS | YES | NO |
|---|---|---|
| Chewing gum | | |
| Chocolates | | |
| Lollies | | |
| Cakes (e.g. fruit loaf, muffins, carrot cake, etc.) | | |
| Sweet bakery items (e.g. slices, pastries, tartlets, doughnuts, etc.) | | |
| Plain biscuits (e.g. Superwines biscuits, Milk Arrowroot biscuits, etc.) | | |
| Fancy biscuits (e.g. Tim tams, Toffee pops, Squiggles, etc.) | | |
| Pancakes, crepes, pikelets, waffles | | |
| Desserts and puddings (e.g. bread and butter pudding, cheesecake, etc.) | | |
| Jelly | | |
| Ice blocks | | |
| Other | | |

| 13. SAVOURY SNACKS | YES | NO |
|---|---|---|
| Chips/crisps | | |
| Orange cheese puffs (e.g. Twisties, Cheezels, Rashuns, etc.) | | |
| Corn chips (e.g. Dorito's, etc.) | | |
| Savoury bakery items (e.g. quiche, etc.) | | |
| Pretzels | | |
| Popcorn | | |
| Prepackaged bars (e.g. Muesli, Nut, Cereal bars, etc.) | | |
| Bhuja mix | | |
| Other | | |

| 14. TAKEAWAYS AND FASTFOOD | YES | NO |
|---|---|---|
| Pizza (e.g. Domino's, Hell's, etc.) | | |
| Hamburger (e.g. Burger King, Burger Fuel, McDonalds, Fish & Chips Shop, etc.) | | |
| Hot chips, French fries, kumara chips, potato wedges | | |
| Battered hot dog | | |
| Battered fish | | |
| Fried chicken (e.g. KFC, etc.) | | |
| Pies, sausage roll | | |
| Chinese | | |
| Indian | | |
| Thai | | |
| Sandwiches, wraps, pitas (e.g. Subway, Pita Pit, Turkish kebabs, etc.) | | |
| Sushi | | |
| Noodle canteen | | |
| Other | | |

Appendix C.1

Supplementary table 1. Median and mode food variety scores from both nutritious and discretionary food groups over a seven day period segregated by ethnicity

| Food group (# of food items in group) | Median Food Variety Scores | | | | *P*- value | | *% of participants who consumed each # of food items (to nearest whole number) Mode Score Highlighted* | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Ethnicity | | | | | | | | | | | | | | | |
| | Overall n=235 | NZE n=141 | Māori n=47 | Pacific n=47 | | | | | | | | | | | | |
| Meat (6) | 2 (1,3) | 2 (1,2) | 2 (1,3) | 2 (1,3) | 0.290 | # | 0 | 1 | 2 | 3 | 4 | | | | | |
| | | | | | | NZE | 13 | 37 | 30 | 17 | 2 | | | | | |
| | | | | | | Māori | 13 | 28 | 21 | 34 | 4 | | | | | |
| | | | | | | Pacific | 13 | 34 | 23 | 23 | 6 | | | | | |
| Poultry (4) | 1 (1,2) | 1 (1,1)[a,b] | 1 (1,2)[a] | 2 (1,2)[b] | <0.001 | # | 0 | 1 | 2 | 3 | 4 | | | | | |
| | | | | | | NZE | 12 | 69 | 17 | 2 | 0 | | | | | |
| | | | | | | Māori | 6 | 47 | 45 | 2 | 0 | | | | | |
| | | | | | | Pacific | 9 | 21 | 55 | 13 | 2 | | | | | |
| Fish and seafood (9) | 1 (0,3) | 1 (0,2)[a] | 2 (1,4)[a] | 2 (0,3) | 0.031 | # | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| | | | | | | NZE | 32 | 24 | 20 | 9 | 8 | 5 | 2 | 0 | 1 | 0 |
| | | | | | | Māori | 21 | 17 | 19 | 13 | 9 | 11 | 4 | 4 | 2 | 0 |
| | | | | | | Pacific | 30 | 13 | 19 | 17 | 4 | 2 | 6 | 6 | 0 | 2 |
| Eggs (1) | 1 (1,1) | 1 (1,1)[a] | 1 (1,1)[b] | 1 (1,1)[a,b] | 0.015 | # | 0 | 1 | | | | | | | | |
| | | | | | | NZE | 9 | 91 | | | | | | | | |
| | | | | | | Māori | 6 | 94 | | | | | | | | |
| | | | | | | Pacific | 23 | 77 | | | | | | | | |
| Nutritious dairy (9) | 2 (2,3) | 3 (2,3) | 2 (2,3) | 2 (1,4) | 0.998 | # | 0 | 1 | 2 | 3 | 4 | 5 | 6 | | | |
| | | | | | | NZE | 4 | 16 | 30 | 32 | 14 | 4 | 1 | | | |
| | | | | | | Māori | 2 | 21 | 30 | 23 | 13 | 6 | 4 | | | |
| | | | | | | Pacific | 4 | 23 | 26 | 17 | 19 | 9 | 2 | | | |
| Cheese (2) | 1 (1,2) | 1 (1,2)[a] | 2 (1,2)[b] | 1 (0,2)[a,b] | <0.001 | # | 0 | 1 | 2 | | | | | | | |
| | | | | | | NZE | 9 | 42 | 50 | | | | | | | |
| | | | | | | Māori | 6 | 38 | 55 | | | | | | | |
| | | | | | | Pacific | 36 | 34 | 30 | | | | | | | |
| Breads (6) | 2 (1,3) | 2 (1,3) | 2 (2,4) | 3 (1,4) | 0.026 | # | 0 | 1 | 2 | 3 | 4 | 5 | 6 | | | |
| | | | | | | NZE | 4 | 22 | 38 | 24 | 9 | 2 | 0 | | | |
| | | | | | | Māori | 2 | 19 | 30 | 21 | 19 | 9 | 0 | | | |
| | | | | | | Pacific | 6 | 19 | 17 | 23 | 26 | 4 | 4 | | | |

| Food group (# of food items in group) | Median Food Variety Scores Ethnicity | | | | *P*-value | | *% of participants who consumed each # of food items in each food group (to nearest whole number) Mode Score Highlighted* | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Overall n=235 | NZE n=141 | Māori n=47 | Pacific n=47 | | | | | | | | | | | | | | | | | | | | | | | |
| Cereal (13) | 4 (3,5) | 4 (3,5) | 4 (3,6) | 4 (3,6) | 0.623 | # | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | | | | | | | | |
| | | | | | | NZE | 5 | 3 | 10 | 18 | **26** | 18 | 11 | 5 | 1 | 3 | 1 | 0 | 0 | | | | | | | | |
| | | | | | | Māori | 6 | 2 | 11 | 21 | **21** | 11 | 4 | 6 | 4 | 6 | 6 | 0 | 0 | | | | | | | | |
| | | | | | | Pacific | 2 | 11 | 9 | 15 | **17** | 13 | 13 | 0 | 9 | 6 | 2 | 2 | 2 | | | | | | | | |
| Starchy vegetables (9) | 2 (1,3) | 2 (1,3)[a] | 2 (1,3) | 3 (2,4)[a] | <0.001 | # | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | | | | | | | | | | | | | |
| | | | | | | NZE | 11 | 26 | **33** | 22 | 4 | 1 | 3 | 0 | | | | | | | | | | | | | |
| | | | | | | Māori | 6 | 21 | **40** | 19 | 9 | 4 | 0 | 0 | | | | | | | | | | | | | |
| | | | | | | Pacific | 11 | 13 | 17 | **19** | 19 | 15 | 4 | 2 | | | | | | | | | | | | | |
| Vitamin A-rich F & V (23) | 8 (6,10) | 7 (6,9) | 8 (6,11) | 7 (4,12) | 0.242 | # | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| | | | | | | NZE | 0 | 1 | 1 | 2 | 5 | 9 | **20** | 13 | 16 | 11 | 9 | 6 | 3 | 2 | 1 | 1 | 0 | 1 | 0 | 0 | 0 |
| | | | | | | Māori | 2 | 0 | 4 | 0 | 4 | 9 | 11 | 6 | **15** | 11 | 11 | 13 | 6 | 0 | 4 | 0 | 0 | 0 | 2 | 2 | 0 |
| | | | | | | Pacific | 3 | 1 | 0 | **15** | 11 | 6 | 6 | 11 | 9 | 4 | 2 | 4 | 9 | 9 | 2 | 4 | 2 | 0 | 0 | 0 | 2 |
| Vitamin C-rich F & V (14) | 4 (2,6) | 4 (3,6) | 4 (3,6) | 3 (1,6) | 0.634 | # | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | | | | | | | |
| | | | | | | NZE | 4 | 6 | 12 | **26** | 11 | 11 | 16 | 9 | 4 | 1 | 0 | 1 | 0 | 0 | | | | | | | |
| | | | | | | Māori | 4 | 9 | 11 | 15 | 13 | 15 | **17** | 6 | 0 | 6 | 0 | 2 | 2 | 0 | | | | | | | |
| | | | | | | Pacific | 13 | 13 | **13** | 13 | 6 | 9 | 11 | 9 | 2 | 0 | 2 | 4 | 4 | 2 | | | | | | | |
| Other vegetables (15) | 7 (5,8) | 7 (5,8) | 7 (5,9) | 6 (4,8) | 0.256 | # | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | | | | | | |
| | | | | | | NZE | 2 | 1 | 3 | 7 | 11 | 10 | 13 | **16** | 16 | 11 | 3 | 4 | 2 | 1 | 0 | | | | | | |
| | | | | | | Māori | 2 | 0 | 4 | 2 | 9 | 15 | 9 | 11 | **17** | 21 | 4 | 0 | 2 | 2 | 2 | | | | | | |
| | | | | | | Pacific | 0 | 2 | 4 | 11 | **19** | 13 | 4 | 15 | 9 | 6 | 11 | 2 | 4 | 0 | 0 | | | | | | |
| Other fruits (12) | 5 (3,7) | 5 (4,6) | 5 (4,7) | 6 (3,8) | 0.089 | # | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | | | | | | | | |
| | | | | | | NZE | 3 | 7 | 6 | 9 | 21 | **21** | 16 | 9 | 7 | 0 | 1 | 1 | 0 | | | | | | | | |
| | | | | | | Māori | 0 | 4 | 9 | 11 | 13 | **19** | 13 | 9 | 15 | 2 | 2 | 4 | 0 | | | | | | | | |
| | | | | | | Pacific | 4 | 6 | 6 | 15 | 9 | 6 | 11 | **15** | 11 | 2 | 9 | 4 | 2 | | | | | | | | |
| Legumes (7) | 1 (0,2) | 1 (0,2)[b] | 1 (0,2) | 0 (0,1)[b] | 0.016 | # | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | | | | | | | | | | | | | |
| | | | | | | NZE | **38** | 23 | 18 | 14 | 5 | 2 | 0 | 0 | | | | | | | | | | | | | |
| | | | | | | Māori | **36** | 30 | 17 | 11 | 2 | 2 | 0 | 2 | | | | | | | | | | | | | |
| | | | | | | Pacific | **62** | 19 | 9 | 2 | 4 | 2 | 2 | 0 | | | | | | | | | | | | | |

| Food group (# of food items in group) | Median Food Variety Scores Overall n=235 | Ethnicity NZE n=141 | Māori n=47 | Pacific n=47 | *P*- value | | *% of participants who consumed each # of food items in each food group (to nearest whole number) Mode Score Highlighted* | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Nuts and seeds (4) | 2 (1,3) | 2 (1,3) | 2 (1,2) | 2 (1,3) | 0.636 | # | 0 | 1 | 2 | 3 | 4 | | | | | | | | | | |
| | | | | | | NZE | 16 | 25 | 33 | 23 | 3 | | | | | | | | | | |
| | | | | | | Māori | 21 | 28 | 32 | 13 | 6 | | | | | | | | | | |
| | | | | | | Pacific | 23 | 23 | 19 | 28 | 6 | | | | | | | | | | |
| Oils and fats (8) | 3 (2,4) | 3 (2,3)[a] | 2 (2,3)[b] | 3 (2,4)[a,b] | 0.009 | # | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | | | | | | | |
| | | | | | | NZE | 1 | 11 | 38 | 28 | 16 | 4 | 2 | 0 | | | | | | | |
| | | | | | | Māori | 0 | 15 | 36 | 28 | 13 | 2 | 4 | 2 | | | | | | | |
| | | | | | | Pacific | 2 | 4 | 23 | 28 | 21 | 15 | 2 | 4 | | | | | | | |
| Disc meat (8) | 2 (1,3) | 2 (1,2)[a] | 2 (1,4)[a] | 2 (1,3) | 0.031 | # | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | | | | | | |
| | | | | | | NZE | 16 | 33 | 27 | 12 | 9 | 2 | 1 | 0 | 0 | | | | | | |
| | | | | | | Māori | 13 | 23 | 15 | 17 | 17 | 4 | 6 | 2 | 2 | | | | | | |
| | | | | | | Pacific | 19 | 23 | 23 | 11 | 2 | 15 | 2 | 4 | 0 | | | | | | |
| Disc dairy products (7) | 1 (1,2) | 1 (0,2)[a,b] | 2 (1,3)[a] | 2 (1,3)[b] | <0.001 | # | 0 | 1 | 2 | 3 | 4 | 5 | 6 | | | | | | | | |
| | | | | | | NZE | 26 | 36 | 24 | 12 | 0 | 1 | 1 | | | | | | | | |
| | | | | | | Māori | 13 | 34 | 21 | 19 | 9 | 4 | 0 | | | | | | | | |
| | | | | | | Pacific | 11 | 32 | 21 | 19 | 4 | 11 | 2 | | | | | | | | |
| Disc breads cereals & starchy vegetables (5) | 0 (0,1) | 0 (0,1)[a,b] | 1 (0,1)[a] | 1 (0,2)[b] | <0.001 | # | 0 | 1 | 2 | 3 | 4 | 5 | | | | | | | | | |
| | | | | | | NZE | 67 | 27 | 5 | 1 | 0 | 0 | | | | | | | | | |
| | | | | | | Māori | 47 | 30 | 11 | 6 | 4 | 2 | | | | | | | | | |
| | | | | | | Pacific | 36 | 32 | 17 | 6 | 4 | 4 | | | | | | | | | |
| Drinks (15) | 5 (4,7) | 5 (4,6)[a] | 6 (4,8)[a] | 5 (4,8) | <0.001 | # | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| | | | | | | NZE | 1 | 1 | 8 | 13 | 21 | 20 | 15 | 9 | 9 | 1 | 2 | 1 | 0 | 0 | 0 |
| | | | | | | Māori | 0 | 0 | 2 | 13 | 15 | 6 | 26 | 13 | 9 | 4 | 6 | 0 | 4 | 2 | 0 |
| | | | | | | Pacific | 0 | 2 | 6 | 9 | 15 | 23 | 9 | 9 | 6 | 6 | 6 | 2 | 2 | 2 | 2 |
| Alcohol (7) | 1 (0,2) | 2 (1,3)[a] | 1 (0,2)[b] | 0 (0,1)[a,b] | <0.001 | # | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | | | | | | | |
| | | | | | | NZE | 23 | 26 | 26 | 20 | 4 | 1 | 0 | 0 | | | | | | | |
| | | | | | | Māori | 34 | 17 | 26 | 13 | 9 | 2 | 0 | 0 | | | | | | | |
| | | | | | | Pacific | 64 | 13 | 11 | 6 | 4 | 0 | 0 | 2 | | | | | | | |

| Food group (# of food items in group) | Median Food Variety Scores | | | | *P*- value | | *% of participants who consumed each # of food items in each food group (to nearest whole number) Mode Score Highlighted* | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Ethnicity | | | | | | | | | | | | | | | | | | | | | | | |
| | Overall n=235 | NZE n=141 | Māori n=47 | Pacific n=47 | | | | | | | | | | | | | | | | | | | | |
| Sauce, spreads & flavourings (19) | 7 (5,9) | 7 (5,9) | 8 (5,10) | 7 (5,9) | 0.077 | # | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 |
| | | | | | | NZE | 3 | 1 | 5 | 8 | 6 | 16 | 9 | **16** | 11 | 8 | 9 | 5 | 2 | 0 | 0 | 2 | 1 | 0 |
| | | | | | | Māori | 0 | 2 | 2 | 0 | **15** | 9 | 9 | 13 | 9 | 9 | 11 | 11 | 2 | 4 | 2 | 4 | 0 | 0 |
| | | | | | | Pacific | 0 | 2 | 4 | 2 | 9 | 11 | 11 | **19** | 13 | 6 | 6 | 0 | 4 | 2 | 4 | 2 | 2 | 2 |
| Savoury snacks (9) | 2 (1,3) | 2 (1,3)[a] | 2 (1,4) | 3 (2,5)[a] | <0.001 | # | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | | | | | | | | | |
| | | | | | | NZE | 18 | **24** | 19 | 20 | 12 | 5 | 2 | 0 | 0 | | | | | | | | | |
| | | | | | | Māori | 11 | **23** | 21 | 19 | 9 | 2 | 2 | 11 | 2 | | | | | | | | | |
| | | | | | | Pacific | 6 | 13 | 11 | **30** | 9 | 15 | 9 | 4 | 4 | | | | | | | | | |
| Sweet snacks (11) | 4 (3,5) | 4 (2,5)[a] | 4 (2,6) | 5 (3,6)[a] | 0.034 | # | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | | | | | | | |
| | | | | | | NZE | 4 | 6 | 16 | 18 | **23** | 15 | 11 | 4 | 2 | 1 | 0 | | | | | | | |
| | | | | | | Māori | 2 | 6 | 17 | 15 | **21** | 11 | 13 | 9 | 2 | 2 | 2 | | | | | | | |
| | | | | | | Pacific | 0 | 4 | 15 | 11 | **19** | 13 | 17 | 6 | 2 | 11 | 2 | | | | | | | |
| Takeaways and fast food (13) | 3 (2,5) | 2 (1,4)[a,b] | 4 (3,6)[a] | 4 (3,7)[b] | <0.001 | # | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | | | | | |
| | | | | | | NZE | 16 | 16 | **23** | 18 | 9 | 9 | 3 | 2 | 3 | 1 | 0 | 1 | 0 | | | | | |
| | | | | | | Māori | 4 | 2 | **17** | 17 | 15 | 9 | 15 | 4 | 6 | 4 | 2 | 0 | 4 | | | | | |
| | | | | | | Pacific | 0 | 4 | 13 | 17 | **19** | 6 | 15 | 9 | 4 | 0 | 4 | 4 | 4 | | | | | |

NZE, New Zealand European F&V, fruits and vegetables; #, number of food items in group consumed; Disc, discretionary. Food groups in green are nutritious, food groups in light red are discretionary. Food Variety Scores presented as Median (25th, 75th percentiles). *P*-values determined by Kruskal-Wallis. Following Mann-Whitney post hoc test and Bonferroni correction with a *P*-value of 0.0167, matching alphabetical subscripts indicate that two medians differ significantly. Numbers highlighted by colour indicate the Mode, when two modes exist, the mode with the highest % on each side was selected. Orange = statistical significant at $P<0.05$, red = Statistical significant at $P<0.01$.

Appendix C.2

Supplementary table 2. Median and mode food variety scores from both nutritious and discretionary food groups over a seven day period segregated by body composition profile group

| Food group (# of food items in group) | Median Food Variety Scores – Body Composition Profile Group: Overall n=235 | Normal n=76 | Hid'n n=47 | Apparent n=112 | *P*- value | | *% of participants who consumed each # of food items in each food group (to nearest whole number) Mode Score Highlighted* | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Meat (6) | 2 (1,3) | 2 (1,2) | 1 (0,3) | 2 (1,3) | 0.132 | # | 0 | 1 | 2 | 3 | 4 | 5 | | | | |
| | | | | | | Norm | 20 | **26** | 25 | 20 | 5 | 5 | | | | |
| | | | | | | Hid'n | 26 | **28** | 21 | 19 | 4 | 2 | | | | |
| | | | | | | App | 3 | **41** | 29 | 24 | 4 | 0 | | | | |
| Poultry (4) | 1 (1,2) | 1 (1,2)[a] | 1 (0,1)[b] | 1 (1,2)[a,b] | 0.001 | # | 0 | 1 | 2 | 3 | 4 | | | | | |
| | | | | | | Norm | 11 | **61** | 26 | 3 | 0 | | | | | |
| | | | | | | Hid'n | 26 | **51** | 19 | 4 | 0 | | | | | |
| | | | | | | App | 4 | 53 | **38** | 5 | 1 | | | | | |
| Fish and seafood (9) | 2 (0,3) | 2 (0,3) | 2 (1,3) | 1 (0,3) | 0.713 | # | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| | | | | | | Norm | **29** | 20 | 16 | 12 | 12 | 7 | 1 | 3 | 1 | 0 |
| | | | | | | Hid'n | **23** | 26 | 26 | 2 | 9 | 4 | 6 | 2 | 2 | 0 |
| | | | | | | App | **32** | 19 | 20 | 14 | 4 | 5 | 4 | 2 | 0 | 1 |
| Eggs (1) | 1 (1,1) | 1 (1,1)[a] | 1 (1,1) | 1 (1,1)[a] | 0.023 | # | 0 | 1 | | | | | | | | |
| | | | | | | Norm | 4 | **96** | | | | | | | | |
| | | | | | | Hid'n | 11 | **89** | | | | | | | | |
| | | | | | | App | 17 | **83** | | | | | | | | |
| Nutritious dairy (9) | 2 (2,3) | 3 (2,4) | 2 (1,3) | 2 (1,3) | 0.058 | # | 0 | 1 | 2 | 3 | 4 | 5 | 6 | | | |
| | | | | | | Norm | 3 | 11 | 28 | **33** | 17 | 8 | 1 | | | |
| | | | | | | Hid'n | 9 | 17 | **30** | 23 | 15 | 4 | 2 | | | |
| | | | | | | App | 3 | 24 | **29** | 25 | 13 | 4 | 2 | | | |
| Cheese (2) | 1 (1,2) | 2 (1,2)[a] | 1 (1,2) | 1 (1,2)[a] | 0.006 | # | 0 | 1 | 2 | | | | | | | |
| | | | | | | Norm | 8 | 30 | **62** | | | | | | | |
| | | | | | | Hid'n | 13 | **49** | 38 | | | | | | | |
| | | | | | | App | 18 | **42** | 40 | | | | | | | |
| Breads (6) | 2 (1,3) | 2 (2,3) | 2 (1,3) | 2 (2,3) | 0.794 | # | 0 | 1 | 2 | 3 | 4 | 5 | 6 | | | |
| | | | | | | Norm | 4 | 21 | **32** | 28 | 13 | 3 | 0 | | | |
| | | | | | | Hid'n | 4 | 21 | **34** | 28 | 9 | 4 | 0 | | | |
| | | | | | | App | 4 | 21 | **32** | 19 | 18 | 4 | 2 | | | |

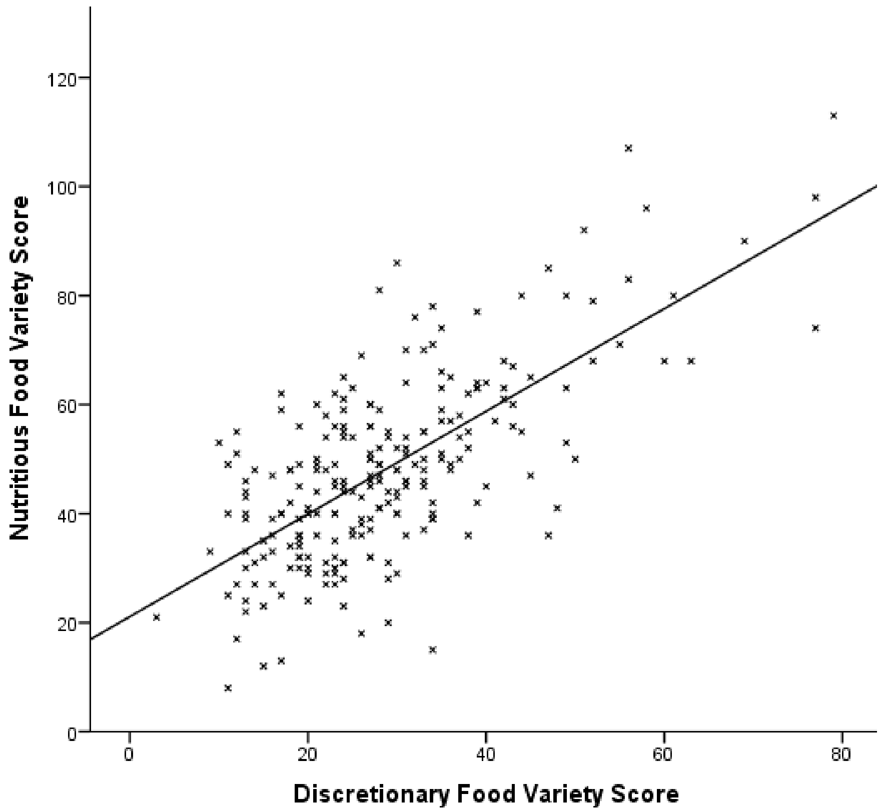
| Food group (# of food items in group) | Median Food Variety Scores<br>Body Composition Profile Group | | | | *P-* value | | *% of participants who consumed each # of food items in each food group (to nearest whole number)*<br>*Mode Score Highlighted* | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Overall n=235 | Normal n=76 | Hid'n n=47 | App n=112 | | | | | | | | | | | | | | | | | | | | | | | |
| Cereal (13) | 4 (3,5) | 5 (4,6)[a] | 4 (3,6) | 4 (3,5)[a] | 0.017 | # | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | | | | | | | | |
| | | | | | | Norm | 0 | 4 | 9 | 12 | **25** | 18 | 12 | 7 | 3 | 8 | 3 | 0 | 0 | | | | | | | | |
| | | | | | | Hid'n | 6 | 2 | 11 | 13 | **32** | 11 | 13 | 4 | 2 | 2 | 4 | 0 | 0 | | | | | | | | |
| | | | | | | App | 7 | 5 | 10 | **24** | 19 | 16 | 7 | 3 | 4 | 3 | 1 | 1 | 1 | | | | | | | | |
| Starchy vegetables (9) | 2 (1,3) | 2 (1,3) | 2 (1,3) | 2 (1,3) | 0.954 | # | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | | | | | | | | | | | | | |
| | | | | | | Norm | 8 | 24 | **34** | 24 | 7 | 1 | 3 | 0 | | | | | | | | | | | | | |
| | | | | | | Hid'n | 11 | 17 | **36** | 23 | 6 | 4 | 2 | 0 | | | | | | | | | | | | | |
| | | | | | | App | 12 | 24 | **27** | 18 | 10 | 6 | 3 | 1 | | | | | | | | | | | | | |
| Vitamin A-rich F & V (23) | 8 (6,10) | 8 (6,10) | 8 (6,10) | 7 (5,10) | 0.159 | # | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| | | | | | | Norm | 0 | 1 | 0 | 3 | 5 | 7 | 11 | 12 | **22** | 13 | 5 | 5 | 5 | 3 | 4 | 1 | 1 | 0 | 1 | 0 | 0 |
| | | | | | | Hid'n | 0 | 2 | 4 | 2 | 4 | 6 | **21** | 9 | 17 | 6 | 11 | 9 | 4 | 2 | 0 | 0 | 0 | 2 | 0 | 2 | 0 |
| | | | | | | App | 2 | 1 | 2 | 6 | 7 | 10 | 17 | **13** | 7 | 8 | 8 | 7 | 4 | 4 | 2 | 2 | 0 | 0 | 0 | 0 | 1 |
| Vitamin C-rich F & V (14) | 4 (2,6) | 4 (3,6) | 4 (2,6) | 4 (2,6) | 0.257 | # | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | | | | | | |
| | | | | | | Norm | 4 | 3 | 11 | **24** | 14 | 9 | 12 | 16 | 1 | 4 | 0 | 0 | 3 | 0 | | | | | | | |
| | | | | | | Hid'n | 2 | 11 | 15 | 19 | 6 | **15** | 15 | 4 | 9 | 2 | 0 | 2 | 0 | 0 | | | | | | | |
| | | | | | | App | 8 | 10 | 12 | **20** | 9 | 12 | 18 | 5 | 1 | 1 | 1 | 3 | 1 | 1 | | | | | | | |
| Other vegetables (15) | 7 (5,8) | 7 (5,9) | 7 (5,8) | 6 (4,8) | 0.332 | # | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | | | | | |
| | | | | | | Norm | 3 | 0 | 1 | 5 | 13 | 9 | 8 | **17** | 14 | 14 | 5 | 4 | 4 | 1 | 0 | | | | | | |
| | | | | | | Hid'n | 2 | 0 | 6 | 6 | 6 | 13 | 13 | 15 | **17** | 11 | 4 | 0 | 2 | 2 | 2 | | | | | | |
| | | | | | | App | 1 | 2 | 4 | 8 | 13 | 13 | 11 | 13 | **14** | 12 | 4 | 3 | 2 | 1 | 0 | | | | | | |
| Other fruits (12) | 5 (3,7) | 5 (4,7) | 5 (3,6) | 5 (3,7) | 0.648 | # | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | | | | | | | | |
| | | | | | | Norm | 3 | 8 | 3 | 9 | 13 | **22** | 12 | 16 | 11 | 1 | 0 | 3 | 0 | | | | | | | | |
| | | | | | | Hid'n | 4 | 4 | 11 | 6 | 19 | **21** | 15 | 0 | 11 | 0 | 4 | 4 | 0 | | | | | | | | |
| | | | | | | App | 2 | 6 | 7 | 13 | **19** | 13 | 15 | 11 | 8 | 1 | 4 | 1 | 1 | | | | | | | | |
| Legumes (7) | 1 (0,2) | 1 (0,2)[a] | 1 (0,3)[b] | 0 (0,1)[a,b] | <0.001 | # | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | | | | | | | | | | | | | |
| | | | | | | Norm | **28** | 26 | 22 | 17 | 4 | 3 | 0 | 0 | | | | | | | | | | | | | |
| | | | | | | Hid'n | **30** | 26 | 15 | 17 | 9 | 2 | 0 | 2 | | | | | | | | | | | | | |
| | | | | | | App | **57** | 21 | 12 | 4 | 3 | 2 | 1 | 0 | | | | | | | | | | | | | |

| Food group (# of food items in group) | Median Food Variety Scores, Body Composition Profile Group: Overall n=235 | Normal n=76 | Hid'n n=47 | App n=112 | *P*- value | | *% of participants who consumed each # of food items in each food group (to nearest whole number) Mode Score Highlighted* | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Nuts and seeds (4) | 2 (1,3) | 2 (1,3) | 2 (1,3) | 1 (1,2) | 0.060 | # | 0 | 1 | 2 | 3 | 4 | | | | | | | | | | |
| | | | | | | Norm | 13 | 22 | 33 | 26 | 5 | | | | | | | | | | |
| | | | | | | Hid'n | 21 | 15 | 36 | 21 | 6 | | | | | | | | | | |
| | | | | | | App | 21 | 31 | 26 | 19 | 3 | | | | | | | | | | |
| Oils and fats (8) | 3 (2,4) | 3 (2,4) | 3 (2,4) | 3 (2,4) | 0.918 | # | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | | | | | | | |
| | | | | | | Norm | 3 | 8 | 37 | 25 | 21 | 5 | 1 | 0 | | | | | | | |
| | | | | | | Hid'n | 2 | 11 | 36 | 23 | 19 | 2 | 4 | 2 | | | | | | | |
| | | | | | | App | 0 | 12 | 32 | 31 | 13 | 8 | 3 | 2 | | | | | | | |
| Disc meat (8) | 2 (1,3) | 2 (1,3) | 2 (1,3) | 1 (1,2) | 0.083 | # | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | | | | | | |
| | | | | | | Norm | 16 | 29 | 24 | 13 | 9 | 5 | 4 | 0 | 0 | | | | | | |
| | | | | | | Hid'n | 26 | 34 | 17 | 6 | 13 | 2 | 0 | 0 | 2 | | | | | | |
| | | | | | | App | 13 | 27 | 27 | 15 | 8 | 6 | 2 | 3 | 0 | | | | | | |
| Disc dairy products (7) | 1 (1,2) | 1 (1,2) | 1 (0,2) | 1 (1,2) | 0.571 | # | 0 | 1 | 2 | 3 | 4 | 5 | 6 | | | | | | | | |
| | | | | | | Norm | 18 | 33 | 26 | 18 | 3 | 0 | 1 | | | | | | | | |
| | | | | | | Hid'n | 28 | 34 | 15 | 19 | 0 | 4 | 0 | | | | | | | | |
| | | | | | | App | 19 | 37 | 24 | 11 | 4 | 5 | 1 | | | | | | | | |
| Disc breads cereals & starchy vegetables (5) | 0 (0,1) | 0 (0,1) | 0 (0,1) | 0 (0,1) | 0.102 | # | 0 | 1 | 2 | 3 | 4 | 5 | | | | | | | | | |
| | | | | | | Norm | 62 | 28 | 7 | 4 | 0 | 0 | | | | | | | | | |
| | | | | | | Hid'n | 64 | 28 | 4 | 0 | 2 | 2 | | | | | | | | | |
| | | | | | | App | 51 | 29 | 12 | 4 | 3 | 2 | | | | | | | | | |
| Drinks (15) | 5 (4,7) | 6 (4,8)[a] | 5 (3,6)[a] | 5 (4,7) | 0.008 | # | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| | | | | | | Norm | 0 | 1 | 3 | 9 | 13 | 20 | 16 | 12 | 14 | 7 | 3 | 0 | 3 | 0 | 0 |
| | | | | | | Hid'n | 2 | 2 | 13 | 15 | 15 | 21 | 17 | 4 | 4 | 0 | 4 | 0 | 0 | 2 | 0 |
| | | | | | | App | 0 | 1 | 6 | 13 | 23 | 15 | 15 | 11 | 5 | 2 | 4 | 2 | 1 | 1 | 1 |
| Alcohol (7) | 1 (0,2) | 2 (1,3) | 1 (0,2) | 1 (0,2) | 0.017 | # | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | | | | | | | |
| | | | | | | Norm | 16 | 33 | 24 | 22 | 5 | 0 | 0 | 0 | | | | | | | |
| | | | | | | Hid'n | 34 | 17 | 28 | 17 | 2 | 2 | 0 | 0 | | | | | | | |
| | | | | | | App | 46 | 15 | 20 | 11 | 6 | 2 | 0 | 1 | | | | | | | |

| Food group (# of food items in group) | Median Food Variety Scores | | | | *P*- value | | *% of participants who consumed each # of food items in each food group (to nearest whole number) Mode Score Highlighted* | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Body Composition Profile Group | | | | | | | | | | | | | | | | | | | | | | | |
| | Overall n=235 | Normal n=76 | Hid'n n=47 | App n=112 | | | | | | | | | | | | | | | | | | | | |
| Sauce, spreads & flavourings (19) | 7 (5,9) | 7 (6,9) | 6 (4,8) | 7 (4,10) | 0.108 | # | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 |
| | | | | | | Norm | 0 | 0 | 3 | 4 | 3 | 14 | 11 | 20 | 11 | 12 | 11 | 7 | 3 | 0 | 1 | 1 | 1 | 0 |
| | | | | | | Hid'n | 4 | 4 | 4 | 4 | 11 | 13 | 11 | 11 | 19 | 4 | 2 | 4 | 2 | 0 | 2 | 4 | 0 | 0 |
| | | | | | | App | 2 | 1 | 5 | 6 | 12 | 13 | 8 | 15 | 7 | 6 | 10 | 4 | 3 | 3 | 1 | 3 | 1 | 1 |
| Savoury snacks (9) | 2 (1,3) | 2 (1,3) | 2 (1,3) | 2 (1,4) | 0.431 | # | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | | | | | | | | | |
| | | | | | | Norm | 13 | 25 | 14 | 24 | 13 | 4 | 5 | 1 | 0 | | | | | | | | | |
| | | | | | | Hid'n | 19 | 19 | 23 | 17 | 11 | 6 | 0 | 4 | 0 | | | | | | | | | |
| | | | | | | App | 13 | 21 | 18 | 22 | 9 | 8 | 4 | 4 | 3 | | | | | | | | | |
| Sweet snacks (11) | 4 (3,5) | 4 (3,5) | 3 (2,5) | 4 (2,6) | 0.343 | # | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | | | | | | | |
| | | | | | | Norm | 1 | 4 | 9 | 21 | 26 | 14 | 16 | 3 | 3 | 3 | 0 | | | | | | | |
| | | | | | | Hid'n | 6 | 4 | 19 | 23 | 17 | 9 | 6 | 9 | 2 | 2 | 2 | | | | | | | |
| | | | | | | App | 2 | 8 | 19 | 10 | 21 | 15 | 13 | 5 | 2 | 4 | 1 | | | | | | | |
| Takeaways and fast food (13) | 3 (2,5) | 3 (2,5)[a] | 2 (0,4)[b] | 4 (3,6)[a,b] | <0.001 | # | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | | | | | |
| | | | | | | Norm | 11 | 12 | 26 | 17 | 9 | 11 | 9 | 1 | 3 | 0 | 0 | 1 | 0 | | | | | |
| | | | | | | Hid'n | 26 | 17 | 23 | 9 | 11 | 2 | 4 | 4 | 0 | 2 | 0 | 0 | 2 | | | | | |
| | | | | | | App | 4 | 7 | 13 | 22 | 15 | 9 | 8 | 5 | 6 | 2 | 3 | 3 | 3 | | | | | |

Normal, normal-fat; Hid'n, hidden-fat; App, apparent-fat, F&V, fruits and vegetables; #, number of food items in group consumed; Disc, discretionary. F&V, fruits and vegetables; #, number of food items in group consumed; Disc, discretionary. Food groups in green are nutritious, food groups in red are discretionary. Food Variety Scores presented as Median (25, 75 percentiles). *P*-values determined by Kruskal-Wallis. Numbers highlighted by colour indicate the Mode, when two modes exist, the mode with the highest % on each side was selected. Following Mann-Whitney post hoc test and Bonferroni correction with a *P*-value of 0.0167, matching alphabetical subscripts indicate that two medians differ significantly. P values in Orange = statistical significant at $P$ <0.05, P values in red = Statistical significant at $P$ <0.01.

Appendix C.3




Supplementary figure 1. Correlation of nutritious and discretionary food score