Iron intakes and food sources of iron in New Zealand adolescent females

By

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Abstract

Background: Adolescent females may be at risk of poor iron status even when following a diet that includes iron-rich meat, due to a combination of high requirements for growth, expanding blood volume, and the onset of menstruation. No studies have investigated the dietary intakes and main food sources of iron in New Zealand (NZ) adolescent females 15-18 years of age since the 2008/09 Adult Nutrition Survey (ANS) 10 years ago. An understanding of the current iron intakes of adolescent females is important for the purpose of informing up to date health-based recommendations on adolescent diet.

Objectives: The aim of this study was to describe the dietary intakes and main food sources of iron in female adolescents 15-18 years of age in New Zealand. The specific objectives were to: 1) determine the iron intake of female adolescents 15-18 years of age in New Zealand, 2) assess the prevalence of inadequate and potentially excessive intakes of iron using dietary and supplement intake data in female adolescents in New Zealand, and 3) describe the main food sources that are contributing to the iron intakes of female adolescents in New Zealand.

Design: The Survey of Nutrition Dietary Assessment and Lifestyle (SuNDiAL) study was a cross-sectional survey conducted with 145 female high school students aged 15-18 years from seven cities in New Zealand. This thesis used questionnaire data including: demographics and dietary habits, and two 24-hour recalls collected by Master of Dietetic (MDiet) students, including the Candidate, to determine participants’ dietary intakes and main food sources of iron. The 24-hour recalls were entered into a web-based dietary software programme, “FoodWorks”, to determine the energy and iron content of the diet.
**Results:** A total of 145 female adolescents with a mean age of 16.7 years participated in the SuNDiAL study. The mean dietary iron intake and median total iron intake (i.e. intake from diet and supplements) were 11.8mg/day. The prevalence of inadequate dietary iron intakes was 20.8% (20.0% for total iron intake), while the prevalence of potentially excessive total iron intakes was just 1.5% with 2 participants having total iron intakes above the upper level of intake (UL). The main food sources contributing to the participants’ iron intakes were the “bread” food group providing 10% of dietary iron, followed by “grains and pasta” (10%), and “breakfast cereals” (9%).

**Conclusion:** The results from the present study suggest that dietary iron intakes may have increased, and the prevalence of inadequate intakes decreased, over the past decade. However, these data should not be used in isolation of iron status data and need to be interpreted with caution as they are not representative of the whole NZ adolescent female population.
Preface

This cross-sectional survey was carried out as part of a larger Survey of Nutrition Dietary Assessment and Lifestyle (SuNDiAL) study. The overall aim of the SuNDiAL study was to compare the dietary intakes and habits, nutritional status, health status, motivations, attitudes, and lifestyles of vegetarian and non-vegetarian adolescent females in New Zealand (NZ).

Dr Jill Haszard (study biostatistician) and Dr Meredith Peddie were the Principal Investigators of the SuNDiAL study and were responsible for designing the study, securing funding and supervised the application for ethical approval. The Candidate was supervised by Associate Professor Anne-Louise Heath from the Department of Human Nutrition who was a Co-investigator.

The SuNDiAL study was conducted in the Department of Human Nutrition (University of Otago, Dunedin). Data collection began in early 2019 and will be completed in late 2020. This thesis is based on data available from the first half of 2019.

As part of writing this thesis the Candidate was responsible for the following under supervision:

Measurement tool and ethics application development:

- The Candidate contributed to modifications made to the ‘dietary habits’ and ‘attitudes and motivations’ questionnaires used in the study (alongside other Master of Dietetic (MDiet) students, Dr Jill Haszard and Dr Meredith Peddie) to make them suitable for New Zealand female adolescents.
- Drafted one section of the ethics application with two other MDiet students.
Recruitment process

- Met with the Deputy Principal of Hornby High School in Christchurch with two other MDiet students to discuss the logistics of the project and how many participants we were looking to recruit.
- Presented information about the SuNDiAL project at a Hornby High School assembly with two other MDiet students.
- Recruited 14 participants with two other MDiet students.

Data collection

- Conducted two 24-hour recalls for each of six different participants (in person at an in-school visit and via video call).
- Measured these participants’ height, weight and ulna length as per the measurement protocols.
- Assisted in the coordination of follow up emails and text reminders to participants.
- Fitted participants with accelerometers and provided verbal and written instructions on how to fill out the seven day wear time log.
- Emailed participants to organise appointment times for blood and urine sample collection.
- Liased with the phlebotomist/research nurse and delivered participants’ blood samples to Canterbury Southern Communities Laboratories Ltd.

Data entry

- Entered 24-hour diet recall information into FoodWorks version 9 analysis programme (12 recalls).
- Exported nutrient analysis data to be checked for statistical analysis.
- Contributed to the development of the SuNDiAL study codebook which was used to guide: weight estimations, default foods, substitutions, cooking methods of certain food items that were missing from the database or had insufficient information (data used by all MDiet students).

**Statistical analysis**

- Participated in skype meetings with the Primary Investigators of the study.
- Interpreted and analysed participants’ iron intakes and food sources of iron with guidance from Associate Professor Anne-louise Heath.
- Carried out statistical analyses in Excel with guidance from the study biostatistician (Dr Jill Haszard) and Associate Professor Anne-Louise Heath.
- Developed (with one other MDiet student) a database in Microsoft Office Excel with the nutrient composition of all the iron and zinc containing supplements consumed by the participants (n=21), (these data will also be used by other MDiet students in the final analyses on iron and zinc in the SuNDiAL study).
- Identified **Table I-6** (Institute of Medicine, 2001, p. 702) which describes the probability of inadequate iron intake and then applied it to the SuNDiAL data to determine the prevalence of inadequate iron intake.

**Presentation**

- Planning to present results from this thesis in New Zealand, November 2019 at the SuNDiAL symposium.
Acknowledgements

This project has been a huge team effort and I have really enjoyed working with everyone involved.

There are several people who I would like to thank who have supported me in the completion of this thesis. Firstly, I would like to express my gratitude to my supervisor Anne-Louise Heath for your continual guidance and support throughout the project. I especially appreciate the effort you gave to promptly respond to my numerous emails and find the time in your busy schedule to fit in zoom sessions. I have learnt a huge amount over the past year working with you, and your expert advice has been invaluable.

Thank you to the Principal Investigators of the SuNDiAL project, Jill Haszard and Meredith Peddie, all your hard work towards the project has not gone unnoticed. I would also like to thank all the study participants involved whom I enjoyed working with; without them this thesis would not have been possible.

Thank you to Liz Fleming, Kirsten Webster and Chaya Ranasinghe for going above and beyond to provide tutorials, assistance with the use of FoodWorks and checking of the data. To my two MDiet colleagues, Isabelle and Lana-Marie, thank you for being such great team mates to work alongside and organise data collection with, I have learnt a lot from you both.

Finally, I would like to thank my family. Mum and dad your continual support throughout the past 5 years of study is something I will be forever grateful for. My Aunty, Uncle and cousin I would also like to thank for providing their hospitality in Christchurch and support throughout the semester.
Table of Contents

Abstract.................................................................................................................................ii
Preface.....................................................................................................................................iv
Acknowledgements .............................................................................................................. vii
Table of Contents .................................................................................................................. viii
List of Tables .......................................................................................................................... x
List of Figures ......................................................................................................................... xi
List of Abbreviations ............................................................................................................. xii

1. Introduction .........................................................................................................................1

2. Literature Review .................................................................................................................3
  2.1 Literature review methods .................................................................................................3
  2.2 Challenges to achieving sufficient iron intake for adolescent females .........................4
    2.2.1 Physiological challenges ..............................................................................................4
    2.2.2 Dietary challenges (enhancers and inhibitors) ..............................................................5
    2.2.3 Behavioural challenges ...............................................................................................7
  2.3 Dietary iron recommendations for adolescent females .....................................................8
  2.4 Measurement of iron intake ..............................................................................................9
  2.5 Iron intakes in adolescent females .....................................................................................11
  2.6 Food sources of iron in adolescent females .....................................................................18

3. Objective Statement ........................................................................................................... 19

4. Methods .............................................................................................................................. 20
  4.1 Study design .................................................................................................................... 20
  4.2 Participants and recruitment .............................................................................................. 21
  4.3 Data collection .................................................................................................................. 22
    4.3.1 Demographic Questionnaire ....................................................................................... 23
    4.3.2 Iron supplement questions ......................................................................................... 24
    4.3.3 Anthropometry ........................................................................................................... 24
    4.3.4 24-hour recall .............................................................................................................. 25
  4.4 Data entry ........................................................................................................................ 26
  4.5 Statistical methods .......................................................................................................... 28

5. Results ................................................................................................................................... 31
  5.1 School and participant response rates ............................................................................. 31
  5.2 Demographic and anthropometric characteristics of participants .................................. 33
  5.3 Iron intakes (Objective 1) ............................................................................................... 35
List of Tables

Table 2.1: Iron intake studies in adolescents ................................................................. 16
Table 2.2: Iron studies in adult females in the past decade ........................................... 17
Table 5.1: Demographic and anthropometric characteristics of the SuNDiAL Study
participants (n=145) 1 ........................................................................................................... 34
Table 5.2: Number of participants from each high school and each high school’s school
decile (n=145) ...................................................................................................................... 35
Table 5.3: Iron and energy intakes of participants (n=132) .............................................. 39
Table 5.4: Iron intake, by age group, BMI z-score, decile and ethnic group (n=132) ...... 40
Table 5.5: Dietary sources of iron consumed by the SuNDiAL study participants ........... 42
List of Figures

Figure 5.1: Flow diagram of the SuNDiAL study participants, as relevant to the analysis of iron intake ................................................................. 32

Figure 5.2: Dietary iron intakes of participants (n=132) ................................................................. 37

Figure 5.3: Dietary iron Q-Q plot (normal distribution probability plot)................................. 37

Figure 5.4: Total iron intakes (intake from diet and supplements) of participants (n=132) 38

Figure 5.5: Total iron Q-Q plot (normal distribution probability plot) ................................. 38
**List of Abbreviations**

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>ANS</td>
<td>Adult Nutrition Survey</td>
</tr>
<tr>
<td>BLISS</td>
<td>Baby-led Introduction to Solids</td>
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<tr>
<td>BMI</td>
<td>Body mass index</td>
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<td>BMIZ</td>
<td>Body mass index-for-age Z score</td>
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<tr>
<td>CI</td>
<td>Confidence interval</td>
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<tr>
<td>EAR</td>
<td>Estimated average requirement</td>
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<td>FFQ</td>
<td>Food frequency Questionnaire</td>
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<td>MDiet</td>
<td>Master of Dietetics</td>
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<td>MFP</td>
<td>Meat, Fish, Poultry</td>
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<td>MSM</td>
<td>Multiple Source Method</td>
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<td>NNS</td>
<td>National Nutrition Survey</td>
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<td>NZ</td>
<td>New Zealand</td>
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<td>NZDep</td>
<td>New Zealand index of Deprivation</td>
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<tr>
<td>NZEO</td>
<td>New Zealand European and others</td>
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<tr>
<td>RDI</td>
<td>Recommended dietary intake</td>
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<tr>
<td>REDCap</td>
<td>Research electronic data capture</td>
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<tr>
<td>SD</td>
<td>Standard deviation</td>
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<tr>
<td>SES</td>
<td>Socioeconomic status</td>
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<tr>
<td>SuNDiAL</td>
<td>Survey of Nutrition Dietary Assessment and Lifestyle</td>
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<tr>
<td>SWIFT</td>
<td>Support strategies for Whole-foods diets, Intermittent Fasting and Training</td>
</tr>
<tr>
<td>UL</td>
<td>Upper level of intake</td>
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<td>WHO</td>
<td>World Health Organisation</td>
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1. Introduction

Adolescent females are particularly vulnerable to iron deficiency due to a combination of high physiological requirements for growth, expanding blood volume, and the onset of menstruation (Greger et al., 1978). Available data from surveys in Australia (Australian Bureau of Statistics, 2014) and New Zealand (NZ) suggest that many adolescent females have dietary intakes of iron that fail to meet these high physiological requirements. In fact, the NZ 2008/09 Adult nutrition survey (ANS) reported that 34.2% of females 15-18 years of age had inadequate iron intakes (University of Otago and Ministry of Health, 2011). Such dietary inadequacies may be attributed to poor food selection patterns, and low energy intakes in at least some individuals in this age group (Gibson et al., 2002). To the Candidate’s knowledge, the NZ 2008/09 ANS survey is the only study in recent years that has assessed the dietary intakes and main food sources of iron in the diets of NZ female adolescents, 15-18 years of age. However, these data are now a decade old and so there is good reason to believe that the intakes of NZ adolescent females may well have changed since then because food trends, dietary patterns and behaviours are continually evolving.

Vegetarianism in particular appears to be an increasingly popular eating pattern, especially among adolescent females, resulting in reduced consumption of red meat and higher intakes of plant-based foods (some of which have factors that inhibit iron absorption). Surveys conducted in 2011 and 2015 indicate that rates of vegetarianism in those 14-24 years of age exhibited the largest increase of any age group – from 8.6% to 13.3% (Vegetarianism on the rise in New Zealand, 2016). There has also been an increase in social media influence towards the desirability of a certain body image, with current emphasis on ‘thinness’ (Meier and Gray, 2014). There are concerns that this may be leading to low energy intake in some adolescent females, and low energy intake
would be expected to also be associated with poor iron intake. These changes in eating patterns, and concerns about body image, suggest that iron intakes may well have decreased since the ANS data were collected.

Therefore, it is important to describe dietary iron intakes and the main food sources of iron in NZ female adolescents 15-18 years of age for the purpose of informing up to date health-based recommendations on adolescent diet.
2. Literature Review

2.1 Literature review methods

The literature searches found in the panel below were developed to identify studies that reported iron intakes and the main food sources of iron in New Zealand (NZ) adolescent females. The searches were conducted using Medline (Ovid MEDLINE 1946 to September 2018), Scopus, as well as The Cochrane Library. Additionally, reference lists from original review articles were reviewed further for more studies.

Panel: Search strategy and search terms used within this literature review to identify studies on iron intakes and the main food sources of iron in adolescent females ¹

1) “Iron Intake”
2) Adolescen*
3) teen*
4) (2) OR (3)
5) Female*
6) women
7) woman
8) girl*
9) (5) OR (6) OR (7) OR (8)
10) (1) AND (4) AND (9)
11) Iron
12) Deficien*
13) “Dietary recommendations”
14) New Zealand
15) (11) and (12) and (14)
16) (11) and (13) and (14)
17) “Iron sources”
18) (9) and (14) and (17)

¹BOLD means papers looked at
2.2 Challenges to achieving sufficient iron intake for adolescent females

2.2.1 Physiological challenges

Adolescents are defined by the World Health Organisation (WHO) as people between 10 and 19 years of age (World Health Organisation, 2018). Adolescence is a period of nutritional vulnerability due to increased dietary requirements for rapid growth and development (Mesías, Seiquer, & Navarro, 2013). Several surveys in NZ and Australia have found that adolescent females in particular have insufficient dietary iron intakes that fail to meet their high physiological requirements (Gibson et al., 2002). Factors including rapid growth, the onset of menstruation, low iron intakes, pregnancy and irregular eating behaviours combine to put adolescent females at risk of developing iron deficiency (National Academy of Sciences, 1980).

Adolescent females are particularly important to look at in terms of their iron intake and status. During periods of growth, blood volume increases to transport nutrients to fuel growing tissues (Institute of Medicine, 2001). As iron is a major component of blood and muscle, adequate iron intake is essential. The increase in blood volume requires iron to build the haemoglobin molecule necessary to carry oxygen in the blood. Additionally, iron supports the myoglobin component in growing muscle (Institute of Medicine, 2001).

Higher losses of iron due to menstruation translates into adolescent girls requiring a greater amount of iron to balance blood loss. On average, women lose around 0.5 mg per day of iron through menstruation, with approximately 5% of women losing more than 1.4 mg per day (Mahan & Escott-Stump, 2004). High menstrual blood loss has been found to be negatively associated with iron stores, resulting in a greater possibility for iron deficiency (Harvey et al., 2005).
Furthermore, having adequate iron intakes and status prior to and during pregnancy is essential to supply the growing foetus and placenta (Hallberg, 1988). If adolescent females were to enter pregnancy with compromised iron intake and status, this may flow on to unfavourable effects on the pregnancy outcome.

2.2.2 Dietary challenges (enhancers and inhibitors)

Unfortunately, many adolescent females fail to meet their higher physiological requirements for iron during puberty. Currently, adolescents tend to consume unbalanced diets which may limit their iron intake and/or bioavailability, leading to iron deficiency (Mesías et al., 2013). There are several dietary factors that can influence and greatly alter the efficiency of iron absorption. It is important to identify these dietary factors (enhancers and inhibitors) of iron absorption because overall bioavailability influences iron status.

Enhancers of iron absorption. Dietary factors known to enhance the amount of iron absorbed include vitamin C and the meat, fish, poultry (MFP) factor. The MFP factor is thought to increase the bioavailability of iron in the meal through the promotion of non-haem iron absorption (Hallberg & Rossander-Hulten, 1984). Although the factor responsible for enhancing non-haem iron remains elusive, it is hypothesised that specific amino acids or dipeptides may facilitate absorption (Mahan & Escott-Stump, 2004). Meat Fish Poultry also acts in a dual way as it provides haem iron to the diet which has a higher bioavailability than non-haem iron (15-25% iron absorbed vs 5-12%) and is less affected by other dietary constituents (Hallberg et al., 1993; Hurrell & Egli, 2010; Carpenter & Mahoney, 1992). Baech et al. (2003) reported a dose-related increase in iron absorption, where 50g of meat significantly increased non-haem iron absorption by 44% and 75g by 57%. Therefore, the greater the amount of
meat consumed the greater the amount of haem and non-haem iron consumed, and the amount of non-haem iron absorbed from the whole meal.

Vitamin C is known to enhance iron absorption when co-ingested because of its ability to reduce ferric iron to ferrous iron (Mahan & Escott-Stump, 2004). There are two main positions regarding the effects of vitamin C on iron absorption: 1) There is a clear enhancing effect of vitamin C on iron absorption in the absorption studies (Hallberg et al., 1986; Ballot et al., 1987), but 2) when vitamin C is supplemented into the diet the effect on iron absorption is very much smaller and no significant alteration to iron status is apparent (Hunt et al., 1994). The explanation for this disparity in the effect of vitamin C on iron absorption is that it appears to be much less pronounced when studying the whole diet rather than single meals (Cook & Reddy, 2001).

Inhibitors of iron absorption. Dietary factors considered to inhibit iron absorption include phytates, tannins, oxalates, and calcium. There are two main positions on the impact of inhibitory dietary factors on iron absorption: 1) There is convincing evidence for their inhibitory effect in absorption studies (Monsen, 1988; Zijp et al., 2000), but 2) when we look at observational studies there is conflicting evidence as some studies see no association between iron status and calcium intake (Galan et al., 1985; Heath et al., 2001; Pynaert et al., 2009; Asakura et al., 2009; Cade et al., 2005; Blanco-Rojo et al., 2011; Leonard et al., 2014), tannins from tea or coffee (Brussard et al., 1997; Heath et al., 2001; Galan et al., 1998; Rigas et al, 2014; Mennen et al., 2007), and phytate (Heath et al., 2001; Asakura et al., 2009; Ramakrishnan et al., 2002); 2) in young women, whereas others have found a negative association between iron status and calcium consumption (Rangan et al., 1997; Galan et al., 1998), and tannins from tea and coffee (Razaguil & Barlow, 1991; Galan et al., 1985; Pynaert et al, 2009). Further research is needed to resolve this apparent uncertainty about the role of
inhibitors of iron absorption, with particular focus on dietary patterns that consider the whole diet, and how foods are consumed in combination, rather than the traditional approach of investigating individual foods and nutrients.

2.2.3 Behavioural challenges

Adolescence is a period marked by both physical and psychological lifestyle changes, along with the formation of new eating behaviours (Mahan & Pees, 1984). Developing healthful behaviours during adolescence is of great importance, as the high rates of growth bring with them heightened nutritional needs. However, the food choices and nutritional intake of female adolescents in particular tend to be influenced by factors including, but not limited to, social media activity, peer influence (Truswell & Darnton-Hill, 1991; Huenemann et al., 1968) and socioeconomic status (Kim et al., 2014).

Over the last decade the internet has come to dominate the lives of many people within society (Das, Mohan, & Makaya, 2014). Adolescent female exposure to social media often creates a desire for a certain body image, with a current emphasis on ‘thinness’ (Meier and Gray, 2014). These concerns surrounding body image and weight unfortunately tend to result in poor dietary habits concomitant with low energy intakes in some adolescents. As a result, this makes it difficult for some adolescent females to achieve adequate nutrient intake (Donovan & Gibson, 1995), particularly iron intake which is essential for growth and metabolic processes (Abbaspour et al., 2014).

As adolescents strive further towards independence, they begin to spend more time away from home, often surrounded by their peers. Peers exert a major influence on eating behaviour during adolescence. They essentially define what is socially acceptable, setting behavioural standards and expectations (Mahan and Pees, 1984). Food trends, dietary patterns and behaviours are continually evolving (Edward, 2016), with particular emphasis on vegetarianism, rising in New Zealanders 14-18 years of age.
from 8.6% in 2011, to 13.3% in 2015 (Vegetarianism on the rise in New Zealand, 2016). Whilst there may be a positive influence from peers to adopt this dietary pattern, there is some fear that teens may be unaware of how to adjust to this diet whilst ensuring they receive adequate nutrition. The biggest concern with this is that they may be missing certain nutrients, such as iron, which are vital to their development.

Previous reports have shown that there is a definite correlation between socioeconomic status and iron status (World Health Organisation, 2001; Gompakis et al., 2007). Kim et al. (2014) found that higher socioeconomic status leads to lower prevalence of iron deficiency in Korean adolescent girls 10-18 years of age, which was possibly due to that fact that higher socioeconomic status individuals consumed more iron and vitamin C (an enhancer of iron absorption).

### 2.3 Dietary iron recommendations for adolescent females

The estimated average requirement (EAR) is the daily nutrient intake level estimated to meet the requirements of half (50%) the healthy individuals of a particular life stage and gender group (Institute of Medicine, 2001). The prevalence of adequate daily iron intakes can be determined from the EAR. The recommended dietary intake (RDI) is the average daily dietary intake level that is sufficient to meet the nutrient requirements of nearly all (97-98%) healthy individuals in a particular life stage and gender group (Institute of Medicine, 2001).

Iron recommendations are difficult to establish for several reasons, including difficulties in assessing iron intakes and the fact that blood (and subsequent iron) loss from menstruation varies between women (Hallberg & Rossander-Hulten, 1991). The wide range of iron bioavailability of individual foods consumed within the diet also makes it difficult to accurately estimate iron requirements (Scientific Advisory Committee on Nutrition, 2010).
In setting the EAR and RDI for girls, it was assumed that those younger than 14 years do not menstruate and that all girls 14 years and older do menstruate (Ministry of Health, 2014). The EAR for girls 14-18 years of age is 8mg/d which is based on the need to maintain a normal, functional iron concentration, but only a small store (serum ferritin concentration of 15µg/L) (Ministry of Health, 2014). The RDI for girls aged 14-18 years is 15mg/d, however given that it is aimed to meet the requirements of 97-98% of the population, such intakes would be in excess of actual requirements for the majority of girls (Scientific Advisory Committee on Nutrition, 2010).

2.4 Measurement of iron intake

To estimate the nutritional adequacy of a population or sub-group, a dietary assessment method that collects information on ‘usual’ food intake is needed (Carriquiry, 2003). There are several different methods that can be used to estimate dietary intakes including: Food frequency questionnaires (FFQ’s), 24-hour diet recalls, diet histories and weighed diet records. Among the available dietary assessment methods, the FFQ has been widely used in large epidemiological studies since the 1990s (Shim, Oh, & Kim, 2014). Although FFQ’s have several advantages over other methods, including their low respondent and researcher burden (Gibson, 2005), they require validation before their use to ensure accurate average intakes are established. Validation of the FFQ is usually against 24-hour recalls or weighed food records as the independent standard (Willett, 1998). Weighed food records and 24-hour recalls are methods designed to estimate current diets of individuals and population groups, as well as to identify groups at risk of inadequacy. High precision and validity have been reported for these methods when used following adequate procedures and collecting sufficient days to get accurate measures of usual intake (Ortega et al., 2015). A diet history is a structured interview method consisting of questions about habitual intake of foods in the
last seven days (Morán Fagúndez et al., 2015). This method, however, is predominantly used for individuals in clinical settings to describe food intake, rather than in a research setting.

To accurately measure a population’s usual intake of iron, it is appropriate to use 24-hour recalls over at least two non-consecutive days to get an idea of actual mean iron intakes, which then get adjusted to account for day-to-day variability to get usual intake by using statistical methods such as the Multiple Source Method (MSM) (Harttig et al., 2011). It is necessary to establish usual intakes as these data can then be used to estimate the prevalence of inadequate intake within a population.

Due to wide inter-individual variation in menstrual losses, iron requirements in premenopausal women are distributed asymmetrically around the median, thus unlike most nutrients, the cut-point method of assessing intakes against the EAR cannot be used to estimate the prevalence of inadequate iron intakes (National Research Council Nutrient Adequacy, 1986). The Candidate hypothesises that the EAR cut-point method would be likely to underestimate the prevalence of inadequate iron intake because it is based on a normal distribution of requirements so would not take into account the requirements of women with very high menstrual blood loss (i.e. the skewed distribution of menstrual blood loss). The adequacy of dietary iron intakes therefore should be determined using the full probability approach. This approach quantifies the prevalence of inadequate iron intakes in a cohort by comparing the cohort’s distribution of usual iron intakes to a proposed distribution of iron requirements (National Research Council Nutrient Adequacy, 1986).

Some other important aspects to take into consideration when measuring iron intake include: iron supplements and low energy reporting. When searching the literature, it is important to identify whether studies have included or excluded iron
supplement use, as this may affect the results for iron intakes, (the mean iron intake would be skewed by the high intake of iron through supplements in those who consume them).

Of special concern is underreporting of dietary intake (Millen et al., 2009). Several studies (Livingstone & Black, 2003; Trabulsi & Schoeller, 2001; Hill & Davies, 2001) have shown that some individuals, referred to as low energy reporters, underreport their total energy intake on assessment, which occurs to a greater extent for 24-hour recalls and FFQs (Subar et al., 2003). Reporting lower mean energy intakes results in lower apparent average iron intakes, underestimating their actual iron intake. Such low energy reporters should be identified and accounted for to ensure accuracy of estimates for iron intakes using methods such as the Goldberg cut-off (Black, 2000). Caution should be taken when identifying under-reporters in adolescents who are still growing where many of them are also trying to lose weight and may in fact be truthfully reporting low energy intakes.

2.5 Iron intakes in adolescent females

Despite adolescence being a particularly challenging time to achieve adequate nutrition for growth and development, very little recent research has directly examined the iron intake of NZ adolescent girls 15-18 years of age (Table 2.1). Previous research from the NZ 2008/09 Adult Nutrition Survey (ANS) reported that median (10th, 90th percentile) usual daily iron intake for females 15-18 years of age was 9.1 (6.1, 13.1) mg per day (excluding supplements), with an estimated prevalence of inadequate intakes of 34.2% (University of Otago and Ministry of Health, 2011). These data were collected in 2008/09 and have not been updated since. Although the data are excellent because they are from a representative sample and include a large sample of New Zealanders (n=4721 aged 15 years and over), they may not necessarily be the same for adolescent
females in 2019 as food trends, dietary patterns and behaviours are continually evolving (Edward, 2016). There are no other studies in the literature that have determined iron intake in New Zealand adolescents aged 15-18 years.

The Australian 2011/12 Health Survey provides more recent data and therefore may be more reflective of current nutritional behaviours in adolescents. The survey reported that mean daily iron intake for females 14-18 years of age was 9.2 mg per day, with an estimated prevalence of inadequate intakes of 40%. Similarly, to the NZ 2008/09 ANS, these results did not consider the contribution of dietary supplements to iron intakes (Australian Bureau of Statistics, 2014). In contrast, Rangan et al (1997) conducted a study looking at iron status and factors associated with iron deficiency in 15-30-year-old female students in Perth. The median daily iron intake was 11.7 mg which is considerably higher than the ANS data for NZ 15-18-year olds (9.1 mg) (University of Otago and Ministry of Health, 2011) and the Australian Health Survey for 14-18-year olds (9.2 mg) (Australian Bureau of Statistics, 2014). These differing results could be attributed to the fact that the mean age of participants in the study was 20.7 years (which is older than the two surveys), they included the contribution of dietary supplements, (whereas the Australian 2011/12 Health Survey and NZ ANS 2008/09 did not), the data were collected in 1997 (a decade earlier than the Australian and NZ health survey data), that the data collected by Rangan et al (1997) are not from a representative sample of all Australian female adolescents, rather a convenience sample of female students from Perth (whereas the Australian and New Zealand Health surveys are representative of all female adolescents across the country), and that the adolescents were from Australia not NZ.

To the Candidate’s knowledge, the NZ 2008/09 survey described above is the only study in recent years that has assessed iron intake in NZ adolescents 15-18 years of
Surprisingly, there have not even been any studies, other than the ANS, investigating iron intake in young NZ adults (i.e. people slightly older than adolescents) in the past 10 years (Table 2.2). The NZ 2008/09 ANS reported that median daily iron intake for adult females aged 19-30 years was 10.2 mg per day, with an estimated prevalence of inadequate intakes of 6% (University of Otago and Ministry of Health, 2011). The only study that has looked at iron nutrition in NZ adults was by Beck et al (2013). Although they investigated associations between iron related dietary patterns and suboptimal iron status in premenopausal women aged 18-44 years, they did not report iron intakes. They did report, however, that 70 of the 375 participants (18.7%) had suboptimal iron status, which suggests that a substantial number of these women aged 18-44 years are likely to have had inadequate iron intakes, but in the absence of data on iron intakes it is not possible to quantify this.

The results reported from studies in NZ and Australian adolescents and adults regarding iron intakes and rates of inadequate intakes vary considerably. This could be due to: 1) different methods and time periods being used to collect dietary data, 2) low energy reporting being an issue for some studies, and 3) the age range varying between studies, as discussed below.

Lim et al (2015) and Rangan et al (1997) used FFQs to determine dietary iron intake. There are several advantages to using an FFQ, particularly in large studies, however they are not considered the gold standard method for determining iron intakes or rates of inadequate iron intakes. FFQs need to be validated to ensure they provide accurate estimates of intake. Validation of FFQs is usually against 24-hour recalls or weighed food records as the independent standard (Willett, 1998). Both Lim et al (2015) and Rangan et al (1997) stated the FFQ used was validated for their study population against seven-day weighed food records. The FFQ used by Lim et al gave a mean
difference of −0.22 mg/day for dietary iron intake, therefore providing a reasonably accurate estimate of iron intakes. However, the FFQ used by Rangan et al (1997) gave a mean difference of 1.2mg/day (with the FFQ estimating higher iron intake), so we can conclude that these results from this study may be an over representation of actual iron intake. Although FFQs can estimate usual mean intake, they cannot usually be used for assessing the adequacy of nutrient intake because they have not usually been validated for their ability to determine adequate or inadequate intakes. Furthermore, adequacy of intake is dependent on where each person’s individual value lies, and we know that FFQs do not perform well for estimating individual intakes accurately (Institute of Medicine, 2002).

Low energy reporting was identified as being an issue in the study by Young et al, (2018) using the Goldberg equation and a cut-off of 1.1 for determining plausible habitual intake (Black, 2000). As a result, they excluded 12 participants who they considered did not have plausible energy intakes. Importantly, even after they had done this, lower mean energy intakes were associated with low iron intakes. In contrast, Lim et al (2015) and Rangan et al (1997) did not look at or identify low energy reporters, which means it is likely they have included them which could affect the accuracy of their estimate for iron intakes, presumably resulting in a lower average iron intake.

Age is a crucial aspect to consider when talking about iron intake and adequacy of iron intakes. During adolescence iron requirements are higher due to growth and development as discussed above in section 2.2. (Mesías et al., 2013), so they need a higher intake in order to consume adequate intakes (i.e. adolescent female EAR for 14-18 years = 8mg/d vs. adult EAR 51-70 years = 5mg/d (Ministry of Health, 2014)). Therefore, adult data need to be treated with some caution as sources of insight into possible adolescent intakes. The NZ 2008/09 ANS results show an increase in dietary
iron intake after 18 years of age. The median usual daily iron intakes for females aged 15-18 years increased from 9.1 mg per day to 10.2 mg per day (at 19-30 years), with an estimated prevalence of inadequate intake of just 6% in females aged 19-30 years compared to 34.2% in adolescents (University of Otago and Ministry of Health, 2011). These data would suggest that adult women aged 19-30 years tend to be better off in terms of their iron intake than adolescents, so when looking at studies in the older age group we should expect lower intakes and a higher prevalence of inadequacy in adolescents.

In conclusion, iron intake in those 15-18 years of age is not well defined even though, due to increased iron requirements, this is likely to be one of the most vulnerable age groups at risk of iron deficiency. Furthermore, given the NZ ANS data have not been updated since 2008/09, it is important to determine iron intake specifically in 15-18-year old women in NZ. Food sources of iron in adolescent females are discussed in the following section.
### Table 2.1: Iron intake studies in adolescents

<table>
<thead>
<tr>
<th>Reference</th>
<th>Country</th>
<th>Participants, age</th>
<th>Aim/objectives</th>
<th>Design/methods</th>
<th>Results</th>
<th>Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ministry of Health, (2008-09) Adult Nutrition Survey</td>
<td>New Zealand</td>
<td>n = 4721 (15 years and over) n= not stated (15-18 years) New Zealanders</td>
<td>Assess the nutrient intakes of the population and assess dietary adequacy against the nutrient reference values for New Zealand.</td>
<td>• National survey • 24-hour recall</td>
<td>Intake: • 9.1 (6.1, 13.1) mg/day Prevalence inadequate intake: • 34.2%</td>
<td>• Data collected in 2008/09 so are not up to date</td>
</tr>
<tr>
<td>Australian Health Survey: Nutrition First Results – Food and Nutrients, 2011-12</td>
<td>Australia</td>
<td>n = 20,500 Australians aged 2 years and older</td>
<td>Determining the iron intake in a representative sample of Australians.</td>
<td>• National survey • 24-hour recall</td>
<td>Intake: (females aged 14-18) • 9.2mg/day Prevalence inadequate intake: • 40%</td>
<td>• Data collected in 2011/12 so are not up to date</td>
</tr>
<tr>
<td>Rangan et al. (1997)</td>
<td>Australia</td>
<td>n = 265 female students 15-30 years.</td>
<td>To determine the iron status of 15-30-year-old female students to identify factors associated with iron deficiency in this population.</td>
<td>• Cross sectional study • Validated quantitative FFQ (270 food and drink items)</td>
<td>Intake: • 11.7mg per day</td>
<td>• Did not report prevalence of inadequate iron intakes. • Did not look for or identify low energy reporters.</td>
</tr>
</tbody>
</table>

1 Median (10th, 90th percentile)
Table 2.2: Iron intake and status studies in adult females in the past decade

<table>
<thead>
<tr>
<th>Reference</th>
<th>Country</th>
<th>Participants, age</th>
<th>Aim/objectives</th>
<th>Design/methods</th>
<th>Results</th>
<th>Limitations</th>
</tr>
</thead>
</table>
| Beck et al. (2013)   | New Zealand | n = 375 premenopausal women, 18-44 years. | To investigate the associations between iron-related dietary patterns and suboptimal iron status in premenopausal women living in Auckland, New Zealand. | • Cross sectional analysis  
• 144-tem iron FFQ on dietary practices to assess dietary intake over the past month. | • No data on iron intake  
• 70 of the 375 participants (18.7%) had suboptimal iron status | • Only measured dietary patterns and suboptimal iron status – not iron intake or inadequate intake as such. |
| Lim et al. (2015)    | Australia | n = 396 women, 18-50 years. | Describe dietary intakes and biochemical status of iron in a sample of premenopausal women. | • Cross sectional study  
• Usual Fe intakes were assessed using a validated 154-item FFQ.  
• Used the full probability approach to identify % of inadequate iron intake. | • Participants usual intakes of dietary iron was 10.5 mg/day.  
• 31% were at risk of inadequate dietary iron intakes. | • Did not look for or identify low energy reporters. |
| Young et al. (2018)  | Australia | n = 299 women, 18-35 years. | Determine the association between both haem and non-haem iron intakes and serum ferritin. | • Cross sectional study.  
• A semi-quantitative validated FFQ was used to assess usual dietary iron intake. | • Approximately one third of the women has sub-optimal iron status | • Prevalence of inadequate intake of iron was not measured, only iron status. |
2.6 Food sources of iron in adolescent females

As mentioned above, very little recent research has been conducted examining the iron intake of NZ adolescent girls 15-18 years of age. The same is apparent in terms of research identifying food sources of iron. Previous research from the NZ 2008/09 ANS investigated the dietary food sources of iron for females aged 15-18 years and found: the “bread” group was the highest contributor providing 11% of dietary iron, followed by “bread-based dishes” (10%), “breakfast cereals” (9%), and “grains and pasta” (8%) (Ministry of Health, 2014). Other than this national survey, to the Candidate’s knowledge, there are no other studies in the literature that have looked at food sources of iron in NZ adolescent females 15-18 years of age.

Looking to data from the Australian 2011/12 Health Survey, comparable results were found for females aged 14-18 years but with the inclusion of a meat category in the top three sources. The major food groups contributing to dietary iron intake were “cereals and cereal products” (31%, including 17% from breakfast cereals, and 10% from regular breads, and rolls), “meat”, “poultry” and “game products and dishes” (17%) and cereal-based products and dishes (16%) (Australian Bureau of Statistics, 2014).

This literature review has demonstrated there are limited published research around the current iron intakes and dietary sources of iron in NZ adolescent females 15-18 years of age. Therefore, research is necessary to fill this gap in the literature, using the correct methodology, as described in section 4.
3. Objective Statement

The aim of this study was to describe the dietary intakes and main food sources of iron in female adolescents 15-18 years of age in New Zealand.

The specific objectives were to:

1. Determine the iron intake of female adolescents 15-18 years of age in New Zealand.

2. Assess the prevalence of inadequate and potentially excessive intakes of iron using dietary and supplement intake data in female adolescents in New Zealand.

3. Describe the main food sources that are contributing to the iron intakes of female adolescents in New Zealand.
4. Methods

This study was a multicentered project and there is some content that was common across all of the Master of Dietetic (MDiet) theses based on the Survey of Nutrition Dietary Assessment and Lifestyle (SuNDiAL) project. The text on the overall study that was provided by the research team has been indicated in italics below.

4.1 Study design

The SuNDiAL study was a cross-sectional survey conducted in female high school students 15-18 years of age from seven cities in New Zealand (NZ). The overall study aimed to compare the dietary intakes and habits, nutritional status, health status, motivations, attitudes, and lifestyles of vegetarian and non-vegetarian adolescent females in New Zealand. The intention was to recruit a convenience sample of at least 300 adolescent females enrolled from 14 high schools to participate in the SuNDiAL study. Recruitment was bounded by time (the 2019 school year) but participant numbers were maximised where possible. The research was conducted with the understanding and written informed consent of participants (and consent from parents/guardians for those under 16 years of age) before they took part in the study (Appendix A). The study has been approved by the University of Otago Human Ethics Committee (Health): H19/004 (Appendix B) and the Ngāi Tahu Research Consultation Committee (Appendix C) and is registered with the Australian New Zealand Clinical Trials Registry: ACTRN12619000290190.

In this thesis, the Candidate used data collected from the first phase of recruitment (November 2018 and March 2019) into the SuNDiAL study, and focused on intake of iron and iron-containing foods. The localities of data collection were Dunedin, Wellington, Christchurch, New Plymouth, Nelson, Whangarei and Tauranga. The
Candidate collected data over three in-school visits from the Christchurch participants who were in the first phase of the study. Other MDiet students will recruit and collect the remaining data in August 2019.

4.2 Participants and recruitment

The first phase of the SuNDiAL study recruited 263 eligible participants of which 145 completed enrolment and participated in the study. Recruitment of participants and the collection of dietary data were conducted by the Principal Investigators and 15 other MDiet students (student investigators), including the Candidate. High schools were selected to be invited to participate based on their location (limited to accessible schools for data collectors), decile (to ensure good representation) and female roll number (a preference for schools with higher rolls; >400 (co-ed), >200 (girls only)) and were contacted via telephone or email in November 2018. School deciles indicate the extent the school draws their students from low socio-economic communities. Decile 1 represents the 10% of schools with the highest proportion of students from low socio-economic communities and decile 10 are the 10% of schools with the lowest proportion (Ministry of Education, 2019). Additional schools were recruited by research teams in the area via word of mouth, or because a staff member was known to the research team. Interested schools were then telephoned regarding information about dates and times that suited them to have research teams (at least two MDiet students and a qualified phlebotomist or research nurse) conduct data collection. Recruitment of school students was initiated by MDiet students early in the 2019 academic year by giving presentations to school or year group assemblies (Appendix D). As an incentive, participants were informed during the presentations that upon completion of the study they would receive their iron results if they completed the blood test component, and a supermarket voucher of up to $30 ($5 for each component they completed). A results
report was also provided at the end of the study to schools that participated. This included statistics regarding the proportion of females who: reported brushing their teeth twice a day, different ways they got to school, reported consuming 2+ servings of fruit and 3+ servings of vegetables, reported having breakfast every day, and the proportion who gave a blood sample.

Students were eligible to participate in the study if they were female 15-18 years of age, who were enrolled in one of the recruited high schools, spoke and understood English and were able to complete the required online questionnaires. Participants who knew they were pregnant were excluded from the study. Participants who were interested in taking part were provided with a participant information sheet explaining the study aims and procedures (Appendix E). They were then asked to visit the study website (www.otago.ac.nz/sundial) where further information regarding what was involved in participating in the study was available. Participants then completed an online consent and answered initial questions about demographics, vegetarianism and health.

Each participant was allocated an ID number upon entry into the study. This ID number was used on all data collected about the participant. Only study interviewers knew the names of the participants.

4.3 Data collection

Questionnaire data including: demographics, dietary habits, and motivations and attitudes were administered through the web application Research electronic data capture (REDCap) (Vanderbilt, Tennessee). The majority of these questionnaires have been previously validated and pre-tested by MDiet students with some modifications made to make them suitable for New Zealand female adolescents (Rosenfeld & Burrow, 2018; Steptoe et al., 1995; Lindema & Väänänen, 2000; Piazza et al., 2015). The dietary
habits questionnaire was not validated but is based on questionnaires that have been used in the NZ 2008/09 Adult Nutrition Survey (ANS) (Ministry of Health, 2011). Anthropometry, accelerometry, biochemistry and dietary data were collected by the research team based at each recruited high school. This chapter will focus on the data used in this thesis: demographics, iron supplement use, anthropometry and 24-hour recalls, as described below.

4.3.1 Demographic Questionnaire

Eligible individuals who chose to participate completed a demographic questionnaire which was comprised of 27 questions, of which 13 were used in this thesis, covering topics including age, ethnicity, menstruation pattern, blood donation, nose bleeds and contraceptive use. If participants selected more than one ethnicity, they were allocated to a single ethnic group based on the ethnic groups they identified with, which are, in order of priority: Māori, Pacific, Asian and European/Other (Ministry of Health 2008). Questions about menstruation pattern were collected because this impacts on iron requirements. Participants answered the following questions: how old they were when they had their first period (with options: “11 years or younger”, “12-14 years”, “15 years or older”, or “I haven’t had a period yet”), how long it is usually from the start of one period to the start of the next (with options: less than a week, 1-2 weeks, 3-4 weeks, 4-5 weeks, more than 5 weeks, I haven’t had a period for 3 months, the timing of my period is not regular), how many days their period usually lasts (with options: less than 4 days, 4-6 days, 7-9 days, and 10 days or more), and whether or not their periods are so heavy that it makes it hard for them to go to school (with options: yes – often, yes – sometimes, and no). Information about whether or not participants had donated blood and how long ago (with options: in the last 4 months, between 4 and 12 months ago, and more than a year ago) or had nose bleeds in the last year (and whether they were regular
or not) was asked as these also impact blood loss. Contraceptive use and type used was also collected because this has an impact on menstrual blood loss and therefore affects iron requirements and status.

4.3.2 Iron supplement questions

The dietary habits questionnaire contained a section of questions regarding supplement use during the past year. Participants were asked the type of supplement used, duration during the past year, brand or product name, and were able to upload a photograph of the packaging and list of contents if possible. The questions contained in this section that are relevant to this thesis are presented in Appendix F.

4.3.3 Anthropometry

Anthropometric measurements were taken by trained MDiet students, including the Candidate, during one of the in-school visits. Heights were measured using a mobile Stadiometer (Wedderburn, Seca 213) placed with the vertical board against a wall and base on a hard flat surface, without shoes, with the participant’s head aligned in the Frankfort horizontal plane touching the stadiometer, along with shoulder blades, buttocks and heels (with toes apart pointing outward at approximately a 60-degree angle). The Candidate checked the participant was in the correct position before lowering the headpiece to rest firmly on the top of the participant’s head. A step tool was used if the participant was taller than the Candidate. Weights were measured using digital scales (Medisana PS 420, Salter 9037 BK3R, Seca Alpha 770, Soehnle Style Sense Comfort 400) placed on a flat even surface, without heavy clothes or items such as shoes. Height and weight were measured to the nearest 0.1 unit (cm or kg) in duplicate to ensure accurate results had been collected. If measurements were more than 0.5 units apart a third measurement was taken. The protocol used by all MDiet students,
including the Candidate, for measuring weight and height was based on the Ministry of
Health, (2008) protocols (Appendix G). The participants’ BMI z-scores were calculated
from z-scores based on the WHO growth charts (Onis et al., 2007).

4.3.4 24-hour recall

For each participant, estimates of dietary intake were determined using two 24-hour
recalls collected by trained MDiet students, including the Candidate. During each 24-
hour recall, participants were asked to recall everything they ate from midnight to
midnight the previous day. Participants were prompted to recall details including time
of consumption, cooking methods, brands and amounts of food items, and types of
drinks. To help participants estimate quantities of the food items, household measures,
food models, and photographs of different portion sizes were used (Appendix H). The
initial 24-hour recalls took approximately 60 minutes and were conducted at an in-
school data collection visit. The Candidate then double-checked the recall to identify
whether any of the dietary data were not sufficiently detailed. When this was the case
the data were clarified with the participant at the second 24-hour recall which was
completed over the telephone or by video-call the following weekend if possible. The
second 24-hour recall was collected so that ‘usual intake’ could be calculated (see
below).

The most common day of the week on which data were collected from the first
24-hour recall was Wednesday, with just 0.8% collected on a weekend day (Table 4.1).
Saturday, Sunday and Monday were the most common days of the week on which data
were collected from the second 24-hour recall, with 44.2% collected on a weekend day.
Overall, 45% of recall data were collected on a weekend day.
<table>
<thead>
<tr>
<th>Day of week</th>
<th>First 24-hour recall</th>
<th>Second 24-hour recall</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n (%)</td>
<td>n (%)</td>
</tr>
<tr>
<td>Monday</td>
<td>13 (9.9)</td>
<td>25 (22.1)</td>
</tr>
<tr>
<td>Tuesday</td>
<td>17 (12.9)</td>
<td>10 (8.9)</td>
</tr>
<tr>
<td>Wednesday</td>
<td>46 (34.9)</td>
<td>7 (6.2)</td>
</tr>
<tr>
<td>Thursday</td>
<td>39 (29.6)</td>
<td>6 (5.3)</td>
</tr>
<tr>
<td>Friday</td>
<td>16 (12.1)</td>
<td>15 (13.3)</td>
</tr>
<tr>
<td>Saturday</td>
<td>0 (0)</td>
<td>25 (22.1)</td>
</tr>
<tr>
<td>Sunday</td>
<td>1 (0.8)</td>
<td>25 (22.1)</td>
</tr>
</tbody>
</table>

The 24-hour recall used a 3-stage process; Stage 1: Quick list, Stage 2: Collecting more detailed information on foods (including brand names) and amounts, and Stage 3: Checking for any further additions. In the quick list the participant was asked to verbally list everything they had to eat and drink from midnight to midnight the previous day. The participant and interviewer then went over the information gathered from the quick list to establish more specific details for each food and beverage: time of consumption, brand and product name, amount consumed and how the product was cooked. The diet recall was reviewed by the interviewer verbally reading back to the participant the information they had gathered. If anything was incorrect or missing, additional changes were made.

### 4.4 Data entry

The completed 24-hour recalls were entered by MDiet Students, including the Candidate, into FoodWorks version number 9 created by Xyris software (2015) following a standardized protocol. FoodWorks analyses food data using the New Zealand food composition database NZFOODfiles (Institute of Plant and Food Research, 2016), plus recipes developed from the 2008/09 Adult Nutrition Survey (Ministry of Health, 2014) to calculate the energy, macronutrients and micronutrients contained in the diet. A protocol was developed by Kirsten Webster and Liz Fleming.
describing the steps for entry of data into FoodWorks to ensure consistency for all 24-hour recalls (Appendix I). This was particularly important because the recalls were being entered by each MDiet student interviewer.

A codebook was developed by Kirsten Webster, Chaya Ranasinghe and Liz Fleming to assign instructions to certain food items when insufficient information was provided or no exact food match was present in FoodWorks, to ensure consistent treatment of foods across all MDiet students, including the Candidate. The Candidate contributed to the SuNDiAL codebook by identifying default foods, substitutions and creating recipes when necessary, (Appendix J) as discussed below.

For commercial food products or beverages not included in the FoodWorks database, lists of “default foods” that had been created and used in two prior research studies (i.e. the BLISS (Daniels et al., 2015) and SWIFT (Taylor et al., 2015) studies)) were examined. If the unmatched food item was present in one of the two default food lists, the list would suggest a closely related food (same type and most similar nutrient composition) that was available in FoodWorks. These foods were then added to the SuNDiAL default foods page. However, if the unmatched food item was not present on the BLISS or SWIFT default food lists, suitable foods in the FoodWorks database that could be used as a substitution were found. A target was set for the energy, protein, fat and carbohydrate content of the substitute food, so that these could be no more than 10% different to the nutrition content of the product described on its nutrient information panel. Any substitutions made were recorded, added to the SuNDiAL substitution list and checked by research staff. If no food in the database matched closely enough for substitution, a recipe in FoodWorks was generated to represent the product by using its ingredients, again matching the macronutrients to within a 10% difference. When participants reported homemade recipes, they provided all ingredients
with brands and amounts where possible, which were entered into FoodWorks by the Candidate as a recipe. Retention factors were taken into consideration if the product in the recipe required cooking. Following that, the serving size of the recipe consumed by the participant was entered into their respective food record in FoodWorks. All recipes produced by MDiet students, including the Candidate, were checked by research staff and added to the FoodWorks database. When commercial products stated they were fortified with a specific nutrient this was recorded on the FoodWorks database under “notes”, so these amounts were accounted for by research staff when analysing the data.

In addition the Candidate, along with one other MDiet student, developed a database in an Excel spreadsheet (Microsoft Excel 2018; Version 16.0; Microsoft Corporation, Santa Rosa, California) with the nutrient composition of all the iron and zinc containing supplements consumed by the 21 participants who took an iron or zinc containing supplement (See Appendix K for iron data). These data provided iron intake from supplements so that total iron intake (i.e. intake from diet and supplements) could be calculated.

4.5 Statistical methods

A sample size of 300 high school students enrolled from 14 high schools is the aim for the overall SuNDiAL project which gives 80% power to the $\alpha=0.05$ level to detect a 0.5 standard deviation difference (a “moderate” difference) in continuous outcome variables between vegetarians and non-vegetarians, assuming a prevalence of vegetarianism of 20% and a design effect (for school clusters) of 1.5. During the period this MDiet thesis was being conducted, 145 participants were enrolled.

The Candidate conducted all descriptive statistical analyses using Microsoft Office Excel (Microsoft Excel 2018; Version 16.0; Microsoft Corporation, Santa Rosa, California). Results are given as means, standard deviations, absolute values and
percentages to describe variables, unless mentioned otherwise. The Candidate generated Q-Q plots to determine how normally distributed the iron data were. Where the Q-Q plot suggested the data were not sufficiently normally distributed, it was not appropriate to calculate means and standard deviations, so instead the median (25th, 75th) was calculated. Where means were appropriate, 95% confidence intervals were also calculated. To determine the difference in dietary iron intake between categories for age, BMI z-score, school decile and ethnicity, the mean difference and 95% CI were calculated, with values excluding the null value (zero) considered to indicate statistical significance.

The food groups used in this study were the same as those used for the 2008/09 ANS (University of Otago and Ministry of Health, 2011). Food group data for iron were calculated by Jill Haszard (biostatistician) using Stata 15.1 (StataCorp, Texas). For each participant, the proportion of their total iron intake from each of the 33 food groups was calculated. Mean and 95% confidence intervals of these proportions were calculated for the whole group.

Dietary intake data was adjusted for usual intake using the Multiple Source Method (MSM) (Harttig et al., 2011). This estimates the day-to-day variation in nutrient intake using those participants with two days of diet recall data and applies this information to the whole dataset to give an adjusted estimate of usual intake for each participant. To calculate total iron intake the “Shrink then add method” was applied (Bailey et al., 2019). In this method the nutrients from food sources are first processed through the “usual intake” procedures for the entire sample. Next an “adjustment” incorporates the estimated usual intakes of dietary supplements (the dietary habits questionnaire was assumed to give “usual intake” for supplements) and the adjusted
distribution of nutrients from foods sources to produce a final distribution of usual total nutrient intake (Bailey et al., 2019).

As mentioned in section 2.4, the adequacy of iron intakes should be determined using the full probability approach because inter-individual variation in menstrual losses and iron requirements in premenopausal women are distributed asymmetrically around the median and therefore it is not appropriate to use the EAR cut-point method. The Candidate used Table 1-6 (Institute of Medicine, 2001, p. 702) which describes the probability of inadequacy for a range of iron intakes for “mixed population” females 14-18 years of age. “Mixed population” assumes 17% oral contraceptive users. The Candidate then assigned each individual’s iron intake to a category of risk from the Institute of Medicine table and summed this to determine the prevalence of inadequate iron intake. This process was followed twice, to determine the prevalence of inadequate dietary iron intake, and the prevalence of inadequate total iron intake.

The procedure for determining the proportion of individuals in a group who are potentially at risk of adverse health effects from excess nutrient intake is to determine the proportion of participants with intakes above the upper level of intake (UL) (Institute of Medicine, 2000). The Australian and New Zealand UL for iron for adolescents 14-18 years of age of 45mg/day was used (Ministry of Health, 2014).
5. Results

5.1 School and participant response rates

There were 97 eligible schools for the Survey of Nutrition Dietary Assessment and Lifestyle (SuNDiAL) study of which 25 were selected for invitation by the SuNDiAL Principal Investigators. Of the 25 selected schools, 3 schools declined, 15 schools did not respond, and 2 schools accepted but then did not respond further. Three additional schools were invited in person by Master of Dietetic (MDiet) students, resulting in 8 schools overall consenting (Appendix L).

Figure 5.1 outlines the participant recruitment process to achieve a total of 145 participants who completed enrolment and were included in this thesis. Of the 145 participants, 144 completed the health and demographics questionnaire, 124 completed the dietary habits questionnaire, 132 participants completed the first 24-hour recall and 113 the second 24-hour recall. Of the 132 participants who attended the school visit, 130 had complete anthropometric measures.
1882 eligible participants
- ~806 present at recruitment drives

263 eligible participants sent link to enrolment

Excluded (n=543)
- Did not express interest in participating in the study

Reasons for not consenting to participate (n=118)
- 84 16-18-year olds did not respond (46% of 182)
- 13 parents of 15-year olds did not respond (16% of 81)
- 0 parents of 15-year olds declined (0% of 28)
- 10 15-year olds did not respond after parental consent (31% of 32)
- 2 responded to link but declined
- 9 parents of 16-18-year olds from one school that required parental consent did not respond or were uncontactable (50% of 18)

145 consented to participate and completed enrolment
- 144 completed the health & demographics questionnaire
- 129 completed the attitudes and motivations questionnaire
- 124 completed the dietary habits questionnaire

132 attended the in-school visit
- 130 had complete anthropometric measures
  - 2 missing due to technical issues
- 132 completed first 24 hr recall
- 113 completed repeat 24 hr recall
- 19 refused repeat 24 hr recall

127 consented to blood sample
121 consented to urine sample
129 consented to accelerometer
- Data not used in this thesis

Figure 5.1: Flow diagram of the SuNDiAL study participants, as relevant to the analysis of iron intake. (Adapted from a diagram prepared by Jill Haszard (Appendix M)).
5.2 Demographic and anthropometric characteristics of participants

The demographic characteristics of the 145 SuNDiAL study participants are presented in Table 5.1. On average, adolescent females enrolled in the study were 16.7 years of age and were predominantly New Zealand European (72.2%), with 20.1% identifying as Māori, 3.5% as Pacific and 4.2% as Asian. The mean BMI z-score for the participants was 0.65 (1.0). Using the recommended cut-off for overweight values of +1 standard deviation for adolescents (Onis et al., 2007), 45 (34.6%) participants were classified as overweight. The majority of participants attended schools with a school decile of 4-7 (85 of 145) (Table 5.2). In total 31.9% of participants were using an oral contraceptive pill. Of the 124 participants who completed the dietary habits questionnaire, 21 reported using iron supplements in the past year.
Table 5.1: Characteristics of the SuNDiAL Study participants (n=145)

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>n (%)</th>
<th>Mean (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td></td>
<td>16.7 (0.8)</td>
</tr>
<tr>
<td>15</td>
<td>28 (19.3)</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>54 (37.2)</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>60 (41.4)</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>3 (2.1)</td>
<td></td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td></td>
<td>23.7 (4.4)</td>
</tr>
<tr>
<td>BMI z-score</td>
<td></td>
<td>0.65 (1.0)</td>
</tr>
<tr>
<td>Not overweight (BMI z-score &lt;1)</td>
<td>85 (65.4)</td>
<td>0.05 (0.61)</td>
</tr>
<tr>
<td>Overweight (BMI z-score &gt;1)</td>
<td>45 (34.6)</td>
<td>1.79 (0.67)</td>
</tr>
<tr>
<td>Ethnicity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NZEO</td>
<td>104 (72.2)</td>
<td></td>
</tr>
<tr>
<td>Māori</td>
<td>29 (20.1)</td>
<td></td>
</tr>
<tr>
<td>Pacific</td>
<td>5 (3.5)</td>
<td></td>
</tr>
<tr>
<td>Asian</td>
<td>6 (4.2)</td>
<td></td>
</tr>
<tr>
<td>School decile</td>
<td></td>
<td>6.5 (1.9)</td>
</tr>
<tr>
<td>1-3 (low decile)</td>
<td>14 (9.7)</td>
<td></td>
</tr>
<tr>
<td>4-7</td>
<td>85 (58.6)</td>
<td></td>
</tr>
<tr>
<td>8-10 (high decile)</td>
<td>46 (31.7)</td>
<td></td>
</tr>
<tr>
<td>Any blood donation ever</td>
<td>4 (2.8)</td>
<td></td>
</tr>
<tr>
<td>Current oral contraceptive use</td>
<td>46 (31.9)</td>
<td></td>
</tr>
<tr>
<td>Gets nose bleeds</td>
<td>56 (38.9)</td>
<td></td>
</tr>
<tr>
<td>Duration of menstrual period</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;4 days</td>
<td>18 (12.5)</td>
<td></td>
</tr>
<tr>
<td>4-6 days</td>
<td>97 (67.4)</td>
<td></td>
</tr>
<tr>
<td>7-9 days</td>
<td>27 (18.8)</td>
<td></td>
</tr>
<tr>
<td>&gt;10 days</td>
<td>2 (1.4)</td>
<td></td>
</tr>
<tr>
<td>Used iron supplements in the past year</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Abbreviations: BMI z-score = body mass index-for-age z-score, BMI = body mass index (weight (kg) / (height (m²))), SD = standard deviation, n = number of participants, % = percentage of participants, NZEO = New Zealand European and other.

1 The Candidate collected data from the 14 Christchurch participants from the first phase of recruitment
2 15 of the 145 participants were excluded as they did not provide height or weight data
3 The recommended cut-off for overweight values was set at +1 standard deviation for adolescents (Onis et al., 2007)
4 1 missing value as one participant did not complete the demographic questionnaire
Decile 1 represents the 10% of schools with the highest proportion of students from low socio-economic communities and decile 10 are the 10% of schools with the lowest proportion (Ministry of Education, 2019).

6. 20 of the 145 participants were excluded as they did not complete the dietary habits questionnaire, plus 1 missing value as one participant did not complete the demographic questionnaire.

Table 5.2: Number of participants from each high school and each high school’s school decile (n=145)

<table>
<thead>
<tr>
<th>High school (region)</th>
<th>School decile</th>
<th>n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hornby High School (Christchurch)</td>
<td>3</td>
<td>14 (9.7)</td>
</tr>
<tr>
<td>Kaikorai Valley College (Dunedin)</td>
<td>5</td>
<td>15 (10.3)</td>
</tr>
<tr>
<td>Spotswood College (New Plymouth)</td>
<td>5</td>
<td>14 (9.7)</td>
</tr>
<tr>
<td>Mt Maunganui College (Tauranga)</td>
<td>6</td>
<td>16 (11)</td>
</tr>
<tr>
<td>St Catherines College (Wellington)</td>
<td>6</td>
<td>19 (13.1)</td>
</tr>
<tr>
<td>Tauraroa Area School (Whangarei)</td>
<td>7</td>
<td>21 (14.5)</td>
</tr>
<tr>
<td>Waimea College (Nelson)</td>
<td>8</td>
<td>28 (19.3)</td>
</tr>
<tr>
<td>Columba College (Dunedin)</td>
<td>10</td>
<td>18 (12.4)</td>
</tr>
</tbody>
</table>

5.3 Iron intakes (Objective 1)

Figure 5.2 shows that 56 (42.4%) participants had dietary iron intakes that were between 8 and 11.9mg/day. Figure 5.3 shows the Q-Q plot for dietary iron intakes which suggests that the dietary iron data are sufficiently normally distributed for it to be appropriate to calculate means and SDs. The mean dietary iron intake was 11.8mg/day (Table 5.3).

Figure 5.4 shows that 49 (37.1%) participants had total iron (intake from diet and supplements) intakes that were between 8 and 11.9mg/day. Figure 5.5 shows a systematic deviation from the trendline (i.e. there are two outliers) therefore the total iron data were not normally distributed so calculating means and SDs was not appropriate. Instead, the median (25th, 75th) were calculated. The median total iron intake was 11.8mg/day (Table 5.3).
A total of 21 participants out of 124 who completed the dietary habits questionnaire reported they had used iron supplements in the past year (Table 5.1). Of these 21 participants, 2 were excluded from the total iron (intake from diet and supplements) intake results as they did not provide dietary iron data. The mean amount of iron from supplements was estimated at 15mg for consumers, but the median was 0mg for the participants as a whole because so few were consuming supplements (Table 5.3).

There was no significant difference in mean dietary iron intake between 17-18 and 15-16-year olds, those who were overweight or not, (Table 5.4), or between NZEO and Māori (mean difference; 95% CI: 0.6; -1.1, 2.3) or Asian (2.3; -1.2, 5.8) participants. In contrast, there was a statistically significant difference in iron intake between participants attending a school with a school decile of 1-3 (low) and those attending a school with a school decile of 8-10 (high) (3.9; 95% CI: 1.9, 5.8) (Table 5.4), as well as between participants who were NZEO and Pacific (5.7; 95% CI 2.7, 8.7).
Figure 5.2: Dietary iron intakes of participants (n=132)

Figure 5.3: Dietary iron Q-Q plot (normal distribution probability plot)
**Figure 5.4:** Total iron intakes (intake from diet and supplements) of participants (n=132)

**Figure 5.5:** Total iron Q-Q plot (normal distribution probability plot)
Table 5.3: Iron and energy intakes of participants (n=132) ¹

<table>
<thead>
<tr>
<th>Variables</th>
<th>Mean (95% CI)</th>
<th>Median (25th, 75th) ³</th>
<th>Inadequate intake (%)</th>
<th>Excessive intakes n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dietary iron intake (mg/d)</td>
<td>11.8 (11.1, 12.5)</td>
<td>-</td>
<td>20.8%</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>Iron (mg) from supplements (mg)</td>
<td>15 (3.5, 26.4)</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Iron (mg) from supplements (all)</td>
<td>-</td>
<td>0 (0, 0)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Total iron intake (mg/d)</td>
<td>-</td>
<td>11.8 (8.8, 14.6)</td>
<td>20%</td>
<td>2 (1.5%)</td>
</tr>
<tr>
<td>Energy (kJ)</td>
<td>8066 (7754, 8379)</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Abbreviations: CI = confidence interval, n = number, kJ = kilojoules, mg = milligrams, d = day

¹ 2 of the 21 participants who reported taking iron supplements were excluded from the total iron intake results as they did not provide dietary iron data

² Percentile

³ There were two outliers in the total iron intake distribution (see figures 5.4 and 5.5) so a mean and SD could not be calculated, instead the median (25th, 75th) was calculated
Table 5.4: Iron intake by age group, BMI z-score, school decile and ethnic group (n=132)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Dietary iron (mg)</th>
<th>Mean (SD)</th>
<th>Mean difference (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age (years)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>11.8 (4.0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15-16</td>
<td>11.8 (4.4)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17-18</td>
<td>11.9 (3.5)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17-18 compared to 15-16</td>
<td></td>
<td>0.1 (-1.3, 1.4)</td>
<td></td>
</tr>
<tr>
<td><strong>BMI z-score</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>11.7 (3.8)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not overweight</td>
<td>12.1 (4.0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overweight</td>
<td>10.9 (3.5)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not overweight compared to overweight</td>
<td></td>
<td>1.2 (-0.2, 2.6)</td>
<td></td>
</tr>
<tr>
<td><strong>School decile</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>12.2 (4.4)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-3 (low)</td>
<td>9.2 (2.8)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8-10 (high)</td>
<td>13.1 (4.4)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8-10 compared to 1-3</td>
<td></td>
<td>3.9 (1.9, 5.8)</td>
<td></td>
</tr>
<tr>
<td><strong>Ethnicity</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>11.9 (4.0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NZEO</td>
<td>11.9 (3.7)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Māori</td>
<td>11.3 (4.1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pacific</td>
<td>17.6 (4.9)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Asian</td>
<td>9.6 (4.2)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pacific compared to NZEO</td>
<td></td>
<td>5.7 (2.7, 8.7)</td>
<td></td>
</tr>
</tbody>
</table>

**Abbreviations:** NZEO = New Zealand European and other, BMI = Body mass index, mg = milligram, SD = standard deviation, CI = confidence interval

1 Usual iron intake calculated as the daily intake from two 24-hour recalls. These data were adjusted for intra-individual variation using the multiple source method (Harttig et al., 2011)

2 Two participants were excluded as they did not provide weight or height data

3 The recommended cut-off for overweight values was set at +1 standard deviation for adolescents (Onis et al., 2007)

4 Includes only one school from decile 3

5 Difference between groups is statistically significant (CI excludes the null value 0)

6 1 missing value as the participant did not identify their ethnicity
5.4 Prevalence of inadequate and potentially excessive intakes of iron (Objective 2)

The prevalence of inadequate dietary iron intake using the full probability approach was 20.8% and for total iron intake was 20.0% (Table 5.3). The prevalence of potentially excessive total iron intakes was 1.5% with 2 participants having total iron intakes above the upper level of intake (UL) (Table 5.3). This is to be expected as both of these participants reported consuming a Ferrogradumet iron tablet (105mg elemental iron) each day.

5.5 Dietary sources of iron (Objective 3)

The “bread” food group provided 10% of dietary iron, followed by “grains and pasta” (10%), “breakfast cereals” (9%), “vegetables” (7%), “bread based dishes” (7%), “potatoes, kumara, taro”, “beef and veal” (5%), “poultry” and “fruit” (5%) (Table 5.5).
Table 5.5: Dietary sources of iron consumed by the SuNDiAL study participants

<table>
<thead>
<tr>
<th>Food group</th>
<th>Percent 1 (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bread (inc rolls &amp; speciality breads)</td>
<td>10.2 (8.4, 12.1)</td>
</tr>
<tr>
<td>Grains and Pasta</td>
<td>10 (7.8, 12.2)</td>
</tr>
<tr>
<td>Breakfast cereals</td>
<td>9.2 (6.7, 11.7)</td>
</tr>
<tr>
<td>Vegetables</td>
<td>6.9 (5.6, 8.3)</td>
</tr>
<tr>
<td>Bread based dishes</td>
<td>6.6 (4.5, 8.7)</td>
</tr>
<tr>
<td>Potatoes, kumara, taro</td>
<td>4.8 (3.8, 5.7)</td>
</tr>
<tr>
<td>Beef and veal</td>
<td>4.8 (3.0, 6.6)</td>
</tr>
<tr>
<td>Poultry</td>
<td>4.6 (3.5, 5.7)</td>
</tr>
<tr>
<td>Fruit</td>
<td>4.6 (3.7, 5.5)</td>
</tr>
<tr>
<td>Savoury sauces and condiments</td>
<td>3.5 (2.4, 4.6)</td>
</tr>
<tr>
<td>Snacks sweet</td>
<td>3.2 (2.1, 4.3)</td>
</tr>
<tr>
<td>Biscuits</td>
<td>3.0 (1.9, 4.2)</td>
</tr>
<tr>
<td>Sausages and processed meats</td>
<td>2.9 (1.7, 4.1)</td>
</tr>
<tr>
<td>Pork</td>
<td>2.6 (1.8, 3.5)</td>
</tr>
<tr>
<td>Eggs and egg dishes</td>
<td>2.6 (1.7, 3.6)</td>
</tr>
<tr>
<td>Pies and pasties</td>
<td>2.6 (1.3, 3.8)</td>
</tr>
<tr>
<td>Cakes and muffins</td>
<td>2.5 (1.8, 3.2)</td>
</tr>
<tr>
<td>Nuts and Seeds</td>
<td>2.4 (1.5, 3.3)</td>
</tr>
<tr>
<td>Snack foods</td>
<td>2.2 (1.4, 3.0)</td>
</tr>
<tr>
<td>Supplements providing energy</td>
<td>2.0 (0.99, 3.1)</td>
</tr>
<tr>
<td>Sugar/sweets</td>
<td>1.8 (1.2, 2.4)</td>
</tr>
<tr>
<td>Non-alcoholic beverages</td>
<td>1.5 (0.9, 2.1)</td>
</tr>
<tr>
<td>Fish/Seafood</td>
<td>1.5 (0.66, 2.3)</td>
</tr>
<tr>
<td>Lamb/Mutton</td>
<td>0.9 (0.2, 1.6)</td>
</tr>
<tr>
<td>Soups and stocks</td>
<td>0.6 (0.13, 1.1)</td>
</tr>
<tr>
<td>Dairy products</td>
<td>0.6 (0.22, 0.89)</td>
</tr>
<tr>
<td>Milk</td>
<td>0.5 (0.21, 0.84)</td>
</tr>
<tr>
<td>Alcoholic beverages</td>
<td>0.5 (-0.11, 1.1)</td>
</tr>
<tr>
<td>Food Group</td>
<td>Mean Percent of Iron</td>
</tr>
<tr>
<td>------------------------</td>
<td>----------------------</td>
</tr>
<tr>
<td>Cheese</td>
<td>0.3 (0.15, 0.39)</td>
</tr>
<tr>
<td>Other meat</td>
<td>0.3 (-0.24, 0.75)</td>
</tr>
<tr>
<td>Puddings/desserts</td>
<td>0.1 (0.02, 0.24)</td>
</tr>
<tr>
<td>Butter and Margarine</td>
<td>0.03 (0.002, 0.06)</td>
</tr>
<tr>
<td>Fats and oils</td>
<td>0.03 (0.01, 0.05)</td>
</tr>
</tbody>
</table>

\(^1\) Mean percent of iron obtained from each food group.
6. Discussion and Conclusion

6.1 Summary of main findings

To the Candidate’s knowledge, this is the first study in New Zealand (NZ) since the 2008/2009 Adult Nutrition Survey (ANS) to look at the iron intake and the main food sources of iron in the diets of adolescent females 15-18 years of age. The present study found mean dietary iron intakes and median total iron intakes (i.e. intake from diet and supplements) of 11.8mg/day. The prevalence of inadequate dietary iron intakes was 20.8% (20.0% for total iron intakes), while the prevalence of potentially excessive total iron intakes was just 1.5% with 2 participants above the upper level of intake (UL). The main food sources of iron were the “bread” food group providing 10% of dietary iron, followed by “grains and pasta” (10%), and “breakfast cereals” (9%).

6.2 Iron intakes (Objective 1)

The SuNDiAL participants were consuming a mean dietary iron intake of 11.8mg/day which is higher than intakes reported for females 15-18 years of age in the NZ 2008/09 ANS (9.4mg/day) and Australian 2011/12 Health survey (9.2mg/day). The Candidate had hypothesised that with the anecdotal increase in vegetarianism and exposure in social media to the desirability of a ‘thinner’ body image, the SuNDiAL participants would have lower iron intakes, but this was not supported by the data. The difference in results may not be attributable to changes in food trends over the past decade, rather that our iron data are not from a representative sample of all NZ 15-18-year-old female adolescents. Certainly, there was low ethnic diversity (104 New Zealand European and others (NZEO), 29 Māori, 5 Pacific, 6 Asian) and under-representation of those from lower decile schools (n=14 students from one decile 3 school) in this convenience sample of female adolescents. In
contrast, the Australian and NZ Health surveys are representative of all female adolescents. The median total iron intake consumed by SuNDiAL participants was 11.8mg/day which was consistent with the results reported by Rangan et al (1997) (11.7mg/day). This is somewhat surprising because these data were collected from Australia in 1997 from participants with a mean age of 20.7 years, a very different population to that in SuNDiAL.

Mean dietary iron intakes differed among ethnicities in the SuNDiAL study. The highest dietary iron intake was in Pacific participants (17.6mg/day) who had intakes that were significantly higher than NZEO (11.9mg/day), Māori (11.3mg/day) and Asian (9.6mg/day) participants. These findings however are not consistent with the data from the NZ 2008/09 ANS where mean dietary iron intakes for Pacific females 15-18 years of age were lower (8.9mg/day) than those for NZEO (9.5mg/day) and similar to Māori (8.6mg/day) - Asian data were not reported separately. Our data may not be representative of all Pacific people because there were just 5 Pacific participants included, of which three attended a school with a school decile of 10, which as discussed below had students with a higher mean iron intake overall.

Dietary iron intake also appeared to differ by school decile category, so that participants attending a school with a school decile of 1-3 (low) had significantly lower iron intakes (9.2mg/day) than participants attending a school with a school decile of 8-10 (high) (13.1mg/day). Participants from school decile 1-3 compared to 8-10 may have had lower dietary iron intakes due to: having lower food security therefore lower intakes of iron rich foods because of the high cost of meat, and potentially less food consumption overall therefore lower total energy intake and hence lower iron intake. Participants from school decile 1-3 did have lower average energy intakes (7893kJ) compared to those in school
decile 8-10 (8788kJ). However, there are problems with using the school decile data in this way. In particular, school deciles indicate the extent to which the school draws their students from low socioeconomic communities (Ministry of Education, 2019), rather than the socioeconomic status (SES) of individual students. In contrast, the New Zealand Index of deprivation (NZDep) is a direct area-based measure of socioeconomic deprivation in NZ (Atkinson et al., 2014), therefore future research should use this measure of SES. In addition, there was just one school included from the lower decile category (n=14), compared to two schools from the higher decile (n=46), so it is not possible to know whether the intakes are due to the school’s decile or to a particular characteristic of the school.

6.3 Inadequate and excessive intakes of iron (Objective 2)

Using the full probability approach, the prevalence of inadequate dietary iron intake for our study sample was 20.8% (excluding supplements) and for total iron intake was 20.0% (including supplements). This negligible difference between inadequate dietary and total iron intakes is presumably because so few participants were taking iron supplements (just 14%), and when supplements were taken, they were almost always taken in small amounts. The prevalence of inadequate dietary iron intakes in our study sample (20.8%) is somewhat lower than the NZ 2008/09 ANS (34.2%) and the Australian 2011/12 Health Survey (40.0%) (all excluding supplements). This may be because our study under-represented adolescents from lower decile schools - there was just one school in school decile 1-3 which only contributed 14 participants (as discussed above, the lower decile school had significantly lower iron intakes than the highest decile schools).
However, it is possible that the true prevalence of inadequate intakes in SuNDiAL is even lower. Participants who are contraceptive users are likely to have less menstrual blood loss and therefore lower iron intake requirements. When the Institute of Medicine (2001) developed the EAR, they assumed a lower percent of oral contraceptive users (17%) compared to that observed in SuNDiAL (32%). The calculation therefore assumes higher requirements than in fact is likely for SuNDiAL participants, so probably over-estimates the prevalence of inadequate intakes in our study sample. Moreover, the duration of menstrual periods, experiencing nose bleeds and donating blood also impact on iron requirements. Compared to the literature, the percentage of SuNDiAL participants having nose bleeds (38.9%) was almost double the results reported by Heath et al. (2001) (20.0%), and the prevalence of blood donation much lower (3% vs 27%). We expect these may impact on the participants iron requirements, but it is hard to know the extent since nose bleeds are more common, but blood donation is less common. There were two participants who had total iron intakes above the UL of 45mg/day (Ministry of Health, 2014), both because they reported consuming the prescribed iron supplement Ferrogradumet.

6.4 Food sources of iron (Objective 3)

Comparing the NZ 2008/09 ANS data to ours, it appears there has been little change in the food groups providing iron for adolescent females 15-18 years of age in NZ. The “bread” food group still provided the majority of dietary iron (10% vs 11% in the ANS), followed by “grains and pasta” (10% vs 8%) and “breakfast cereals” (both 9%). Interestingly, non-alcoholic beverages was the only food group that varied in the top 10 food groups contributing to iron intake (5% in the ANS vs 1.5% in SuNDiAL). Although the grain-based food groups are not necessarily ‘iron-rich,’ they still contain small amounts of iron,
and as people tend to eat these food groups in relatively large amounts and frequently, they ultimately provide a considerable amount of iron.

### 6.5 Challenges with the data

There were several challenges involved in creating the supplement data including: dealing with incomplete data, and the fact that some supplement manufacturers only provided the iron compound on the label and not the amount of elemental iron within the compound. In these cases, default formulations had to be assigned to products, however the way the default was chosen may have introduced error (Appendix K).

Although the levels of low energy reporting were not analysed in this study, there is good reason to believe that low energy reporting was present. It is known that 24-hour recalls can make participants feel judged and less likely to accurately report foods that they consider are ‘unhealthy’ (Gibson, 2005). Low energy reporting is also consistently associated with higher BMI (Macdiarmid et al., 1998), and 34.6% of the SuNDiAL participants were overweight. Even if we had identified low energy reporters, it is unclear that they should be excluded from the analysis because 46% of participants reported trying to lose weight, therefore many would have been truthfully reporting low energy intakes. If they were excluded, the results would reflect only the iron intakes of adolescents who were not on a diet, which would not have been representative of the study sample.

### 6.6 Strengths and limitations

The present study has several strengths. First, the study used two 24-hour recalls and calculated usual intakes. This is the dietary assessment method of choice for most national nutrition surveys worldwide (Ministry of Health, 2011). Second, the majority of the first
24-hour recalls were collected on a weekday and the second on the weekend to capture intraparticipant variability as weekends are a time of the week when energy intake is greatest and energy expenditure is lower, compared to weekdays (Racette et al., 2008). Third, when products were not included in FoodWorks, the Candidate developed recipes using the manufacturers’ ingredients list, generating an accurate representation of products the participants ate. Fourth, a codebook for the SuNDiAL study was generated by research staff and MDiet students, including the Candidate, to ensure consistent entry of dietary data. All 24-hour recalls were checked by research staff and errors were rectified to ensure the data were accurate. Finally, supplement data were collected. Although there was almost no difference in dietary and total iron intakes, without inclusion of nutrients from supplements, the prevalence of inadequacy may be overestimated and intakes above the UL may be underestimated (Murphy et al., 2007; Bailey et al., 2012).

The study also has some limitations. First, the 95% CI for the mean dietary intake is relatively narrow so we could be 95% confident that the true mean lies somewhere between 11.1mg/day and 12.5mg/day for the whole NZ adolescent female population 15-18 years of age. However, our data are unlikely to be representative of all female adolescents in NZ because of the inclusion of more participants attending higher decile schools, and the low ethnic diversity in the sample. Second, four different brands of scales and two of stadiometers were used across the centres which may have introduced measurement bias. The scales were also not calibrated so there may have been variations in the accuracy of weights and heights. Finally, the use of the school decile system as an indicator of SES of participants is problematic as clustering was not accounted for so, within a school, participants are likely to have similar characteristics because they are all at the same school.
6.7 **Recommendations for future research**

Aspects to consider when planning future studies should include: using a different recruitment method, using the same anthropometric equipment across centres, including supplement questions in the 24-hour recall, and using the NZDep as a measure of SES. First, the data should be collected in a similar way to the NZ 2008/09 ANS with a multi-stage stratified probability proportional to size sample design (University of Otago and Ministry of Health, 2011) to identify a more representative sample. Second, the same anthropometric equipment (i.e. brands and models) should be used throughout the study sample, and should be calibrated regularly, and whenever moved. Third, supplement questions should be included in the 24-hour recall video-call, as well as a questionnaire, so that probing of information can take place, and supplement labels can be shown on camera. Fourth, the NZDep should be used instead of the school decile system as this provides a much more widely accepted measure of SES. Finally, statistical analysis should take into account the impact of clustering of participants within schools.

This thesis focused on iron intake because biochemical iron status data were not available. A future SuNDiAL project will look at iron status. These data will be important for confirming the estimates of inadequate iron intakes and determining the extent to which iron status is a concern in NZ female adolescents.

6.8 **Conclusions**

Very little research to date has been conducted on NZ adolescent females’ iron intakes, despite concerns they are particularly vulnerable to iron deficiency because of high requirements for growth and the onset of menstruation (Greger et al., 1978). The results from this study suggest that dietary iron intakes may have increased, and the prevalence of
inadequate intakes decreased, over the past decade. However, these data should not be used in isolation of iron status data and need to be interpreted with caution as they are not representative of the whole NZ adolescent female population.

7. Application of Research to Dietetic Practice

Up-to-date evidence is the basis of dietetic practice. Moreover, dietitians should continually be reviewing the literature so that their recommendations are current and realistic for clients. From the present study, it appears that the iron intakes of adolescent females may be improving, however, these data should not be used in isolation of iron status data, and need to be interpreted with caution as they are not representative of the whole New Zealand (NZ) adolescent female population.

The suggestion from the present study that iron intake is lower in participants attending a school with a school decile of 1-3 (low) compared to those attending a school with a school decile of 8-10 (high) is potentially important but is also problematic. It is important that the next nutrition survey looks at the iron intakes of female adolescents by socioeconomic status measured with an even distribution of SES and accounting for clustering. If the results of the present study are confirmed by such research, there is action that could be taken by public health dietitians including: initiatives in schools promoting ‘healthy eating on a budget’ through hands on workshops for parents and students with an emphasis on ‘iron rich’ food sources and how to increase fruit and vegetable intake at a low cost (for example through seasonal purchasing, buying in bulk and choosing frozen or canned options). Having collected data from participants attending a decile 3 school provides insight into the need for such action as the majority of these participants consumed high levels of commercial packaged food products, with just 36% reporting consuming the
recommended 2+ servings of fruit a day and 27% reporting consuming the recommended 3+ servings of vegetables a day. Furthermore, only 9% reported having breakfast every day. However, as I was only involved with collecting data from a decile 3 school, it may well be that all schools in fact need support around these areas.

Experiencing this research journey has reinforced the importance of being able to communicate effectively, and that it requires competence and practice. In future, as a practicing dietitian, I would like to put into practice how to implement effective communication by: remembering to reiterate back to the person communicating with me what I understood, and alternatively when communicating my perspective to others instead of asking ‘do you understand’ rather rephrasing it to ‘what do you understand’ will allow for an open-ended answer. Ultimately, establishing and applying effective communication in the workplace is essential to ensure optimal care for clients.
8. References


FoodWorks (Version 9) [Computer software]. (2015). High Gate Hill, Qld: Xyris Software


9. Appendices

Appendix A: Participant consent form

Appendix B: Human ethics application: approval letter

Appendix C: Ngāi Tahu Research Consultation Committee letter

Appendix D: Presentation PowerPoint

Appendix E: Participant information sheet

Appendix F: Dietary Habits questionnaire

Appendix G: Anthropometric protocols

Appendix H: Food model booklet

Appendix I: Protocol for entry of dietary data into FoodWorks

Appendix J: SuNDiAL codebook

Appendix K: Iron supplement data

Appendix L: School recruitment flow diagram

Appendix M: Original participant recruitment flow diagram
Appendix A: Participant consent form

This consent form was developed by the Principal Investigators of SuNDiAL. The Candidate used this form when recruiting participants.
The SuNDiAL Project 2019: A survey of nutrition, dietary assessment and lifestyle

Principal Investigators: Dr Jill Haszard (jill.haszard@otago.ac.nz, ph 03 479 5683) and Dr Meredith Peddie (meredith.peddie@otago.ac.nz, ph 03 479 8157)

PARTICIPANT CONSENT

Please click the “Agree” button below if:
- You have read the information sheet above and understand the aims of the study
- You have had all your questions answered about the study and understand that you can ask for more information at any stage
- You are a young woman who is 15 to 18 years old who isn’t pregnant
- You have chosen to take part, but you know you can pull out of the study any time before it finishes in October 2019.
- You know that as a participant you will be asked to complete online questionnaires about why you choose to eat the foods that you do, and have your height, weight and the length of your forearm measured, and complete interviews about the food that you eat over two different 24 h periods.
- You know that the responses you provide to the questionnaires in this study will be recorded against an ID number not your name. The information linking you to this ID number will be destroyed once all the data has been collected and you have been given the opportunity to request your individual information. The remaining data, which will not be able to be linked back to you in anyway, will be placed in secure storage and kept for at least ten years.
- You understand the results of the project may be published and be available from the University of Otago Library
- You know that no commercial use will be made of this data
- You know that for each of component of the study you complete you will receive a $5 voucher

Agreeing to this part of the study does not mean that you have agreed to give a blood sample, a urine sample or to wear an accelerometer (you will be asked about those bits separately)

If you do not wish to participate in the SuNDiAL Project, please decline participation by clicking on the “disagree” button

AGREE/DISAGREE
If DISAGREE selected
Thank you for thinking about taking part in the SuNDiAL project and for telling us it isn’t something you’re interested in doing.

*If AGREE selected*

Thank you for agreeing to taking part in the SuNDiAL project! Please answer the following two questions so we can check you are eligible:

1) What is your date of birth? (set format)
2) Which high school do you attend? (select from drop down box)

*If not met: Thank you! Unfortunately you are not eligible to take part in the SuNDiAL project this year because you aren’t in our age range, or aren’t attending one of our participating schools – keep an eye out for us in future years 😊*

*If met: Thank you! You are eligible to take part in the SuNDiAL project. Would you also like to participate in any of the optional components of the study?*** If they are 15 years old the following message will appear: “Even though you have agreed to take part in the SuNDiAL project, because you are 15, we still need to check that it is OK with your parent or guardian. Please enter an email address where we can contact them and tell them about the study. We won’t share any of the information you give to us with anyone, including your parents or guardians”*

Optional components:
1) Providing a Blood Sample

Please click the **agree** button below if:

- You agree to have a blood sample collected by a phlebotomist (someone with special training in how to take a blood sample)
- You understand the possible risk and discomfort involved in providing a blood sample
- You understand that your blood sample will be split into several different bits and frozen. Different components will be analysed locally, in Germany, and at the University of Otago.
- You understand that your blood sample will only be analysed for the things listed in the information sheet
- You know that the concentrations of things measured in your blood will be recorded against an ID number. The information linking you to this ID number will be destroyed once all the data has been collected and you have been given the opportunity to request your individual information. The remaining data, which will not be able to be linked back to you in anyway, will be placed in secure storage and kept for at least ten years.
- You will receive an additional $5 voucher if you provide a blood sample

If you do not wish to provide a blood sample, please click the “**disagree**” button

**AGREE/DISAGREE**
If agree: Please click here if you want your samples disposed of with a Karakia (Māori Prayer)

2) Providing a Urine Sample
Please click the agree button below if:
- You agree to provide a urine sample
- You understand that your urine sample will be frozen and transported to the University of Otago where it will be stored until it is analysed for iodine concentrations.
- You understand that your urine sample will only be analysed iodine concentrations
- You know that the concentrations iodine measured in your urine will be recorded against an ID number. The information linking you to this ID number will be destroyed once all the data has been collected and you have been given the opportunity to request your individual information. The remaining data, which will not be able to be linked back to you in anyway, will be placed in secure storage and kept for at least ten years.
- You will receive an additional $5 voucher if you provide a urine sample

If you do not wish to provide a urine sample, please click the "disagree" button

AGREE/DISAGREE

If agree: Please click here if you want your samples disposed of with a Karakia (Māori Prayer)

3) Wearing an accelerometer for 7 days
Please click the agree button below if:
- You agree to wear an accelerometer for 24 hours a day for seven days
- You understand the during this time you will asked to record in a diary provided to you when you take the accelerometer on and off, and when you go to bed each night
- You know that amount of time you spend sleeping and moving will be recorded against an ID number. The information linking you to this ID number will be destroyed once all the data has been collected and you have been given the opportunity to request your individual information. The remaining data, which will not be able to be linked back to you in anyway, will be placed in secure storage and kept for at least ten years.
- You will receive an additional $5 voucher if you wear the accelerometer for seven days and return it to the research team when they visit your school

If you do not wish to wear an accelerometer, please click the “disagree” button

AGREE/DISAGREE
Appendix B: Human ethics application: approval letter

The application for ethical approval was developed by the Principal Investigators of SuNDiAL.
Dear Dr Haszard,

I am writing to let you know that, at its recent meeting, the Ethics Committee considered your proposal entitled “SuNDiAL Project 2019: Survey of Nutrition Dietary Assessment and Lifestyle Phase 1: Adolescent Females”. As a result of that consideration, the current status of your proposal is: Approved. For your future reference, the Ethics Committee’s reference code for this project is: H19/004.

The comments and views expressed by the Ethics Committee concerning your proposal are as follows:

While approving the application, the Committee would be grateful if you would respond to the following:

**Information Sheet**
A typing error was noted on the Information Sheet, under the heading “Is there any risk of discomfort or harm from participation?”, line 3, “some” should read “someone”.

**Consent Form**
Please amend the Consent Form to include an option for participants to indicate whether they would prefer for their blood samples to be disposed of using standard methods or with a Karakia.

Please provide the Committee with copies of the updated documents, if changes have been necessary.
The standard conditions of approval for all human research projects reviewed and approved by the Committee are the following:

Conduct the research project strictly in accordance with the research proposal submitted and granted ethics approval, including any amendments required to be made to the proposal by the Human Research Ethics Committee.

Inform the Human Research Ethics Committee immediately of anything which may warrant review of ethics approval of the research project, including: serious or unexpected adverse effects on participants; unforeseen events that might affect continued ethical acceptability of the project; and a written report about these matters must be submitted to the Academic Committees Office by no later than the next working day after recognition of an adverse occurrence/event. Please note that in cases of adverse events an incident report should also be made to the Health and Safety Office:

http://www.otago.ac.nz/healthandsafety/index.html

Advise the Committee in writing as soon as practicable if the research project is discontinued.

Make no change to the project as approved in its entirety by the Committee, including any wording in any document approved as part of the project, without prior written approval of the Committee for any change. If you are applying for an amendment to your approved research, please email your request to the Academic Committees Office:

gary.witte@otago.ac.nz

jo.farrondediaz@otago.ac.nz

Approval is for up to three years from the date of this letter. If this project has not been completed within three years from the date of this letter, re-approval or an extension of approval must be requested. If the nature, consent, location, procedures or personnel of your approved application change, please advise me in writing.

The Human Ethics Committee (Health) asks for a Final Report to be provided upon completion of the study. The Final Report template can be found on the Human Ethics Web Page

http://www.otago.ac.nz/council/committees/committees/HumanEthicsCommittees.html
Yours sincerely,

[Signature]

Mr Gary Witte  
**Manager, Academic Committees**  
Tel: 479 8256  
Email: gary.witte@otago.ac.nz

c.c. Assoc. Prof. L Houghton  Department of Human Nutrition
Appendix C: Ngāi Tahu Research Consultation Committee letter

The Māori Consultation letter was developed by the Principal Investigators of SuNDiAL.
Monday, 17 December 2018

Dr Meredith Peddie
Department of Human Nutrition

Tēnā Koe Dr Meredith Peddie

The SuNDiAL Project 2019: Survey of Nutrition, Dietary Assessment and Lifestyle.

The Ngāi Tahu Research Consultation Committee (the Committee) met on Tuesday, 11 December 2018 to discuss your research proposition.

By way of introduction, this response from The Committee is provided as part of the Memorandum of Understanding between Te Rūnanga o Ngāi Tahu and the University. In the statement of principles of the memorandum it states “Ngāi Tahu acknowledges that the consultation process outline in this policy provides no power of veto by Ngāi Tahu to research undertaken at the University of Otago”. As such, this response is not "approval" or "mandate" for the research, rather it is a mandated response from a Ngāi Tahu appointed Committee. This process is part of a number of requirements for researchers to undertake and does not cover other issues relating to ethics, including methodology they are separate requirements with other Committees, for example the Human Ethics Committee, etc.

Within the context of the Policy for Research Consultation with Māori, the Committee base consultation on that defined by Justice McGechan:

"Consultation does not mean negotiation or agreement. It means: setting out a proposal not fully decided upon; adequately informing a party about relevant information upon which the proposal is based; listening to what the others have to say with an open mind (in that there is room to be persuaded against the proposal); undertaking that task in a genuine and not cosmetic manner. Reaching a decision that may or may not alter the original proposal."

The Committee considers the research to be of importance to Māori health.

As this study involves human participants, the Committee strongly encourages that ethnicity data be collected as part of the research project as a right to express their self-identity.
The Committee suggests researchers consider the Southern District Health Board's Tikaka Best Practice document, in particular patient engagement. The document also covers the collection, storage and disposal of blood and tissue samples. This document is available on the Southern District Health Board website. The Committee also refers researchers to Te Mana Raraungā Māori Data Audit Tool, which gives an overview of key Māori Data Sovereignty terms and principles.

We wish you every success in your research and the Committee also requests a copy of the research findings.

This letter of suggestion, recommendation and advice is current for an 18-month period from Tuesday, 11 December 2018 to 3 June 2020.

The recommendations and suggestions above are provided on your proposal submitted through the consultation website process. These recommendations and suggestions do not necessarily relate to ethical issues with the research, including methodology. Other Committees may also provide feedback in these areas.

Nāhaku noa, nā

Claire Porima Kaiwhakahaere
Pūtere
Senior Project Manager Office of
Māori Development
Te Whare Wānanga o Otāgo Ph:
+64 3 479 7461
Email: claire.porima@otago.ac.nz Web:
www.otago.ac.nz
Appendix D: Presentation PowerPoint

The Candidate, along with two other MDiet students, developed this PowerPoint and presented it to Hornby High School students in Christchurch.
WHAT IS A DIETITIAN?

- Dietitians are registered health professionals
- Provide expert nutrition advice for people of all ages
- Prescribe dietary treatments for conditions such as diabetes, food allergies, cancers, gastro-intestinal diseases, and overweight and obesity.

WHERE DOES A DIETITIAN WORK?

- Hospitals
- Private practice
- Foodservice
- Sports dietetics e.g. for sports teams like the crusaders
- Public health
- Rest homes
- Media
- Research – e.g. the SuNDiAL project!
STUDY NUTRITION & DIETETICS AT OTAGO

Bachelor of Science Majoring in Human Nutrition (3 years)

OR

Bachelor of Applied Science Majoring in Sport and Exercise Nutrition (3 years)

Followed by:

Masters of Dietetics (2 years)

THE SuNDiAL PROJECT

Survey of Nutrition, Dietary Assessment and Lifestyle project

Nationwide survey of girls aged 15-18 years old
WHY IS IT IMPORTANT?

• Adolescent females are an important group

• We don’t know enough about the nutrition status, food intakes, motivations, attitudes and lifestyles of adolescents in New Zealanders

• The results will allow us to give up to date nutrition advice and create food recommendations specific to you

WHAT DOES THE STUDY INVOLVE?

• SIGN UP
• QUESTIONNAIRES
• 2 X 24 HOUR DIET RECALLS
• WEIGHT,
• HEIGHT
• FOREARM LENGTH
OTHER COMPONENTS

- ACCELEROMETER
- BLOOD TEST
- URINE TEST

EVERYTHING IS CONFIDENTIAL!

- ID numbers instead of names
- Measurements are taken in private
- Everything is OPTIONAL!
- You can pull out of the study at any time
SO, WHATS IN IT FOR ME?

- $5 supermarket voucher for each part of the study you complete
- 6 separate sections of the study
- Blood test results - Iron

 TOTAL OF $30 WORTH OF SUPERMARKET VOUCHERS

HOW DO I SIGN UP?

- Come and see us after today’s assembly and fill out the sign up sheet
- You will receive a link via email to complete the sign up and questionnaires online
- We will then contact you via text to organise to meet sometime later this week or next week
- If you have any questions, come and have a chat!
Appendix E: Participant information sheet

The participant information sheet was developed by the Principal Investigators of SuNDiAL.
Introduction

Thank you for showing an interest in this project. Please read this information sheet carefully. Take time to think about it and talk with family or friends before you decide whether to take part or not.

If you decide to take part we thank you. If you decide not to take part that won’t disadvantage you and we thank you for considering our request.

What is the aim of this research project?

We don’t know much about teenage women’s food intakes and lifestyles in New Zealand. We suspect that they don’t get enough of some nutrients like iron sometimes, and that this can make them feel tired and affect their health. Teenagers often make their own decisions about what foods to eat, but we don’t know very much about why they choose the foods they eat. Therefore in 2019 the SuNDiAL project is going to investigate food intakes, nutrition, health, and why female high school students (aged 15-18 years) choose to eat the way they do.

Who is funding this project?

This project is funded by the Department of Human Nutrition, University of Otago, and a Lottery Health Research Grant.

Who are we seeking to participate in the project?

We are looking for at least 300 female high school students who are between 15 and 18 years old. To be eligible to take part, your high school must have agreed to take
part in the study, you must speak and understand English, and be able to complete the questionnaires.

If you participate, what will you be asked to do?

If you agree to take part in this study you will be asked to do three things:

1) **Complete an online questionnaire**
   After you have completed the consent process you will be asked to complete a questionnaire that asks questions about your health and some general questions such as what ethnicity you identify with this questionnaire also asks you about your overall eating habits, and why you choose to eat the foods that you do. This questionnaire will take about 30 min to complete.

2) **Attend a session at your school with our research team**
   This visit will take about 60 minutes and you will be asked to:
   - Complete a face to face interview with one of our research team during which you will be asked to recall everything you ate and drank the day before.
   - At this session one of our research team will also measure your height, your weight, and the length of your lower arm – these measurements will be done twice to make sure they are as accurate as possible. This will be done in a private space and you won’t be told these measurements unless you ask for them.

3) **Complete a second interview about the food you have eaten on another day**
   Sometime in the 2 weeks after you have finished the session at school you will be contacted by the research team and asked to complete a second interview in which you will be asked to recall everything you ate and drank on a different day of the week than the first interview. This is important because sometimes you can eat quite differently from one day to the next. This interview will be performed over facetime or zoom, at a time that is convenient for you.

There are three other parts to the SuNDiAL project that are entirely optional. Please read the following information carefully before you decide whether to take part in these optional bits of the study. If you agree to do these, but change your mind later, that’s OK - there is no disadvantage to not you if you decide not to do these. You will be asked again on the day if you still want to do them.

1) **Provide a blood sample**
   We would like you to provide a blood sample (which would be collected by someone with extensive training in how to collect blood during the session at school), but we understand that not everyone feels comfortable about this so it is entirely up to you if you do this. However, if you do provide a blood sample, we can tell you whether you’re iron deficient or not. You can still take part in the rest of the study even if you don’t do this bit.

2) **Provide a urine sample**
We would also like you to give a urine (“pee”) sample (which is easy for you collect yourself in the bathroom with the equipment we give you, during the session at school). You can still take part in the rest of the study even if you don’t do this bit.

3) Wear an accelerometer for a week

We would also like you to wear a small red box called an accelerometer on an elastic belt 24 hours a day for the seven days following the session at your school. This will tell us how much time you spend sitting down, moving around, and sleeping. If you choose to wear the accelerometer you will be asked to complete a little diary about the times your took the device off, and what time you went to bed each night on the days that you wear it. One of our research team will return to your school the week after this visit to collect the accelerometer. You can still take part in the rest of the study even if you don’t do this bit.

After the completion of the study you will receive a $5 voucher for each component of the study that you complete. That is $5 for completing the online questionnaire, $5 for completing the face to face interview about what you ate in the last 24 hours, $5 got completing the second interview about what you ate; $5 for providing a blood sample; $5 for providing a urine sample or $5 for wearing the accelerometer for a week. Adding to a possible total of $30 in vouchers.

**Is there any risk of discomfort or harm from participation?**

If you choose to provide a blood sample, you should know that there is a risk of a little pain or discomfort, and possibly a small bruise from the blood test. Any bruising should only last a few days and an experienced nurse or phlebotomist (someone with training to take blood samples) will collect the blood to minimize any discomfort to you.

**What specimens, data or information will be collected, and how will they be used?**

The answers you provide to the questionnaires and the food questionnaire will be entered into a database with every other participants’ answers. All your answers will be kept confidential and stored using an id number, not your name. This information will provide valuable and unique information about the nutrition status of female high school students in New Zealand. Information about why people eat the way they do will also be very helpful if some eating patterns provide health benefits. Ultimately, the results of this study will support the development of up-to-date government and health agency guidelines for young women in New Zealand.

If you provide a blood sample it will be divided into 3 separate parts. One part will be taken to a local laboratory where it will be analysed for Vitamin B12 concentrations and a complete blood count. The other two parts of your blood sample will be transported
to the Department of Human Nutrition at the University of Otago where they will be stored in a freezer until we have finished collecting all the blood samples from around the country. When all the blood samples have been collected, one part of your blood sample will be sent to Germany where it will be analysed for ferritin, soluble transferrin receptor, retinol binding protein, C-reactive protein and alpha-glycoprotein. We are sending this sample to Germany because they have a special machine that can measure these things on a much smaller amount of blood, at a smaller cost, than we can do in New Zealand. The remaining part of your blood sample will remain at the Department of Human Nutrition, where it will be analysed for plasma selenium and plasma zinc, thiamin, plasma folate, Vitamin B6, Leptin, Interlukin-6 and blood lipids.

If you provide a urine sample it will also be transported to the Department of Human Nutrition at the University of Otago where it will be stored in a freezer until it is analysed for iodine concentrations. Once all of the analysis on your blood and urine samples has been completed they will be disposed of using standard biohazard protocols. On the consent form you can indicate to us if you would like your samples disposed of with a Karakia (Māori Prayer). We will only test your samples for the things listed here, and won't test them for anything else.

What about anonymity and confidentiality?

Your information will be identified with an ID number only in the database that contains the results of the study. This database will be stored on the researchers’ computers which are password protected. A backup copy may also be stored on the University’s shared server space, but only Jill Haszard and Meredith Peddie will have the password so no one else can access the information. The information linking you to your ID number will be stored in a separate password protected file that only Jill Haszard and Meredith Peddie will have access to. The only reason they would access this information once you have completed the study would be if you requested your individual results. This file will be destroyed once all participants have been given the opportunity to request individual information. The de-identified information collected as part of this research will be kept in secure storage for at least 10 years.

If you agree to participate, can you withdraw later?

You may pull out of the project before the study has been completed (anticipated to be October 2019) without any disadvantage to yourself of any kind. Once data collection is completed and your information is integrated into the study it will no longer be possible to withdraw your information from the study.

Any questions?
If you have any questions now or in the future, please feel free to contact either:

<table>
<thead>
<tr>
<th>Name</th>
<th>Contact phone number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dr Jill Hazzard</td>
<td>03 479 5683</td>
</tr>
<tr>
<td>Senior Research Fellow</td>
<td></td>
</tr>
<tr>
<td>Department of Human Nutrition</td>
<td></td>
</tr>
<tr>
<td>Dr Meredith Peddie</td>
<td>03 479 8157</td>
</tr>
<tr>
<td>Research Fellow</td>
<td></td>
</tr>
<tr>
<td>Department of Human Nutrition</td>
<td></td>
</tr>
</tbody>
</table>

This study has been approved by the University of Otago Human Ethics Committee (Health). If you have any concerns about the ethical conduct of the research you may contact the Committee through the Human Ethics Committee Administrator (phone +64 3 479 8256 or email gary.witte@otago.ac.nz). Any issues you raise will be treated in confidence and investigated and you will be informed of the outcome.
Appendix F: Dietary Habits questionnaire

The dietary habits questionnaire was developed by the Principal Investigators and MDiet students, including the Candidate, based on questionnaires that have been used in the NZ 2008/09 Adult Nutrition Survey (Ministry of Health, 2011). Below are the supplement questions of the questionnaire only.
### Supplement Use

**Did you take any supplements during the last year?**  
- [ ] Yes  
- [ ] No

**What type of supplement was it? (Select as many as apply)**
- [ ] Multivitamin and/or multimineral  
- [ ] Single vitamin or mineral  
- [ ] Oil  
- [ ] Bran  
- [ ] Lecithin  
- [ ] LSA  
- [ ] Kelp  
- [ ] Spirulina  
- [ ] Glucosamine and/or chondroitin  
- [ ] Echinacea  
- [ ] Ginkgo  
- [ ] Hypericum (St John's Wort)  
- [ ] Sports supplement  
- [ ] Other (please specify)

**Multivitamin and/or multimineral: How long did you take the supplement in the last 12 months?**
- [ ] Daily  
- [ ] More than once a week  
- [ ] Once per week  
- [ ] Monthly  
- [ ] Regularly but for a limited time  
- [ ] Not very often

**Multivitamin and/or multimineral:**

If you know the brand name and/or the product name please write them here. Please provide as much information about the product as possible.

**Multivitamin and/or multimineral:**

If you are able to take a photo of your supplement packaging, please do so and upload here (you can complete the questionnaire and come back to upload a photo at a later time).

When taking a photo (or two), please make visible the brand and the list of contents.

**Single vitamin or mineral:**

Please tell us what vitamin or mineral it was:

**Single vitamin or mineral: How long did you take the supplement in the last 12 months?**
- [ ] Daily  
- [ ] More than once a week  
- [ ] Once per week  
- [ ] Monthly  
- [ ] Regularly but for a limited time  
- [ ] Not very often

**Single vitamin or mineral:**

If you know the brand name and/or the product name please write them here. Please provide as much information about the product as possible.
Single vitamin or mineral:

If you are able to take a photo of your supplement packaging, please do so and upload here (you can complete the questionnaire and come back to upload a photo at a later time).

When taking a photo (or two), please make visible the brand and the list of contents.

<table>
<thead>
<tr>
<th>Spirulina: How long did you take the supplement in the last 12 months?</th>
<th>Daily</th>
<th>More than once a week</th>
<th>Once per week</th>
<th>Monthly</th>
<th>Regularly but for a limited time</th>
<th>Not very often</th>
</tr>
</thead>
</table>

Spirulina:

If you know the brand name and/or the product name please write them here. Please provide as much information about the product as possible.

Echinacea: How long did you take the supplement in the last 12 months?

<table>
<thead>
<tr>
<th>Echinacea: How long did you take the supplement in the last 12 months?</th>
<th>Daily</th>
<th>More than once a week</th>
<th>Once per week</th>
<th>Monthly</th>
<th>Regularly but for a limited time</th>
<th>Not very often</th>
</tr>
</thead>
</table>

Echinacea:

If you know the brand name and/or the product name please write them here. Please provide as much information about the product as possible.

Echinacea:

If you are able to take a photo of your supplement packaging, please do so and upload here (you can complete the questionnaire and come back to upload a photo at a later time).

When taking a photo (or two), please make visible the brand and the list of contents.
If Other, please specify: ________________________________

Other: How long did you take the supplement in the last 12 months?

☐ Daily
☐ More than once a week
☐ Once per week
☐ Monthly
☐ Regularly but for a limited time
☐ Not very often

Other: ________________________________

If you know the brand name and/or the product name please write them here. Please provide as much information about the product as possible.

Other: ________________________________

If you are able to take a photo of your supplement packaging, please do so and upload here (you can complete the questionnaire and come back to upload a photo at a later time).

When taking a photo (or two), please make visible the brand and the list of contents.
Appendix G: Anthropometric protocols

This protocol was developed by Jill Haszard based on the Ministry of Health, (2008). The Candidate used it to collect height and weight data from participants.
Gain verbal consent from the participant for each measurement and explain fully what you will do to obtain them. Before beginning, gain consent from the participant to use non-permanent pen for marking anatomical landmarks.

NB: anthropometry tapes have a blank lead before measurement markings start - consider this when reading a measurement.

**HEIGHT**

1. Ask the participant to remove their shoes, as well as any hair ornaments or buns/braids on the top of the head.

2. If the participant is taller than the investigator, use a step tool to take the measurements. Errors can be minimised by the investigator being parallel to the participant and the headpiece.

3. Tell the participant to stand with their heels together and toes apart pointing outward at approximately a 60-degree angle.

4. Make sure the back of the head, shoulder blades, buttocks, and heels of the participant are touching the backboard/stadiometer.

5. Make sure the participant’s head is aligned in the Frankfort horizontal plane, where a horizontal line connects from the ear canal to the lower border of the orbit of the eye.

6. Lower the headpiece to rest firmly on the top of the participant’s head and ask the participant to stand as tall as possible and take a deep breath.

7. Record the result to the nearest 0.1 cm in the HEIGHT 1 box on the recording sheet without informing the participants.
WEIGHT

1. Ask the participant to remove any heavy clothing (such as jackets, heavy tops, boots etc). As the participant would have just had their height measurement done, they should not be wearing shoes.

2. Turn on the scales, ensure they are switched on to metric (kg).

3. Ask the participant to step on to the scales so that they are facing away from the display (prevent seeing the weight) cautioning them that they need to step up onto the scales.

4. Wait for the scales to read or come to a stable number.

5. Record the participant’s weight to the nearest 0.1 kg in the WEIGHT 1 box on the recording sheet without informing the participant

REPEAT ALL MEASUREMENTS

Repeat all measurements again, in the same order, entering the measurements in the HEIGHT 2 and WEIGHT 2 box as appropriate (do no tell participant measurements).

CHECK: are any of the 1st and 2nd measurements are more than 0.5 units apart? If so, take a third measurement where required.
Appendix H: Food model booklet

This food booklet was developed by Chaya Ranasinghe. The following photos are attributed to intake 24 and are copyright (c) 2016. They are made available under an open government license. The Candidate used the booklet to help participants estimate portion sizes.
Appendix I: Protocol for entry of dietary data into FoodWorks

This protocol was developed by Kirsten Webster and Liz Fleming. The Candidate was responsible for applying this protocol to twelve 24-hour recalls when entering them.
FoodWorks instructions HUNT5B SunDial project S1 – 2019

On your laptop:

1. Go to www.otago.ac.nz/studentdesktop and login

   Kirsten will give you some verbal instructions to get to the student desktop.

   You can then choose to use the “light” version which runs the student desktop in a browser window, or follow the instructions and install the Citrix software which allows the student desktop to run more efficiently and in full screen mode.

   You may need to enable popups for this website.

Opening FoodWorks

1. Click the Windows icon in the bottom left corner
2. Click All programs, click course specific resources/Human Nutrition/FoodWorks
3. Click Open and click on Otago/FoodList 2018.fwb change if get updated Otago Foodlist
4. Click Open

Entering a 24-hour recall

A. First, create the new 24-hour recall:
   1. On the toolbar, click New ☐ then click Food Record,
   2. On the General tab, in the Name box, type the name for the 24 hour recall i.e., for your practice 24 hour recall type your name or ID number, for all Sundial participants type sundial_xx_dr1 or sundial_xx_dr2 depending on which diet recall you are entering, and there the xx will be replaced with the ID number for that participant. For example if you are entering the first 24 h recall for participant ID 10 you will enter sundial_10_dr1
   3. Click the Folder drop-down button and select the folder in which you want to store the food record. By default there is one folder called Documents. Click Save or find a folder on your student desktop to save it to.
   4. Enter your student ID number into the ID Box (this is so Jill can easily identify where data has come from later), do not enter other personal details.

B. Entering foods

1. Click the Foods tab.
2. Click in the Day column and select the date that record was taken.
3. In the Meal column, type the time of the first meal (be sure to enter the time using the 24 h clock, using a colon to separate the hours and minutes. For
example if the food was eaten at 10 pm record the time as 22:00) then press Enter.

4. In the Food column, type the first few letters of each word of the food. A list of matching foods (the food selection list) is shown. Use the arrow keys to select the food from the drop-down list box, then press Enter. (alternate option double click on chosen food)

5. In the Quantity column, use the arrow keys to select the measure that you want to use, or type the first few letters of the measure name. Then type the number of units for the measure that you want to use, then press Enter. (alternate option double click on measure descriptor)

6. Repeat the steps as necessary

NB: To copy foods – hover over the food you want to copy and right click on the mouse and choose copy. Then hover over the blank cell where you want the food to appear and click paste. If the words are in blue font instead of black then double click and select the food to make it 'enter' properly. It needs to be in black font for the correct measures to show.

C. Create the new recipe

To create a new recipe:

1. On the FoodWorks toolbar, click New, then click Recipe.

2. On the General tab, in the Name box, type the name for the recipe.
3. Optionally, enter your ID for the recipe.
4. Click the **Folder** drop-down button and select the folder in which you want to store the food. By default there is one folder, *Documents*.

If you want to create a new folder, click the ellipsis (...) button, type the folder name, and click **OK**.
5. On the toolbar, click the **Save** button.
B. Enter the ingredients for the recipe
To enter the ingredients for the recipe:
1. Click the Ingredients tab.

*Example Ingredients grid*

2. In the **Ingredient** column, type the first few letters of each word of the ingredient. Use the arrow keys to select the ingredient from the drop-down list box, then press **Enter**. A list of matching foods (the food selection list) is shown.

*Example recipe showing the food selection list*
3. In the **Quantity** column, type the value (a number) for the measure that you want to use. A drop-down list displays the available measures for this item.

*Example*

4. Use the arrow keys to select the measure that you want to use, or type the first few letters of the measure name. Then press Enter.
5. Repeat these steps for each ingredient in the recipe.
C. Enter the serve weight for the recipe
To enter the serve weight (in grams):
• On the Ingredients tab, in the Serve Weight (g) box (at the bottom of the Ingredients grid), enter the serve weight.

**NOTE: Number of Serves versus Serve Weight**
Click the button to toggle between Serve Weight (g) and Number of Serves and enter whichever value is more convenient.

D. Enter the yield for the recipe
If the processing step for this recipe will result in a change in weight due to the loss or gain of water, then you need to set the yield.
To set the yield:
• If you already know the final percentage weight of the recipe, on the Ingredients tab, in the Yield box, type the percentage.
• If you know the final weight of the recipe, FoodWorks can calculate the yield for you.
To enter the final weight, click the ellipsis (...) button, type in the final weight, then click OK.

E. If the recipe is a beverage or liquid
If the recipe is a beverage or liquid:
1. Click the Measures tab.
2. Set the density by entering a volume (in mL) and its corresponding weight (in g).
3. Select the Liquid check box.

**F. Save the recipe**
To save the recipe: On the FoodWorks toolbar, click Save.

**D. Save the 24 hour recall**
To save: On the FoodWorks toolbar, click Save.

---

**Analysing dietary intakes and meal plans**

**A. Basics—Using the Analysis Pane**
To view the analyses for the food record:
1. To show the Analysis Pane (if it is not already displayed), on the FoodWorks toolbar, click the View Analyses button.
2. To choose the unit of analysis for the 24 hour recall: Click the tabs at the top of the Analysis Pane. You can look at the analyses as an average per day or per megajoule.
3. Then, in the list of analyses, click the analysis you require (e.g. General): If the Analysis Pane is wide, the analyses are listed down the left of the pane. If the Analysis Pane is narrow, the analyses are shown as a drop-down list. Click the down arrow to display the list.

**B. Customising the nutrient profile**
You can create your own customised list of the nutrients of interest to you by editing the Profile analysis. To add or delete nutrients from the Profile analysis:
1. If the Analysis Pane is wide: In the list of analyses on the left, click Profile, then click the Edit Profile button. - OR - If the Analysis Pane is narrow: Point over the Analysis Pane, click right, then click Edit Profile Nutrients.
2. Select or de-select nutrients as required (for this assignment click Energy, Carbohydrate, protein, fat, fibre, water, iron, sodium, potassium, calcium and vitamin C. Then click OK. These nutrients will appear on your analysis page.

**Investigating a particular nutrient**
To see more information for a nutrient:
1. Make sure the Analysis Pane is wide, that is, showing the list of analyses on the left (Drag the left side of the table towards the left).
2. Then, in the Analysis Pane, click the nutrient name. Some information appears on the left of the Analysis Pane, and a new column appears in the foods grid.
Example—Clicking protein – information in the Analysis Pane

**Checking your partner’s data entry**
Save a screen shot of the practice 24-hour recall that you entered.
1. Make sure you have the whole day in the screen shot or scroll down and take a second screen shot. (on a Mac - Print part screen: Shift command 4 and select the section to print)
2. Send to or print screen shot for your partner to check.
3. If alterations are needed record them on the manual copy and discuss with your partner. Make changes required on FoodWorks. Take notice of the changed nutrient values and assess whether they make sense or not. If you still have questions ask Liz or Kirsten.

Exporting your SunDial data for further analysis by Jill Haszard

You can export your data to Microsoft Access for further analysis in other software such as an Excel spreadsheet.

To export data from a FoodWorks database to Microsoft Access:

1. Open the FoodWorks database.
2. On the Tools menu, click Export.
3. Follow the instructions shown. However, do not tick the option boxes. FoodWorks creates a new Microsoft Access database containing the data from your FoodWorks database. This takes several minutes on the student desktop. Select yes to View exported data with Microsoft Access?
4. Double-click on ‘Diets’ under ‘Queries’. A nutrient line(s) for your 24-hour recall(s) will show in the first row (and subsequent rows). Click External data, click Excel under the words database tools and tick the first two tick boxes. Save to the student desktop with a name you will remember, e.g., ‘SunDial (your name or student ID number) 24 hour recalls’. Click OK.
5. An Excel screen opens with your saved data.
6. Close Excel which will have your saved data, then close the Access database without saving
Appendix J: SuNDiAL codebook

The SuNDiAL codebook was developed by Kirsten Webster, Chaya Ranasinghe, Liz Fleming and MDiet students, including the Candidate. The Candidate identified these default foods, substitutions and recipes below which were added to the SuNDiAL Codebook by Chaya Ranasinghe.
### Default foods & Substitutions:

<table>
<thead>
<tr>
<th>Unspecified/unmatched food item</th>
<th>FOODfiles Food ID</th>
<th>FOODfiles food description</th>
</tr>
</thead>
<tbody>
<tr>
<td>White bread Coupland’s</td>
<td>A1007</td>
<td>BREAD, WHITE, SLICED, PREPACKED</td>
</tr>
<tr>
<td>Pie Coupland’s potato top with mince</td>
<td>R3089</td>
<td>Pie, bought, mince, potato topping only (no crusts)</td>
</tr>
<tr>
<td>SUNNY CRUST MULTIGRAIN TOAST 600G</td>
<td>R4659</td>
<td>Bread, multi-grain light</td>
</tr>
<tr>
<td>homemade white bread</td>
<td>A143</td>
<td>pizza base [Documents]</td>
</tr>
<tr>
<td>White bread rolls Coupland’s</td>
<td>A174</td>
<td>bread roll, white, spmkt fresh, south island</td>
</tr>
</tbody>
</table>
## Recipes:

<table>
<thead>
<tr>
<th>Unspecified/unmatched food item</th>
<th>FOODfiles recipe</th>
<th>Amount</th>
<th>Retention factor (RF)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Belvita breakfast biscuit (2 serves)</td>
<td>- Biscuit, oatcake</td>
<td>90g</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Sugar, caster</td>
<td>10g</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Oats, rolled, raw</td>
<td>1g</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Coconut oil</td>
<td>0.4g</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Butter, anchor spread blue dairy (20 serves)</td>
<td>- Cream, standard</td>
<td>42g</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Oil, canola</td>
<td>35g</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Milk, 2% fat, ancho</td>
<td>3g</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Oil, vegetable, blend</td>
<td>20g</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mayonnaise best foods (28 serves)</td>
<td>- Oil, vegetable, blend</td>
<td>312g</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Egg, whole, raw</td>
<td>24g</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Egg, yolk, raw</td>
<td>3g</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Vinegar</td>
<td>3g</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Juice concentrate, lime/lemon, unsweetened (undiluted)</td>
<td>1tb</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Sugar, raw</td>
<td>1 tsp</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Salt, table</td>
<td>1 tsp</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Spices, allspice, ground</td>
<td>4g</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Water, tap</td>
<td>24g</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pizza hut pepperoni (1 slice)</td>
<td>- Pizza, dominoes, pepperoni, classic crust</td>
<td>60g</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Oil, coconut</td>
<td>2g</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Cheese, mozzarella</td>
<td>4g</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Savoury cheese pie (12 serves)</td>
<td>- Cheese, Colby</td>
<td>350g</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Egg, whole, raw</td>
<td>(6 x size 6 eggs)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Pastry sheets, flaky/puff, bought ready to use</td>
<td>(2 ready rolled sheets flaky puff, raw yield)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Milk, cow, standard 3.3% fat, fluid, Christchurch, May, Meadow Fresh</td>
<td>1 cup</td>
<td></td>
</tr>
<tr>
<td>Meatball Subway (6-inch sub)</td>
<td></td>
<td>Vegetable and lentil soup (1 serve)</td>
<td></td>
</tr>
<tr>
<td>-----------------------------</td>
<td>---</td>
<td>-----------------------------------</td>
<td></td>
</tr>
<tr>
<td>• Bread roll, white, spmkt fresh, South Island</td>
<td>• (1 frankfurter roll (&gt;15cm long)</td>
<td>• potatoes boiled in skin</td>
<td></td>
</tr>
<tr>
<td>• Mini meatballs in tomato sauce (RH03)</td>
<td>• (4 meatballs)</td>
<td>• vege, green, boiled, water used</td>
<td></td>
</tr>
<tr>
<td>• Cheese, cheddar, mild</td>
<td>• (1.5 slices, prepacked)</td>
<td>• vege, other; boiled, water used</td>
<td></td>
</tr>
<tr>
<td>• Lettuce, raw</td>
<td>• (1/3 cup chopped)</td>
<td>• vege, other; boiled, water used</td>
<td></td>
</tr>
<tr>
<td>• Onion, flesh, raw</td>
<td>• 1 tb</td>
<td>• legumes, cooked, 45/75mins, boiled, water used</td>
<td></td>
</tr>
<tr>
<td>• Carrot, raw</td>
<td>• 1 tb</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Cucumber, flesh, raw</td>
<td>• 5 slices (1 slice 3.5cm dia, 0.5cm thick)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Sauce, barbecue</td>
<td>• 1 tb</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vegetable and lentil soup (1 serve)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Potato, flesh &amp; skin, waxy, boiled, drained, no salt added</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Celery, stem, raw</td>
<td>• 1/2 small potato (small potato = 5.5 x 4.4cm diameter)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Onion, flesh, raw</td>
<td>• (1 small stalk (13cm long))</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Carrot raw</td>
<td>• (1/4 cup)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Lentils, red, cooked</td>
<td>• (1/2 cup chopped)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Oxo cubes</td>
<td>• (1/2 cup cooked)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Water, tap</td>
<td>• 1 tsp</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• 2 cups</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix K: Iron supplement data

The iron supplement data was developed by the Candidate and one other MDiet student in an Excel spreadsheet. The Candidate calculated the daily iron amount from supplements for each participant in order to calculate total iron intakes (i.e. intake from diet and supplements).
<table>
<thead>
<tr>
<th>Supplement_code</th>
<th>Unit</th>
<th>Supplement_brand/type</th>
<th>Iron</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4</td>
<td>Healtheries / spirulina</td>
<td>4.6</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>Red_seal / Womens_Multivitamin</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>1</td>
<td>Care_Pharmaceuticals / Fab_Iron_+_VitaminB_complex</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>1</td>
<td>Healtheries / Iron_Vit C</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>1</td>
<td>Blackmores / nail_hair_skin</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>1</td>
<td>Floradix / iron_vitamin</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>4</td>
<td>Healtheries / super_green_smoothie_booster</td>
<td>2.07</td>
<td>The proportion of iron was estimated as 2.07mg based off the healtheries / spirulina value</td>
</tr>
<tr>
<td>12</td>
<td>3</td>
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<td>Comes in sachets that contain 25mls trefriw wells mineral water equivalent to 5mg elemental iron (oral liquid). Assumed that 100% of ferrous iron is iron.</td>
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Calculation for the amount of iron in healtheries / super_green_smoothie_booster based off the healtheries /spirulina value

- The amount of iron in the healtheries spirulina powder is 4.6mg per serve (10 serves per packet) and 82.7mg per 100g. \( \therefore \) 82.7mg / 100g = 0.827mg of iron in 1g of spirulina powder.
- The healtheries super green smoothie booster contains 120g of product made up with 25% spirulina powder \( \therefore \) 120g x 0.25 = 30g of spirulina powder in the 120g product. (note: there are 12 servings per packet \( \therefore \) 30 / 12 = 2.5g of spirulina powder per serve)
- \( \therefore \) 2.5g of spirulina powder from the super green smoothie booster multiplied by the amount of iron in 1g of the healtheries spirulina (2.5g x 0.827mg = 2.07mg)
## Iron data dictionary

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<th>Variable / measured in mg per serve</th>
<th>Variable_label</th>
<th>Data_type</th>
<th>Value_label</th>
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<td>Unique name for each supplement reported by participants</td>
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## Iron data

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Appendix L: School recruitment flow diagram

This flow diagram was developed by Jill Haszard.
97 eligible schools

25 schools selected for invitation
Selection criteria:
• Female roll (larger preferred)
• School decile (range from all deciles)

25 selected schools invited by email
• 3 schools declined
• 15 schools no response
• 2 schools accepted but no further response

3 additional schools invited in person
• 0 schools declined
• 0 schools no response
• 0 schools accepted but no further response

8 schools consented
Appendix M: Original participant recruitment flow diagram

This flow diagram was developed by Jill Haszard. The Candidate used it to develop a similar flow diagram presented in the thesis.
1882 eligible participants
• ~806 present at recruitment drives

263 eligible participants sent link to enrolment
• 84/182 16-18 year olds did not respond
• 13/81 parents of 15 year olds did not respond
• 0 parents of 15 year olds declined
• 10/32 15 year olds did not respond after parental consent
• 2 responded to link but declined
• (9/18 parents of 16-18 year olds from one school that required parental consent did not respond or were uncontactable)

154 consented to participate

145 completed enrolment
• 144 completed the health & demographics questionnaire
• 129 completed the attitudes and motivations questionnaire
• 124 completed the dietary habits questionnaire

132 attended school visit
• 130 had complete anthropometric measures
  - 2 missing due to technical issues
• 132 completed first 24 hr recall
• 113 completed repeat 24 hr recall
• 19 refused repeat 24 hr recall

127 consented to blood sample
• X gave blood
• X changed mind
• X not available on the day
• X not able to get sample

129 consented to accelerometer
• X have data
• X no available accelerometer
• X did not return accelerometer

121 consented to urine sample
• X gave urine
• X changed mind
• X not available on the day