Zinc intakes and main food sources of zinc in New Zealand adolescent females

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Abstract

Background: It has been proposed that New Zealand (NZ) adolescent females are currently going through a dramatic change in food selection patterns. Due to this, there have been concerns around the adequacy of zinc intake in these young women. The research in NZ on zinc intake and its main food sources in adolescent females is currently limited to only one nationally representative survey conducted a decade ago.

Objective: The aim of this thesis was to describe the zinc intake of adolescent females 15-18 years of age in NZ. The objectives were to: 1) determine the zinc intake of NZ adolescents 15-18 years of age, 2) determine the prevalence of inadequate and potentially excessive intakes of zinc in NZ female adolescents at 15-18 years of age using diet and supplemental intake data, and 3) identify key food sources of zinc for NZ female adolescents at 15-18 years of age.

Design: The Survey of Nutrition Dietary Assessment and Lifestyle (SuNDiAL) project is a cross-sectional survey of adolescent females 15-18 years of age (n=145) recruited from eight secondary schools between February and March 2019. The Candidate collected data from a subset of these participants. Data from all participants are reported in the thesis. Online self-administered questionnaires were used to collect data on participants’ demographics, health and supplement use. Following this, participants attended three appointments over the course of two weeks where height and weight were measured and two 24-hour recalls were conducted. Data from the 24-hour recalls were analysed using the dietary software programme FoodWorks to calculate zinc intakes and the main food sources of zinc in the diet.
**Results:** The majority of the study participants appeared to have an adequate intake of zinc with a mean dietary zinc intake of 9.3mg/day and a median total zinc intake of 9.2mg/day when dietary and supplemental zinc intake was combined. In total, 10.6% of participants were at risk of inadequate zinc intake and one participant had an excessive intake when using the Australian and NZ age-specific Estimated Average Requirement and Upper Level of Intake for females. ‘Grains and pasta’ was the primary food source of zinc intake contributing 10.9%, followed by ‘bread-based dishes’ and ‘bread’, at 9.3% and 8.1% respectively. In an additional analysis, there was only one significant association found between dietary zinc intake and characteristics measured in the study: students who attended the school from the lowest school decile had a significantly lower zinc intake on average than students from the highest decile schools ($p=0.010$).

**Conclusion:** These findings are consistent with current NZ and Australian literature which suggest that the majority of adolescent females are consuming an adequate zinc intake. However, we cannot conclude that zinc is not a nutrient of concern in the NZ adolescent female population based on dietary zinc alone. Further research should assess the biochemical zinc status of this age group of young women, in order to determine whether these dietary zinc intake data reflect zinc status.

**Key words:** adolescent, female, New Zealand, zinc, dietary intake, adequacy, excessive intakes, supplement, food source
Preface

The Candidate was supervised by Associate Professor Anne-Louise Heath (Department of Human Nutrition, University of Otago). This thesis focuses on the data collected during the first phase of the SuNDiAL (Survey of Nutrition Dietary Assessment and Lifestyle) project. The overall SuNDiAL study design and concept were developed by the Principal Investigators Dr Jill Haszard (Division of Sciences, University of Otago) and Dr Meredith Peddie (Department of Human Nutrition, University of Otago), who applied for ethical approval, research funding and were responsible for overseeing and guiding all aspects of the study. Liz Fleming (Department of Human Nutrition, University of Otago) provided guidance and oversaw the use of the dietary analysis software, FoodWorks (Xyris software, Australia). Dr Jill Haszard provided advice on the statistical analyses. The Candidate, under supervision, was responsible for the following:

- Searching the literature and writing the literature review.
- Assisting in developing the PowerPoint presentation used for advertising the project to potential participants.
- Presenting the study to a school assembly at a school in Christchurch, New Zealand, to recruit participants.
- Recruiting participants at a school in Christchurch, New Zealand.
- Administering the study information sheet to potential participants.
- Communicating with the high-school principal, the phlebotomist and potential participants when scheduling in-school and online appointments.
- Conducting first, second and third appointments, as per protocols:
First appointment: Conducting a face-to-face 24-hour recall and collecting anthropometric measurements (weight, height, and ulna length).

Second appointment: Conducting the urine sample collection.

Third appointment: Conducting a 24-hour recall online.

- Arranging the collection of accelerometers.
- Dropping off blood samples to Southern Community Laboratories (SCL) in Christchurch, New Zealand.
- Assisting with follow-up and reminder text messages to participants.
- Entering 24-hour recall data into dietary analysis software, FoodWorks:
  - Entering data from four first 24-hour recalls and six second 24-hour recalls.
  - Creating 20 recipes
    - Identifying 21 default and 21 substitutions for foods that were not available on FoodWorks but had a close match.
- Assisting in the organisation of grocery vouchers for participants.
- Processing and creating a database (with one other Master of Dietetics student) of supplements containing iron or zinc taken by participants.
- Statistically analysing the data (except the food group data).
- Interpreting the data.
- Writing this thesis.
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<th>Description</th>
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<td>ANS</td>
<td>Adult Nutrition Survey</td>
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<tr>
<td>BMI</td>
<td>Body mass index</td>
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<td>BMI-for-age</td>
<td>Body mass index-for-age</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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<tr>
<td>IZiNCG</td>
<td>The International Zinc Nutrition Collaborative Group</td>
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<tr>
<td>kJ</td>
<td>Kilojoules</td>
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<tr>
<td>mg</td>
<td>Milligrams</td>
</tr>
<tr>
<td>n</td>
<td>Sample size</td>
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<tr>
<td>NIP</td>
<td>Nutrition information panel</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 Other</td>
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<tr>
<td>PhD</td>
<td>Doctor of Philosophy</td>
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<tr>
<td>RDI</td>
<td>Recommended Dietary Intake</td>
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<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>
</tr>
<tr>
<td>UL</td>
<td>Upper Level of Intake</td>
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<td>WHO</td>
<td>World Health Organization</td>
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1 Introduction

Over the years there has been a dramatic change in food selection patterns in adolescent females driven by perceived health benefits of particular eating patterns; and body weight, financial and/or moral concerns (Gibson & Heath, 2011; Puloka et al., 2017; Richardson, 1994; Utter et al., 2019). This has raised questions around the prevalence of nutrient inadequacy in adolescent females, with New Zealand (NZ) and Australian literature showing some concern around the risk of zinc deficiency (Gibson & Heath, 2011; Gibson et al., 2002; Rangan & Samman, 2012). Zinc has been identified as an at-risk nutrient during adolescence due to the combination of high zinc requirements during periods of rapid growth and inadequate dietary zinc intake due to poor quality diets with dietary habits and preferences beginning to form (Gibson & Heath, 2011; Gibson et al., 2002; Gibson et al., 2008). Zinc deficiencies can lead to detrimental effects including abnormalities in skeletal growth and delayed sexual and bone maturation (Brown et al., 2004; Gibson & Heath, 2011; Ministry of Health, 2014).

As inadequate dietary intake of zinc is the most likely cause of zinc deficiency, dietary assessment is an important component in evaluating its risk (Hotz, 2007). To date, studies from Australia show the rates of inadequate intake of zinc in adolescent females to be approximately between 8% and 17% (Ho et al., 2017; Rangan & Samman, 2012). Although these data represent zinc intakes in Australia, a country likely to have similar eating patterns to NZ, zinc intake has not yet been extensively studied in NZ. In NZ, research on zinc intake in adolescent females is limited to one nationally representative survey which was conducted a decade ago (University of Otago and Ministry of Health, 2011a). The 2008/09 NZ Adult Nutrition Survey reported a 6.5% estimated prevalence of inadequate intakes with ‘bread-based dishes’ being the highest
contributor to dietary zinc intake, followed by ‘grains and pasta’ and ‘bread’ (University of Otago and Ministry of Health, 2011a), none of these sources containing highly bioavailable zinc.

The aim of this study was to describe zinc intake and the main food sources of zinc in adolescent females aged 15-18 years in NZ and determine the adequacy and safety of their current zinc intakes. Subsequently, this study will be part of a larger, nationwide study which will determine health benefits of the modern vegetarian eating pattern, while also examining the possible risks of nutrient inadequacy.
2 Literature Review

2.1 Aim of this literature review

Zinc intakes and zinc dietary sources are discussed in this chapter with a particular focus on intake in New Zealand (NZ) adolescent females. As the literature has expressed concerns around the adequacy of zinc intakes in these young women, this literature review also discusses the dietary zinc recommendations for adolescent females and the challenges of achieving adequate zinc intake in this population.

2.2 Literature review methods

The following searches were conducted in September, October, and November of 2018 in order to review the literature on zinc intake and zinc dietary sources in adolescent females. The electronic databases used were PubMed (from 2000 to 2018), Ovid (from 2000 to 2018), Google Scholar (from 1970 to 2018), and Scopus (from 2000 to 2018). The University of Otago library website (https://www.otago.ac.nz/library/index.html) was also used to identify relevant literature. Reference lists of original and review articles were examined to identify additional studies. Search strategies and key terminology used are outlined in Table 2.1. For inclusion in the literature review, articles were full length, in human participants and in English. Searches were limited to articles reporting studies carried out in NZ and Australia only. Searches focused on findings in adolescent females (aged 15-18 years) but were extended to include pre-menopausal adult women (aged 18-50 years) as limited research in adolescent females was available.

The World Wide Web was used to access information from the NZ Ministry of Health, World Health Organization (WHO), The International Zinc Nutrition
Collaborative Group (IZiNCG) and guidelines from the government sites of NZ, Britain, and Canada.

Table 2.1 Search strategies and key terminology used to identify zinc intake and zinc food sources in female adolescents and pre-menopausal adult women

The following terms were used in search engines:

1. Zinc
2. Intake
3. Source
4. Adolescent
5. Teenager
6. Female
7. Women
8. Adult

The following combinations of terms were used to search for zinc intakes in adolescent females:

9. (1) and [(4 or (5)] and [(6 or 7)]
10. (1) and (2) and [(4 or (5)] and [(6 or (7)]

The following combination of terms were used to search for food sources of zinc in adolescent females:

11. (3) and (9)

The following combination of terms was used to search for zinc intakes and zinc food sources in pre-menopausal adult women:

12. (1) and (2) and (3) and [(6 or (7)] and (8)

2.3 Challenges to achieving adequate zinc intake for adolescent females

Zinc is involved in a diverse range of physiological and metabolic functions in the human body which peak at adolescence (Brown et al., 2004). These functions include physical growth, reproductive function, immune-competence, and neuro-behavioural development (Brown et al., 2004). As a group, adolescent females are likely to be at
high risk of zinc inadequacy due to increased growth rate, demanding social pressures and possible changes in eating patterns (Gibson & Heath, 2011; Gibson et al., 2008).

2.3.1 Physiology
Adolescence is a time of peak growth and development which provides challenges when trying to maintain adequate zinc status (Urbano et al., 2002). A major challenge to achieving zinc adequacy is the high physiological requirements as a result of puberty, which is accompanied by processes such as sexual maturation, onset of menarche and increased erythropoiesis (Brown et al., 2004; Gibson & Heath, 2011; Roohani et al., 2013; Urbano et al., 2002). The maximum rate of muscle growth also occurs during adolescence (Urbano et al., 2002). As zinc has no functional reserve or body store, when dietary zinc intakes are inadequate, growth is reduced in order to maintain homeostasis and conserve tissue zinc levels (Brown et al., 2004; Gibson et al., 2008). Consequently, a diet with inadequate amounts of zinc during adolescence can also delay sexual maturation and limit skeletal growth and mineralisation (King, 1996; Urbano et al., 2002). Despite the growth spurt finishing around the mid-teens, additional zinc may still be required after this phase in order to restore zinc pools as a result of these previously increased demands (Brown et al., 2004; Roohani et al., 2013).

More research is still required on the subject of adolescent females and the amount of endogenous zinc lost from different areas, including integument and menstrual fluid (Brown et al., 2004).

2.3.2 Dietary
Due to interactions in the intestine, achieving adequate zinc intake depends on the quantity and the bioavailability of zinc in foods (Hotz et al., 2003). Identification of
dietary factors that inhibit and enhance zinc absorption is therefore of paramount importance, as with such knowledge adequate zinc intake may be met through suitable dietary advice. Dietary protein has been shown to enhance zinc absorption whereas phytate, calcium, and iron supplements are all thought to inhibit zinc absorption (Hotz et al., 2003; Hunt & Beiseigel, 2009; Lonnerdal, 2000; Ojo & Brooke, 2016; Roohani et al., 2013). The type of diet consumed can provide challenges when trying to achieve adequate zinc intake as inhibitors of zinc absorption in foods tend to be a main contributing factor in zinc deficiency (Lonnerdal, 2000).

The amount of protein in food is positively associated with zinc absorption (Sandstrom & Cederblad, 1980). Increasing protein content results in a larger percentage of dietary zinc absorbed, however, it should be acknowledged that protein is also a major source of dietary zinc thus, in general, an increased protein intake leads to an increased zinc intake and a higher bioavailability of the total zinc (Lonnerdal, 2000). Animal protein appears to have further enhancing effects on zinc absorption, although casein which is the protein found in milk, has shown inhibitory effects (Lonnerdal, 2000).

Phytate has been shown to have an inhibitory effect on zinc absorption (Lonnerdal, 2000). Phytate has the ability to bind and form insoluble complexes with minerals such as zinc, meaning they pass through the intestine unabsorbed (Lonnerdal, 2000). Foods containing fibre have also shown to have the same effect, however, this may be attributable to the fact most foods containing fibre also contain phytate (Lonnerdal, 2000). The inhibitory effect of phytate seems to have a dose-dependent response on zinc absorption (Brown et al., 2004).

The calcium content of the diet may affect zinc absorption, although this may only occur in phytate-containing meals (Lonnerdal, 2000). The inhibitory effect on zinc
absorption may be due to the ability of calcium to form complexes with zinc and phytate which also pass through the intestinal tract undigested (Lonnerdal, 2000).

An additional diet related factor thought to inhibit the absorption of zinc is iron supplements which may be taken by adolescent females due to the presence of iron deficiency anaemia (Grant et al., 2007). The evidence is not clear on whether this association exists, however, it is possible that the consumption of iron supplements over a long period of time may affect zinc uptake and transport (Lonnerdal, 2000), particularly if they are consumed between meals (Prosser et al., 2010).

### 2.3.3 Behavioural

The quality of zinc in adolescent diets may be influenced by poor food selection patterns and a low energy intake (Donovan & Gibson, 1995; Gibson et al., 2008). Among this age group, the interest in vegetarian dietary patterns has increased due to perceived health benefits of particular eating patterns; and body weight, financial and/or moral concerns (Gibson & Heath, 2011; Gibson et al., 2002). Reports in NZ have shown a steady decline in red meat consumption which reduces an available source of zinc, and a high intake of plant-based foods such as cereal products, nuts, and legumes which contain phytate, an inhibitor of zinc absorption as discussed in Section 2.3.2 (Laugesen & Swinburn, 2000). In Western countries, a low energy intake is often induced by concerns around body weight which may consequently lead to inadequate intakes of dietary zinc (Gibson et al., 2008).

In addition, there is reason to believe socio-economic factors may be an underlying determinant of dietary patterns which may affect zinc status (Brown et al., 2004; Novaković et al., 2014). Certainly, the high price of red meat may affect the consumption of this rich source of zinc and protein.
2.4 Dietary zinc recommendations for adolescent females

Nutrient reference values ‘are a set of recommendations for nutritional intake based on currently available scientific knowledge’ (Ministry of Health, 2019).

The Estimated Average Requirement (EAR) is defined as the ‘daily nutrient intake level that would meet the requirements of 50% of healthy individuals in a particular life stage and gender group’ (National Health and Medical Research Council, 2006). The NZ zinc EAR for females aged 15-18 years old is 6mg/day (Ministry of Health, 2014). Other countries such as Canada recommend a higher value of 7.3mg/day (Government of Canada, 2010). IZiNCG recommend a value of 7mg/day for mixed or refined vegetarian diets and a value of 9mg/day for unrefined, cereal-based diets (Brown et al., 2004). As Section 2.3.2 demonstrates, dietary factors affect zinc absorption. The NZ zinc EAR was estimated using a predicted absorption of 31% for women (Brown et al., 2004). The EAR can be used to evaluate the risk of inadequate intakes for a population by determining the proportion of the population whose dietary intakes fall below the EAR (the ‘EAR cut-point method’) (Brown et al., 2004). The application of this is explained further in Section 2.5.

The Recommended Dietary Intake (RDI) is defined as the ‘average daily dietary intake level that is sufficient to meet the nutrient requirement of nearly all (97 to 98%) healthy individuals in a particular life stage and gender group’ (National Health and Medical Research Council, 2006). The NZ zinc RDI for females aged 15-18 years old is 7mg/day (Ministry of Health, 2014). Other countries such as Canada and the UK recommend a value of 9mg/day and 7mg/day, respectively (British Nutrition Foundation, 2017; Government of Canada, 2010). IZiNCG recommend a value of 9mg/day for mixed or refined vegetarian diets and a value of 11mg/day for unrefined, cereal-based diets (Brown et al., 2004). It is not possible to determine an absolute
nutrient requirement due to the variation among individuals. However, ‘when the normal variation of a physiological nutrient requirement is known, the RDI for that nutrient can be set at two standard deviations above the EAR’ (Brown et al., 2004). Unfortunately, as no information was available on the standard deviation, for requirements the NZ zinc RDI had to be set ‘based on the unrounded EAR using a coefficient of variation of 10% for the EAR and rounded up’ (Ministry of Health, 2014).

2.5 Measurement of zinc intake

In order to determine the adequacy of zinc intake in a population, measurements of zinc intakes must be determined and then compared with an appropriate set of dietary reference values (International Zinc Nutrition Consultative Group, 2019). The EAR cut-point method is a simple method that determines the portion of individuals with zinc intakes below the EAR (Brown et al., 2004). The prevalence of inadequate intakes can be estimated by determining the number of individuals with intakes below the EAR for age, sex-specific subgroups or dietary types (International Zinc Nutrition Consultative Group, 2019). This measurement is appropriate for zinc as ‘the variability of intakes among individuals within a population is greater than the variability in requirements of individuals’ (Brown et al., 2004), and requirements are not skewed. It is important to note that total zinc intake should include a measurement of zinc supplementation. This avoids overestimating the prevalence of low dietary zinc intakes (Hotz, 2007).

2.6 Zinc intakes in adolescent females

To date, there have been limited studies which have examined zinc intake in adolescent females and adult women in NZ and Australia. To the Candidate’s knowledge, only one
study in NZ (University of Otago and Ministry of Health, 2011a) and two studies in Australia (Ho et al., 2017; Rangan & Samman, 2012) have looked at the zinc intake of adolescent females in the past decade (Table 2.2). These studies reported an average (median or mean) zinc intake range of 8.5 – 9.8 mg/day and indicated widely varying prevalences of inadequate dietary zinc intake from 6.5% - 17% in adolescent females (Ho et al., 2017; University of Otago and Ministry of Health, 2011a). In addition, six studies have examined zinc intake in pre-menopausal adult women in NZ and Australia (Table 2.3) (Fayet et al., 2011; Gibson et al., 2001; Guthrie & Robinson, 1977; Lim et al., 2015; Samman et al., 2010; University of Otago and Ministry of Health, 2011a). These studies reported an average (median or mean) zinc intake range from 8.8 – 19.3 mg/day with a prevalence of inadequate dietary zinc intake of 6% - 19% in adult women (Fayet et al., 2011; Gibson et al., 2001; Guthrie & Robinson, 1977; Ho et al., 2017; Lim et al., 2015; University of Otago and Ministry of Health, 2011a). The methods and statistical analysis differ between the studies and this may be at least partially responsible for the large inconsistencies in reported dietary zinc intakes and number of people at risk of inadequate zinc intakes. These differences between studies include: 1) the type of study design, 2) the year the study was conducted, and 3) the recommended nutrient intake values used to measure the prevalence of inadequate intakes.

The 2008/09 NZ Adult Nutrition Survey (ANS) (University of Otago and Ministry of Health, 2011a) is directly related to this thesis as it collected data on NZ adolescents. In 15-18 year olds, the mean (10th, 90th percentile) usual dietary intake of zinc was 9.1 (6.4, 12.1) mg/day, with a 6.5% estimated prevalence of inadequate intakes (University of Otago and Ministry of Health, 2011a). As the study was conducted 10 years ago it is possible that the dietary patterns in NZ may have changed (Laugesen &
Swinburn, 2000) so that the findings of the 2008/09 NZ ANS may be less applicable in 2019.

The 2007 Australian National Children’s Nutrition and Physical Activity Survey (Rangan & Samman, 2012) looked at 565 adolescent females aged 14-16 years old and reported a mean (standard deviation [SD]) dietary zinc intake of 9.8 (2.7) mg/day and a mean (SD) total zinc intake, when dietary and supplemental zinc intake was combined, of 10.3 (3.5) mg/day, with a prevalence of inadequate intake of 7.7% (Rangan & Samman, 2012). This study was conducted around the same time as the 2008/09 NZ ANS study and the same method was used to determine the prevalence of inadequacy. Remarkably both surveys gave very similar results within the same age group. It is difficult to determine whether this was due to similar trends in eating patterns between the countries at that time but it may have been. Again, as the study was conducted around a decade ago, the findings may be less applicable in 2019.

More recently, a study investigating 150 adolescent females aged 15 years in Australia reported a median (25th, 75th percentile) intake of 8.5 (6.8, 10.7) mg/day, but with a higher prevalence of inadequate intakes of 17% (Ho et al., 2017). The higher prevalence of inadequate intakes may be attributable to the fact the prevalence of inadequate intakes was assessed by comparing the estimated zinc intake to the nutrient reference values for Australia and NZ. This means it is not clear whether they used the EAR cut-point method or not. In comparison, the age-specific EAR for females of 6mg/day (Ministry of Health, 2014) was used to determine the prevalence of inadequacy in the 2008/09 NZ ANS, producing a much lower prevalence of inadequacy of 6.5% (University of Otago and Ministry of Health, 2011a).

Six studies have looked at dietary zinc intake in pre-menopausal adult women, however, the different age group limits generalizability to the zinc intake of adolescent
females. Three of the adult studies available are in NZ women (Gibson et al., 2001; Guthrie & Robinson, 1977; University of Otago and Ministry of Health, 2011a) and three in Australian women (Fayet et al., 2011; Lim et al., 2015; Samman et al., 2010).

The three studies in NZ pre-menopausal adult women reported very similar dietary zinc intake results with a mean (10th, 90th percentile) of 9.2 (5.8, 13.0) mg/day (University of Otago and Ministry of Health, 2011a), a median (1st, 3rd quartile) dietary zinc intake of 9.9 (7.9, 12.3) mg/day (Gibson et al., 2001), and a mean (SD) dietary zinc intake of 10.0 (4.1) mg/day (Guthrie & Robinson, 1977). Despite the 40 year difference between the three studies, it is interesting that the dietary zinc intakes are all relatively similar given that you might expect a change in the dietary patterns over time. The difference between the prevalence of inadequate intakes of 6% (Gibson et al., 2001) and 18.8% (University of Otago and Ministry of Health, 2011a) indicates a wider distribution of intakes between one study compared to the other. This inconsistency may be due to the different sample populations as the 2008/09 NZ ANS (University of Otago and Ministry of Health, 2011a) was nationally representative in comparison to Gibson et al (2001) which only looked at participants in Dunedin. The study by Guthrie and Robinson (1977) could not assess the prevalence of inadequate intakes as the sample size was only 23.

The three studies in Australian pre-menopausal adult women reported a mean (SD) daily zinc intake of 9.3 (3.8) mg/day and a prevalence of inadequate intakes of 19% (Lim et al., 2015), a mean (SD) daily zinc intake of 10.5 (3.1) mg/day (Samman et al., 2010), and a mean (SD) daily zinc intake of 19.3 (4.3) mg/day (Fayet et al., 2011). Both studies reporting a dietary zinc intake over 10 mg/day used a food frequency questionnaire (FFQ) (Fayet et al., 2011; Samman et al., 2010). When validating the food frequency questionnaires against a weighed diet record (Samman et al., 2010) or
a 24-hour recall (Fayet et al., 2011), both FFQs reported zinc intakes that were significantly higher than the reference method so these means are likely to be overestimates of actual intake.

In summary, no conclusion can be made regarding the current dietary zinc intakes of NZ adolescent females. Although dietary intake indicates the amount of zinc consumed in the diet, as discussed in section 2.3.2, in order to comment on the likely proportion of zinc that is readily available for absorption the dietary sources of the zinc must be known (Hotz, 2007).
Table 2.2 Studies assessing zinc intake and/or food sources in adolescent females in Australia and New Zealand

<table>
<thead>
<tr>
<th>Reference</th>
<th>Country</th>
<th>Participants</th>
<th>Design/Methods</th>
<th>Main Findings</th>
</tr>
</thead>
</table>
| University of Otago and Ministry of Health, 2011 | New Zealand | n= not stated  
Aged 15-18 years  
Nationally representative survey - recruiters visited selected dwellings and recruited willing participants | Multi-stage, stratified, probability-proportional-to-size sample design  
24-hour diet recall  
Zn intake  
Food Sources of Zn | Zinc Intake  
Mean: 9.1mg  
10th percentile: 6.4mg  
90th percentile: 12.1mg  
6.5% estimated prevalence of inadequacy |
| Rangan and Samman, 2012 | Australia | n= 565  
Aged 14-16 years  
Nationally representative survey - randomly selected using a stratified quota sampling scheme by postcodes | Nationally representative survey  
24-hour diet recalls  
Zn intake  
Food Sources of Zn  
Zn-containing supplement | Zinc Intake  
Mean (SD): 9.8 ± 2.7mg  
Supplement Zinc Intake  
Mean (SD): 10.3 ± (3.5) mg  
7.7% estimated prevalence of inadequacy |
| Ho et al., 2017 | Australia | n= 150  
Aged 15 years old  
Australian birth cohort at Sydney Hospital between 1989-1990 | Secondary data analysis of a prospective cohort study, the Nepean Longitudinal Study  
Semi-quantitative food frequency questionnaire | Zinc intake  
Median (n=150): 8.5mg  
25th Percentile: 6.8mg  
75th Percentile: 10.7mg  
17% at risk of inadequate dietary zinc intake |
<table>
<thead>
<tr>
<th>Zn intake</th>
<th>Bioavailability of Zn intake</th>
<th>Biochemical Zn status</th>
</tr>
</thead>
</table>


Table 2.3 Studies assessing the zinc intake of pre-menopausal adult women in Australia and New Zealand

<table>
<thead>
<tr>
<th>Reference</th>
<th>Country</th>
<th>Participants</th>
<th>Design/Methods</th>
<th>Main Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>University of Otago and Ministry of Health, 2011</td>
<td>New Zealand</td>
<td>n= not stated</td>
<td>Multi-stage, stratified, probability-proportional-to-size sample design</td>
<td>Zinc Intake</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Aged 19-30 years</td>
<td>24-hour diet recall</td>
<td>Mean: 9.2mg</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Nationally representative survey</td>
<td></td>
<td>10th percentile: 5.8mg</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- recruiters visited selected dwellings and recruited willing participants</td>
<td></td>
<td>90th percentile: 13mg</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>18.8% estimated prevalence of inadequacy</td>
</tr>
<tr>
<td>Gibson et al., 2001</td>
<td>New Zealand</td>
<td>n= 330</td>
<td>Cross-sectional study</td>
<td>Zinc Intake</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Aged 18 – 40 years</td>
<td>Food frequency questionnaire</td>
<td>Median (n=330): 9.9mg</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Recruited via publicity in the media, university and community groups from March 1996 to May 1998</td>
<td>Zn intake</td>
<td>Quartile 1: 7.9mg</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Food sources of Zinc</td>
<td>Quartile 3: 12.3mg</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Biochemical Zn status</td>
<td>6 % at risk of inadequate intakes of dietary Zn</td>
</tr>
<tr>
<td>Guthrie and Robinson, 1977</td>
<td>New Zealand</td>
<td>n= 23</td>
<td>Cross-sectional Study</td>
<td>Zinc Intake</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Aged 19-50 years</td>
<td>Weighed food records of duplicate diets for 3-21 days</td>
<td>Institutional- Mean (SD) (n=12): 11.6 ± 3.7mg</td>
</tr>
<tr>
<td>Study</td>
<td>Country</td>
<td>Sample Size</td>
<td>Recruitment Method</td>
<td>Study Type</td>
</tr>
<tr>
<td>-----------------------</td>
<td>---------</td>
<td>-------------</td>
<td>-------------------------------------------------------------------------------------</td>
<td>-----------------</td>
</tr>
<tr>
<td>Fayet et al., 2011</td>
<td>Australia</td>
<td>n=256</td>
<td>Aged 18 – 35&lt;br&gt;Recruited from the University of Sydney using flyers, word of mouth referrals, and university publications.</td>
<td>Validation study</td>
</tr>
<tr>
<td>Lim et al., 2015</td>
<td>Australia</td>
<td>n=379</td>
<td>Women aged 18-50 years old from Melbourne&lt;br&gt;Blood donors registered with the Australian Red Cross Blood Service at Deakin University in Victoria and residents of metropolitan Melbourne</td>
<td>Cross-sectional study</td>
</tr>
</tbody>
</table>
19% of participants were at risk of inadequate dietary zinc intakes.

<table>
<thead>
<tr>
<th>Authors</th>
<th>Country</th>
<th>Sample Details</th>
<th>Methodology</th>
<th>Results</th>
</tr>
</thead>
</table>
| Samman et al., 2010 | Australia   | n= 22 Aged 21-46 Females from the postgraduate nutrition and dietetics class at the University of Sydney. | Validation study Food frequency and a weight food record for 7 days Zn Intake | Zinc Intake  
Weight records- Mean (SD) (n=22): 8.8 (2.3)mg  
Food frequency questionnaire- Mean (SD) (n=22): 10.5 (3.1)mg  
No calculation of inadequate intake |
2.7 Food sources of zinc in adolescent females

To the Candidate’s knowledge, there is one study in NZ (University of Otago and Ministry of Health, 2011a) and one study in Australia (Rangan & Samman, 2012) which have looked at the food sources of zinc in adolescent females. Surprisingly, it seems only two studies in NZ (Gibson et al., 2001; University of Otago and Ministry of Health, 2011a) and no studies in Australia have looked at zinc food sources in pre-menopausal adult women. The food sources of zinc differ between each study depending on the year the study was done, the age range of participants in the study, and the classification of foods to food groups in the study.

The 2008/09 NZ ANS (University of Otago and Ministry of Health, 2011a) was a nationally representative survey which examined food sources of zinc in 15-18 year old females. Unexpectedly, the survey reported that ‘bread-based dishes’ was the highest contributor to adolescent dietary zinc intake, contributing 12.6% of zinc intake. This was followed by ‘grains and pasta’ (12.1%), ‘bread’ (8.8%), ‘beef and veal’ (6.9%), ‘poultry’ (6.0%), ‘milk’ (5.3%), ‘potatoes, kumara and taro’ (5.3%), ‘sausage and processed meats’ (4.1%), ‘non-alcoholic beverage’ (3.8%) and ‘cheese’ (3.4%) (University of Otago and Ministry of Health, 2011a). As discussed in Section 2.6, this study was conducted 10 years ago, therefore, it is possible that the dietary patterns in NZ may have changed over time (Laugesen & Swinburn, 2000) so that the findings of the ANS may be less applicable in 2019.

A study by Rangan and Samman (2012) looked at the dietary sources of zinc in 14-16 year olds in the 2007 Australian National Children’s Nutrition and Physical Activity Survey. The main food source of zinc was ‘meat, poultry and game products’ (2.97mg/day), followed by ‘cereals and cereal products’ (1.92mg/day), ‘milk products and dishes’ (1.77mg/day), ‘cereal-based products/dishes’ (1.32mg/day), ‘vegetable
products/dishes’ (0.83mg/day), ‘non-alcoholic beverages’ (0.36mg/day), ‘fruit products/dishes’ (0.18mg/day), ‘fish and seafood products/dishes’ (0.12mg/day), ‘eggs products/dishes’ (0.10mg/day) and ‘seed and nut product/dishes’ (0.10mg/day).

As this study was conducted in Australia, we would assume findings may be less applicable to NZ due to potential differences in dietary patterns between Australia and NZ. Surprisingly, both studies in adolescent females had similar findings reporting a mean (10th, 90th percentile) total zinc intake of 9.8 (6.4, 13.1) mg/day (Rangan & Samman, 2012) in Australian adolescent females and a mean (10th, 90th percentile) total zinc intake of 9.1 (6.4, 12.1) mg/day (University of Otago and Ministry of Health, 2011a) in NZ adolescent females.

The 2008/09 NZ ANS (University of Otago and Ministry of Health, 2011a) also examined the food sources of zinc in 19-30 year old pre-menopausal adult women. In adult women, ‘grains and pasta’ were the highest contributor to the food sources of zinc making up 12.9% of total zinc intake, in contrast to ‘bread-based dishes’ in adolescent females. This was followed, in the adult women, by ‘bread’ (7.6%), ‘bread-based dishes’ (7.4%), ‘poultry’ (6.9%), ‘milk’ (6.6%), ‘beef and veal’ (5.9%), ‘vegetables’ (5.3%), ‘potatoes, kumara and taro’ (5.3%), ‘non-alcoholic beverages’ (4.3%) and ‘pork’ (3.6%) (University of Otago and Ministry of Health, 2011a).

The cross-sectional study by Gibson et al. (2001) measured dietary intakes in 330 pre-menopausal NZ women 18-40 years of age. ‘Meat, poultry, and fish’ contributed the largest amount to total dietary zinc making up 27.9%, which was closely followed by ‘cereal products, nuts, and legumes’ (26.7%), ‘dairy products’ (18.4%), ‘vegetables’ (7.6%), and 19.4% from other dietary sources. The higher intake of ‘meat, poultry and fish’ may be attributable to the inclusion criteria of the study. The participants in the study were consuming a ‘typical Western-type diet’ which is
characterised by a ‘high portion of foods such as red meat, processed meat, refined grains, sweets and desserts, hot chips, and high-fat dairy products’ (Heart Foundation, 2013). It is possible the study did not include participants following other dietary approaches, such as a vegetarian diet, explaining why ‘meat, poultry, and fish’ contributed the largest amount to zinc intake out of the food sources investigated.

In summary, a moderate zinc source eaten in large amounts regularly can supply more zinc than a rich zinc source eaten in smaller amounts less frequently. Therefore, although meat sources may have the highest zinc content and provide more bioavailable zinc, they may not be the largest contributor to zinc intake.
3 Objective Statement

The primary aim of this thesis was to describe the zinc intake of adolescent females 15-18 years of age in New Zealand.

The specific objectives were to:

1. Determine the zinc intake of New Zealand female adolescents at 15-18 years of age.
2. Determine the prevalence of inadequate and potentially excessive intakes of zinc in New Zealand female adolescents at 15-18 years of age using diet and supplemental intake data.
3. Identify key food sources of zinc for New Zealand female adolescents at 15-18 years of age.
4 Methods

This was a large multicentre trial, therefore, the methods were designed by the Survey of Nutrition Dietary Assessment and Lifestyle (SuNDiAL) Principal Investigators, Dr Jill Haszard (Division of Sciences, University of Otago) and Dr Meredith Peddie (Department of Human Nutrition, University of Otago). Text which has been directly taken from the SuNDiAL Project 2019 Study Protocol is indicated in italics.

4.1 Study design

This thesis contributes to the wider SuNDiAL project. The SuNDiAL project is a two-year cross-sectional survey with the aim to compare the nutritional status, dietary habits, health status and attitudes and motivations for food choice of vegetarian and non-vegetarian adolescent women. As part of the wider SuNDiAL project, the study collected online data from self-administered questionnaires regarding participants’ demographics, health, dietary habits, attitudes, and motivation. Participants also attended three appointments over the course of two weeks. At the first appointment, a face-to-face 24-hour recall was conducted and anthropometric measurements were collected. At the second appointment, a blood sample and a urine test were collected and accelerometers were allocated to students for a week. On the third appointment, a second 24-hour recall was completed online. The Candidate collected all dietary data for four participants and partial data from two participants, but this thesis analyses the combined data for the participants recruited in all eight centres. For the purpose of this thesis, the Candidate focused on the data collected from the health and demographics questionnaire, the dietary habits questionnaire, 24-hour recalls and the anthropometric
measurements in the first of four periods of data collection, i.e. the data collected to date.

### 4.2 Recruitment and participants

SuNDiAL was approved by the Human Ethics Committee of the University of Otago, Dunedin (Appendix A) and is registered on the Australian New Zealand Clinical Trials Registry (ACTRN12619000290190). Maori consultation was also undertaken. Electronic consent was obtained from all participants before they took part in the study. If a student was 15 years of age (i.e. less than 16 years), online consent was obtained in an email to the primary caregiver’s email address.

Participants were recruited from schools in Dunedin, Christchurch, Wellington, New Plymouth, Nelson, Whangarei, and Tauranga between February and March 2019. The SuNDiAL Principal Investigators recruited schools 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 rolls of at least 200 girls) between November 2018 and March 2019 (Figure 4.1). A school decile is a schools socio-economic score assigned by the New Zealand Ministry of Education based on five census derived socio-economic factors with a range from 1 (low) to 10 (high) (Ministry of Education, 2019b). 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.

The Candidate recruited participants 15-18 years of age at Hornby High school’s senior assembly (Christchurch, New Zealand) in March 2019 using a presentation (Appendix B). The Candidate also recruited by word-of-mouth and encouraged participants to invite their friends.
Figure 4.1 Flow chart of the school recruitment process

Eligible schools

Schools selected for invitation

Selection criteria:
- Female roll (larger preferred)
- School decile (range from all deciles)

Selected schools invited by email

- Schools declined  \( n=3 \)
- No response  \( n=15 \)
- Accepted but no further response  \( n=2 \)

Additional schools invited in person

- Schools declined  \( n=0 \)
- Schools no response  \( n=0 \)
- Schools accepted but no further response  \( n=0 \)

Total schools consented to participate  \( n=8 \)
The inclusion criteria for the study were:

- Females or participants who self-identify as female 15-18 years of age.
- Enrolled in one of the recruited high schools.
- Able to communicate in English.
- Not pregnant.

Directly after the presentation, participants had the opportunity to ask the Candidate any questions and indicate their interest in the study by providing their name, age, email address (or caregiver’s email if they were 15 years of age) to the Candidate. Potential participants were given an identification number, to maintain anonymity and confidentiality. The SuNDiAL Principal Investigators then contacted the potential participant, or potential participant’s caregiver, via email inviting them to enrol in the study. The email contained a link to the online consent form and reminded students to visit the study website (www.otago.ac.nz/sundial) if they wanted further information about the study including a copy of the information sheet (Appendix C). If the participant was eligible for the study, the Candidate then texted the participant to arrange a date and time for the appointments to be carried out at school.

As a reimbursement, participants received a grocery voucher of up to $30 ($5 for each subsection of the study completed) once data collection in the participating school was completed. At the end of the study, if requested, participants who provided a blood sample were given their biochemical iron status, with a note about how to interpret these values. If investigators identified a risk of anaemia in any participant they were advised to see their general practitioner to speak to them about these results. Participating schools were provided with a summary of both the overall results as well
as a summary of selected results obtained from their school (e.g., percentage of girls consuming breakfast, average number of servings of fruits and vegetables etc).

4.3 Data collection

4.3.1 Demographic data
After informed consent was obtained electronically, the participant answered a series of questions about their demographics and health using a questionnaire in REDCap (Research Electronic Data Capture) (REDCap, Vanderbilt University, Tennessee), a web application designed to build and manage online surveys and databases (Appendix D). The health and demographics questionnaire asked details about participant age, ethnicity and the high school they attended.

4.3.2 Dietary supplement use
Once the participants had answered the initial health and demographics questionnaire, the dietary habits questionnaire was available on REDCap to complete in their own time (Appendix E). The questionnaire asked for detailed information about the participant’s supplement use in the past 12 months, including the type and brand name of supplement consumed and any additional information they could provide including a photograph of the package if possible. The Candidate, along with one other Master of Dietetics student, was responsible for determining the zinc form and content of the supplements that had been consumed, and then analysing the supplement data in Microsoft Excel Version 16.23 (Microsoft Corporation, Washington, USA) to determine how much iron or zinc participants had consumed from supplements daily (Appendix F). The frequency response categories were converted to generate a daily consumption as follows: ‘Daily’ = 1; ‘More than once a week’ = 0.29; ‘Once per week’
Dietary zinc and supplemental zinc were added together to give total zinc intake.

### 4.3.3 Anthropometric data

At the first visit, once verbal consent was gained, the participant’s weight and height were measured in private. This was collected using the SuNDiAL project anthropometric protocol, which was based on the Ministry of Health height and weight protocol used in the Health Survey (Ministry of Health, 2008). The same technique was used for all participants and a verbal explanation was given before each measurement was taken. Participants were asked to remove their shoes, any heavy clothing, any items in their pockets and any hair ornaments or buns/braids on the top of their head.

Weight was measured using either a Medisana PS 420 (MEDISANA GmbH, Neuss, Germany), Salter 9037 BK3R (Salter Housewares; Kent, UK), Seca Alpha 770 (Seca GmbH, Hamburg, Germany) or Soehnle Style Sense Comfort 400 (Soehnle Industrial Solution, Backnang, Germany) scale placed on a flat hard even surface. Participants were asked to face away from the scale in order to prevent participants from seeing the displayed weight and to step backward onto the scale. Height was measured using either a Webberburn (Webberburn, Otago, NZ) or Seca 213 (Seca GmbH, Hamburg, Germany) stadiometer which was placed on a flat hard even surface against a wall. The participant was asked to stand with their heels together and toes apart pointing outward at approximately a 60-degree angle with their head, shoulder blades, buttocks, and heels touching the vertical backboard. With permission, the participant’s head was aligned so that it was in the Frankfort horizontal plane. The participant was asked to stand as tall as possible and take a deep breath while the
headpiece was lowered to rest firmly on the top of their head. If the participant was
taller than the Candidate, a step tool was used to take the measurements.

All anthropometric measurements were taken twice, alternating between
weight and height. A third weight and height measurement was measured if the first
two differed by more than 0.5 units. The closest two measurements were then
averaged, or a median taken if the values were equal distances apart.

These measurements were used to calculate body mass index-for-age (BMI-
for-age) z-scores (de Onis et al., 2007), and to then determine whether any participants
were overweight (BMI-for-age z-score >+1 SD) using the World Health Organization
(WHO) cut-offs (World Health Organization, 2007).

### 4.3.4 Dietary data

On two occasions, the Candidate conducted a 24-hour dietary recall to collect
quantitative information on all foods and beverages the participant had consumed on
the previous day (from midnight to midnight). The 24-hour recall was conducted in
three stages using the SuNDiAL project 24-hour recall protocol. In the first stage, the
Candidate collected a ‘quicklist’ of the foods and beverages the participant had
consumed. The second stage collected more specific information on all the items on
the quicklist. Portion sizes of foods and beverages consumed were estimated using
measurement aids such as household measures, food portion assessment aids,
packaging information, shape dimensions, and photobooks. Pre-specified prompts
were used to guide the collection of brand and product names, where food was sourced
if appropriate, timing of when foods were eaten, additions made to the plate before
consumption, the cooking method used, recipes for mixed dishes when known and
quantities of any leftovers. In the third stage, the list of foods and beverages was
relayed back to the participant by the Candidate in chronological order to ensure all information was correct and no information was missed. Once the 24-hour diet recall was completed, the Candidate asked the participant if the salt purchased by the household was iodised or not. A second 24-hour recall was conducted over the online communication software Zoom (Zoom Video Communications, California, US) approximately one week after the first appointment on a randomly selected day. If possible, the Candidate planned for one 24-hour recall to take place on a weekday and one 24-hour recall to take place on a weekend day to maximise representativeness of the dietary data.

4.4 Dietary data entry

Nutrient analysis was completed using FoodWorks 9 (Xyris software, Australia). The food composition data in FoodWorks were from FOODfiles 2016 the New Zealand Food Composition Database (New Zealand Institute for Plant and Food Research Limited, New Zealand), recipes from the 2008/09 Adult Nutrition Survey (University of Otago and Ministry of Health, 2011b) and recipes from Kai-culator (Version 1.16a, University of Otago, New Zealand), a web-based dietary software program developed by the Department of Human Nutrition at the University of Otago.

The Candidate entered the ten 24-hour recalls she collected into FoodWorks. Where possible, each food item was matched to a nutrient line from FOODfiles. A code book was developed by Liz Fleming (Department of Human Nutrition, University of Otago) and a Doctor of Philosophy (PhD) student, to assign rules (cooking methods, estimations, default foods and substitutions) to certain foods where a direct match could not be found. Default foods were to be used when insufficient food information was provided to determine exact food code or when no exact match was present in
FoodWorks but a closely related food was available. Substitutions were to be used when there was no exact or close match to the food item in FoodWorks. When a food item’s macronutrient values in FoodWorks differed from the nutrition information panel (NIP) on a commercial product by 10%, or an appropriate nutrient line was not available, then the Candidate created a ‘recipe’. Recipes were created for both commercial foods and homemade recipes. To create a recipe for a commercial food, the list of ingredients on the product packaging was used. The weight of the individual ingredients was determined by the percentages stated on the ingredients list, which are recorded in order of declining weights. If the FoodWorks macronutrient value differed from the product’s NIP by more than 10% quantities of the ingredients were altered until the closest match was achieved. For homemade recipes, ingredients and raw quantities were based on the information provided by the participants in their 24-hour recall. Moisture retention factors were also applied if the recipe was cooked. These moisture retention factors were from the New Zealand Food Composition Database. Based on this information, FoodWorks estimated a total weight for the recipe, so that the Candidate could calculate the proportion of the whole recipe that had been consumed by the participant. This value then allowed FoodWorks to calculate the amount of nutrients consumed. The participants reported a large number of processed foods, therefore, the Candidate added 20 recipes, 21 defaults, and 21 substitutions to the ‘Code book SuNDiAL 2019 S1- default foods and food substitutions’ so that they were documented, and could be used by other students whose participants had consumed the same food. A full list of all the recipes created and the food item substitutions and defaults used by the Candidate when entering diet recalls in FoodWorks is outlined in Appendix G. Liz Fleming and a PhD student were
responsible for checking the entry of all food recalls and correcting them to ensure consistency across all eight centres.

4.5 Statistical analysis

The larger SuNDiAL project intends to have a sample size of 300 high school students enrolled from 14 high schools [to give] 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. The first phase of the study reported here aimed to recruit approximately half of the 300 high school students.

All data management and statistical analysis were overseen by the study biostatistician and primary Principal Investigator, Dr Jill Haszard. Some statistical analyses [were] carried out using Stata version 15.1 (Stata Corp, College Station, Texas) by Dr Jill Haszard, in particular, the BMI-for-age z-score, and the food group data. To calculate the food group results the total amounts of nutrient intake from each of the 33 food groups was calculated for each participant ... The proportion of their total nutrient intake from each of the 33 food groups was [then] calculated. Mean and 95% confidence intervals of these proportions were calculated for the whole group. In order to analyse sources of zinc, food items reported in both 24-hour diet recalls adjusted for usual intake were allocated to food groups based on the 08/09 NZ ANS food group coding (University of Otago and Ministry of Health, 2011b).

The Candidate used Microsoft Excel (Version 16.24, Microsoft Corporation, New Mexico, United States) to calculate means, mean difference, medians, 25\text{th} and 75\text{th} percentiles, standard deviations and 95\% confidence intervals for the data.
Statistical significance for differences between age, school decile, weight status and supplement users was defined as a \( p<0.05 \) based on a two-tailed unpaired t-test carried out by the Candidate. The Candidate also used Microsoft Excel to create Q-Q plots for dietary zinc intake and total zinc intake to determine whether they followed a normal distribution.

Dr Jill Haszard calculated usual energy and dietary intakes for each individual by applying the Multiple Source Method (MSM) (Hartig et al., 2011) to the repeat 24-hour recalls. Supplementary zinc data were added to the dietary zinc intake data by the Candidate after adjustment for usual intakes using Microsoft Excel.

The Estimated Average Requirement (EAR) cut-point method was used to determine the prevalence of inadequate zinc intakes (Brown et al., 2004). The Candidate did this by calculating how many of the group had zinc intakes below the age-specific EAR for females of 6mg/day (Ministry of Health, 2014). The number of participants having an excessive zinc intake was calculated by determining how many of the group had a zinc intake above the age-specific Upper Level of Intake for females of 35mg/day (Ministry of Health, 2014).
5 Results

5.1 Recruitment and participants

Of the 28 schools that were approached to take part in the Survey of Nutrition Dietary Assessment and Lifestyle (SuNDiAL) project by the SuNDiAL Principal Investigators, 20 either declined or did not respond. The remaining eight schools comprised a total of 1882 eligible participants (Figure 5.1). A total of 154 participants consented to the study, of whom nine were excluded, providing a final sample size of 145 participants. Of the participants, 99.3% completed the health and demographic questionnaire, 85.5% completed the dietary habits questionnaire, 89.7% provided anthropometric data and 91% provided at least one 24-hour recall for analysis. The Candidate was responsible for recruiting and collecting anthropometric and dietary data in Christchurch, New Zealand (NZ).
Eligible participants  
$n=1882$

Participants present at recruitment drives  
$n = 806$

Eligible participants sent link to enrolment  
$n = 263$

EXCLUDED (n = 118):  
Eligible but not recruited:  
- Did not respond  
  $n= 84$
- Parents did not respond  
  $n=13$
- Parents of participants 16-18 years of age from one school that required parental consent did not respond or were uncontactable  
  $n=9$
- Did not respond after parental consent  
  $n=10$
- Responded to link but declined  
  $n=2$

Completed enrolment  
$n = 145$

DATA AVAILABLE FOR ANALYSIS:  
- Completed the health and demographics questionnaire  
  $n=144$
- Completed the dietary habits questionnaire  
  $n=124$
- Completed anthropometric measures\(^1\)  
  $n=130$
- Completed first 24-hour recall  
  $n=132$
- Completed repeat 24-hour recall\(^2\)  
  $n=113$

\(^1\) Two missing anthropometric measures due to technical issues  
\(^2\) 19 participants refused repeat 24-hour recall

**Figure 5.1** Participant flow chart for inclusion into this study
Demographic characteristics of the study participants are shown in Table 5.1. The mean age was 16.7 years, ranging between 15 and 18.4 years. A greater proportion of the participants self-identified as NZ European and Other (NZEO) (72.2%) than any other ethnicity. The school deciles from the eight participating schools ranged from three to ten with the majority (58.6%) of students attending a school with a school decile of 4 – 7 (Table 5.2).

**Table 5.1 Demographic characteristics of participants (n=145)**

<table>
<thead>
<tr>
<th></th>
<th>Mean (SD)</th>
<th>n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>16.7 (0.8)</td>
<td></td>
</tr>
<tr>
<td>15 years</td>
<td>28 (19.3)</td>
<td></td>
</tr>
<tr>
<td>16 years</td>
<td>54 (37.2)</td>
<td></td>
</tr>
<tr>
<td>17 years</td>
<td>60 (41.4)</td>
<td></td>
</tr>
<tr>
<td>18 years</td>
<td>3 (2.1)</td>
<td></td>
</tr>
<tr>
<td>Ethnicity1,2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NZEO3</td>
<td>104 (72.2)</td>
<td></td>
</tr>
<tr>
<td>Māori</td>
<td>29 (20.1)</td>
<td></td>
</tr>
<tr>
<td>Asian4</td>
<td>6 (4.2)</td>
<td></td>
</tr>
<tr>
<td>Pacifics</td>
<td>5 (3.5)</td>
<td></td>
</tr>
<tr>
<td>Decile of school attended6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 – 3</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</td>
<td>46 (31.7)</td>
<td></td>
</tr>
<tr>
<td>Completed at least one diet recall</td>
<td>132 (91)</td>
<td></td>
</tr>
</tbody>
</table>

Abbreviations: SD, Standard deviation; NZEO, New Zealand and Others
1 Ethnicity missing for one participant (n=144)
2 Participants identifying as multiple ethnicities were allocated to a single ethnic group. Ethnicities were prioritised in the order: Māori, Pacific, Asian, NZEO
3 NZEO ethnicity comprised: New Zealand European, Ethiopian, Somali, Italian, American, Nicaraguan, Irish, Afrikaans, Dutch, German, South African
4 Asian ethnicity comprised: Filipino, Japanese, Indian
5 Pacific ethnicity comprised: Tokelauan, Fijian, Cook Island, Samoan
6 School decile categories. The New Zealand Ministry of Education assigns schools a socioeconomic score based on five census derived socioeconomic factors with a range from 1 (low) to 10 (high) (Ministry of Education, 2019b)
Anthropometric measurements for the study participants are shown in **Table 5.3**. The participants had a mean body mass index (BMI) of 23.7 kg/m², ranging from 15.2 kg/m² to 38.9 kg/m². In total, 66.9% had a BMI within the healthy range (18.5-24.9 kg/m²) (Ministry of Health, 2018). The mean body mass index-for-age (BMI-for-age) z-score was 0.65 and 34.6% of participants were classified as overweight when using the World Health Organization (WHO) cut-off (BMI-for-age z-score >+1 SD) (World Health Organization, 2007).
Table 5.3 Anthropometric measurements of participants (n=130)

<table>
<thead>
<tr>
<th></th>
<th>Mean (SD)</th>
<th>n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMI (kg/m²)</td>
<td>23.7 (4.4)</td>
<td></td>
</tr>
<tr>
<td>BMI-for-age z-score</td>
<td>0.65 (1)</td>
<td></td>
</tr>
<tr>
<td>Weight status</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not Overweight</td>
<td>0.05 (0.61)</td>
<td>85 (65.4)</td>
</tr>
<tr>
<td>Overweight</td>
<td>1.79 (0.67)</td>
<td>45 (34.6)</td>
</tr>
</tbody>
</table>

Abbreviations: SD, standard deviation; BMI, body mass index

1 kg/m² = weight (kg) divided by height squared (m²)
2 Weight and height missing for two participants so BMI could not be calculated
3 BMI-for-age z-score calculated using the WHO growth reference data (de Onis et al., 2007)
4 Weight status interpreted using the WHO overweight cut-off of BMI z-score >+1SD (World Health Organization, 2007)

5.2 Zinc intake

A total of 132 participants provided dietary intake data in the first 24-hour recall. An additional second 24-hour recall was collected from 113 participants. To account for dietary intake differences between weekend and weekdays, a total of 77.5% of 24-hour recalls were completed on a weekday and 22.5% on a weekend day. Table 5.4 shows the mean and median energy and zinc intakes from the present study. The participants had a mean (SD) energy intake of 8066 (1833) kJ/day. Dietary zinc intake had a normal distribution with a mean (standard deviation [SD]) intake of 9.3 (2.93) mg/day (Figure 5.2). In contrast, total zinc intake had a positive skew distribution (right skew) so median intake was calculated. The median intake of total zinc was 9.2mg/day (Figure 5.3).
Table 5.4 Energy and zinc intake of participants (n=132)

<table>
<thead>
<tr>
<th></th>
<th>Mean (95% CI)</th>
<th>Median (25th, 75th percentile)</th>
<th>n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy (kJ/day)</td>
<td>8066 (7754, 8379)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dietary zinc intake (mg/day)¹</td>
<td>9.3 (8.76, 9.76)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total zinc (dietary and supplemental) (mg/day)²</td>
<td>9.2 (7.20, 10.91)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zinc supplement users³</td>
<td>13 (10.5)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zinc from supplements in consumers (mg/day)</td>
<td>2.2 (0.98, 13.75)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>At risk of inadequate zinc intake⁴</td>
<td>14 (10.5)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exceeding zinc upper level of intakes ⁵</td>
<td>1 (0.8)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Abbreviations: CI, confidence interval
¹Dietary zinc intakes were adjusted for intra-individual variation in intake, using the Multiple Source Method (MSM), so are usual intakes (Harttig et al., 2011)
²One participant’s total zinc value was excluded because supplemental data were provided only (n=132)
³Supplement use collected in dietary habits questionnaire (n=124)
⁴Calculated using the Ministry of Health EAR of 6mg/day (n=133) (Ministry of Health, 2014)
⁵Calculated using the Ministry of Health UL of 35mg/day (n=133) (Ministry of Health, 2014)
Figure 5.2 Q-Q plot of dietary zinc intake (n=132)

Figure 5.3 Q-Q plot of total zinc intake (n=132)
The distribution of zinc intakes is presented in Figure 5.4 with the majority of participants having a zinc intake of 6 - <9mg/day. Inadequate total zinc intake, defined as a zinc intake less than the Estimated Average Requirement (EAR) of 6mg/day (Ministry of Health, 2014), was reported by 14 adolescents. A total of 13 participants had consumed a zinc supplement or a supplement containing zinc in the past 12 month period, with the median intake from supplements being 2.2mg/day in consumers. One participant had a zinc intake above the Upper Level of Intake (UL) of 35mg/day (Ministry of Health, 2014) due to the daily consumption of a supplement containing 50mg of zinc. However, this participant was excluded from the total zinc (dietary and supplemental) data as they did not provide any 24-hour recall data. Of the 13 zinc containing supplements consumed, one (7.7%) was a single zinc supplement and 12 (92.3%) were multivitamin supplements.

Table 5.5 shows the relationship between participant characteristics and dietary zinc intake. School decile was the only variable that had a \( p < 0.05 \), indicating a statistically significant difference. The significant association found between dietary zinc and school decile suggested that adolescents in a school with a school decile 1-3 had an almost 2mg/day lower dietary zinc intake than adolescents in a school with a school decile of 8-10 \( (p=0.010) \).
Note - Dietary zinc and total zinc distributions are for the same participants (n=132). Participants can move to a higher total zinc intake bin as a consequence of consuming a zinc-containing supplement (27-<30mg/day), resulting in fewer participants with a total zinc intake of 6-<9mg/day.

**Figure 5.4** Comparison of distributions of dietary zinc intake and total zinc intake (dietary and supplemental) in New Zealand adolescent females 15-18 years of age (n=132)
Table 5.5 Relationship between participant characteristics and dietary zinc intake (n=132)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Mean (95% CI)</th>
<th>Mean difference (95% CI)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15 – 16 years</td>
<td>9.5 (8.71, 10.22)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17 – 18 years</td>
<td>9.0 (8.40, 9.60)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>School decile3</td>
<td></td>
<td>0.82 (0.41, 3.61)</td>
<td>0.010</td>
</tr>
<tr>
<td>1 - 3</td>
<td>8 (6.67, 9.27)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 – 7</td>
<td>9.1 (8.45, 9.72)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8 - 10</td>
<td>10 (9.05, 10.91)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weight Status5</td>
<td></td>
<td>0.56 (-0.88, 1.32)</td>
<td>0.694</td>
</tr>
<tr>
<td>Not overweight</td>
<td>9.3 (8.75, 9.92)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overweight</td>
<td>9.1 (8.19, 10.04)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Supplement Users</td>
<td></td>
<td>0.97 (-0.70, 3.12)</td>
<td>0.261</td>
</tr>
<tr>
<td>Yes</td>
<td>10.4 (8.58, 12.26)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>9.2 (8.69, 9.72)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Abbreviations: CI, confidence interval

1. Dietary zinc intakes were adjusted for intra-individual variation in intake, using the Multiple Source Method (MSM), so are usual intakes (Harttig et al., 2011)

2. p<0.05 considered statistically significant. Calculated by a two-tailed unpaired t-test

3. School decile categories. The New Zealand Ministry of Education assigns schools a socioeconomic score based on five census derived socioeconomic factors with a range from 1 (low) to 10 (high) (Ministry of Education, 2019b)

4. Comparison is between the lowest (school decile 1-3) and highest categories (school decile 8-10) of school decile

5. Weight status interpreted using the WHO overweight cut-off of BMI z-score >+1SD (World Health Organization, 2007)
5.3 Food group intake

Table 5.6 shows the percentage contribution of the 33 main food groups to dietary zinc intake in the participants. The highest contributor to dietary zinc was ‘grains and pasta’ making up 10.9% of total dietary intake. The food groups that contributed the next highest amounts of dietary zinc intake after ‘grains and pasta’ were: ‘bread-based dishes’ (9.3%), ‘bread’ (8.1%), ‘beef and veal’ (7.7%), ‘poultry’ (6.8%), ‘vegetables’ (5.7%), ‘pork’ (4.6%), ‘sausage and processed meats’ (3.9%), ‘breakfast cereals’ (3.7%) and ‘potatoes, kumara and taro’ (3.6%).
Table 5.6 Dietary zinc sources of participants (n=132)

<table>
<thead>
<tr>
<th>Food Group</th>
<th>Mean % (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grains and pasta</td>
<td>10.9 (9, 12.8)</td>
</tr>
<tr>
<td>Bread-based dishes</td>
<td>9.3 (6.6, 12.1)</td>
</tr>
<tr>
<td>Bread (incl rolls and specialty breads)</td>
<td>8.1 (6.9, 9.4)</td>
</tr>
<tr>
<td>Beef and veal</td>
<td>7.7 (5.2, 10.2)</td>
</tr>
<tr>
<td>Poultry</td>
<td>6.8 (5.3, 8.3)</td>
</tr>
<tr>
<td>Vegetables</td>
<td>5.7 (4.4, 7)</td>
</tr>
<tr>
<td>Pork</td>
<td>4.6 (3.1, 6.2)</td>
</tr>
<tr>
<td>Sausage and processed meats</td>
<td>3.9 (2.4, 5.5)</td>
</tr>
<tr>
<td>Breakfast cereals</td>
<td>3.7 (2.7, 4.8)</td>
</tr>
<tr>
<td>Potatoes, kumara and taro</td>
<td>3.6 (2.7, 4.5)</td>
</tr>
<tr>
<td>Cheese</td>
<td>3.6 (2.5, 4.6)</td>
</tr>
<tr>
<td>Milk</td>
<td>3.5 (2.6, 4.4)</td>
</tr>
<tr>
<td>Pies and pasta</td>
<td>3 (1.5, 4.4)</td>
</tr>
<tr>
<td>Nuts and seeds</td>
<td>2.9 (1.8, 4.1)</td>
</tr>
<tr>
<td>Snacks sweet</td>
<td>2.8 (1.8, 3.8)</td>
</tr>
<tr>
<td>Fruit</td>
<td>2.8 (2.1, 3.4)</td>
</tr>
<tr>
<td>Snack food</td>
<td>2.2 (1.4, 3.1)</td>
</tr>
<tr>
<td>Biscuits</td>
<td>2 (1.5, 2.5)</td>
</tr>
<tr>
<td>Eggs and egg dishes</td>
<td>1.9 (1.2, 2.7)</td>
</tr>
<tr>
<td>Cakes and muffins</td>
<td>1.9 (1.3, 2.4)</td>
</tr>
<tr>
<td>Lamb/Mutton</td>
<td>1.7 (0.5, 2.9)</td>
</tr>
<tr>
<td>Dairy products</td>
<td>1.6 (0.9, 2.2)</td>
</tr>
<tr>
<td>Savoury sauces and condiments</td>
<td>1.1 (0.8, 1.5)</td>
</tr>
<tr>
<td>Sugars/sweets</td>
<td>1.1 (0.8, 1.5)</td>
</tr>
<tr>
<td>Fish/seafood</td>
<td>1.1 (0.6, 1.6)</td>
</tr>
<tr>
<td>Non-alcoholic beverage</td>
<td>0.9 (0.6, 1.2)</td>
</tr>
<tr>
<td>Soups and stocks</td>
<td>0.4 (0.09, 0.7)</td>
</tr>
<tr>
<td>Alcoholic beverages</td>
<td>0.4 (-0.04, 0.8)</td>
</tr>
<tr>
<td>Other meat</td>
<td>0.3 (-0.3, 0.8)</td>
</tr>
<tr>
<td>Supplements providing</td>
<td>0.2 (-0.2, 0.7)</td>
</tr>
<tr>
<td>Puddings/desserts</td>
<td>0.2 (0.03, 0.37)</td>
</tr>
<tr>
<td>Butter and margarine</td>
<td>0.2 (0.013, 0.03)</td>
</tr>
<tr>
<td>Fats and oils</td>
<td>0.0 (-)†</td>
</tr>
</tbody>
</table>

Abbreviations: CI= Confidence interval
† Amount consumed considered too small to calculate a confidence interval
5.4 Comparison of zinc intakes between school decile categories

Table 5.7 presents the relationship between participant characteristics and the school decile category. School decile 4-7 provided the highest proportion of participants for all age groups. The participants attending the school with a school decile of 1-3 had the highest mean BMI-for-age z-score, of 1.26.

The association between school decile and energy and zinc intake is shown in Table 5.8. Overall, as school decile increased, participants’ intakes of zinc increased. Dietary zinc intake was the only variable to be significantly associated with school decile, suggesting a significant increase in mean dietary zinc intake between schools in school decile 1-3 and school decile 8-10 ($p=0.010$). The same trend was observed in total zinc intake with schools in school decile 8-10 having the highest total zinc intake, followed by those in school decile 4-7 and school decile 1-3. Despite schools in school decile 8-10 consuming around 900kJ more energy than those in school decile 1-3, no association was found between school decile and energy intakes ($p=0.136$). Adolescents in schools from school decile 8-10 were more likely to consume supplements containing zinc but the median supplement intake in consumers from school decile 4-7 was the highest. All school categories had participants at risk of inadequate zinc intake. Only one participant had an intake that exceeded the UL of zinc intake. They were from a school decile 4-7 school.
### Table 5.7 Participant characteristics by the school decile of their school

<table>
<thead>
<tr>
<th>School Decile</th>
<th>1 – 3</th>
<th>4 – 7</th>
<th>8 - 10</th>
</tr>
</thead>
<tbody>
<tr>
<td>n= 14</td>
<td>n= 85</td>
<td>n= 46</td>
<td></td>
</tr>
</tbody>
</table>

#### Age

<table>
<thead>
<tr>
<th></th>
<th>Mean (SD)</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>15 – 16 years</td>
<td>16.2 (0.65)</td>
<td>16.7 (0.79)</td>
<td>16.9 (0.79)</td>
<td></td>
</tr>
<tr>
<td>17 – 18 years</td>
<td>12 (85.7)</td>
<td>48 (56.5)</td>
<td>22 (47.8)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2 (14.3)</td>
<td>37 (43.5)</td>
<td>24 (52.2)</td>
<td></td>
</tr>
</tbody>
</table>

#### Ethnicity

<table>
<thead>
<tr>
<th></th>
<th>NZEO</th>
<th>Māori</th>
<th>Asian</th>
<th>Pacific</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>8 (57.1)</td>
<td>5 (35.7)</td>
<td>1 (7.1)</td>
<td>0 (0)</td>
</tr>
<tr>
<td></td>
<td>59 (69.4)</td>
<td>20 (23.5)</td>
<td>4 (4.7)</td>
<td>2 (2.4)</td>
</tr>
<tr>
<td></td>
<td>37 (82.2)</td>
<td>4 (8.9)</td>
<td>1 (2.2)</td>
<td>3 (6.7)</td>
</tr>
</tbody>
</table>

#### Completed a diet recall

|  | 14 (100) | 75 (88.2) | 43 (93.5) |

#### BMI

<table>
<thead>
<tr>
<th></th>
<th>BMI (kg/m²)</th>
<th>BMI-for-age z-score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>26.2 (5.6)</td>
<td>1.26 (1.1)</td>
</tr>
<tr>
<td></td>
<td>23.7 (4.8)</td>
<td>0.61 (1.1)</td>
</tr>
<tr>
<td></td>
<td>23 (2.9)</td>
<td>0.52 (0.8)</td>
</tr>
</tbody>
</table>

#### Weight Status

<table>
<thead>
<tr>
<th></th>
<th>Not overweight</th>
<th>Overweight</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5 (35.7)</td>
<td>9 (64.3)</td>
</tr>
<tr>
<td></td>
<td>49 (66.2)</td>
<td>25 (33.8)</td>
</tr>
<tr>
<td></td>
<td>31 (73.8)</td>
<td>11 (26.2)</td>
</tr>
</tbody>
</table>

Abbreviations: SD, standard deviation; BMI, body mass index

1 School decile categories. The New Zealand Ministry of Education assigns schools a socio-economic score based on five census derived socio-economic factors with a range from 1 (low) to 10 (high) (Ministry of Education, 2019b)

2 n (%)

3 Participants identifying as multiple ethnicities were allocated to a single ethnic group. Ethnicities are prioritised in the order: Māori, Pacific, Asian, NZEO

4 Ethnicity missing for one participant (n=144)

5 NZEO ethnicity comprised: New Zealand European, Ethiopian, Somali, Italian, American, Nicaraguan, Irish, Afrikaans, Dutch, German, South African

6 Asian ethnicity comprised: Filipino, Japanese, Indian

7 Pacific ethnicity comprised: Tokelauan, Fijian, Cook Island, Samoan

8 mean (SD)

9 kg/m² = weight (kg) divided by height squared (m²)

10 Weight and height missing for two participants (n=130)

11 BMI-for-age z-score calculated using the WHO growth reference data (de Onis et al., 2007)

12 Weight status interpreted using the WHO overweight cut-off of BMI z-score > +1SD (World Health Organization, 2007)
Table 5.8 Energy and zinc intake by school decile of participants school (n=132)

<table>
<thead>
<tr>
<th>School Decile</th>
<th>Mean difference (95% CI)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 – 3</td>
<td>580 (-242, 2033)</td>
<td>0.136</td>
</tr>
<tr>
<td>4 – 7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8 – 10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>n= 14</td>
<td>n= 75</td>
<td>n= 43</td>
</tr>
<tr>
<td>Energy (kJ/day)</td>
<td>7893 (6931, 8855)</td>
<td>7685 (7323, 8047)</td>
</tr>
<tr>
<td>Zinc Intake (mg/day)</td>
<td>8 (6.67, 9.27)</td>
<td>9.1 (8.45, 9.72)</td>
</tr>
<tr>
<td>Total zinc (dietary and supplemental) (mg/day)</td>
<td>8 (6.39, 9.85)</td>
<td>8.93 (7.11, 10.58)</td>
</tr>
<tr>
<td>Zinc supplement users</td>
<td>0</td>
<td>4 (5.3)</td>
</tr>
<tr>
<td>Zinc from supplements in consumers (mg/day)</td>
<td>0</td>
<td>25.1 (12.57, 37.52)</td>
</tr>
<tr>
<td>At risk of inadequate zinc intake</td>
<td>2 (14.3)</td>
<td>10 (13.3)</td>
</tr>
<tr>
<td>Exceeding zinc upper level of intake</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

Abbreviations: CI, Confidence intervals
1 School decile categories. The New Zealand Ministry of Education assigns schools a socio-economic score based on five census derived socio-economic factors with a range from 1 (low) to 10 (high) (Ministry of Education, 2019b)
2 Comparison is between the lowest (school decile 1-3) and highest categories (school decile 8-10) of school decile
$p<0.05$ considered statistically significant. Calculated by a two-tailed unpaired t-test.

Dietary zinc intakes were adjusted for intra-individual variation in intake, using the Multiple Source Method (MSM), so are usual intakes (Harttig et al., 2011).

Median (25th, 75th)

One participant’s total zinc value was excluded because supplemental data were provided only ($n=132$).

No $p$-value as cannot calculate the difference between medians.

$n$ (%)

Supplement use collected in dietary habits questionnaire ($n=124$).

Calculated using the Ministry of Health EAR of 6mg/day ($n=133$) (Ministry of Health, 2014)

Calculated using the Ministry of Health UL of 35mg/day ($n=133$) (Ministry of Health, 2014)
6 Discussion and Conclusion

New Zealand (NZ) adolescent females 15-18 years of age in this study had a mean dietary zinc intake of 9.3mg/day and a median total zinc intake of 9.2mg/day when dietary and supplemental zinc intake were combined. In total, 10.6% were at risk of inadequate zinc intake and only one participant had an intake above the UL from supplements alone. The ‘grains and pasta’ food group (10.9%) was the primary source of zinc, followed by ‘bread-based dishes’ (9.3%) and ‘bread’ (8.1%). There was only one significant association found between dietary zinc intake and the characteristics measured: those who were from a school with a low school decile of 1-3 had, on average, a dietary zinc intake 2.0mg/day lower than those from a school with a school decile of 8-10 (p=0.010).

6.1 Zinc intake

Although it is challenging to directly compare the data from this project with data from other studies due to differences in study design, the dietary zinc intake findings in the present study are consistent with previous Australia and NZ studies (Ho et al., 2017; Rangan & Samman, 2012; University of Otago and Ministry of Health, 2011a).

The 2008/09 NZ Adult Nutrition Survey (ANS) (University of Otago and Ministry of Health, 2011a) and Rangan and Samman (2012) both used 24-hour recalls and found that the mean dietary zinc intake of female adolescents was 9.1mg/day and 9.8mg/day, respectively (Rangan & Samman, 2012; University of Otago and Ministry of Health, 2011a), which is very similar to the mean dietary zinc intake of 9.3mg/day observed in the present study. The slightly higher mean zinc intake of 9.8mg/day observed in Rangan and
Samman (2012) could be related to differences in eating patterns between NZ and Australia.

In contrast to the present study, Ho et al, (2017) used a semi-quantitative food frequency questionnaire (FFQ) to determine dietary intake and found a lower median dietary zinc intake in Australian adolescents (8.5mg/day). These results must be interpreted with caution as it is unknown if the FFQ used in that study does not appear to have been validated as it is not explicitly stated that it was validated (Ho et al., 2017).

Until now, the research on zinc intake in NZ and Australian adolescents has tended to focus on describing dietary zinc intake, rather than on determining possible associations with participant characteristics, although Ho and colleagues did find that unadjusted dietary zinc intake was significantly lower in females than males (Ho et al., 2017). The present study suggests there may be an association between dietary zinc intake and socioeconomic status (SES) in NZ adolescent females. Attending a school from the lowest school decile level was associated with a lower zinc intake than attending a school from the highest school decile level ($p=0.010$). However, these results must be interpreted with caution for a number of reasons: 1) the data are from a clustered sample meaning participants may have homogeneous characteristics within a school, 2) the very low number of schools in the extreme categories means findings in school decile 1-3 and school decile 8-10 may be attributable to the characteristics of the school rather than its decile rating, and 3) school decile level is a measure of the ‘socioeconomic position of a school’s student community rather than a measure of individual students’ economic and social status’ (Ministry of Education, 2019a). There is reason to believe SES factors may affect zinc status. For instance, the high price of red meat, a rich source of zinc and protein, might be expected to
reduced consumption in low SES families. It would be of interest to see whether another stronger measure of SES, such as the New Zealand Index of Socioeconomic Deprivation (NZDep) (Atkinson et al., 2014), would produce the same association with dietary zinc intakes in our study group.

6.2 Prevalence of inadequate and excessive zinc intakes

Our results combined with those of the existing NZ literature suggest that the prevalence of inadequate zinc intake in NZ adolescent females is not substantial, as less than 25% of individuals fall below the zinc EAR (Brown et al., 2004). However, The International Zinc Nutrition Collaborative Group (IZiNCG) recommend that information on the adequacy of dietary zinc intake should be interpreted together with data from other assessment methods, in particular biochemical assessment (Brown et al., 2004). So, as no biochemical indicator was available in the present study we cannot conclude that adequate dietary zinc intake is reflective of adequate zinc status in this population (Brown et al., 2004).

Despite both studies finding a similar mean dietary zinc intake to the present study, the 2008/09 NZ ANS (University of Otago and Ministry of Health, 2011a) and Rangan and Samman (2012) found the prevalence of inadequate zinc intake was lower than the present study (6.5% and 7.7%, respectively). It seems possible that the slightly higher prevalence of inadequate intakes in the present study (10.6%) is due to a possible increasing number of adolescent females following vegetarian diets causing a decline in red meat consumption, a rich source of readily available zinc (Donovan & Gibson, 1995; Gibson & Heath, 2011; Laugesen & Swinburn, 2000). This question is going to be examined in another Master of Dietetics student’s research project. Ho et al. (2017) reported a
significantly higher risk of inadequate zinc intake in Australian adolescents (17%), which could be related to the difference in eating patterns between NZ and Australia. However, it is also important to bear in mind these results cannot be directly compared as Ho and colleagues failed to state what method was used to determine the prevalence of inadequate zinc intakes (Ho et al., 2017).

The use of zinc supplements was relatively low among adolescents in the present study (10.5%) and the majority of supplements used provided only small amounts of zinc. Only one adolescent consumed large amounts of supplementary zinc (50mg/day), which exceeded the Upper Level of Intake (UL) (35mg/day) (Ministry of Health, 2014). To date, only one study in NZ and Australian adolescents have addressed zinc-containing supplement intake (Rangan & Samman, 2012). The Australian study reported a higher mean total zinc intake (10.3mg/day) compared with the present study (9.2mg/day), and no participants were consuming an intake above the UL of 35mg/day (Ministry of Health, 2014) (Rangan & Samman, 2012). In that study, a 24-hour recall was used to capture supplement intake, compared to a questionnaire in the present study, and 24-hour recalls may not represent ‘usual’ supplement use (Murphy et al., 2002).

Taken together, the estimated probabilities of inadequate intake in the NZ and Australia studies are less than 25%, which suggests that the risk of zinc inadequacy is not elevated in the NZ adolescent population (Brown et al., 2004). It also appears that excessive intakes of zinc are not common in the adolescent population.
6.3 Contribution of different food groups to zinc intake

The main food sources of zinc in this adolescent groups diet confirm that a moderate zinc source eaten in large amounts regularly supplies more zinc than a rich zinc source eaten in smaller amounts less frequently.

The 2008/09 NZ ANS (University of Otago and Ministry of Health, 2011a) top three main food sources of zinc were the same as the present study: ‘bread-based dishes’, ‘grains and pasta’, and ‘bread’. Although zinc is found widely in the food supply, its bioavailability from different foods is highly variable (Brown et al., 2004). The top three foods found in both studies have lower bioavailability as they are cereal-based products. Cereals can be rich in phytate, which binds zinc in the intestine and reduces its absorption (Brown et al., 2004). Foods from animal sources are rich sources of highly bioavailable zinc (Brown et al., 2004) and have similar low contributions in the present study and the 2008/09 NZ ANS (‘beef and veal’: 7.7% vs 6.9%; ‘poultry’: 6.8% vs 6%; ‘sausage and processed meats’: 3.9% vs 4.1%). Milk (5.3%) was a higher contributor to zinc in the 2008/09 NZ ANS (University of Otago and Ministry of Health, 2011a) than the present study (3.5%). This may be due to the decline in the consumption of cow’s milk due to concerns about the environment, possible lactose intolerance and milk allergies (Vanga & Raghavan, 2018).

In contrast to the 2008/09 NZ ANS (University of Otago and Ministry of Health, 2011a) and the present study, Rangan and Samman (2012) reported absolute amounts of zinc rather than the percentage of zinc from different food sources. Therefore, the findings cannot be directly compared. Surprisingly, ‘meat, poultry and game products’ (2.97mg/day) was the highest contributor to zinc intake, and ‘fruit’ was one of the main
food sources. These very different results to the present study may be due to differences in eating patterns between NZ and Australia, as well as differences in the classification of foods to food groups. For example ‘meat, poultry and game products’ were classified as one food group in Rangan and Samman (2012) rather than being separated into: ‘beef and veal’, ‘poultry’, ‘pork’, ‘sausage and processed meats’, ‘lamb/mutton’, and ‘other meat’ as they were in the present study and the 2008/09 NZ ANS (University of Otago and Ministry of Health, 2011a).

The literature suggests that zinc is being provided by a wide variety of food sources. Future investigation is needed into the bioavailability of zinc from these different food sources and the potential impact on biochemical zinc status in adolescent females.

6.4 Strengths and limitations

A considerable limitation to this study was the inability to look at biochemical zinc status. This means that we cannot conclude from the apparent adequate dietary zinc intake that zinc status is adequate. Biochemical zinc status would have also allowed us to investigate the effect of zinc supplementation and whether zinc status differed according to the food sources consumed.

An important strength of this study was the codebook which was developed by Liz Fleming and a Doctor of Philosophy (PhD) student and used by all Master of Dietetic students when inputting dietary data into FoodWorks. In addition, recipes for commercial foods were created using the ingredients list for the product, and modified by comparing the nutrients against the product’s nutrition information panel in order to determine an accurate macro- and micronutrient content. The Candidate was responsible for generating
20 such recipes. A major strength of the study was that all of the 24-hour recalls were compared with original entries by Liz Fleming and a PhD student.

The present study collected 24-hour recalls which are known to be affected by potential under-reporting. Recent research into the 2008/09 NZ ANS (University of Otago and Ministry of Health, 2011a) suggested that 25% of women potentially under-reported their dietary intake (Gemming et al., 2013).

An unavoidable limitation of this study was the short duration of the study period. This meant the study could not allow for seasonal variability in the intake of food, with foods more commonly consumed over the Easter period (i.e. hot cross buns and chocolate) appearing frequently in the 24-hour recalls.

The collection of data from eight centres across the country strengthened the study as it allowed for a better understanding of zinc intake in adolescents across NZ. The study also had good Māori representation (20%). According to the NZ Census, approximately 20% of adolescents identified as Māori in 2013 (Statistics NZ, 2014). However, there were few Asian and Pacific participants.

### 6.5 Conclusions and implications for future research

The majority of this healthy adolescent cohort appeared to be consuming adequate amounts of zinc, with a low prevalence of both zinc inadequacy (10.6%) and excessive intake (0.8%). The major contributors to zinc intake were ‘grains and pasta’, followed by ‘bread-based dishes’ and ‘bread’. However, as no biochemical measure was available in the present study we cannot conclude that zinc is not a nutrient of concern in NZ adolescents. Further research should assess the biochemical zinc status of this group, in order to
determine whether these dietary zinc intake data reflect zinc status. It would also be worthwhile to include a measure of socioeconomic status, and recruit a sample with a wider ethnic distribution in future studies.
7 Application of Research to Dietetic Practice

Dietitians have a responsibility to provide an evidence-based approach to their work in both clinical and public health dietetics, with support from the Dietitians Board of New Zealand (NZ).

The findings of the present study provide an in-depth up-to-date analysis of dietary zinc intake in the NZ female adolescent population. However, this study must not be used in isolation. Other studies that are from a representative sample and assess a biochemical zinc measure are needed before a confident conclusion can be made on zinc intake, its main food sources, and zinc adequacy in NZ adolescent females. These findings will be beneficial for public health dietitians as a decision can then be made on whether there is a need for programmatic intervention in NZ adolescent females in order to ensure they achieve adequate zinc status.

In a clinical setting, when consulting with adolescent clients, the information provided must be relevant and up-to-date. This is particularly important when you are competing with information which has been found online. The findings from this study can help guide dietitians with clients where zinc may be a nutrient of concern in the diet. The identification of food types that are rich and/or bioavailable sources of zinc compared to the sources of zinc that are commonly consumed in the adolescent diet allows dietitians to ensure nutrition advice is practical and achievable for every patient. For instance, these findings suggest that even though milk is a rich source of zinc, it is not an important source in this population, so there may be little point recommending it. It will be particularly relevant when providing alternatives to those who have eliminated one of the main sources of zinc from their diet, for example, grains and cereals which are food sources of gluten.
Adolescence is a crucial age for the development of life-long dietary choices. The Ministry of Education currently has the ‘healthy people eat healthy food’ curriculum in secondary schools which focuses on food safety, general nutritional requirements and nutritional needs for growth and development. However, it was clear from the data I collected that unhealthy diet habits had already formed in the majority of the students. I was shocked to hear girls were regularly missing meals and consuming large amounts of processed foods. This experience has strengthened my communication skills and taught me to be more empathetic and less judgemental of those who have a differing dietary habit to my own. It has also taught me the value of listening. I feel fortunate and humbled to have had this experience, as it has helped me understand the importance of creating nutritional advice and interventions that are practical, achievable and understood by all that they are intending to target. This advocates for a supportive learning environment - an essential element of the Ottawa Charter for Health Promotion.
8 References


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Appendix A: Ethical Approval

Developed by the SuNDiAL Principal Investigators
4 February 2019
Dr J Haszard
Department of Human Nutrition
Division of Sciences

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
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 Raraunga 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 B: PowerPoint Presentation for Advertising

Developed by the Candidate and two other Master of Dietetics students
WHO ARE WE?

• 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:  
Master of Dietetics (2 years)

THE Sundial Project

Survey of Nutrition, Dietary Assessment and Lifestyle project

Nationwide survey of girls aged 15-18 years old

6/13/19
**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
- 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 C: Information Sheet

Developed by the SuNDiAL Principal Investigators
Participant Information Sheet

| Study title: | The SuNDiAL Project 2019: A survey of nutrition, dietary assessment and lifestyle |
| Principal investigators: | Names Dr Jill Haszard & Dr Meredith Peddie |
| Department: | Human Nutrition |
| Position: | Research Fellows |
| Contact phone number: | 03 479 5683 |
| | 03 479 8157 |

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, Interleukin-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: Dr Jill Hazzard</th>
<th>Contact phone number:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Position: Senior Research Fellow</td>
<td>03 479 5683</td>
</tr>
<tr>
<td>Department of Human Nutrition</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Name: Dr Meredith Peddie</th>
<th>Contact phone number:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Position: Research Fellow</td>
<td>03 479 8157</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 D: Enrolment Questionnaire and Consent Form

Developed by the SuNDiAL Principal Investigators
SuNDiAL 2019 Enrolment Questionnaire

Thank you for showing an interest in this project. Please read the information about SuNDiAL project carefully. This can be found on our website www.otago.ac.nz/sundial. 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 it.

Who are we seeking to take part in the project?
We are looking for female high school students who are 15 to 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 take part, 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 with three parts to it: (i) health & demographics; (ii) why you choose the food you eat; and (iii) your dietary habits.

2) Attend a session at your school with our research team. This visit will take about 60 minutes and you will be asked to recall the food and drink you’ve consumed over the last day. You will also have your height, weight, and length of your lower arm measured. 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 may ask for the measurements if you want them.

3) In the next week or two we’ll ring or video call you to do a second food and drink recall.

Any questions?

Contact Jill (ph 03 479 5683) or Meredith (ph 03 479 8157) or email us on: sundial@otago.ac.nz

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.

Electronic consent.
Click on the “agree” button below if:

You have read the information about the study
02/27/2019 12:59pm
www.projectredcap.org

84
You have had all your questions answered about the study and understand that you can ask for more information at any stage.

You know that when the project is completed all personal information that could be linked to you will be removed from the paper records and electronic files for the project, and that these will be placed in secure storage and kept for at least ten years.

You are a young woman who is 15 to 18 years old and isn’t pregnant.

You know you can pull out of the study anytime before it finishes in October 2019.

If you don’t want to take part in the SuNDIAL project, please click on the "disagree" button.

☐ AGREE
☐ DISAGREE
Thank you for agreeing to take part in the SuNDIAL project! If you are female, aged 15-18 years of age and not pregnant, please answer the following two questions:

<table>
<thead>
<tr>
<th>Question</th>
<th>Options</th>
</tr>
</thead>
</table>
| What age are you as of today?                                            | ○ 15  
○ 16  
○ 17  
○ 18  
○ None of the above                                                     |
| What high school do you attend?                                          | ○ Tauranga Area School  
○ Mt Maunganui College  
○ Spotswood College  
○ St Catherine's College  
○ Waiheka College  
○ Tauranga Boys' College  
○ Columba College  
○ Kakarori Valley College  
○ Wellington Girl's College  
○ Queen's High School  
○ Mt Aspiring College  
○ None of the above |

05/27/2019 12:09pm
Thank you! You are eligible to take part in the SuNDIAL project!

There are three other parts to the SuNDIAL project that are optional. Please read the following information carefully before you decide whether to take part in these optional bits of the study. For each one of these that you do, you will receive a $5 gift voucher from New World or PaknSave.

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.

Once all of the analysis has been completed the samples will be disposed of using standard biohazard protocols. On the consent form (below) you can tell us if you would like your blood sample disposed of with a Karakia (Māori Prayer).

Electronic consent

Click on the “AGREE” button below if:
- You have read the information on the website
- You want to take part in these parts of the study

If you don’t want to take part in these parts of the study, please click on the “DISAGREE” button.

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), but we understand that not everyone feels comfortable about this so it is entirely up to you if you do this. 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.

Click on the agree button below if:

You understand the risks of discomfort involved in providing a blood sample

☐ AGREE
☐ DISAGREE

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

☐ Yes
☐ No

URINE SAMPLE:

We would also like you to give a urine sample (“pee or wee”) - which is easy for you collect yourself with the equipment we give you. You can still take part in the rest of the study even if you don’t do this bit.

Click on the ‘AGREE’ button below if:

☐ AGREE
☐ DISAGREE
ACCELEROMETER:

We would also like you to wear a small red box called an accelerometer on an elastic belt 24 hours a day for seven days. 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 you 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.

☐ AGREE
☐ DISAGREE
## Contact Information

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>What is your name?</td>
<td>(Preferred first name, Last name)</td>
</tr>
<tr>
<td>What is your date of birth?</td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td></td>
</tr>
<tr>
<td>Phone number (mobile would be best - so we can text you reminders)</td>
<td></td>
</tr>
<tr>
<td>What is your home address? [This will be the address where we will send your voucher]</td>
<td>(number &amp; street, suburb, city, postcode)</td>
</tr>
<tr>
<td>Do you live at this address during school term?</td>
<td></td>
</tr>
<tr>
<td>Do you live in a boarding house during school term? [Don’t include private boarding]</td>
<td></td>
</tr>
<tr>
<td>Please put the name and/or address of the boarding house</td>
<td></td>
</tr>
<tr>
<td>What is the address that you live at during school term?</td>
<td></td>
</tr>
</tbody>
</table>
Health information

If you know your height, please write it here: ________________________________

What unit is this measurement in?  
- centimetres  
- metres  
- feet and inches

If you know your weight (in kg) please write it here: ________________________________
Have you been diagnosed with diabetes?  
- Yes
- No

If so, which type?  
- Type 1 diabetes
- Type 2 diabetes
- Don't know

Do you avoid eating gluten?  
- Yes
- No

Have you been diagnosed with either coeliac disease or gluten intolerance?  
- Yes - coeliac disease
- Yes - gluten intolerant
- No diagnosis but suspected intolerance or coeliac
- No

Have you been diagnosed with a food allergy or intolerance? (not gluten)  
- Yes
- No

Which foods are you allergic or intolerant to?  
(Select as many as apply)
- Eggs
- Dairy
- Nuts
- Shellfish
- Other

Other: please specify

Are you vegetarian or vegan?  
- Yes
- No

Which foods do you eat? (Select as many as apply)
- Egg
- Milk (not plant milk like soy milk)
- Fish or seafood
- Chicken or poultry
- Meat/red meat occasionally
- None of the above

Are you vegan?  
- Yes
- No

How long have you been following this way of eating?  
- Less than a month
- Between 1 and 6 months
- Between 6 months and 1 year
- Between 1 and 2 years
- More than 2 years
- My whole life
The following questions are a bit sensitive, but it is necessary for us to ask them because they can help us understand what nutrients are important for the health of young women your age.
<table>
<thead>
<tr>
<th>Question</th>
<th>Options</th>
</tr>
</thead>
</table>
| How old were you when you had your first period?                        | ○ 11 years or younger  
○ 12-14 years  
○ 15 years or older  
○ I haven’t had a period yet |
| How long do you usually have from the start of one period to the start of the next? | ○ 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 periods is not regular |
| How many days does your period usually last? (count your light days as well as your heavy ones) | ○ Less than 4 days  
○ 4-6 days  
○ 7-9 days  
○ 10 days or more |
| Are your periods so heavy that they make it hard for you to go to school? | ○ Yes - often  
○ Yes - sometimes  
○ No |
| Have you donated blood?                                                 | ○ Yes  
○ No |
| When did you last donate blood?                                         | ○ In the last 4 months  
○ Between 4 and 12 months ago  
○ More than a year ago |
| Have you had a nosebleed in the last year?                              | ○ Yes  
○ No |
| Do you have nosebleeds regularly?                                       | ○ Yes  
○ No |
| Over the last year, on average how often did you get nose bleeds?       | ○ More than once a week  
○ Once a week  
○ Every couple of weeks  
○ Once a month  
○ Every few months  
○ Every 6 months  
○ Once a year  
○ Less than once a year |
| Do you use any of the following contraceptives:                         | ○ No - I don’t use those contraceptives  
○ Yes - I use one of those contraceptives |
| - Oral contraceptive (eg ‘the pill’ or ‘the mini-pill’)                 |                                                                   |
| - Depo Provera injection                                                |                                                                   |
| - Implant (eg Jadelle)                                                  |                                                                   |
| - Hormonal IUD (eg Mirena)                                              |                                                                   |
### Other information

Which ethnic group do you belong to? (Mark those that apply)
- [ ] New Zealand European
- [ ] Māori
- [ ] Samoan
- [ ] Cook Island Māori
- [ ] Tongan
- [ ] Niuean
- [ ] Chinese
- [ ] Indian
- [ ] Other such as Dutch, Japanese, Tokelauan, please state...

Other: please state

Please let us know which type of gift card you would prefer:
- [ ] New World
- [ ] PaynSave

Thank you for enrolling in the SuNDIAL project!

What happens next?

We are now going to ask you to complete a questionnaire about why you eat the food you do. If you want to complete it at a later time, please click the Save and Return button at the bottom of this page (don’t forget to make a note of your code so that you can return to this survey). Or, click the “Submit” button to continue.

You will also get an email and/or text to tell you when you can visit the SuNDIAL clinic at your school to complete the other measurements.
Appendix E: Dietary Habits Questionnaire

Questions on supplement use only
Developed by the SuNDiAL Principal Investigators
**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.

Please specify the type of oil:

Oil: 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

Oil:

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.

Oil:

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.

Brand: 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

Brand:

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.

Brand:

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>Lecithin: How long did you take the supplement in the last 12 months?</th>
<th>□ Daily □ More than once a week □ Once per week □ Monthly □ Regularly but for a limited time □ Not very often</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lecithin:</td>
<td></td>
</tr>
</tbody>
</table>
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. | |
| Lecithin: | 
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. |
| LSA: 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 |
| LSA: | 
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. | |
| LSA: | 
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. |
| Kelp: 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 |
| Kelp: | 
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. |
Keep:

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.

Spirulina: 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

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.

Spirulina:
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.

Glucosamine and/or chondroitin: 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

Glucosamine and/or chondroitin:
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.

Glucosamine and/or chondroitin:
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.
Echinacea: 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

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.

Ginkgo: 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

Ginkgo:
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.

Ginkgo:
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.

Hypericum (St John’s Wort): 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

Hypericum (St John’s Wort):
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.
Confidential

Hypericum (St John’s Wort):

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.

Sports supplement: 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

Sports supplement:

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.

Sports supplement:

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 F: Iron and Zinc Supplement Analysis

Analysis on zinc supplement use only
Developed by the Candidate and one other Master of Dietetics student
<table>
<thead>
<tr>
<th>Variable / measured in mg per serve</th>
<th>Variable_label</th>
<th>Data_type</th>
<th>Value_label</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supplement_code</td>
<td>Unique number for each supplement reported by participants</td>
<td>categorical</td>
<td>1, Healthier/s spirulina</td>
</tr>
<tr>
<td>Unit</td>
<td>Unique name for each supplement reported by participants</td>
<td>categorical</td>
<td>1, Tablet</td>
</tr>
<tr>
<td>Supplement brand/ type</td>
<td>Iron amount per unit. Where values were missing for iron a value of 0.2 was used to work out the proportion of iron in iron bis-glycinate chelate, based on values reported from Care_Pharmaceuticals/Fab Iron+/Vitamin B complex</td>
<td>continuous</td>
<td>1, Tablet</td>
</tr>
<tr>
<td>Zinc</td>
<td>Zinc amount per unit. Where values were missing for zinc a value of 0.2 was used to work out the proportion of zinc in the zinc amino acid chelate, zinc glycinate monohydrate and zinc bis-glycinate chelate, based on values reported from blackmores/nail hair skin</td>
<td>continuous</td>
<td>1, Tablet</td>
</tr>
<tr>
<td>Ferrous_fumarate</td>
<td>Ferrous fumarate amount per unit</td>
<td>continuous</td>
<td>1, Tablet</td>
</tr>
<tr>
<td>Zinc_amino_acid_chelate</td>
<td>Zinc amino acid chelate amount per unit</td>
<td>continuous</td>
<td>1, Tablet</td>
</tr>
<tr>
<td>Iron_amino_acid_chelate</td>
<td>Iron amino acid chelate amount per unit</td>
<td>continuous</td>
<td>1, Tablet</td>
</tr>
<tr>
<td>Ferrous_gluconate_iron</td>
<td>Ferrous gluconate iron amount per unit</td>
<td>continuous</td>
<td>1, Tablet</td>
</tr>
<tr>
<td>Ferrous_iron</td>
<td>Ferrous iron amount per unit</td>
<td>continuous</td>
<td>1, Tablet</td>
</tr>
<tr>
<td>Iron_bis_glycinate_chelate</td>
<td>Iron bis-glycinate chelate amount per unit</td>
<td>continuous</td>
<td>1, Tablet</td>
</tr>
<tr>
<td>Zinc_bis_glycinate_chelate</td>
<td>Zinc bis-glycinate chelate amount per unit</td>
<td>continuous</td>
<td>1, Tablet</td>
</tr>
<tr>
<td>Zinc_glycinate_monohydrate</td>
<td>Zinc glycinate monohydrate amount per unit</td>
<td>continuous</td>
<td>1, Tablet</td>
</tr>
<tr>
<td>Generic_multivitamin_mineral</td>
<td>Calculated based on the average of the reported values from Red seal/Womens Multivitamin and healthier/Womens Multi probiotics</td>
<td>continuous</td>
<td>1, Tablet</td>
</tr>
<tr>
<td>Generic_Iron_only</td>
<td>Based off ferro-tab: 65mg and ferrograd: 105mg from pharmas, fully subsidised</td>
<td>continuous</td>
<td>1, Tablet</td>
</tr>
<tr>
<td>Generic_zinc_only</td>
<td>Based off ZINCaps: 50mg. Only fully subsidised prescribed form of zinc on PHARMAC</td>
<td>continuous</td>
<td>1, Tablet</td>
</tr>
<tr>
<td>Unstated_single_vitamin_mineral</td>
<td>When participants did not know the single vitamin brand or type taken</td>
<td>continuous</td>
<td>1, Tablet</td>
</tr>
<tr>
<td>Missing</td>
<td>Used when there is reason to believe there is some of that nutrient in the product just cant find out how much</td>
<td>continuous</td>
<td>1, Tablet</td>
</tr>
<tr>
<td>0</td>
<td>When we are sure there isnt any iron or zinc in the product</td>
<td>continuous</td>
<td>1, Tablet</td>
</tr>
<tr>
<td>Supplement_code</td>
<td>Unit</td>
<td>Supplement_brand / type</td>
<td>Iron_fumarate</td>
</tr>
<tr>
<td>----------------</td>
<td>------</td>
<td>--------------------------</td>
<td>---------------</td>
</tr>
<tr>
<td>1</td>
<td>4</td>
<td>Healthories / spirulina</td>
<td>4.6</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
<td>Blackmores / vitality_super_green</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>Red_seal / Womens_Multivitamin</td>
<td>5</td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td>Red_seal / Zinc_B6 magnesium</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>2</td>
<td>Interclinical_Professional / zinc_plus</td>
<td>0</td>
</tr>
<tr>
<td>6</td>
<td>2</td>
<td>moly_zinc</td>
<td>0</td>
</tr>
<tr>
<td>7</td>
<td>1</td>
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<td>154</td>
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</tbody>
</table>
Appendix G: SuNDiAL Code Book

Recipes, default and substitutions developed by the Candidate
Developed by the SuNDiAL Principal Investigators
### Codebook Instructions

| Default foods: | Default food items: to be used when insufficient food information is provided to determine exact food code OR when no exact match is present in FoodWorks but a closely related food is available. We need to be consistent about the food that is selected: the default foods used in the BLISS and SWIFT studies are on separate sheets. A new sheet has been created for the SunDial study. When you use a default from either the BLISS or SWIFT study please copy that food in to the SunDial study Default foods page.
- have insufficient information provided in the diet recordand so require an established rule to ensure consistent treatment of the situation across all BLISS projects (e.g. "apple", "butter", "porridge", "beef steak", "oil" etc)
- Do not have an exact match in Kai-calculator (e.g. Freya's soy and linseed bread, vitawheat 9 grain crackers, Yoplait seriously smooth banana custard etc) and so a food that is as close a match as possible has to established as the default choice for that specific food |
| Substitutions: | SUBSTITUTIONS are to be used when there is no exact or close match to the diary food item in FoodWorks (e.g. chicken bacon is not present in FOODfiles and so would require a substitute such as pork bacon, muffin muesli bars would need a substitute and so on) There are some listed in the Substitutions BLISS and SWIFT sheet |
| Food weight estimation rules: | to be used when the food weight is not provided |
| Food weight estimation defaults: | to be used when the food weight is not provided |
| Cooking method rules: | When no cooking method has been specified for foods |
| Fruit | When no cooking method is specified for fruits (including apple, pear and tomato) assume that it was offered fresh and use the appropriate default options listed on the "default foods" sheet |
| Vegetables (non starchy vegetables) | When no cooking method is specified for vegetables (such as carrots, broccoli, cauliflower etc) assume that it was offered steamed/microwave or boiled and use the appropriate default options listed on the "default foods" sheet.
For green peas assume that they have been boiled |
| Starchy vegetables | When no cooking method has been specified for starchy vegetables (including potatoes, kumara/sweet potatoes, pumpkin) assume that it was offered steamed/microwave or boiled and use the appropriate default options listed on the "default foods" sheet. However, if the meat accompanying vegetables is roasted then vegetables may have been as well. If meat is stirfried vegetables may be stir fried.
For green peas assume that they have been boiled |
| Meat, fat or skin not mentioned | Use meat with no fat removed or add fat additionally |
| Other: | |
| Coffee pre made (cæle) | Choose milk first, then drink type next, don’t worry too much about shot amount |
| Chocolate | Look up nutrient profile, then choose a similar match (don’t worry about brand) if type not available, match energy, sugar and fat. |
| Food not in FoodWorks | Data that is not in FoodWorks ie edamame beans, look up nutrient profile and match data with similar |
| Milk | Use type and brand if available or if brand not available use composition data for a trim version or std version - don’t use Nov/May data |
| Substitutions | Look up nutrient profile either via google or brand website - then choose a similar profile on FoodWorks regardless of brand difference |
| Spreads, if not specified | Use standard fat, salt or sugar varieties rather than diet ones |
### Food weight estimation rules: to be used when the food weight is not provided

| When a household measure is given (e.g. 1 tsp or 1 cup) but no food weight is provided then the weight should be estimated using one or more of the following: |
| - Use the quantity measure weight options in FoodWorks to calculate the weight of the food item offered |
| - Refer to Food weight estimation DEFAULT sheet |
| - Check the Countdown on-line website product information for brands and specific products |

| When the weight of food items e.g. fruit and vegetables has to be estimated use the quantity measure descriptions in FoodWorks: |
| - Select the relevant food item, click on the quantity column and look for descriptive measure definitions. Choose an appropriate one. |
| - When a measure of the size of a fruit or vegetable is given by the participant (e.g. a medium pear or a large potato) then choose that measure if it is in the list of quantities in FoodWorks |
| - NO measure is given (e.g. a banana, a carrot) then use the medium size piece option |
| - Refer to Food weight estimation DEFAULT sheet |

| For her check the Default Bread page for measure weights OR Check the Countdown on-line website for the brand and type and check the weight per slice. NB often recorded as g per 2 slices. |

| When an overall amount for combined foods has been given and there are no amounts for the individual foods making up the combined offering (e.g. toast with margarine and jam) the amounts of the individual ingredients have to be estimated. |
| - For foods that have default weight estimations available in the “food weights estimation DEFAULTS” page e.g. breads and margarine etc use the “food weights estimation DEFAULTS” page weights to guide estimation of the individual food weights |
| - For foods that do not have default food amounts/weights (e.g. potatoes/corncobs/chickens etc with no other serving size guidelines) assume that equal proportions of each of the individual items were consumed (e.g. chicken = potato + peas + corn (total amount weight of food offered = 2 cups or 300g) assume 0.5 cup (or 75g) of each item. |

| When dimensions of food (e.g. 5cm x 1cm x 1cm) have been given instead of weights OR household measures (e.g. 1/4 cup or 1 Tbsp) OR food unit sizes (e.g. medium carrot or a bread slice of bread) use Cal-culator to convert the dimensions to a weight estimate. |

| If a participant says there were leftovers record the weight or volume of the left overs or a fraction/proportion (i.e. 10% or 1/10) left over. If a word description is given use the following proportions to estimate the amount of food leftover: Used in the BLiSS study but could apply to adult diets as well. |
| - *almost all* = 90% |
| - *most* = 75% |
| - *some* = 50% |
| - *a little bit* or *tiny bit* = 25% |
| - *almost none* = 10% |

### Fluids

| Coffee ground = 1 tsp if not specified |
| Tea = use Indian/Infused tea or black tea both are liquid, do not use ‘Tea, Indian, leaves’ as we do not usually consume the leaves. |
| Espresso shot = 25 ml |

| Record water/liquids when it is X it is consumed. If liquid is recorded at the end of recall record as a whole amount, add to the last entry (e.g. 20.00) |
| Used 180ml for a glass of water when not specified amount |
| Used mug (240ml) if use of tea or coffee not specified |
| Milk for coffee or tea not specified amount use 200ml or guideline amount per 1 ml of beverage |
| Milk for porridge or cold cereal if not specified guideline amount per cup hot or cold cereal |
| Glass of wine - if amount not specified, use Cal-culator guide for a glass of wine e.g. 149 g for wine, white, dry - Rose |
| Alcoholic cocktails = 150 ml - Michelle |

| Print of beer: In New Zealand, there is no legal requirement for beer to be served in standard measures. In pubs, the largest size of glass, which is referred to as a pint, usually contains 450ml. |

### Vegetables

| Roast vegetable salad with dressing: 1 cup = 200 g (Sweetcorn salad dressing, salmon R149) - Liz |
| 1 bunch* of asparagus = 11 spears (counted from the bunch in my fridge) - Rose |
| 1/4 head of cabbage (average) = 128 g (taken from info found on two sites on internet) - Rose |
| 1 stockpot* - 250 g is dissolved in 500 mL of water, therefore = 528 g stock. Reduce the water content of recipe accordingly - Rose |
| Cucumber - small slice = 55 g |
| Herbs or spices do not need to be included unless they are large quantities |
| Oil spray = 1 Tbsp. |

| If they don’t specify size, always assume medium |
| Egg Size 6 unless specified |
| Use 1 cup for pre-made meals such as curries if not specified |

### Comments or coding rules

| NB you can copy and paste water. We never need to use this data that is fine. However, if we do want to use it then the diet recalls don’t need to be checked and re-entered again. It is important in research studies to anticipate and alone for researchers to look at different nutrients, food patterns etc further down the track. We save overall time by including more information now. |
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| Alcoholic cocktails = 150 ml - Michelle |

| Print of beer: In New Zealand, there is no legal requirement for beer to be served in standard measures. In pubs, the largest size of glass, which is referred to as a pint, usually contains 450ml. |

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| Cucumber - small slice = 55 g |
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| Oil spray = 1 Tbsp. |

| If they don’t specify size, always assume medium |
| Egg Size 6 unless specified |
| Use 1 cup for pre-made meals such as curries if not specified |

### Comments or coding rules

| NB you can copy and paste water. We never need to use this data that is fine. However, if we do want to use it then the diet recalls don’t need to be checked and re-entered again. It is important in research studies to anticipate and alone for researchers to look at different nutrients, food patterns etc further down the track. We save overall time by including more information now. |
**Recipes: to be created for a mixed dish (homemade recipe) or when a food item's macronutrient values in FoodWorks differed from the nutrition information panel of the actual product by 10%, or an appropriate nutrient line was not available. Recipes were created for both commercial foods and homemade recipes.**

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<thead>
<tr>
<th>Recipe created</th>
<th>Commercial or Homemade</th>
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<tbody>
<tr>
<td>Best Foods mayonnaise</td>
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<tr>
<td>Cadbury oreo chocolate</td>
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</tr>
<tr>
<td>Chocolate berry balls</td>
<td>Commercial</td>
</tr>
<tr>
<td>Copper kettle sea salt chips</td>
<td>Commercial</td>
</tr>
<tr>
<td>Fantastic Instant Noodles beef flavour</td>
<td>Commercial</td>
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<tr>
<td>Fanta</td>
<td>Commercial</td>
</tr>
<tr>
<td>Griffins Shewsberry biscuits</td>
<td>Commercial</td>
</tr>
<tr>
<td>Lisa hummus</td>
<td>Commercial</td>
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<tr>
<td>Mayonnaise, heinz</td>
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<tr>
<td>Mccain winter mix veggies</td>
<td>Commercial</td>
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<tr>
<td>Musaka</td>
<td>Homemade</td>
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<tr>
<td>Pepsi</td>
<td>Commercial</td>
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<tr>
<td>Popsicle blackcurrent</td>
<td>Commercial</td>
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<tr>
<td>Salami lean dutch</td>
<td>Commercial</td>
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<td>Shredded chicken, Tegal</td>
<td>Commercial</td>
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<tr>
<td>Tasti smoosh berry</td>
<td>Commercial</td>
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<tr>
<td>Tegal honey soy kebabs</td>
<td>Commercial</td>
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<td>Thai sweet chilli doritos</td>
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<tr>
<td>Watties fruit squirtz</td>
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<tr>
<td>Whittakers chocolate</td>
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<td>Food description and food code that can be used as a substitution</td>
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<td>A238</td>
<td>Bread, naan, white plain restaurant</td>
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<td>L2_R4854</td>
<td>Bread, multigrain medium with seeds</td>
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<tr>
<td>R2385</td>
<td>cake, chocolate, rich, icing, no filling</td>
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<tr>
<td>A143</td>
<td>Pizza base</td>
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<tr>
<td>A174</td>
<td>Bread roll, white, spelt fresh, south island</td>
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<tr>
<td>R5297</td>
<td>hot cross bun, chocolate</td>
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<tr>
<td>R3358</td>
<td>pizza, homemade, thin ham, sausage</td>
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<tr>
<td>N58</td>
<td>chicken, nugget, crumbed, baked</td>
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<td>X157</td>
<td>vegetables, 3 mixed, frozen, boiled, drained</td>
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<tr>
<td>C137</td>
<td>juice, apple and blackcurrent, golden circle, fortified</td>
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<tr>
<td>U10</td>
<td>potato crisps, salt and vinegar, pringles</td>
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<td>Q47</td>
<td>Peanut butter, smooth and crunchy, salt added, no sugar added Eta smooth peanut butter</td>
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<tr>
<td>A128</td>
<td>muffin, chocolate</td>
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<td>pineapple, canned, w/ syrup</td>
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<td>F1047</td>
<td>butter, salted, fontina</td>
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<tr>
<td>S47</td>
<td>dressing, coleslaw, etc</td>
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<td>R4953</td>
<td>ice cream, assorted berry flavour, standard</td>
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<td>R4463</td>
<td>pizza, pizza hut, meatlovers, thick base</td>
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<td>HNO04179</td>
<td>Butter chicken SWIFT</td>
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<tr>
<td>R5230</td>
<td>kebabs, chicken/turkey/other poultry, soy based sauce, baked</td>
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<tr>
<td>T38</td>
<td>Ice cream, vanila, standard</td>
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<tr>
<td></td>
<td>Ice Cream, Chocolate, standard</td>
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### Default foods SunDial study

**Default food items: to be used when insufficient food information is provided to determine exact food code OR when no exact match is present in FoodWorks but a closely related food is available**

<table>
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<th>Unspecified/unmatched food item</th>
<th>Comments about FOODfiles food choice match</th>
<th>FOODfiles food description</th>
<th>Record ID</th>
<th>Portion size info (g)</th>
<th>Comments or coding rules</th>
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<td>No NIP on the couplands or supermarket</td>
<td>Bread, white, sliced, prepacked</td>
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<td>Value Straight Cut fries</td>
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<td>Potato, frozen/fries, straight, canola</td>
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<tr>
<td><strong>SUPERSOFT HONEY GRAIN SANDWICH BREAD</strong></td>
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<td>Bread, multigrain light, with folate</td>
<td>LZ_R5111</td>
<td></td>
<td></td>
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<tr>
<td>Beehive Champagne Ham</td>
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<td>Ham, sliced, premium</td>
<td>N66</td>
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<tr>
<td>Salami</td>
<td></td>
<td>Sausage, salami, uncooked</td>
<td>N15</td>
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<tr>
<td>Pie couplands potato top with mince (savoury)</td>
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<td>Pie.bought,mince,potato topping only (no crusts)</td>
<td>R3089</td>
<td>Individual</td>
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<tr>
<td>Pie couplands mince (savoury)</td>
<td></td>
<td>Pie.bought,mince,1 pastry crust only (no topping)</td>
<td>R3102</td>
<td>Individual</td>
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<tr>
<td>Watties tomato sauce</td>
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<td>sauce, tomato</td>
<td>S4</td>
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<td>Select fries (frozen then baked)</td>
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<td>potato, frozen/fries, chunky, polyuns</td>
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<td><strong>COUPLANDS DAILY GRAIN 600G</strong></td>
<td>500000313</td>
<td>Bread, multi-grain light</td>
<td>R4659</td>
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<td>Hellers sausage</td>
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<td>Sausage,mixture of meats (eg mutton, beef, pork), pan fried, with no fat</td>
<td>R2048</td>
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<td>Pams four fruits jam</td>
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<td>Jam, berry frt, asst berries, premium</td>
<td>W73</td>
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<td>Lonestar Shoestring fries</td>
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<td>Potato, fries, independent shops, strained</td>
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<td>Lonestar Ginger Ale (from tap)</td>
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<td>soft drink, ginger ale</td>
<td>C158</td>
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<td></td>
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<tr>
<td>Lonestar Raspberry and Coke (from tap)</td>
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<td>soft drink, cola flavour, sugar sweet/C</td>
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<td>Rice cracker - peckish brand</td>
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<td>Rice cracker, plain, composite</td>
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<tr>
<td>Cheese Scone from Bakery</td>
<td></td>
<td>scone, white, with cheese</td>
<td>R2400</td>
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<tr>
<td>Ernest Chocolate Caramel Slice</td>
<td></td>
<td>slice, caramel, slice</td>
<td>R2381</td>
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<tr>
<td>Contenental Alfredo Pasta</td>
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<td>SWIFT Alfredo Pasta</td>
<td>HN004705</td>
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<tr>
<td>St Piers Crispy Chicken on Rice</td>
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<td>Deep fried chicken and rice</td>
<td>HN001677</td>
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<tr>
<td>Dark Rye bread</td>
<td></td>
<td>FREYAS ROGENBROT DARKR4854</td>
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