Iodine intakes and the main food sources of iodine in adolescent females aged 15-18 years in New Zealand

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Abstract

Background: Iodine plays an essential role in normal growth and development. Formerly iodine deficiency has been common in New Zealand because of the low levels of iodine in the soil. However, in recent times, the Children’s and Adult National Nutrition surveys reported mild iodine deficiency, leading to implementation of mandatory use of iodised salt in bread in 2009. Since then, iodine intake and food sources contributing to dietary iodine intake have not been assessed in New Zealand adolescents. Iodine is particularly important for young women who could become pregnant, because sufficient iodine is needed for normal growth and development of the fetus. This is the first study in New Zealand to assess dietary iodine intakes in adolescent females aged 15-18 years.

Objective: The objectives were to assess 1) the dietary intake of iodine in adolescent females; 2) the main food sources and food groups that contribute to iodine intake in adolescent females; and 3) the proportion of adolescent females using iodised salt.

Design: This was a cross-sectional survey carried out in high schools in seven different towns across New Zealand involving 145 female adolescents aged 15-18 years. Between March and April 2019, 113 participants completed two 24-hour diet recalls, FFQs and anthropometric measurements, provided spot urine and blood samples, and wore accelerometers to measure physical activity. Diet recalls were entered into FoodWorks to determine macro- and micronutrient intakes. Iodine intakes were determined: 1) from diet alone, 2) with the addition of 48 μg of iodine if iodised salt was used, and 3) with the addition of 48 μg of iodine if iodised salt was used and the iodine content from dietary supplements used on a daily basis.
Results: Of the eight schools that consented to participate in the study, the majority (59%) were from deciles 5 to 7. Of 145 participants who undertook enrolment, 113 completed two 24-hour diet recalls. The mean age of participants was 17 years, 72% were of New Zealand European and Other ethnicity, and 56% were weight BMI z-score ≥ -2 to +1 SD. The mean energy intake was 7833 kJ. The mean iodine intake was 81 μg/day (the Estimated Average Requirement for iodine in this age group is 95 μg/day), of which ~10% came from each of the following four food groups: grains and pasta; milk; eggs and egg dishes; and non-alcoholic beverages. Around 7% of total iodine came from bread (including rolls and speciality breads), and ~4% came from each of the following: savoury sauces, condiments, bread based dishes, dairy products, cakes and muffins, and vegetables. Around 41% of participants reported using iodised salt, and only 2 participants reported taking a daily supplement containing iodine.

Conclusion: Dietary iodine intake was low suggesting that this group may be at risk of mild iodine deficiency. This group of adolescent females do not seem to be consuming enough of the typical food source of iodine in the New Zealand diet, namely, fortified bread. More than half of the participants were not using iodised salt. Other strategies to increase iodine intakes, in addition to bread and iodised salt use, need to be considered.
Preface

The Survey of Nutrition Dietary Assessment and Lifestyle (SuNDiAL) was conducted by the Department of Human Nutrition, University of Otago. The research project was developed by Principle Investigators Dr Jill Haszard and Dr Meredith Peddie, who were responsible for applying for funding and ethical approval, as well as forming the study protocol. Dr Jill Haszard was responsible for statistical analysis of all data. Tessa Scott was the SuNDiAL co-ordinator and was involved in school and participant recruitment and organisation of data collection. Associate Professors Lisa Houghton, Anne-Louise Heath, Rachel Brown, Caroline Horwath and Professor Rosalind Gibson, were the Co-investigators. PhD student Chaya Ranasinghe was involved in study design and development, recruitment of schools, data entry and checking all the MDiet student data entries onto FoodWorks. Liz Fleming and Kirsten Webster were also involved in data entry and cleaning of the data.

The Candidate was supervised by Professor Sheila Skeaff for this thesis, which was part of the wider SuNDiAL project. She proofread and provided feedback on the Candidate’s written work.

As part of the SuNDiAL team, the Candidate was responsible for the following:

- Contributed to design of the questionnaire
- Contributed to the development of school presentation used to recruit participants
- Recruitment of participants: presented the SuNDiAL project at two schools in Dunedin (Columba College and Kaikorai Valley College)
- Discussed with school managers availability of facilities during data collection as well as times and places to carry out data collection
• Carried out two 24-hour diet recalls for 7 participants and a single 24-hour diet recall for one participant
• Entered two 24-hour diet recall data for 7 participants and a single 24-hour diet recall data onto FoodWorks
• Carried out multiple anthropometric measurements for 9 participants
• Interpreted results for this thesis
• Wrote up of all thesis components
Acknowledgements

Thank you to everyone who helped me complete this thesis! Specifically, I would like to thank Professor Sheila Skeaff for being the best supervisor I could have hoped for: you always managed to talk about interesting things beyond just writing, which made the whole research project a fun experience. Always encouraging, your guidance throughout this thesis was hugely appreciated and I have learnt a great deal from you. I would also like to thank Dr Jill Haszard, the first person I was in contact with via Zoom (whilst at home in Zimbabwe). It was there that preparation for data collection started taking shape. Thank you for always cheerfully answering my many questions and for spending hours on the statistical analysis of the data, even while you were overseas. I would also like to thank my family and friends who have been with me along this significant journey, and ultimately my loving Heavenly Father.
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List of Abbreviations

ANS Adult Nutrition Survey
BMI Body Mass Index
CNS Children’s Nutrition Survey
DIT Di-iodotyrosine
EAR Estimated Average Requirement
FFQ Food Frequency Questionnaire
I$_2$ Iodine
IDD Iodine Deficiency Disorders
MIT Mono-iodotyrosine
MPI Ministry for Primary Industries
NRV Nutrient Reference Value
NZEO New Zealand European and Others
NZTDS New Zealand Total Diet Study
REDCap Research Electronic Data Capture
RDI Recommended Dietary Intake
SD Standard Deviation
SuNDiAL Survey of Nutrition, Dietary Assessment and Lifestyles
Tg Thyroglobulin
TPO Thyroid Peroxidase
TSH Thyroid Stimulating Hormone
TRH Thyrotropin-Releasing Hormone
T$_4$ Thyroxine
T₃ 3,5,3’-triiodothyronine

UIC Urinary Iodine Concentrations


ppm parts per million

g grams

L Litre

μg micrograms

mg milligrams

kg kilograms
1. Introduction

Iodine is a trace element appearing in different forms in nature: as iodides and iodates, molecular iodine, and organic monoatomic iodine (1). The amount of iodine in soil reflects the level of iodine in animal and plant foods (2). The highest concentrations of dietary iodine are found in foods of marine origin such as fish and seaweed (3), which concentrate iodine from seawater (4). Dietary iodine is converted to iodide ion, before being absorbed through the gastrointestinal lining and into the body (5). Iodine is essential in the body for the synthesis of thyroid hormones, produced in the thyroid gland, which are key regulators of important cellular processes (1, 6).

Iodine deficiency continues to be a significant global burden, as shown by the Global Scorecard of Iodine Nutrition with ~8% of the countries reporting ‘excessive’ iodine status and ~14% as having ‘insufficient’ iodine status (7). The iodine content in New Zealand soil is low (2), and iodine deficiency was common in the late 1800s to early 1900s, and again in the late 1900s and early 2000s (7). This led to prevention strategies such as the fortification of iodine of salt in 1939 and of bread in 2009 (8). Many studies have been carried out to assess iodine status of the New Zealand population. The most comprehensive of these were the Children’s Nutrition Survey (CNS, (9)) in 2002/03, and the Adult Nutrition Survey (ANS, (10)) in 2008/09. In the CNS, the iodine status of children aged 2-14 years was reported (9), and in the ANS, the focus was on adults aged 15 years and over (11). Currently there has only been one study in New Zealand that has assessed iodine status in adolescents (aged 15-18 years) (12).
Adolescence bridges the gap between childhood and adulthood, where growth out of childhood is taking place and preparation for adulthood is underway (13). Nutrition is crucial in the development and growth of adolescents, however, there is little direct evidence about the nutritional status of adolescents (14). The nutritional status of adolescent girls is particularly important, because they will become the mothers of our next generation and their nutrition status can influence the health of their children (13). Iodine is particularly important in young women who could be pregnant, because sufficient iodine is needed for normal growth and development of the fetus, including the brain (15).

The aim of this study is to investigate the iodine intakes and main food sources of iodine in adolescent girls. Findings will be determined from 24-hour diet recalls, and Food Frequency Questionnaires (FFQs), including food sources of iodine, frequency of consumption, and the use of iodised salt. This study is part of a larger, nationwide survey, that may be useful to inform government and health professionals to develop food recommendations and policies regarding iodine in adolescent girls.
2. Literature Review

2.1 Literature search strategy

Database searches were completed through Scopus, PubMed, Medline, Library Ketu and Google Scholar using the terms listed in Table 1 individually and with different combinations. Repeat searches between September 2018 and June 2019 were carried out throughout the research process. Searches were limited to full text articles in English. Relevant references were also identified from the reference lists of the articles used.

Table 1 Literature review search terms

<table>
<thead>
<tr>
<th>Function and Metabolism</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deficiency</td>
</tr>
<tr>
<td>Status</td>
</tr>
<tr>
<td>New Zealand</td>
</tr>
<tr>
<td>History of Iodine in New Zealand</td>
</tr>
<tr>
<td>Assessment</td>
</tr>
<tr>
<td>Urinary Iodine Concentration</td>
</tr>
<tr>
<td>Dietary Assessment</td>
</tr>
<tr>
<td>24 hour diet recalls</td>
</tr>
<tr>
<td>24 hour diet records</td>
</tr>
<tr>
<td>Food Frequency Questionnaires</td>
</tr>
<tr>
<td>Dietary Sources</td>
</tr>
<tr>
<td>'Adolescents' OR &quot;Teenagers&quot; OR &quot;Teens&quot;</td>
</tr>
<tr>
<td>'Females' OR &quot;Girls&quot; OR &quot;School girls&quot;</td>
</tr>
</tbody>
</table>
2.2 Function and metabolism of iodine

Function

Iodine is a trace element found in the upper surface of the earth mainly in or near coastal areas (16). The iodine content of soil is reflected in the iodine content of plant and animal foods (17). This micronutrient is essential in the diet and is needed for the synthesis of the thyroid hormones (1): the prohormone thyroxine (T₄) and the active form 3,5,3’-triiodothyronine (T₃). The hormones are produced in the thyroid gland, which sits at the base of the neck (18). The active form of the thyroid hormone plays a significant role in the body as the primary regulator of important cellular processes (19). They maintain metabolic rate in the body and have an important role in the maturation of most organs, including the brain (6). In addition to a number of other important roles, these hormones are also required for protein synthesis, glycogenolysis, the absorption of glucose in the intestine, and the uptake of glucose by adipocytes (6). If the body has inadequate levels of thyroid hormone, a reduction in basal metabolic rate and level of activity will occur, as well as impaired growth and development.

Metabolism

Iodine metabolism is linked to thyroid function as the production of thyroid hormones is the only established role of iodine (19). Iodine is found in different forms in nature: iodides and iodates, molecular iodine and organic monoatomic iodine (20). Iodide is highly bioavailable and is fully absorbed from food and water (5). Iodine in the molecular form (I₂) is transported through the intestinal lining through facilitated diffusion (21). Iodides, however, are absorbed in the gastric mucosa, with the aid of a transport protein, the sodium-iodide symporter (21). This symporter is found in several other places in the
body that use iodine – mammary tissue, salivary gland, cervix, and the thyroid (21). The symporter actively transports iodide into the thyroid cells where it then attaches to tyrosyl residues of protein produced by thyroid glands called thyroglobulin (Tg) (20). As Figure 1 shows (20), two enzymes (thyroperoxidase and hydrogen peroxidase) oxidise iodide, forming mono-iodotyrosine (MIT) and di-iodotyrosine (DIT). These oxidised forms of iodide are then conjoined through a reaction catalysed by thyroid peroxidase (TPO) to produce thyroxine (T₄) and 3,5,3′-triiodothyronine (T₃). On the surface of destined cells, T₄ is converted to T₃, where they carry out their function in the body (6). Once dietary iodine has carried out its function in the body, more than 90% of it is then excreted in urine (22). The synthesis, release and action of thyroid hormones in the body are regulated by a combination of the thyroid gland, brain, pituitary and peripheral tissues (20). When dietary intake of iodine is low, the production of T₃ and T₄ is reduced, causing the hypothalamus (which sits at the base of the brain) to respond by releasing Thyrotropin-Releasing Hormone (TRH) into the anterior pituitary gland (located below the hypothalamus) (23). TRH stimulates the release of Thyroid Stimulating Hormone (TSH) into the bloodstream. TSH then stimulates thyroid follicular cells to increase the uptake of iodide ions from the bloodstream and increase the production of thyroid hormones. Once T₃ and T₄ are circulating at normal levels, a negative feedback response is created as T₄ inhibits the release of TRH and TSH (23).
Figure 1 Metabolism of iodine

Iodine ($I_2$) is catalyzed by thyroid peroxidase using $H_2O_2$. $H_2O_2$ used in this reaction decreases the amount of $H_2O_2$ that would otherwise be available for damaging oxidation reactions. Selenium containing GPX removes $H_2O_2$ from the tissues, also decreasing oxidative damage.

- **TPO** - Thyroperoxidase
- **GPX** - Glutathione Peroxidase
- **$T_3$** - Triiodothyronine
- **$T_4$** - Tetraiodothyronine

Source: Patrick L, 2008 (20)
2.3 Iodine deficiency

2.3.1 Definition of Iodine Deficiency Disorders (IDD)

Iodine deficiency has a range of adverse impacts in humans due to inadequate production of the thyroid hormones (18), which are collectively called Iodine Deficiency Disorders (IDD) (Table 2) (24).

Table 2 Spectrum of the Iodine Deficiency Disorders (IDD)¹

<table>
<thead>
<tr>
<th>Age</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foetus</td>
<td>Abortions, Stillbirths, Congenital anomalies, Increased perinatal mortality, Increased infant mortality, Neurological Cretinism (Mental deficiency, Deaf mutism, Spastic diplegia, Squint), Myxoedematous cretinism (Mental deficiency, Dwarfism, Hypothyroidism, Psychomotor Defects)</td>
</tr>
<tr>
<td>Neonate</td>
<td>Neonatal goiter, Neonatal hypothyroidism</td>
</tr>
<tr>
<td>Child and Adolescent</td>
<td>Retarded mental and physical development, Juvenile hypothyroidism</td>
</tr>
<tr>
<td>Adult</td>
<td>Goitre and its complications, Iodine-induced hyperthyroidism</td>
</tr>
<tr>
<td>All ages</td>
<td>Goitre, Hypothyroidism, Impaired mental function, Increased susceptibility to nuclear radiation</td>
</tr>
</tbody>
</table>

¹Adapted from the World Health Organisation (24).
The greatest impact of iodine deficiency on the body is on the developing brain (6). Globally, iodine deficiency is the greatest single cause of preventable brain damage and mental impairment (6, 24). From Table 2, the IDD most relevant to adolescent females include physical and mental impairment and juvenile hypothyroidism (24). However, iodine deficiency can be mild, moderate, or severe, and many of the adverse consequences shown in Table 2 would be apparent in moderate to severe iodine deficiency. New Zealand has been characterised by moderate to mild deficiency (24), and the associated consequences would be mental impairment and goitre (6).

2.3.2 Prevalence of iodine status worldwide and in New Zealand

The Global Scorecard of Iodine Nutrition (7) is an annual summary of iodine status across the globe. Iodine status of school-age children (around 6-12 years old) serves as a proxy for the general population (24). The 2017 Scorecard reports on the iodine status of 198 countries, although for 55 countries there was no information. Of the remaining 143 countries with data, 112 (78%) countries had ‘adequate’ iodine status, 11 (8%) countries had ‘excessive’ iodine status, and 20 (14%) countries had ‘insufficient’ iodine status.

For some countries, iodine status was reported for specific groups in the population. For example, of 11 countries with data on women of reproductive age (around 15-49 years), five countries had ‘insufficient’ iodine status; 69 countries assessed pregnant women, of which 39 countries had ‘insufficient’ iodine intakes. Five countries also included adolescents, of which all had ‘adequate’ iodine status. The 2017 Global Scorecard reported the status of New Zealand school-age children (8-10 years old) as having
‘adequate’ iodine status, however pregnant women were classified as ‘insufficient’ based on data collected in 2005.

2.4 History of iodine in New Zealand

Researchers, Sir Charles Hercus and Dr Baker, carried out a study in New Zealand towards the end of the 1800s and the start of the 1900s and observed that many schoolchildren had goitre (8). Following this discovery, an investigation was carried out to assess the relationship between the content of iodine in New Zealand soil and the prevalence of goitre in children, finding an inverse association (8). Subsequently, salt was iodised in 1924 at 5 ppm (parts per million) but increased in 1938 to 50 ppm because the 5 ppm was found to be too low (17). Following the implementation of this strategy (i.e. iodised salt), iodine status was seen to improve, and goitre eliminated by the 1950s (17). During the 1960s, the use of iodophor-containing sanitizers in the dairy industry became common, causing milk and milk products to become contaminated with iodine (25, 26). Because of this practice, iodine intake increased in the New Zealand diet. Several studies carried out between 1964 and 1984 (27-29) show that as well as iodised salt, dietary iodine input from other sources, such as dairy and dairy products, meant that the New Zealand population had adequate iodine status.

Unfortunately, inadequate levels of iodine were reported in several studies during the late 1990s and early 2000s: in 1993/94, Thomson et al. (30) assessed 333 residents from Dunedin and Waikato aged 18-72 years, reporting low urinary iodine; in 1996/97, Skeaff et al. (31) assessed 300 schoolchildren in New Zealand aged 8-10 years, finding mild iodine deficiency; the 2002 Children’s Nutrition Survey (CNS, (9)), in a larger more representative sample of New Zealand children (11-14 years) confirmed mild iodine
deficiency; and in the 2008/09 Adult Nutrition Survey (ANS, (10)), New Zealanders over 15 years of age were also categorized as mildly iodine deficient. This decline in iodine status was thought to be from an increase in consumption of commercially-prepared foods that are manufactured with non-iodised salt, a reduction in iodine containing sanitizers used by the dairy industry, as well as less iodised salt consumed due to health information advising to reduce salt intake (24).

Due to the re-emergence of iodine deficiency in New Zealand, a change to the Food Standards Code mandated the addition of iodised salt to commercially made bread as of September 2009 (32). Following this, a report published in 2012 by the Ministry of Agriculture and Forestry noted that the implementation of this strategy (i.e. iodised salt in bread) had been successful in achieving adequate iodine intakes based on dietary modelling (33). Later, the Ministry of Agriculture and Forestry published another report in 2014 and, also based on dietary modelling, reported that iodine intake in children aged 5-14 years had increased (34). Other studies were carried out in order to analyse iodine status as determined by urinary iodine in New Zealand following the fortification of iodised salt in bread in 2009. Skeaff et al. (35) assessed children aged 8-10 years in New Zealand, with data collection taking place between 2010 and 2011, and observed that children had adequate iodine. This finding was confirmed in a study carried out by Jones et al. (36) when data was collected in 2015. In 2014/15, the Ministry of Primary Industries (MPI) and Ministry of Health measured iodine status in almost 5000 New Zealanders aged 15 years or more and found, overall, that the entire group had adequate iodine status, including adolescent girls aged 15-18 years (12). This is the only study to
have assessed iodine status in adolescents after the mandatory fortification of bread and is limited because it does not include any estimates of dietary iodine intake.
Table 3 Iodine status in New Zealand between 1929 and 2016

<table>
<thead>
<tr>
<th>Paper</th>
<th>Year</th>
<th>Group</th>
<th>Median UIC¹ μg/L</th>
<th>Iodine Status²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shore et al. (37); Hercus et al. (38);</td>
<td>1929-1935</td>
<td>All ages</td>
<td>~25-49</td>
<td>Moderate</td>
</tr>
<tr>
<td>Batchelor et al. (39)</td>
<td></td>
<td></td>
<td></td>
<td>deficiency</td>
</tr>
<tr>
<td>North et al. (27); Cooper et al. (28);</td>
<td>1965-1984</td>
<td>All ages</td>
<td>~101-152³</td>
<td>Adequate</td>
</tr>
<tr>
<td>Simpson et al. (29)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thomson et al. (30)</td>
<td>1993-1994</td>
<td>Adults</td>
<td>60-76</td>
<td>Mild deficiency</td>
</tr>
<tr>
<td>Skeaff et al. (31)</td>
<td>1996-1999</td>
<td>Schoolchildren</td>
<td>67</td>
<td>Mild deficiency</td>
</tr>
<tr>
<td>Children’s Nutrition Survey (9)</td>
<td>2002</td>
<td>Schoolchildren</td>
<td>68</td>
<td>Mild deficiency</td>
</tr>
<tr>
<td>Pettigrew et al. (40)</td>
<td>2005</td>
<td>Pregnant women</td>
<td>38</td>
<td>Deficiency</td>
</tr>
<tr>
<td>Adult Nutrition Survey (10)</td>
<td>2008-2009</td>
<td>Adults</td>
<td>53</td>
<td>Mild deficiency</td>
</tr>
<tr>
<td>Skeaff et al. (15)</td>
<td>2010-2011</td>
<td>Schoolchildren</td>
<td>113</td>
<td>Adequate</td>
</tr>
<tr>
<td>Jones et al. (36)</td>
<td>2015</td>
<td>Schoolchildren</td>
<td>116</td>
<td>Adequate</td>
</tr>
<tr>
<td>Ministry for Primary Industries (12)⁴</td>
<td>2016</td>
<td>Adults</td>
<td>103</td>
<td>Adequate</td>
</tr>
</tbody>
</table>

¹Urinary Iodine Concentration (UIC) > 100 μg/L indicates adequate iodine status.
²Defined from WHO cut-offs.
³Estimated from μg/day based on urinary excretion of 1.5 L/day in adults.
⁴Adolescents had mean UIC 114 μg/L.
2.5 Assessment of iodine status

Iodine status is typically assessed by clinical examination, biochemical measures and dietary assessment (41). Currently, anthropometry is not used as an index of iodine status.

2.5.1 Biochemical assessment of iodine

Measures of iodine status in urine

Approximately 90% of dietary iodine is excreted in urine, thus the measurement of Urinary Iodine Concentration (UIC), in spot or 24-hour urine samples, is used as an index of iodine status and an estimate of iodine intake (42). Urinary iodine concentration is a measure of recent iodine intake (days to weeks) (5, 42). Because there is large inter- and intra-individual variation associated with urinary iodine concentration, urine samples can only be used for groups or populations and not for individuals. Single spot urine samples are preferred in populations as they are quick and easy to carry out (43). Iodine concentration can also be measured in 24-hour urine samples, although collection is associated with a higher respondent burden. The WHO/UNICEF/ICCIDD have established cut-offs for UIC based on spot urine samples, and these are used to categorize iodine status in populations (Table) (41).
Table 4 Cut-offs for assessing severity of IDD based on median urinary iodine levels¹

<table>
<thead>
<tr>
<th>Median value (μg/L)</th>
<th>Severity of IDD</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 20</td>
<td>Severe IDD</td>
</tr>
<tr>
<td>20-49</td>
<td>Moderate IDD</td>
</tr>
<tr>
<td>50-99</td>
<td>Mild IDD</td>
</tr>
<tr>
<td>≥ 100</td>
<td>No deficiency</td>
</tr>
</tbody>
</table>

¹Adapted from WHO/ICCIDD/UNICEF (41).

**Measures of iodine status in blood**

TSH, T₄, T₃ and Thyroglobulin can be measured in blood samples. However, TSH, T₄ and T₃ will only fall outside the normal reference ranges in moderate to severe iodine deficiency, thus are not useful in a New Zealand context (24). Thyroglobulin is a more sensitive index of mild deficiency, but normal reference ranges have not been proposed in adolescents, making interpretation of thyroglobulin in this age group difficult (44).

**2.5.2 Dietary assessment of iodine**

The choice as to which dietary assessment tool to use for assessing iodine status depends on factors such as population size, time and the available resources. Tools to assess usual, long term iodine intake from food sources include Food Frequency Questionnaires (FFQ), diet records, or diet recalls (45). A common limitation of all these dietary assessment tools is the poor accuracy in measuring iodine intake from iodised salt (45).

Several studies (46-48) have used a combination of assessment methods to assess iodine intake. For example, López-Sobaler et al. (46) used one day diet records for children aged six months to 10 years and two 24-hour diet recalls for children aged 11 to 17 years; Lietz et al. (47) used seven-day diet records, FFQ and 24-hour urine collections in schoolchildren aged 11 to 13 years; and Štimec et al. (48) used three day diet records and
an FFQ in adolescents. López-Sobaler et al. (46) reported that diet records and diet recalls provide detailed information in adolescents about the types and amounts of food consumed, and that both records and recalls are less likely to have systematic bias compared to FFQs. Lietz et al. (46) showed that compared to diet records, FFQs overestimated most nutrients. Furthermore, they noted that the seven-day diet record correlated significantly with 24-hour urine values. Therefore, the authors deemed FFQs unsuitable for estimating absolute iodine intakes in adolescents (46). Štimec et al. (48) observed that three day diet records better reflected long term dietary intake compared to FFQs, which involved more detailed questions improving accuracy compared with the FFQ.

**Food Frequency Questionnaires (FFQ)**

This method of dietary assessment requires participants to select from a list of foods and beverages, their most usual frequency of consumption over a retrospective timeframe (48). Regarding iodine, an FFQ should include specific questions about whether iodised salt is used at home. Ideally, there should be questions about iodised salt use at the table and in cooking, however in practice, this seldom occurs. FFQs should also include questions about foods that are good dietary sources of iodine such as cow’s milk, yogurt, cheese, fish, eggs and soymilk (49). FFQs with a greater number of items can result in an overestimation of iodine intake, whereas a shorter FFQ will underestimate iodine intake (50). The study by Štimec et al. (48), however, found that FFQs were more representative of iodine intakes, in particular, than diet records in Slovenian adolescents, primarily because FFQs reflect ‘usual’ intake over a longer time frame than diet records, which measure actual intake over a shorter period of time (48).
24-hour recalls

Twenty four-hour diet recalls are often used for dietary assessment in large populations such as national nutrition surveys (51). Diet recalls provide detailed information such as cooking methods, recipes, as well as type and amount of salt used, and are less prone to systematic bias compared to FFQs (46). A single diet recall has a lot of within-person variation that may result in over- or under-reporting; therefore, two recalls are recommended to provide more accurate measures of usual dietary intake (46). When 24-hour diet recalls are used to assess iodine intakes, probing questions are needed to obtain information about the type of salt used, quantity, use of salt at the table and in cooking (46, 49).

Interpreting iodine intakes

Regardless of the method of dietary assessment, iodine intake is interpreted using the Nutrient Reference Values (NRVs) shown in Table, adapted from the Australian National Health and Medical Research Council (NHMRC) (52). The EAR for children and adolescents was based on balance studies for the age groups 1-3 years, 4-8 years and 14-18 years (53, 54), and by extrapolation from adults using metabolic body weight ratios for 9-13 year olds.
Table 5 Nutrient Reference Values (NRVs)¹

<table>
<thead>
<tr>
<th>Age, years</th>
<th>EAR¹, µg/day</th>
<th>RDI², µg/day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boys and Girls</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9-13</td>
<td>75</td>
<td>120</td>
</tr>
<tr>
<td>14-18</td>
<td>95</td>
<td>150</td>
</tr>
<tr>
<td>Men and Women</td>
<td></td>
<td></td>
</tr>
<tr>
<td>19-30</td>
<td>100</td>
<td>150</td>
</tr>
<tr>
<td>31-50</td>
<td>100</td>
<td>150</td>
</tr>
<tr>
<td>51-70</td>
<td>100</td>
<td>150</td>
</tr>
<tr>
<td>&gt;70</td>
<td>100</td>
<td>150</td>
</tr>
</tbody>
</table>

¹Adapted from Australian National Health and Medical Research Council (52).
²EAR - Estimated Average Requirement, micrograms (µg)/day.
³RDI - Recommended Dietary Intake, micrograms (µg)/day.

2.6 Dietary sources of iodine in the New Zealand diet

The iodine content of food reflects content of iodine in the soil; in New Zealand, because there are low levels of iodine in the soil, the iodine status of the population has a high likelihood of low iodine intakes (2). The most recent, up-to-date New Zealand food composition table (55), shows the iodine content for the majority of 1063 listed foods. Foods that contain the highest concentrations of iodine are of aquatic origin (2): fish, shellfish and seaweed. Oysters, for example, contain 160 µg iodine per 100g (3, 55). The next highest containing concentrations of iodine are found in commercially prepared bread (46 µg/100g), standard milk (23 µg/100g) and eggs (22 µg/100g) (3, 56). Low iodine is found in fruits and vegetables, and animal meats: apples, oranges and grapes (<0.5 µg/100g); and beef, pork and lamb (<1.5 µg/100g) (3). Iodised salt can contain between 25 to 65µg of iodine per gram, but on average, has 48µg of iodine per gram (12).

The New Zealand Total Diet Study (NZTDS) (56) provides detailed information of dietary exposure to agricultural residues, contaminants, metals, as well as some nutrients,
including iodine. The NZTDS estimated iodine intakes from 14-day simulated typical
diets in different age-gender cohorts of the New Zealand population, including Pacific
Island ethnicities; estimates do not include the contribution of discretionary iodised salt.
The most recent 2016 NZTDS reports that from the years 1987/88 to 2016, population
iodine intakes have improved significantly. This increase reflects mandatory use of
iodised salt in the manufacture of commercial breads, with the iodine concentration in
bread increasing from ~0.005 mg/kg in 1987/88 to ~0.425 mg/kg in 2016. Major iodine
contributing food groups in the 2016 NZTDS (56) for the age group 11-14 years (a
surrogate for ‘teenage girls’) estimated that ~13% of total iodine came from chicken,
eggs, fish and meat, ~12% from dairy products and ~54% from grains (includes bread).
For the age group >25 years, ~20% came from chicken, eggs, fish and meat, ~15% from
dairy products and ~40% from grains. The adjusted mean intake for 11-14 year old girls
was 108 µg of iodine per day, and in adult females >25 years, it was 100 µg of iodine per
day; there was no data for either males or females aged 15-18 years.

2.7 Conclusion

Iodine is crucial for maintaining metabolic rate in the body and plays a role in the
maturation of most organs, including the brain. Iodine is therefore vital for growing
adolescents (parents of the next generation), particularly females, who may become
pregnant. In New Zealand, the content of iodine in the soil is low, which may result in a
low iodine intake and consequently, poor iodine status. Interventions have been
implemented to address this issue, the most recent being the addition of iodised salt to
bread since 2009. Studies have been carried out to assess the effects of this strategy, with
only one study undertaken in adolescents – however, it did not collect information on dietary iodine intakes.
3. **Objective Statement**

In New Zealand, two national surveys assessing iodine status have taken place: the Children’s Nutrition Survey (CNS, (9)) in 2002/03 included children aged 5-14 years, and the Adult Nutrition Survey (ANS, (10)) in 2008/09 included adults aged 18 years and more. Both surveys found mild iodine deficiency, which was addressed in 2009 with legislation making the addition of iodised salt to bread mandatory. Since fortification, the iodine status of children and adults in New Zealand has improved (10, 12, 35, 36), but there have been no studies investigating the dietary iodine intakes of adolescents aged 15-18 years.

**Aim of study:** To assess iodine intakes and the main sources of iodine in adolescent females aged 15-18 years across New Zealand.

**In order to achieve this aim, the objectives of this study are to:**

1.) Assess the usual dietary intake of iodine in adolescent females.
2.) Assess the main food sources and food groups that contribute to iodine intake in adolescent females.
3.) Assess the proportion of adolescent females using iodised salt.
4. Methods

The SuNDiAL project (Survey of Nutrition, Dietary Assessment and Lifestyles) aimed to compare the nutritional status, dietary habits, health status, and attitudes and motivations for food choice of vegetarian and non-vegetarian adolescent women. The project recruited 300 females aged between 15 and 18 years from 14 secondary schools throughout New Zealand between February and October 2019. The locations in which data was collected were Dunedin, Wellington, Christchurch, New Plymouth, Nelson, Whangarei, Tauranga, Wanaka and Palmerston North. The participants completed a questionnaire to assess attitudes and beliefs about foods eaten, two 24-hour diet recalls to assess usual dietary intake, provided a blood sample to measure the biochemical status of key nutrients, wore an accelerometer for 7 days to estimate 24-hour activity, and provided a spot urine sample. The results were used to inform dietary advice needed for a more plant-based approach to eating without increasing the risk of nutrient deficiencies.

The focus of this thesis was on one micronutrient – iodine – from data collected between February and April 2019 (i.e. the first recruitment wave of the SuNDiAL project). Procedures that are of interest in this thesis were results derived from the two 24-hour diet recalls. Although urine samples were collected, they were not analysed, thus this thesis did not report on iodine status as determined by a spot urine sample. Furthermore, this thesis did not compare vegetarians with non-vegetarians; the numbers of participants identifying as vegetarian after the first recruitment wave were insufficient to make a valid comparison.
4.1 Study design, location and participants

A cross-sectional survey of 132 high school students aged between 15 to 18 years from eight high schools across New Zealand was conducted between February and March 2019.

The inclusion criteria for eligibility to participate in the SuNDiAL project was as follows: females between the age of 15 and 18 years who were enrolled at one of the recruited high schools, that spoke and understood English, and were able to complete the online questionnaire. Exclusion criteria included participants who knew they were pregnant.

The SuNDiAL project was registered with the Australian New Zealand Clinical Trials Registry, with the registration number ACTRN12619000290190. This study has been approved by the University of Otago Human Ethics Committee (Health): H19/004. See Appendix A for letter of Ethical approval and Appendix B for the Māori consultation documentation.

4.2 Study procedures

4.2.1 Recruitment of schools

High schools were selected by principal investigators and the SuNDiAL coordinator, based on location, female roll number and school decile. Location of the schools depended on accessibility for data collectors. Schools were chosen with preference for a high female roll number. If schools had a roll of less than 400 for coeducational schools, or 200 for girls only schools, they were not invited to participate. A range of high to low decile schools were chosen to ensure accurate representation of adolescent females from all socioeconomic backgrounds. School decile is described between 1 and 10, where
decile 1 indicates 10% of schools with the highest proportion of students from low socio-economic communities, and decile 10 indicates 10% of schools with the lowest proportion of students from low socio-economic communities (57). In November 2018, an email was sent to selected high schools to invite schools to participate in the SuNDiAL project. If the schools did not respond within two weeks, they were sent a second email and follow-up phone call. Because in some locations, the targeted number of schools was not obtained, other schools in that location were approached by word of mouth or if one of the research team knew a staff member at that school. Schools interested in participating were then phoned to discuss when they would be willing to have the research team visit the school to present the project and to determine a time convenient for the school to collect data from participants.

4.2.2 Recruitment of participants

Throughout February 2019, presentations were given at schools that included a description of the SuNDiAL project, study aims and what would be expected of participants. In March 2019, this was followed up by another visit to schools when information leaflets were handed out and students encouraged to enrol; the name, age, phone number and an email address was obtained from interested students. Leaflets were also provided to circulate at the school and study information included in school newsletters. A link to the study website (www.otago.ac.nz/sundial) was provided where more information about the study was available.

An email was sent to all interested students containing the link to the study website. The website required interested participants to register by providing the name of their high school, their name, age, phone number as well as confirming their email address. A
confidential ID number was then assigned to each participant, and a subsequent email contained a link to a questionnaire, that included online consent, as well as questions regarding demographics and health. School students were able to contact researchers at any time, by phone or email, to ask questions regarding the study. Participants under 16 years of age were asked to provide the contact details of their guardian or parent, who were emailed a request asking to provide online consent for the participant. Encouragement to participate in the study included receiving blood iron results, a five dollar gift voucher (New World or PaknSave) for each completed section of the study, as well as the experience of being part of a nationwide study across New Zealand. Once analysis of collected data was completed, the schools were sent a results report as an infographic that summarized the findings from the students of that school.

4.2.3 Data collection

Master of Dietetics (MDiet) students carried out data collection over several days at each school between March and April 2019; individual participants from that school were randomly assigned to each MDiet student. Data obtained included anthropometric measurements (height, weight and ulnar length) in two and 24-hour diet recalls. Because participants were between the ages of 15-18 years and still growing, Body Mass Index (BMI) z-scores were used to describe participant weight (58). The BMI z-scores were calculated using anthropometric measurements (height and weight), participant age and the World Health Organisation growth charts (58). The BMI z-scores were classified as underweight (< -2 SD), normal (≥ -2 to +1 SD), overweight (> +1 to ≤ 2 SD) and obese (> +2 SD) (58). A professionally trained phlebotomist made a single visit to each school to take blood samples and distribute appropriate equipment for participants to provide a
urine sample. Willing participants were provided with an accelerometer to wear over 24 hours for seven days, as well as complete a sleep and wear time diary to record reasons and times when accelerometers were not worn, for example, during showering. Data collection in the school took approximately 60 minutes to complete for each participant.

A time for the second 24-hour diet recall was scheduled between the data collector and their assigned participant at least seven days after the first 24-hour diet recall. This took around 30 minutes per participant over phone or video-teleconference on a day different to the first 24-hour diet recall, to provide day-to-day variation.

4.2.4 Measurement tools used relevant to this study

Demographics, health status, dietary habits, attitudes and motivations

As mentioned previously, a web link to the questionnaire was included in the email that informed participants of their ID number. This online questionnaire was administered through Research Electronic Data Capture (REDCap) software used to create online surveys and questionnaires. Participants completed consent via the questionnaire as well as questions regarding basic demographics (including self-reported ethnicity), vegetarianism, health status, dietary habits, attitudes and motivations for choice of foods consumed, and use of supplements containing iodine. Categories for ethnicity included Māori, Pacific, Asian and New Zealand European and Others (NZEO). If more than one ethnicity was selected, priority was given in the order Māori, Pacific, Asian, NZEO. See Appendix C for the enrolment questionnaire, and Appendix D for the health habits questionnaire.
The health questions were not validated, however, most of the other items in the questionnaire such as dietary habits, attitudes and motivations were validated in age groups between 16-87 years (59-62), and changes were implemented to ensure suitability for a New Zealand female adolescent population.

**Dietary intake**

Dietary intake was determined by two 24-hour diet recalls and were undertaken by the MDiet students. The MDiet students had practice and training to complete 24-hour diet recalls during their university placements in 2018, and again in February 2019. They followed a 24-hour diet recall protocol and used a 24-hour diet recall recording sheet (Appendix E), which provided detailed instruction on how to structure a 24-hour diet recall interview to obtain the most accurate recall.

The 24-hour diet recall involved collecting detailed information of everything the participant ate and drank from midnight to midnight of the previous day (the whole of the day before). The information gathered was to include as much detail as possible regarding brand, cooking method, portion size and time consumed. A ‘tips sheet’ gave useful word phrasing and a ‘prompt list’ was provided for specific food groups to gather as much detail as possible from participants. A booklet of brand names, as well as physical and visual aids (household measures, food models and photographs of portion sizes), assisted participants in remembering and describing foods to further increase the accuracy of the dietary data collected (see the list of food models in Appendix F).

In brief, after developing rapport and explaining the interview process to the participant, the MDiet student initiated the 24-hour diet recall with a ‘Quicklist’ of what the
participant ate and drank from the previous day. Further information was included after this, gathering more details by asking specific questions about cooking details, what time and how much was consumed, and what brands were chosen. The back of the recording sheet allowed space for recipes to be written out. Once completed, participants were then asked about the type of salt they use at home, including whether it was iodised or not. Finally, MDiet students would arrange a time with the participant for the second 24-hour recall to take place.

**Data entry**

MDiet students were responsible for entering the data from the 24-hour recall of their participants into a FoodWorks 9 (Xyris Software) nutrient analysis software based on an enhanced version of the 2016 New Zealand food composition database FOODfiles, which includes the ANS 2008/09 recipes (11). FoodWorks was used to calculate daily energy, macronutrients and micronutrients (relevant to this thesis: iodine and energy) from the 24-hour diet recalls from each participant.

A SuNDiAL code book was developed to guide data entry of 24-hour diet recalls whilst eliminating discordance in decision making regarding unavailable foods, and inaccurate or missing information. The code book included default foods from previous studies conducted in the Department of Human Nutrition including the BLISS (Baby-led introduction to solids) and the SWIFT (Support strategies for whole food diets, intermittent fasting and training) study.

Once each MDiet student had completed data entry of their 24-hour diet recalls into FoodWorks, a PhD student reviewed 100% of these data entries using the 24-hour diet
recall recording sheets. If any discrepancies were found, MDiet students made corrections and the PhD student reviewed the data entry again. Following this, the PhD student then checked the top and bottom 10% of the samples according to energy, protein, carbohydrate and fat, and again, corrections were made to the data.

**Biological specimens – urine samples**

Spot urine samples were provided by participants during in-school data collection visits following a set protocol. Urine samples were stored and transported on ice to the University of Otago, Department of Human Nutrition, and will be stored at minus 20 degrees Celsius until analysis in the year 2020. Hence, urinary iodine concentration is not included in this study.

4.3 **Statistical analysis**

Dietary intake data was adjusted for usual intake using the Multiple Source Method (63). This estimates the day-to-day variation in nutrient intake using those participants with two days of diet recall data and applies this information to the whole dataset to give an adjusted estimate of usual intake for each participant. Iodine consumption is presented three ways: from the diet alone; from the diet with the addition of 48 μg of iodine for those who indicated they consumed iodised salt (34); and from the diet with the addition of 48 μg of iodine for those who indicated they consumed iodised salt and with the addition of iodine coming from dietary supplements. Iodine from supplement intake was determined only from those participants who reported daily supplement use (n=22 of 42 participants who took dietary supplements), and iodine content was calculated from the ingredient list of each supplement; the contribution of iodine from participants who took dietary supplements less frequently than daily was not included (n=20). The mean, 95%
confidence intervals (CI), median and the 10th and 90th percentiles were calculated for energy and iodine intakes, respectively, using Microsoft excel.

Stata 15.1 (StataCorp, Texas) was used for calculations regarding food group results. Total amounts of nutrient intake from each of the 33 major food groups was calculated for each participant. The 10 food groups with the highest median intakes for the whole group were then reported. If the median intake was the same between groups, then the top 75th percentile was used. For each participant, the proportion of their total nutrient intake from each of the 33 food groups was calculated. Mean and 95% CI of these proportions were calculated for the whole group. The food groupings used were the same as those used for the most recent Adult Nutrition Survey (11).
5. Results

5.1 Recruitment

Of 97 eligible schools, 25 were selected and invited by email. Three schools declined, 15 schools did not respond, and two accepted but gave no further response. Three additional schools were personally invited to take part and all three responded. In all, eight schools consented to participate in the study: Tauraroa Area School (Whangarei), Mt Maunganui College (Tauranga), Spotswood College (New Plymouth), St Catherine's College (Wellington), Waimea College (Nelson), Hornby High School (Christchurch), Columba College and Kaikorai Valley College (Dunedin). Participant recruitment is shown in Figure 2. Of the 1882 eligible participants, 12% gave consent to participate and 8% completed enrolment. Of the 145 participants who completed enrolment, 78% completed two 24-hour diet recalls.
Figure 2 Flow diagram showing participant recruitment

- Eligible participants (n=1882)
  - Present at recruitment (n≈806)
  - Sent link to enrolment (n=263)

- Did not respond/declined (n=109)
  - Parents of 15 year olds (n=13)
  - 15 year olds, after parental consent given (n=10)
  - 16-18 year olds (n=84)
  - Declined link to enrolment (n=2)

- Consented to participate (n=154)
  - 16-18 year olds responded (n=98)
  - 15 year olds responded after parental consent (n=56)

- Completed enrolment (n=145)
  - Completed health and demographics questionnaire (n=144)
  - Completed attitudes and motivations questionnaire (n=129)
  - Completed dietary habits questionnaire (n=124)

- Present during school visits (n=132)
  - Completed anthropometric measurements (n=130)
  - Missing due to technical issues (n=2)
  - Completed first 24-hour diet recall (n=132)
  - Completed repeat 24-hour diet recalls (n=113)
5.2 Participant characteristics

The participant’s demographic characteristics are summarized in Table 6. Of the 145 participants involved, the majority were aged 17 years (60; 41%), with 28 participants aged 15 years, 54 participants aged 16 years and 4 participants aged 18 years. The ethnicity of most participants (72%) was categorized as New Zealand European and Others (NZEO), where the ‘Others’ include those who identified as Ethiopian, Somali, Italian, American, Nicaraguan, Irish, Afrikaans, South African, Dutch and German. There were 29 participants that identified as Māori, six Asian participants (Filipino, Japanese, Indian) and five Pacific participants (Tokelau, Fijian, Cook Island, Samoan).

The most common school decile was between 5 and 7 (59%), with only 10% of schools having a decile of 1 to 4 and 32% with a decile of 8 to 10. The majority of participants were categorized as having a normal weight (56%), with four participants underweight (1%), 33 participants overweight (23%), and 12 participants obese (8%).
Table 6 Characteristics of participants

<table>
<thead>
<tr>
<th>Variable</th>
<th>Category</th>
<th>n=145</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, years</td>
<td>15</td>
<td>28</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>16</td>
<td>54</td>
<td>37</td>
</tr>
<tr>
<td></td>
<td>17</td>
<td>60</td>
<td>41</td>
</tr>
<tr>
<td></td>
<td>18</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Ethnicity¹</td>
<td>NZEO²</td>
<td>104</td>
<td>72</td>
</tr>
<tr>
<td></td>
<td>Māori</td>
<td>29</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>Asian</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Pacific</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>School decile</td>
<td>1 to 4</td>
<td>14</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>5 to 7</td>
<td>85</td>
<td>59</td>
</tr>
<tr>
<td></td>
<td>8 to 10</td>
<td>46</td>
<td>32</td>
</tr>
<tr>
<td>BMI z-score³</td>
<td>Underweight</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Normal weight</td>
<td>81</td>
<td>56</td>
</tr>
<tr>
<td></td>
<td>Overweight</td>
<td>33</td>
<td>23</td>
</tr>
<tr>
<td></td>
<td>Obese</td>
<td>12</td>
<td>8</td>
</tr>
</tbody>
</table>

¹Missing value: (n=1).
²NZEO: New Zealand European and Others
³BMI z-score missing values: (n=17; 12%) are those who enrolled but did not get their height and/or weight measured;
Classification: underweight (< -2 SD), normal (≥ -2 to +1 SD), overweight (> +1 to ≤ +2 SD), obese (> +2 SD) (58).
5.3 Iodine intakes from 24-hour diet recalls

Table 7 shows the number and proportion of participants who reported using iodised salt, those who did not use iodised salt and those for whom this information is missing. Of the 145 participants, 41% reported using iodised salt.

Table 7 Iodised salt use

<table>
<thead>
<tr>
<th>Iodised salt</th>
<th>n=145</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>60</td>
<td>41</td>
</tr>
<tr>
<td>No</td>
<td>72</td>
<td>50</td>
</tr>
<tr>
<td>Missing values</td>
<td>13</td>
<td>9</td>
</tr>
</tbody>
</table>

Diet recalls were carried out on weekdays and weekend days with a ratio of 8:2, showing that data was collected on more weekdays than weekend days. Table 8 shows the mean, 95% confidence interval, and median (10th and 90th percentiles) of dietary energy and iodine intake. The median (10th, 90th percentile) energy intake was 7833 (6002, 10653) kJ. The median (10th, 90th percentile) iodine intake was 58 (35, 103) μg/day from diet alone, which increased to 83 (32, 126) μg/day when iodine from iodised salt was included. Other types of salt used by participants which do not contain iodine and are not included in Table 8, were rock sea salt, pink Himalayan sea salt, sea salt and Malborough sea salt.
Table 8 Mean and median energy and iodine intakes ($n = 144$)

<table>
<thead>
<tr>
<th></th>
<th>Mean (95% CI)</th>
<th>10th percentile</th>
<th>Median (50th percentile)</th>
<th>90th percentile</th>
<th>% &lt; EAR¹</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Energy, kJ/day</strong></td>
<td>8071</td>
<td>6036</td>
<td>7816</td>
<td>10622</td>
<td></td>
</tr>
<tr>
<td><strong>Iodine², µg/day</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diet only</td>
<td>78</td>
<td>40</td>
<td>72</td>
<td>114</td>
<td>69</td>
</tr>
<tr>
<td>Diet + iodised salt³</td>
<td>91</td>
<td>36</td>
<td>96</td>
<td>143</td>
<td>41</td>
</tr>
<tr>
<td>Diet + iodised salt + supplement⁴</td>
<td>93</td>
<td>36</td>
<td>96</td>
<td>144</td>
<td>41</td>
</tr>
</tbody>
</table>

¹EAR: Estimated Average Requirement, EAR of iodine in teenage girls aged 15-18 years is 95 µg/day.
²Mean daily intake from 24 hour recalls, adjusted for usual intake.
³48 ug/day of iodine was added to participants who reported using iodised salt ($n = 60$).
⁴Two participants used iodine containing supplements.
The top 10 food groups that contributed the most to dietary iodine intake of participants are shown in **Table 9**. Approximately 40% of total dietary iodine came from grains and pasta, milk, eggs and egg dishes, and non-alcoholic beverages combined; ~7% from bread (including rolls and specialty breads); ~4% from savoury sauces, condiments, bread based dishes and dairy products, cakes and muffins and vegetables.

**Table 9 Percent of total iodine intake from food groups** ($n = 132$)

<table>
<thead>
<tr>
<th>Major Foodgroups</th>
<th>% Mean (95% CI)</th>
<th>% Contribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grains and pasta</td>
<td>9.9 (6.8, 13.1)</td>
<td>58</td>
</tr>
<tr>
<td>Milk</td>
<td>11.0 (8.3, 13.7)</td>
<td>58</td>
</tr>
<tr>
<td>Eggs and egg dishes</td>
<td>9.2 (6.2, 12.3)</td>
<td>27</td>
</tr>
<tr>
<td>Non-alcoholic beverages</td>
<td>12.7 (10.9, 14.6)</td>
<td>97</td>
</tr>
<tr>
<td>Bread (including rolls &amp; speciality breads)</td>
<td>7.6 (5.1, 10.2)</td>
<td>58</td>
</tr>
<tr>
<td>Savoury sauces and condiments</td>
<td>3.7 (1.9, 5.5)</td>
<td>50</td>
</tr>
<tr>
<td>Bread based dishes</td>
<td>3.9 (2.5, 5.2)</td>
<td>33</td>
</tr>
<tr>
<td>Dairy products</td>
<td>3.4 (2.0, 4.7)</td>
<td>40</td>
</tr>
<tr>
<td>Cakes and muffins</td>
<td>3.5 (2.1, 4.9)</td>
<td>36</td>
</tr>
<tr>
<td>Vegetables</td>
<td>5.1 (3.1, 7.0)</td>
<td>72</td>
</tr>
</tbody>
</table>
6. **Discussion and Conclusion**

Iodine plays an essential role in normal growth and development. Because New Zealand has low levels of iodine in the soil, historically iodine deficiency has been common. In the 21st century, both the children’s and adult national nutrition surveys reported mild iodine deficiency necessitating a change to the Food Standards Code in 2009, making the addition of iodised salt to bread mandatory. Since the iodisation of salt in bread, iodine intake in New Zealand adolescents has not been assessed and the food sources contributing to dietary iodine intake have not been evaluated. This is the first study in New Zealand to assess iodine status in adolescent females aged 15-18 years that includes measurements of dietary iodine intake.

6.1 **Dietary intake of iodine in New Zealand female adolescents aged 15-18 years**

In this sample of teenage girls aged 15-18 years, the mean iodine intake was 81 μg/day; the Estimated Average Requirement (EAR) for iodine in this age group is 95 μg/day and the Recommended Dietary Intake is 150 μg/day (41). Meškaitė et al. (64) observed lower iodine intakes of 35 μg/day in a group of Lithuanian adolescent girls aged 11-14 years. Lopez et al. (46) found similar results to the present thesis using two 24-hour diet recalls in Spanish girls aged 14-17 years, reporting iodine intakes of 91 μg/day. Another study in Norwegian adolescents aged 10-17 year olds (63% were females) carried out by Brantsæter et al. (65) recorded higher iodine intakes of 108 μg/day compared to the present study. Brantsæter et al. calculated the prevalence of inadequacy of iodine intakes
among Norwegian adolescents to be 61% (65). In this study, the prevalence of inadequacy was 69% with diet alone, and 41% after the inclusion of iodised salt.

Iodine status is typically assessed using Urinary Iodine Concentration (UIC), which is a good indicator of recent dietary intake (22). Although UIC was not measured in this thesis, based on the mean intake of iodine, UIC is predicted to be low. Approximately 92% of dietary iodine is excreted in the urine (66), thus a mean intake of 93 μg/day (median: 83 μg/day), would equate to a median UIC of around 86 μg/L, which falls in the 50-99 μg/L used to categorise groups as mildly iodine deficient (41). The only other study assessing iodine status in New Zealand female adolescents aged 15-18 was done in 2014/15 (12) and found the median UIC to be 114 μg/L. Studies carried out in other countries show varying results of iodine intakes in this population: Heidari et al. (67) reported a median UIC of 129 μg/L in 14-19 year old Iranian girls; Herrick et al. (68) assessed iodine status in American women showing a group of 12-19 year olds to have a mean UIC of 139 μg/L. Brantsæter et al. (65) not only assessed dietary iodine intake in Norwegian females aged 10-17 years, but urinary iodine, reporting a median UIC of 109 μg/L.

The low iodine intake of adolescent females in this study, and consequently a predicted median UIC of 86 μg/L that falls below 100 μg/L, contrasts with the findings of Jones et al. (36), who reported adequate iodine status in New Zealand children aged 8-10 years (females: median UIC of 106 μg/L). The difference in UIC between girls and adolescent females is likely to reflect differences in study design as well as dietary behaviour, particularly in the consumption of bread and use of iodised salt.
6.2 Food sources and food groups of iodine as assessed from 24-hour diet recalls

In this study, the top food group (~11%) contributing to dietary iodine intake was grains and pasta. This food group consisted of ~325 different foods, however, the only foods in this group likely to make a significant contribution to iodine intake was sushi. Sushi made with seaweed contains an average of 92 μg/100g of iodine (3). The next food group contributing a substantial amount of iodine to the diet was milk (10.4%); milk contains 23 μg/100g (3). The fourth food group was non-alcoholic beverages and most of the 246 different beverages in this group contained milk, for example, hot chocolate, milo, smoothies, tea and coffee. If the milk and non-alcoholic beverage groups are combined, more than 20% of total iodine in the diet of these adolescent females came from milk. Egg and egg dishes contributed ~10% of total dietary iodine; one medium egg weighing 44 g contains around 11 μg of iodine (3). When the proportion of total iodine from the food group bread (including rolls and speciality breads) and the food group bread-based dishes are combined, bread contributes ~11% to total iodine intake. In summary, in this sample of adolescent females, milk appears to make the largest contribution to total iodine intake, followed by bread and bread-based dishes, sushi and eggs.

In the most recent 2016 New Zealand Total Diet Study (NZTDS) (56), which is based on simulated diets for the group of girls aged 11-14 years, the major food groups that contributed to their dietary iodine intake was from grains including bread (~54%), followed by ~13% from chicken, eggs, fish and meat, and ~12% from dairy products.
The present thesis suggests that the diet of the study population differ from the typical diet used in the NZTDS (56), which report that the greatest contributors of dietary iodine come from bread.

6.3 Proportion of female adolescents in New Zealand using iodised salt

Under half the participants (41%) in this thesis reported use of iodised salt. If all the participants that used salt had chosen iodised salt rather than other types of salt (rock sea salt, pink Himalayan sea salt, sea salt and Malborough sea salt), that contain negligible amounts of iodine, iodine intakes in this sample of adolescents would be higher. Iodised salt is a major contributor to dietary iodine intake and the Ministry of Health (69) recommend that if salt is used, at the table or in cooking, it should be iodised. Further research, therefore, would be beneficial in assessing strategies to improve iodised salt intake in the diet of adolescent females.

6.4 Strengths and limitations

Strengths

The present thesis collected data from schools located in seven separate areas across New Zealand. There were several ethnic groups involved, with an over-representation of Māori (20%) compared to the New Zealand 2013 Census for this group (15%) (70). There was a good representation of Europeans (72%), similar to that from the 2013 Census (74%). Particular care was taken to ensure that the quality of dietary data collected was high. Throughout data collection, each participant had data collected from them by one assigned MDiet student, which allowed for continuity and consistency of data collected. Two diet recalls were carried out to capture intra-individual variation. Although this may have been a burden for participants, they were faster and more
familiar with the procedure second time round. At the end of data entry, 24-hour diet recalls were all checked for accuracy. The nutrient analysis software used for data entry was based on a recent enhanced version of the 2016 New Zealand Food Composition Database (71).

**Limitations**

The number of participants in this study was relatively small and the characteristics were not representative of the New Zealand adolescent female population. In comparison to the 2013 New Zealand Census data, there was an under-representation of Asian (6% vs 12% in the New Zealand population) and Pacific (5% vs 7% in the New Zealand population) (70). Similarly, less participants are likely to have come from lower socio-economic status as only 10% of schools were decile 1 to 4, compared to an expected 40% (70). For participants that did not know what type of salt was used at home, there was no follow-up, therefore there was no information on the type of salt used for ~10% of participants. In this study, iodine status was determined using dietary data only, rather than UIC, which is recommended. The type of salt used in recipes was not collected, which may have resulted in an underestimate of iodine intakes. Additionally, only daily supplement users were included in the results, however less frequent use could have impacted usual intakes – and thus, iodine intakes may be underestimated. This information was difficult to obtain since most participants did not prepare their meals. The code book used for data entry to aid decisions regarding substitute or default foods was based on the diets of children and adults, rather than adolescents. It was beyond the scope of this project to determine the prevalence of inadequate intakes using the EAR cut-point method; therefore, the percentage of participates with an iodine intake less than
the EAR, presented in Table 7, should be interpreted with caution. Finally, the 48 μg of iodine added to the intake of participants who reported using iodised salt may have resulted in an overestimation of iodine, since participants may not consume iodised salt daily.

6.5 Implications for future research

Further research is recommended to investigate dietary iodine intakes in adolescent females from a sample more representative of the New Zealand population. To do this, more time will be needed for recruitment, which may involve oversampling low decile schools in order to increase the proportion of participants from lower socioeconomic status. Furthermore, more Pacific and Asian participants are required.

In order to improve the accuracy of measuring iodine intake, more information about the use of iodised salt, as well as current practices in the home and on the day of data collection, is needed. The inclusion of validated, iodine-specific questionnaire designed for use in adolescents may provide other insights, particularly with regard to usual consumption of fortified bread and other foods high in iodine, such as sushi. The inclusion of objective measures of iodine status, such as urinary iodine concentration, would support the findings from any methods of dietary assessment. Research on finding alternative ways to increase iodine intake is also required. Alternative ways could include adding iodine to food that is more frequently consumed in this population, such as flour, or sushi, as this was the most commonly consumed food within this population.
6.6 Conclusions

This is the first study to assess dietary iodine intakes in a sample of New Zealand female adolescents aged 15-18 years. The study found that the mean intake of iodine was low, suggesting that this group may be at risk of mild iodine deficiency. This group of adolescent females do not appear to be consuming enough of the main food source of iodine in the New Zealand diet, namely, fortified bread. Results also show that more than half of the participants were not using iodised salt. Findings from this thesis suggest that other strategies to increase iodine intakes in New Zealand, in addition to bread, should be considered. The Ministry of Health (69) recommends that all salt used for consumption is iodised. Specifically, when preparing or choosing pre-prepared food, choose iodised salt, for example iodised salt could be used in meals. The results of this thesis suggest that the use of iodised salt in the production of other foods such as pasta, tinned goods, and manufactured foods, may be needed to ensure that adolescent females consume sufficient iodine. As adolescent girls will become the mothers of the future, the foods that they consume, as well as their dietary practices and behaviours, are important for entering pregnancy with good iodine status.
7. **Application of Research to Dietetic Practice**

The present thesis has highlighted the need to improve dietary iodine intakes in female adolescents aged 15-18 years in New Zealand. The content of iodine in New Zealand soil is low. This is the only study to assess dietary iodine intakes of adolescent females in New Zealand. This is a vital group in the population as they may become mothers of our future generation, and their nutrient status may impact that of their children. Furthermore, iodine is essential for normal growth and development of a fetus, therefore it is crucial that these girls are providing a healthy environment for their fetus. Adolescents are responsible for what they eat. This thesis has shown the need for adolescent females to consume foods that are rich in iodine, as well as an understanding of the potential consequences if inadequate iodine is consumed. As a dietitian, having an awareness of these facts, is fundamental for guiding adolescent female patients. Working alongside these girls to improve their familiarity with rich food sources of iodine, such as bread, eggs and milk, will show them how to improve their food choice and, consequently, their iodine intake. Discussing potential consequences of diets low in iodine (i.e. impaired development and problems later in life such as goitre and impaired development of their fetus) may aid healthier food choices and inform these girls of the responsibility not only of their health, but that of the future generation. As dietitians, understanding the irregular patterns of eating behaviours in adolescents will aid intervention. Rather than dietary restriction, dietitians could explore options with these patients to replace poor food sources of iodine with better sources. Finally, dietitians could remind adolescent females of the Ministry of Health’s recommendation (69) to choose iodised salt whenever salt is used.
8. References


11. University of Otago and Ministry of Health. A Focus on Nutrition: Key findings of the 2008/09 New Zealand Adult Nutrition Survey [Internet]. Wellington:


38. Hercus CE, Benson NW, Carter CL. Endemic Goitre in New Zealand, and its relation to soil-iodine studies from the University of Otago, New Zealand. J Hyg. 1925;24(3-4).


9. Appendices

Appendix A: Ethical approval

Appendix B: Māori consultation documentation

Appendix C: Enrolment questionnaire

Appendix D: Dietary habits questionnaire

Appendix E: 24-hour diet recall recording sheet

Appendix F: Food models list
Appendix A: Ethical approval

Dr J Haszard
Department of Human Nutrition
Division of Sciences

4 February 2019

Dear Dr Haszard,

I am writing to let you know that, at its recent meeting, the Ethics Committee considered your proposal entitled “SuNDIAL Project 2019: Survey of Nutrition Dietary Assessment and Lifestyle Phase 1: Adolescent Females”.

As a result of that consideration, the current status of your proposal is:- Approved

For your future reference, the Ethics Committee’s reference code for this project is:- H19/004.

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

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

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

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

Please provide the Committee with copies of the updated documents, if changes have been necessary.

The standard conditions of approval for all human research projects reviewed and approved by the Committee are the following:

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

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

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

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

gary.witte@otago.ac.nz

jo.farrondediaz@otago.ac.nz

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

The Human Ethics Committee (Health) asks for a Final Report to be provided upon completion of the study. The Final Report template can be found on the Human Ethics Web Page http://www.otago.ac.nz/council/committees/committees/HumanEthicsCommittees.html

Yours sincerely,

[Signature]

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

c.c. Assoc. Prof. L Houghton  Department of Human Nutrition
Appendix B: Māori consultation documentation

Ngāi Tahu Research Consultation Committee
Te Komiti Rakahau ki Kai Tahu

Monday, 17 December 2018

Dr Meredith Peddie
Department of Human Nutrition

Tēnā Koe Dr Meredith Peddie


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 outlined 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 Rakaunga Māori Data Audit Tool, which gives an overview of key Māori Data Sovereignty terms and principles.
NGĀI TAHU RESEARCH CONSULTATION COMMITTEE
Te Komiti Rakahau ki Kai Tahu

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 Pūtēre
Senior Project Manager
Office of Māori Development
Te Whare Whānau o Otago
Ph: +64 3 479 7461
Email: claire.porima@otago.ac.nz
Web: www.otago.ac.nz

The Ngāi Tahu Research Consultation Committee has membership from:

Te Rūnanga o Ōtāhú Incorporated
Kīti Huiāpō Rūnaka ki Puketōoki
Te Rūnanga o Moeraki
Appendix C: Enrolment questionnaire

Confidential

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
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.

<table>
<thead>
<tr>
<th>AGREE</th>
<th>DISAGREE</th>
</tr>
</thead>
</table>

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

What age are you as of today?
- [ ] 15
- [ ] 16
- [ ] 17
- [ ] 18
- [ ] None of the above

What high school do you attend?
- [ ] Tauraroa Area School
- [ ] Mt Maunganui College
- [ ] Spotswood College
- [ ] Wellington Girls College
- [ ] Waimea College
- [ ] Hornby High School
- [ ] Columba College
- [ ] Kaikorai Valley College
- [ ] Queens High School
- [ ] Mt Aspiring College
- [ ] None of the above
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 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.

○ AGREE
○ DISAGREE

Contact Information

What is your name? (Preferred first name, Last name)

What is your date of birth?

Age

Phone number (mobile would be best - so we can text you reminders)

What is your home address? (This will be the address where we will send your voucher) (number & street, suburb, city, postcode)

Do you live at this address during school term? ○ Yes ○ No

Do you live in a boarding house during school term? ○ Yes ○ No (Don’t include private boarding)

Please put the name and/or address of the boarding house (number & street, suburb, city, postcode)

What is the address that you live at during school term? (number & street, suburb, city, postcode)

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: ________________
<table>
<thead>
<tr>
<th>Question</th>
<th>Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>Have you been diagnosed with diabetes?</td>
<td>Yes</td>
</tr>
<tr>
<td>If so, which type?</td>
<td>Type 1 diabetes</td>
</tr>
<tr>
<td>Do you avoid eating gluten?</td>
<td>Yes</td>
</tr>
<tr>
<td>Have you been diagnosed with either coeliac disease or gluten intolerance?</td>
<td>Yes - coeliac disease</td>
</tr>
<tr>
<td>Have you been diagnosed with a food allergy or intolerance? (not gluten)</td>
<td>Yes</td>
</tr>
<tr>
<td>Which foods are you allergic or intolerant to? (Select as many as apply)</td>
<td>Eggs</td>
</tr>
<tr>
<td>Other: please specify</td>
<td></td>
</tr>
<tr>
<td>Are you vegetarian or vegan?</td>
<td>Yes</td>
</tr>
<tr>
<td>Which foods do you eat? (Select as many as apply)</td>
<td>Egg</td>
</tr>
<tr>
<td>Are you vegan?</td>
<td>Yes</td>
</tr>
<tr>
<td>How long have you been following this way of eating?</td>
<td>Less than a month</td>
</tr>
</tbody>
</table>

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>
<tbody>
<tr>
<td>How old were you when you had your first period?</td>
<td>11 years or younger</td>
</tr>
<tr>
<td></td>
<td>12-14 years</td>
</tr>
<tr>
<td></td>
<td>15 years or older</td>
</tr>
<tr>
<td></td>
<td>I haven't had a period yet</td>
</tr>
<tr>
<td>How long do you usually have from the start of one period to the start of the next?</td>
<td>Less than a week</td>
</tr>
<tr>
<td></td>
<td>1-2 weeks</td>
</tr>
<tr>
<td></td>
<td>3-4 weeks</td>
</tr>
<tr>
<td></td>
<td>4-5 weeks</td>
</tr>
<tr>
<td></td>
<td>More than 5 weeks</td>
</tr>
<tr>
<td></td>
<td>I haven't had a period for 3 months</td>
</tr>
<tr>
<td></td>
<td>The timing of my periods is not regular</td>
</tr>
<tr>
<td>How many days does your period usually last? (count your light days as well as your heavy ones)</td>
<td>Less than 4 days</td>
</tr>
<tr>
<td></td>
<td>4-6 days</td>
</tr>
<tr>
<td></td>
<td>7-9 days</td>
</tr>
<tr>
<td></td>
<td>10 days or more</td>
</tr>
<tr>
<td>Are your periods so heavy that they make it hard for you to go to school?</td>
<td>Yes - often</td>
</tr>
<tr>
<td></td>
<td>Yes - sometimes</td>
</tr>
<tr>
<td></td>
<td>No</td>
</tr>
<tr>
<td>Have you donated blood?</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>No</td>
</tr>
<tr>
<td>When did you last donate blood?</td>
<td>In the last 4 months</td>
</tr>
<tr>
<td></td>
<td>Between 4 and 12 months</td>
</tr>
<tr>
<td></td>
<td>More than a year</td>
</tr>
<tr>
<td>Have you had a nosebleed in the last year?</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>No</td>
</tr>
<tr>
<td>Do you have nosebleeds regularly?</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>No</td>
</tr>
<tr>
<td>Over the last year, on average how often did you get nose bleeds?</td>
<td>More than once a week</td>
</tr>
<tr>
<td></td>
<td>Once a week</td>
</tr>
<tr>
<td></td>
<td>Every couple of weeks</td>
</tr>
<tr>
<td></td>
<td>Once a month</td>
</tr>
<tr>
<td></td>
<td>Every few months</td>
</tr>
<tr>
<td></td>
<td>Every 6 months</td>
</tr>
<tr>
<td></td>
<td>Once a year</td>
</tr>
<tr>
<td></td>
<td>Less than once a year</td>
</tr>
<tr>
<td>Do you use any of the following contraceptives:</td>
<td>No - I don't use those contraceptives</td>
</tr>
<tr>
<td></td>
<td>Yes - I use one of those contraceptives</td>
</tr>
<tr>
<td>- Oral contraceptive (eg ‘the pill’ or ‘the mini-pill’)</td>
<td></td>
</tr>
<tr>
<td>- Depo Provera injection</td>
<td></td>
</tr>
<tr>
<td>- Implant (eg Jadelle)</td>
<td></td>
</tr>
<tr>
<td>- Hormonal IUD (eg Mirena)</td>
<td></td>
</tr>
</tbody>
</table>
## Other information

Which ethnic group do you belong to? (Mark those that apply)
- [ ] New Zealand European
- [ ] Māori
- [ ] Samoan
- [ ] Cook Island Maori
- [ ] 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
- [ ] PaknSave

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 D: Dietary habits questionnaire

Dietary Habits Questionnaire

Fruit

On average how many servings of fruit - fresh, frozen, canned or stewed - do you eat per day or per week? Do not include fruit juice or dried fruit.

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

- Never I don't eat fruit
- Less than 1 serving a week
- 1 serving a week
- 2-4 servings a week
- 5-6 servings a week
- 1 serving a day
- 2 servings a day
- 3 servings a day
- More than 3 servings a day
### Vegetables

On average how many servings of vegetables - fresh, frozen or canned - do you eat per day or per week? Do not include vegetable juices.

A serving is the same as one potato, half a cup of peas or a cup of salad.

- Never I don't eat vegetables
- Less than 1 serving a week
- 1 serving a week
- 2-4 servings a week
- 5-6 servings a week
- 1 serving a day
- 2 servings a day
- 3 servings a day
- More than 3 servings a day

### Bread

On average how often do you eat bread?

Include slices of bread, rolls, bagels, wraps, and gluten-free bread.

- Never I don't eat bread
- Less than once a week
- Once a week
- 2-4 times a week
- 5-6 times a week
- Once a day
- Twice a day
- 3 times a day
- More than 3 times a day

What type of bread, rolls or toast do you eat most of the time?

- White
- Wholemeal (brown colour)
- Light grain - has some grains but soft to eat (eg honey grain)
- Heavy grain - has some grains and a bit chewier (eg Vogels)
- Other (please specify)

If Other, please specify: ____________________________
Milk
How often do you have milk (cow's milk or plant milk)?

- I do not have any milk
- Rarely
- Monthly
- 2-3 times a month
- Once a week
- 2-4 times a week
- 5-6 times a week
- Once a day
- More than once a day

What type of milk do you use the most of?

- None
- Cow's milk
- Plant-based milk (eg soy, rice, almond, coconut)
- Other (such as goat or sheep milk)

What kind of milk do you usually have?

- Whole or standard milk (Dark blue or silver)
- Reduced fat (light blue)
- Skim or trim (green or yellow)
- Other (please specify)

If Other, please specify:

--------------------------------------------------

What kind of milk do you usually have?

- Regular
- Lite
- Sweetened or flavoured

Spreads and Oils
What type of spread do you use the most of?

- None
- Butter (including semi soft)
- Margarine (eg Canola, Sunflower, Olive oil based, or table spread)
- Other (eg avocado, cream cheese), please specify
- I don't know

If other, please specify:

--------------------------------------------------

What type of fat or oil is used most often in cooking in your household?

- None
- Butter
- Coconut oil
- Margarine
- Oil (eg Olive, Canola, or one in a bottle)
- Dripping or Lard
- I don't know
### Nuts

How often do you eat the following types of nuts? (Include nuts in cooked foods, bars, cereals etc but don't include peanut butter or other nut butters)

<table>
<thead>
<tr>
<th></th>
<th>More than once a day</th>
<th>Once a day</th>
<th>5-6 times a week</th>
<th>2-4 times a week</th>
<th>Once a week</th>
<th>2-3 times a month</th>
<th>Monthly</th>
<th>Rarely</th>
<th>I do not eat these</th>
</tr>
</thead>
<tbody>
<tr>
<td>Almonds</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brazil</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cashew</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hazelnut</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Macadamia</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peanut</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pecan</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pine nut</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pistachio</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Walnut</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### How often do you eat nut butters?

<table>
<thead>
<tr>
<th></th>
<th>More than once a day</th>
<th>Once a day</th>
<th>5-6 times a week</th>
<th>2-4 times a week</th>
<th>Once a week</th>
<th>2-3 times a month</th>
<th>Monthly</th>
<th>Rarely</th>
<th>I don't eat this type of nut butter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Almond butter</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cashew butter</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hazelnut butter</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peanut butter</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Walnut butter</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
# Meat, Dairy and Eggs

<table>
<thead>
<tr>
<th>Food Description</th>
<th>More than once a day</th>
<th>Once a day</th>
<th>5-6 times a week</th>
<th>2-4 times a week</th>
<th>Once a week</th>
<th>2-3 times a month</th>
<th>Monthly</th>
<th>Rarely</th>
<th>I do not eat this</th>
</tr>
</thead>
<tbody>
<tr>
<td>Egg</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Cow’s milk</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Dairy products excluding milk (e.g. cheese, yoghurt - don’t include plant based)</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Processed meat (e.g. ham, bacon, sausages, luncheon, canned corned beef, pastrami, salami)</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Other red meat (including beef, lamb, venison etc. don’t include processed meat)</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Pork</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Poultry (including chicken, turkey etc.)</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Fish</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Other seafood/shellfish (e.g. prawns, squid, crab)</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>

# Legumes

<table>
<thead>
<tr>
<th>How often do you eat lentils, chickpeas, kidney beans or baked beans? (Don’t include peas or peanuts)</th>
<th>I do not eat legumes</th>
<th>Rarely</th>
<th>Monthly</th>
<th>2-3 times a month</th>
<th>Once a week</th>
<th>2-4 times a week</th>
<th>5-6 times a week</th>
<th>Once a day</th>
<th>More than once a day</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>
### Other Foods

**How often do you eat tofu, tempeh and tofu products?**
- [ ] I do not eat these
- [ ] Rarely
- [ ] Monthly
- [ ] 2-3 times a month
- [ ] Once a week
- [ ] 2-4 times a week
- [ ] 5-6 times a week
- [ ] Once a day
- [ ] More than once a day

**How often do you eat vegetarian ingredients (like quorn, nut meat, vegetarian mince) that are used in other dishes?**
- [ ] I do not eat these
- [ ] Rarely
- [ ] Monthly
- [ ] 2-3 times a month
- [ ] Once a week
- [ ] 2-4 times a week
- [ ] 5-6 times a week
- [ ] Once a day
- [ ] More than once a day

**How often do you eat vegetarian sausages, nuggets, patties etc?**
- [ ] I do not eat vegetarian meat alternatives
- [ ] Rarely
- [ ] Monthly
- [ ] 2-3 times a month
- [ ] Once a week
- [ ] 2-4 times a week
- [ ] 5-6 times a week
- [ ] Once a day
- [ ] More than once a day

**How often do you eat vegetarian "meat alternatives" (like chicken-free chicken, vegetarian chicken schnitzel, meat-free bacon rashers etc)?**
- [ ] I do not eat these
- [ ] Rarely
- [ ] Monthly
- [ ] 2-3 times a month
- [ ] Once a week
- [ ] 2-4 times a week
- [ ] 5-6 times a week
- [ ] Once a day
- [ ] More than once a day
### Sweet Drinks

**How often do you drink diet or drinks labelled “sugar-free”?**

- [ ] I do not drink diet or sugar-free drinks
- [ ] Rarely
- [ ] Monthly
- [ ] 2-3 times a month
- [ ] Once a week
- [ ] 2-4 times a week
- [ ] 5-6 times a week
- [ ] Once a day
- [ ] More than once a day

**How often do you drink fizzy drinks? Don’t include diet varieties. (e.g. Coca-cola, Pepsi, lemonade)**

- [ ] I do not drink fizzy drinks
- [ ] Rarely
- [ ] Monthly
- [ ] 2-3 times a month
- [ ] Once a week
- [ ] 2-4 times a week
- [ ] 5-6 times a week
- [ ] Once a day
- [ ] More than once a day

**How often do you drink fruit juices, drinks or cordials? (e.g. Just Juice, Fresh-up, Keri, Golden Circle, Ribena, Charlie’s, Raro). Don’t include diabetic, diet or sugar-free varieties.**

- [ ] I do not drink juice or cordial
- [ ] Rarely
- [ ] Monthly
- [ ] 2-3 times a month
- [ ] Once a week
- [ ] 2-4 times a week
- [ ] 5-6 times a week
- [ ] Once a day
- [ ] More than once a day

**How often do you drink energy drinks? (e.g. V, Lift plus, Red Bull, Powerade)**

- [ ] I do not drink energy drinks
- [ ] Rarely
- [ ] Monthly
- [ ] 2-3 times a month
- [ ] Once a week
- [ ] 2-4 times a week
- [ ] 5-6 times a week
- [ ] Once a day
- [ ] More than once a day
### Snacks

How often do you eat lollies, sweets, chocolate or confectionary?

- I do not eat these
- Rarely
- Monthly
- 2-3 times a month
- Once a week
- 2-4 times a week
- 5-6 times a week
- Once a day
- More than once a day

How often do you eat biscuits, cakes, slices, muffins, sweet pastries or muesli bars?

Include nut and other sweet snack bars.

- I do not eat these
- Rarely
- Monthly
- 2-3 times a month
- Once a week
- 2-4 times a week
- 5-6 times a week
- Once a day
- More than once a day

How often do you eat savoury snacks such as chips (crisps not hot chips) and crackers?

- I do not eat these
- Rarely
- Monthly
- 2-3 times a month
- Once a week
- 2-4 times a week
- 5-6 times a week
- Once a day
- More than once a day

---

### Fast Food

How often do you eat fast food or takeaways from places like McDonalds, KFC, Burger King, Pizza shops or fish and chip shops?

- I do not eat fast food
- Rarely
- Monthly
- 2-3 times a month
- Once a week
- 2-4 times a week
- 5-6 times a week
- Once a day
- More than once a day

How often do you eat pies and other hot food that you buy ready-to-eat?

- I do not eat these
- Rarely
- Monthly
- 2-3 times a month
- Once a week
- 2-4 times a week
- 5-6 times a week
- Once a day
- More than once a day
## Breakfast Consumption

How many days in an average week do you have something to eat for breakfast?

- [ ] I don't usually have breakfast
- [ ] 1 day a week
- [ ] 2 days a week
- [ ] 3 days a week
- [ ] 4 days a week
- [ ] 5 days a week
- [ ] 6 days a week
- [ ] 7 days a week
### 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 mineral
- 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 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

**Multivitamin and/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.

**Multivitamin and/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.

**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:  

<table>
<thead>
<tr>
<th>Oil: How long did you take the supplement in the last 12 months?</th>
</tr>
</thead>
<tbody>
<tr>
<td>○ Daily</td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>Oil:</th>
</tr>
</thead>
<tbody>
<tr>
<td>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).</td>
</tr>
<tr>
<td>When taking a photo (or two), please make visible the brand and the list of contents.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Bran: How long did you take the supplement in the last 12 months?</th>
</tr>
</thead>
<tbody>
<tr>
<td>○ Daily</td>
</tr>
</tbody>
</table>

Bran:

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.

<table>
<thead>
<tr>
<th>Bran:</th>
</tr>
</thead>
<tbody>
<tr>
<td>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).</td>
</tr>
<tr>
<td>When taking a photo (or two), please make visible the brand and the list of contents.</td>
</tr>
<tr>
<td>Supplement</td>
</tr>
<tr>
<td>------------</td>
</tr>
<tr>
<td>Lecithin</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.

<table>
<thead>
<tr>
<th>Supplement</th>
<th>How long did you take the supplement in the last 12 months?</th>
</tr>
</thead>
<tbody>
<tr>
<td>LSA</td>
<td>○ Daily&lt;br&gt;○ More than once a week&lt;br&gt;○ Once per week&lt;br&gt;○ Monthly&lt;br&gt;○ Regularly but for a limited time&lt;br&gt;○ Not very often</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.

<table>
<thead>
<tr>
<th>Supplement</th>
<th>How long did you take the supplement in the last 12 months?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kelp</td>
<td>○ Daily&lt;br&gt;○ More than once a week&lt;br&gt;○ Once per week&lt;br&gt;○ Monthly&lt;br&gt;○ Regularly but for a limited time&lt;br&gt;○ Not very often</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.
Kelp:
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>Spululina: How long did you take the supplement in the last 12 months?</th>
</tr>
</thead>
<tbody>
<tr>
<td>○ Daily                      ○ More than once a week</td>
</tr>
<tr>
<td>○ Once per week             ○ Monthly</td>
</tr>
<tr>
<td>○ Regularly but for a limited time</td>
</tr>
<tr>
<td>○ Not very often</td>
</tr>
</tbody>
</table>

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

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

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.
<table>
<thead>
<tr>
<th>Supplement</th>
<th>Frequency Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>Echinacea</td>
<td>Daily, More than once a week, Once per week, Monthly, Regularly but for a limited time, Not very often</td>
</tr>
<tr>
<td></td>
<td>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.</td>
</tr>
<tr>
<td>Ginkgo</td>
<td>Daily, More than once a week, Once per week, Monthly, Regularly but for a limited time, Not very often</td>
</tr>
<tr>
<td></td>
<td>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.</td>
</tr>
<tr>
<td>Hypericum (St John’s Wort)</td>
<td>Daily, More than once a week, Once per week, Monthly, Regularly but for a limited time, Not very often</td>
</tr>
<tr>
<td></td>
<td>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.</td>
</tr>
</tbody>
</table>
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.
Do you have any comments about this survey?

Please add any comments you may have about this questionnaire here:

_________________________________________
Appendix E: 24-hour diet recall recording sheet

First □ or Second □ 24 h Recall

Participant ID: ________________  Interviewer: ________________

Date: ________________  Day of the Week: ________________

QUICK LIST

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

Ask about water consumption at the end of quick list
Participant ID:  
Interviewer:  
Date:  
Day of the Week:  

### Detailed 24 h Recall

<table>
<thead>
<tr>
<th>Time</th>
<th>Description of Food or Drink</th>
<th>Brand</th>
<th>Amount</th>
<th>Leftovers/Second helpings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Is the salt used at home iodised? Yes ☐  No ☐  Don’t know ☐  Don’t use salt ☐
Is this participant willing to participate in a second 24 recall? Yes □ No □

Are they happy to do a video call? Yes □ No □

This will most likely happen in the weekend sometime – are there any times in the weekend that are particularly suitable or unsuitable?

<table>
<thead>
<tr>
<th>Unavailable</th>
<th>Available</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix F: Food models list

Department of Human Nutrition
University of Otago
PO BOX 56 Dunedin
New Zealand

Human Nutrition Department (2019)

The following photos are attributed to intake 24 and are copyright (c) 2016. They are made available under an open government license.

<table>
<thead>
<tr>
<th>Baked beans</th>
<th>Ice cream</th>
<th>Rice</th>
</tr>
</thead>
<tbody>
<tr>
<td>Broccoli</td>
<td>Mac and cheese</td>
<td>Scrambled eggs</td>
</tr>
<tr>
<td>Cabbage</td>
<td>Mashed potato</td>
<td>Shepard’s pie</td>
</tr>
<tr>
<td>Carrots</td>
<td>Mixed vegetables</td>
<td>Sliced chicken</td>
</tr>
<tr>
<td>Chips</td>
<td>Noodles</td>
<td>Sliced meat</td>
</tr>
<tr>
<td>Cornflakes</td>
<td>Peas</td>
<td>Spiral pasta</td>
</tr>
<tr>
<td>Grated cheese</td>
<td>Popcorn</td>
<td>Tomato sauce</td>
</tr>
<tr>
<td>Gravy</td>
<td>Porridge</td>
<td></td>
</tr>
</tbody>
</table>

Food list with quantities

<table>
<thead>
<tr>
<th>Coffee cups</th>
<th>Heaped Spoons</th>
<th>Dessert spoon</th>
<th>Teaspoon</th>
<th>Canned drinks</th>
<th>Glass bottles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heaped Spoons</td>
<td>60ml</td>
<td>30ml</td>
<td>14ml</td>
<td>250ml</td>
<td>328ml</td>
</tr>
<tr>
<td>Dessert spoon</td>
<td>20ml</td>
<td>16ml</td>
<td>7ml</td>
<td>225ml</td>
<td>330ml</td>
</tr>
<tr>
<td>Teaspoon</td>
<td>14ml</td>
<td>6ml</td>
<td>4ml</td>
<td>500ml</td>
<td>500ml</td>
</tr>
<tr>
<td>Canned drinks</td>
<td>250ml</td>
<td>225ml</td>
<td>500ml</td>
<td>330ml</td>
<td></td>
</tr>
<tr>
<td>Glass bottles</td>
<td>328ml</td>
<td>330ml</td>
<td>500ml</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Milk tops</th>
<th>Muesli</th>
<th>Peaches</th>
<th>Cornflakes</th>
<th>Porridge</th>
<th>Porridge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk tops</td>
<td>silver</td>
<td>yellow</td>
<td>Dark blue</td>
<td>Light blue</td>
<td>green</td>
</tr>
<tr>
<td>Muesli</td>
<td>25g</td>
<td>50g</td>
<td>75g</td>
<td>100g</td>
<td></td>
</tr>
<tr>
<td>Peaches</td>
<td>23g</td>
<td>56g</td>
<td>138g</td>
<td>340g</td>
<td></td>
</tr>
<tr>
<td>Cornflakes</td>
<td>32g</td>
<td>41g</td>
<td>55g</td>
<td>72g</td>
<td></td>
</tr>
<tr>
<td>Porridge</td>
<td>11g</td>
<td>183g</td>
<td>278g</td>
<td>418g</td>
<td></td>
</tr>
<tr>
<td>Porridge</td>
<td>111g</td>
<td>183g</td>
<td>278g</td>
<td>418g</td>
<td></td>
</tr>
<tr>
<td>Margarine/butter</td>
<td>4g</td>
<td>5g</td>
<td>9g</td>
<td>12g</td>
<td></td>
</tr>
<tr>
<td>Honey</td>
<td>10g</td>
<td>18g</td>
<td>25g</td>
<td>35g</td>
<td></td>
</tr>
<tr>
<td>Jam</td>
<td>10g</td>
<td>18g</td>
<td>25g</td>
<td>35g</td>
<td></td>
</tr>
<tr>
<td>Peanut butter</td>
<td>9g</td>
<td>12g</td>
<td>16g</td>
<td>30g</td>
<td></td>
</tr>
<tr>
<td>Marmite</td>
<td>4g</td>
<td>5g</td>
<td>9g</td>
<td>12g</td>
<td></td>
</tr>
<tr>
<td>Chickpea stew</td>
<td>130g</td>
<td>200g</td>
<td>250g</td>
<td>300g</td>
<td></td>
</tr>
<tr>
<td>Tofu</td>
<td>41g</td>
<td>69g</td>
<td>109g</td>
<td>168g</td>
<td></td>
</tr>
<tr>
<td>Stir fry</td>
<td>100g</td>
<td>182g</td>
<td>320g</td>
<td>480g</td>
<td></td>
</tr>
<tr>
<td>Broccoli</td>
<td>17g</td>
<td>33g</td>
<td>66g</td>
<td>137g</td>
<td></td>
</tr>
<tr>
<td>Peas</td>
<td>16g</td>
<td>31g</td>
<td>59g</td>
<td>112g</td>
<td></td>
</tr>
<tr>
<td></td>
<td>25g</td>
<td>50g</td>
<td>101g</td>
<td>204g</td>
<td></td>
</tr>
<tr>
<td>----------------</td>
<td>-----</td>
<td>-----</td>
<td>------</td>
<td>------</td>
<td></td>
</tr>
<tr>
<td>Sliced chicken</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spaghetti</td>
<td>60g</td>
<td>100g</td>
<td>145g</td>
<td>224g</td>
<td></td>
</tr>
<tr>
<td>Rice</td>
<td>54g</td>
<td>101g</td>
<td>191g</td>
<td>359g</td>
<td></td>
</tr>
<tr>
<td>Noodles</td>
<td>92g</td>
<td>148g</td>
<td>246g</td>
<td>387g</td>
<td></td>
</tr>
<tr>
<td>Spiral pasta</td>
<td>55g</td>
<td>101g</td>
<td>188g</td>
<td>350g</td>
<td></td>
</tr>
<tr>
<td>Shepard’s pie</td>
<td>43g</td>
<td>85g</td>
<td>168g</td>
<td>332g</td>
<td></td>
</tr>
<tr>
<td>Baked beans</td>
<td>40g</td>
<td>81g</td>
<td>166g</td>
<td>337g</td>
<td></td>
</tr>
<tr>
<td>Stew</td>
<td>100g</td>
<td>170g</td>
<td>260g</td>
<td>360g</td>
<td></td>
</tr>
<tr>
<td>Mac &amp; cheese</td>
<td>24g</td>
<td>52g</td>
<td>113g</td>
<td>243g</td>
<td></td>
</tr>
<tr>
<td>Chips</td>
<td>70g</td>
<td>118g</td>
<td>198g</td>
<td>334g</td>
<td></td>
</tr>
<tr>
<td>Ice cream</td>
<td>30g</td>
<td>54g</td>
<td>99g</td>
<td>180g</td>
<td></td>
</tr>
<tr>
<td>Gravy</td>
<td>20g</td>
<td>41g</td>
<td>85g</td>
<td>175g</td>
<td></td>
</tr>
<tr>
<td>Whittaker’s chocolate</td>
<td>4g</td>
<td>22g</td>
<td>250g</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cadbury</td>
<td>5g</td>
<td>25g</td>
<td>200g</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lindt</td>
<td>10g</td>
<td>20g</td>
<td>100g</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Milky bar</td>
<td>5g</td>
<td>25g</td>
<td>200g</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Muffin</td>
<td>50g</td>
<td>130g</td>
<td>146g</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nut bar</td>
<td>19g</td>
<td>22g</td>
<td>50g</td>
<td>35g</td>
<td>40g</td>
</tr>
</tbody>
</table>