IRON STATUS AND FACTORS INFLUENCING IRON STATUS OF SOLOMON ISLANDS WOMEN LIVING IN NEW ZEALAND

A THESIS PRESENTED IN THE PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTERS OF SCIENCE (HUMAN NUTRITION)

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Abstract

Iron deficiency is a global problem among women of reproductive age, particularly in developing countries. A recent survey from the Solomon Islands reported that 44% of women of reproductive aged were anaemic. Currently nothing is known about the iron status of women from the Solomon Islands living in New Zealand (NZ).

Aim:

This study aims to assess and compare iron status and factors influencing iron status of Solomon Islands with Caucasian women living in and around Auckland, NZ.

Methods:

This was a cross-sectional study comparing 40 Solomon Islands women with 80 age-matched Caucasian women living in and around Auckland. Serum ferritin (SF), C-reactive protein (CRP) and haemoglobin (Hb) were analyzed. Iron status was defined as: iron replete (SF > 20 µg/L + Hb > 120 g/L), iron deficiency (ID) (SF < 20 µg/L + Hb > 120 g/L) and iron deficiency anaemia (IDA) (SF < 20 µg/L + Hb < 120 g/L). Participants with CRP >10 mg/L were excluded from this study. Dietary assessment was conducted using a computerised iron food frequency questionnaire including questions on dietary habits, purposely to assess foods affecting iron status. In addition, a 24-hour dietary recall was used to assess the average daily nutrient intake of Solomon Islands women. Demographic and body composition data were also collected together with data on other factors affecting iron status such as blood loss and general health history.

Results:

No significant difference in the prevalence of low iron stores + IDA was found in Solomon Islands and Caucasian women (17 *vs.* 23%, p=0.478). The frequency of red meat, prepared meat and offal, and all white meat consumption did not differ between the two groups (p=0.187). There was a significant difference in fish/seafood consumption (p=0.001), Solomon Islands women consumed fish/seafood more frequently than Caucasian women. Solomon Islands women also consumed medium-high vitamin C fruits more frequently (p=0.002) and dairy products less frequently (p=0.001) than Caucasian women. No significant difference (p=0.872) was identified in the frequency of intake of beverages

containing polyphenol between the two groups. But the analysis of individual beverages showed that Solomon Islands women more frequently consumed black tea compared to Caucasian women, the similar practice was identified from the dietary habit assessment where 40% of Solomon Islands women drank black tea an hour before or after evening meals. Fewer Solomon Islands women consumed multivitamins/minerals than Caucasian women (12.8% vs. 66.7% respectively) and none of the Solomon Islands women reported taking dietary supplements compared to 44% Caucasian women. In regards to menstrual blood loss, although there was no significant difference between the two groups in overall menstrual blood loss units, Caucasian women reported on average 1 day longer menstrual period than Solomon Islands women. A small number of women in each group had previously donated blood, but in every case it had taken place more than 6 months prior to this study. Contraceptive use was significantly lower among Solomon Islands women compared to Caucasian women (p=0.001). Body mass index and waist circumferences were significantly higher (p=0.001 and p=0.001 respectively) in the Solomon Islands women compared to the Caucasian women.

Conclusion:

The iron status of Solomon Islands and Caucasian women did not differ, but there was variability between groups in the intake of foods and behaviours that are known to influence iron status. This study found both protective and non-protective factors for ID among Solomon Islands women, although the correlation of those factors with iron status were not able to be assessed due to a relatively small sample size and low prevalence of ID/IDA. This study therefore concludes that ID was not a concern for Solomon Islands women living in NZ, and that the prevalence was lower in this group than in women living in the Solomon Islands. This is possibly the result of adapting to different dietary habits and behaviours, increased accessibility to animal sources of iron, and high intakes of vitamin C-rich foods in their host country.

Acknowledgement

It is an honour for me to express my deepest gratitude to all the participants, families and the Solomon Island communities in Auckland and Hamilton for the abundant support offered during the course of this research; this thesis would not have been possible without your participation and support. **Big TAGIO lo iu fala evri wantok.**

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Research team

The research reported in this thesis was planned and executed by a team of researchers. The contribution of each team member is described in the table below.

Rosemary Kafa	Study proposal, ethics application, development of study protocols, participant recruitment, data collection, data processing, statistical analysis and thesis writing
Dr. Cath Conlon (Main supervisor)	Supervised and assisted with study proposal, ethics application, development of questionnaires, development of study protocols, data collection, blood processing, supervised and review of the final thesis
Dr. Rozanne Kruger (Co-supervisor)	Supervised and assisted with study proposal, ethics application, development of study protocols, development of questionnaires, training in dietary assessment, data collection, dietary data analysis, supervised and review of the final thesis
Associate Professor Welma Stonehouse (Co-supervisor)	Supervised and assisted with study proposal, ethics application, data collection, blood processing, data processing, statistical analysis, supervised and review of the final thesis.
Simon Bennett	Phlebotomist
Avril Balmer	Phlebotomist
Carlos Miranda	Blood processing
Regina Wypch	Assistance with body composition measurements
Cheryl Gammon	Assistance with statistical data analysis
Kathryn Beck	Compilation of Caucasian women's databases and assistance with calculation of menstrual blood loss
Michelle Ingram	Language editing

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Abbreviations

Abs	Absorbency
AGP	α_1 – acid glycoprotein
AHA	American Heart Association
AMDR	Acceptable macronutrient distribution range
ASIWA	Aotearoa Solomon Islands wantoks' association
APPs	Acute phase proteins
BLU	Blood loss unit
BMI	Body mass index
CIHAT	Computerised iron habits assessment tool
Cm	Centrimetre
CO_2	Carbon dioxide
CRP	C – reactive protein
D_1	Dopamine receptor 1
D_2	Dopamine receptor 2
DA	Dopamine
DALYs	Disability adjusted life years
Dcytb	Duodenal cytochrome b
DHS	Demographic health survey
DMT1	Divalent metal transporter 1
DNA	Deoxyribonucleic acid
$FADH_2$	Flavin Adenine Dinucleotide
FeFFQ	Iron food frequency questionnaire
Fe^{2+}	Iron ferrous
Fe^{3+}	Iron ferric
FPN	Ferroportin
g	gram
GABA	γ aminobutyric acid
GAD	Glutamate decarboxylase
GBD	Global burden of disease

GDP	Gross domestic product
Hb	Haemoglobin
HCP1	Haem carrier protein 1
HD	Number of ‘heavy’ days during an average period
HP	Number of pads on a ‘heavy’ day
HT	Number of tampons on a ‘heavy’ day
Ht	Height
5-HT	5-Hydroxytryptophan
IANZ	International Accreditation New Zealand
ID	Iron deficiency
IDA	Iron deficiency anaemia
IDE	Iron deficiency erythropoiesis
IREs	Iron responsive elements
IRPs	Iron regulatory proteins
ISAK	International society for the Advancement of Kin anthropometry
IUD	Intrauterine device
IUD	Intrauterine foetal demise
Kcal	Kilocalorie
Kg	Kilogram
KiWI	Kiwi women iron study
KJ	Kilo joule
L	Litre
LBW	Low birth weight
LD	Number of ‘light’ days during an average period
LP	Number of pads on a ‘light’ day
LT	Number of tampons on a ‘light’ days
NA	Not assessed
NM	Not measured
m^2	Metre square
MCV	Mean cell volume
mg	Milligram
µg	Microgram

MID	Mild iron deficiency
MoHNZ	Ministry of Health New Zealand
MoHSI	Ministry of Health Solomon Islands
MUFA	Mono unsaturated fatty acids
NADH	Nicotinamide adenine dinucleotide plus Hydrogen
NNS	National nutrition survey
NZ	New Zealand
NZ NCEA L3	New Zealand national education achievement level 3
O_2	Oxygen
p	Probability
PKU	Phenylketonuria
PI	Pacific Islands
PUFA	Poly unsaturated fatty acids
RDI	Recommended daily intake
SD	Standard deviation
SDT	Suggested dietary target
SF	Serum ferritin
SFA	Saturated fatty acids
SI	Solomon Islands
SLS	Sodium lauryl sulphate –Hb
SOP	Standard operation protocols
SPC	Secretariat of the Pacific community
SPSS	Statistical package for social science
TBI	Transferrin bound iron
TfR1	Transferrin receptor 1
UK	United Kingdom
UN	United Nations
UNDP	United Nations development programme
UNICEF	United Nations international children’s fund
US	United States
USA	United State of America
WHO	World health organization

WISE	Women iron status and education
Wt	Weight

Chapter 1: Introduction

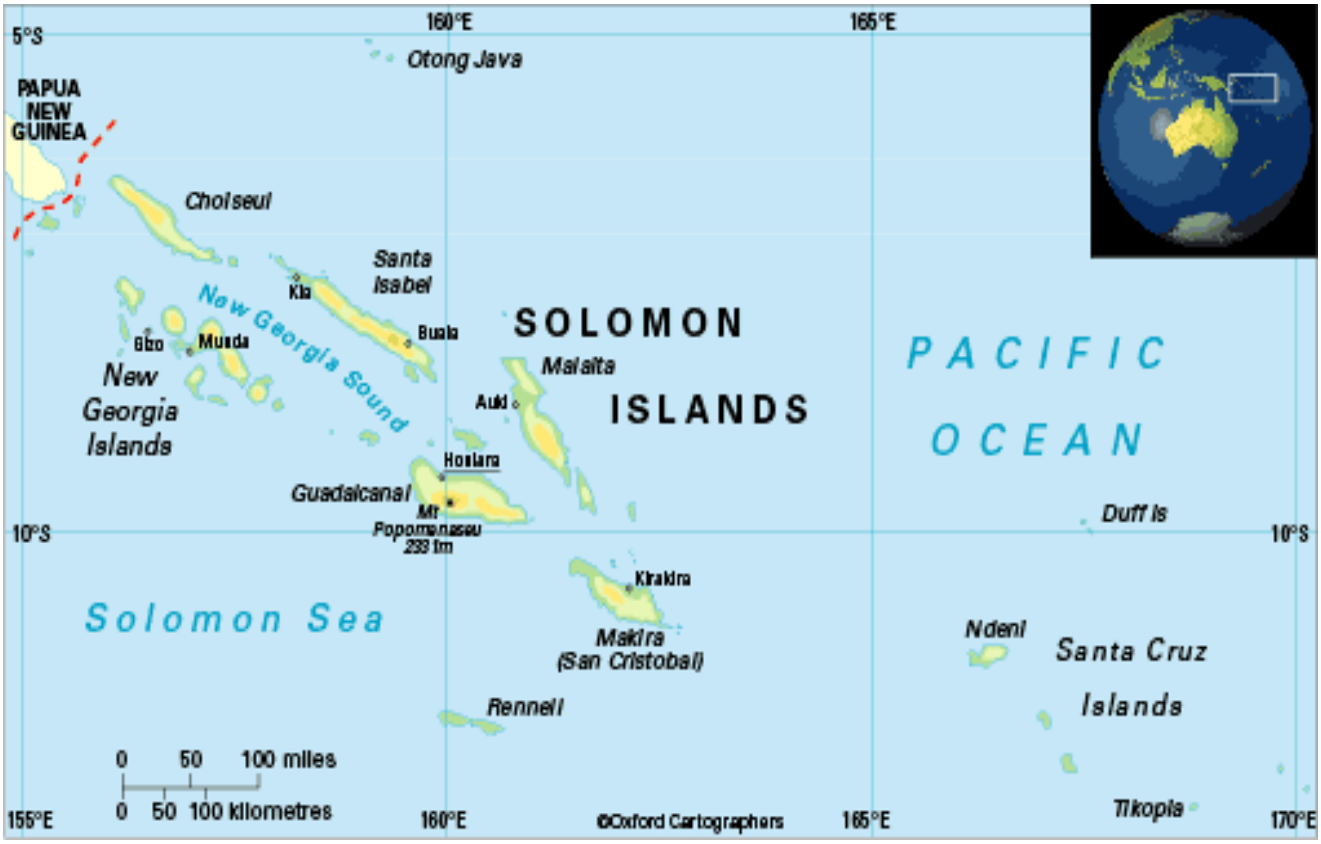
Around two billion people are affected by iron deficiency (ID) globally (Zimmermann & Hurrell, 2007; WHO, 2004) but it is most common in women of reproductive age in developing countries (World Health Organization (WHO), 2001). According to WHO (2004),

> *Iron deficiency is a state in which there is insufficient iron to maintain the normal physiological function of tissues such as the blood, brain, and muscles. Iron deficiency can exist in the absence of anaemia if it has not lasted long enough or if it has not been severe enough to cause the haemoglobin (Hb) concentration to fall below the threshold for the specific sex and age group.*

While there is no available information on the prevalence of ID in Solomon Islands women, the first National Nutrition Survey in the Solomon Islands identified 23% of reproductive aged women as having anaemia (Solomon Islands Ministry of Health (MoHSI), 1990). Anaemia is an advance stage or third stage in the progress of ID with Hb < 120 g/L. In the more recent Health and Demographic Survey of 2006/07, the prevalence of anaemia had increased to 44.3% (Secretariat of the Pacific Community (SPC), 2009b) which is a 21% increase from the last 1989/90 survey. This shows an increasing trend in the prevalence of anaemia among women of reproductive age in the Solomon Islands. The current available data only represent anaemia and therefore, iron deficiency is also likely to be a significant problem in this population. As ID is one of the eminent risk factors for disability, maternal and perinatal mortality globally (Zimmermann & Hurrell, 2007; Stoltzfus, 2003), widespread ID among Solomon Islands women would have far-reaching implications for the health of the Solomon Islands population.

Solomon Islands is one of the developing Pacific Island nations situated 1800 kilometres north-east of Australia. It has a total land area of 28,900 square kilometres scattered over 1.3 million square kilometres of the Pacific Ocean (Figure 1.1). The six main islands are Guadalcanal, Malaita, Choiseul, San Cristobal, Santa Isabel and New Georgia, and there are hundreds of smaller, uninhabited islands (WHO, 2008). While IDA has been identified in women throughout the islands, it is most prevalent on the more densely populalated islands

such as Guadalcanal (55%), Malaita (45%), Western province (41%) and in the capital city, Honiara (49%) (SPC, 2009b).



Source: http://www.thecommonwealth.org/YearbookHomeInternal

Figure 1.1: Map of Solomon Islands

The population of the Solomon Islands was projected to be 542,287 in 2011, with an annual population growth rate of 4.4% between 1999 and 2005 (Solomon Islands Statistics Office, 2006). The Solomon Islands population increased since the 1999 national population census record from 404,511 to 552,438 an estimated figure from July 2006, with 42% of the total population younger than 15 years of age (WHO, 2008). As it has a youthful population, the Solomon Islands is likely to face increasing challenges with IDA, especially as young girls reach reproductive age. Also, it is predicted that the Solomon Islands will continue to experience high population growth in the future (SPC, 2009b), which will further escalate the risks of IDA in women of reproductive age. According to WHO (2008), the estimated life

expectancy of Solomon Islanders at birth was 63.4 years (62.6 years for males and 64.3 years for females). More than 80% of the population of the Solomon Islands lives in rural areas. Traditional communal living is the norm in villages, and subsistence farming and fishing are the means of survival with surplus produce as a source of income for the family (Secretariat of the Pacific Community (SPC), 2008; National Planning Solomon Islands Government, 2002).

1.1. Economic situation of the Solomon Islands

The cash economy of Solomon Islands is largely based on timber, fish, copra, cocoa, palm oil and gold (Commonwealth of Australia, 2004; SPC, 2008). The gross domestic product (GDP) growth rate slowly increased from 6.4% in 2008 to 7.1% in 2010, despite a decline (– 2%) in 2009 (Wasuka, 2011). It is likely that, the current economic situation of the Solomon Islands has been affected by the global recession, which has contributed to high food prices and therefore affected food choices. In this regard, the country's economic status has the potential to impact the nutritional status of more affluent and low income groups in the urban population. This is supported by the identification of the high percentage (49%) of anaemic women in the capital city (Honiara) and other areas where urbanization has occurred and people are exposed to more affluent foods and lifestyles (SPC, 2009b).

1.2. Pacific Island Countries migration pattern

The Pacific Islands is made up of 20,000 to 30,000 islands and comprises 22 states. The indigenous populations are from Melanesia (black islands), Micronesia (small islands) and Polynesia (many islands) (Fitzpatrick-Nietschmann, 1983). In Melanesia, internal migration is common, while Polynesians have widespread international emigration and Micronesians undertake both internal and international migration (Connell & Brown, 1995). The population of Pacific people in NZ comprises groups with diverse cultures and several different languages, although there are also numerous similarities. The largest group is Samoan (49%), followed by Cook Islanders (22%), Tongans (19%), Niuean (8%) and other minority groups, including Solomon Islanders (Tukuitonga, 2011). Solomon Islanders, from a Melanesian Pacific country, form a small growing population in NZ. The first record of Solomon Islanders coming into NZ was in the 1951 national census with a population of 20, which increased to 184 in the 1996 census, 507 in 2001 and 522 in 2006 (Walrond, 2009).

1.3. Traditional Solomon Islands diet

Historically, Solomon Islanders were hunters and gatherers whose survival was dependent on cultivation of the sea, rivers, forest and land. The traditional Solomon Island diet predominantly consists of root vegetables, coconut, fresh fish and green leaves (Coyne, 2000). Common root crops are taro, yams, sweet potato and cassava (Liloqula, Saelea & Levela, 1980). Local green leaves cooked in coconut cream are more frequently eaten with root crops than animal protein sources (Coyne, 2000). This diet is poor in sources of iron, especially meat, which may be a significant factor contributing to the high prevalence of IDA in Solomon Islands women.

Many changes to the traditional Solomon Islands diet have occurred over several decades ago (Coyne, 2000). Imported foods such as rice, flour, noodles, sugar, tea, salt and canned fish and/or meat are becoming increasingly consumed by many Solomon Islanders, particularly urban dwellers (Coyne, 2000). These dietary changes may have contributed to the increased rates of Western disease patterns that are now seen in the Solomon Islands; the major causes of mortality from 1990 to 2005 were cancer, cardiovascular diseases, malaria, respiratory infections and neonatal causes in infants (WHO, 2008; MoHSI, 2007).

1.4. Problem statement

It is likely that the small Solomon Islands immigrant population in NZ will increase over the coming years, and will form another of this country's significant Pacific Island ethnic groups. The lower rate of IDA in NZ compared to the Solomon Islands raises questions about the iron status of Solomon Island women living in NZ, and whether their iron status may have been affected by emigrating to NZ. However, there is currently no information about the iron status of women from the Solomon Islands living in NZ.

Studies on Pacific Islanders in NZ did not represent the minority Pacific Island groups such as Solomon Islanders. This is the first study to address whether ID is a problem among Solomon Islands women who are living outside of their native country, and to assess the factors that contribute to their iron status. Therefore, this research will provide baseline information on the iron status of Solomon Islands women living in NZ. It will also provide important information

for designing future interventions, should ID be found to be a concern in this population group. A group of age-matched Caucasian women will be included in this study to allow comparisons of iron status and factors contributing to ID and IDA. Information acquired from each group will be useful to understand the dietary intake of the two groups involved and their influences on iron status.

1.5. Aim of the study

To assess the iron status of Solomon Islands women aged 18 – 45 years living in and around Auckland, and to compare the results with a sample of age-matched Caucasian women from the same location.

Objectives:

1. To determine iron status for both groups through assessing haemoglobin (Hb), serum ferritin (SF) and C-reactive protein (CRP) concentrations as biomarkers.
2. To assess the following factors influencing iron status of Solomon Islands women and compare with age-matched Caucasian women living in and around Auckland.

    - To assess dietary factors influencing iron status through a computerised iron food frequency questionnaire (FeFFQ) including a questionnaire on dietary habits
    - To assess nutrient intake of the Solomon Islands women through a single 24 hour dietary recall interview
    - To assess blood loss using an adapted computerised blood loss questionnaire
    - To assess the health history and lifestyle practices of the participants in relation to iron status
    - To assess BMI, waist circumference using standard anthropometric measures and percentage of body fat using BODPOD

1.6. Structure of thesis

This report comprises six chapters. Each chapter will be briefly introduced in this section to highlight the composition of this report.

Chapter one: Introduction

This chapter gives a brief description of the magnitude of ID/IDA, the classification of iron status, overview of the Solomon Islands, rationale, aims and objectives of this study.

Chapter two: Literature Review

This chapter reviews information and evidence relating to iron, ID, IDA, factors influencing the iron status of women of reproductive age and the effects of IDA on women's health and pregnancy outcomes. This information comes from a range of sources, including peer-

reviewed experimental and observational studies, population-based surveys, review papers and textbooks.

Chapter three: Methodology

This section describes the study design, sample population and different standardised methodologies that were used to collect data for this study. These methodologies include biochemical analyses for the identification of iron status; body composition measurements; and questionnaires on demographic data, diet and other factors influencing iron status such as blood loss and the general health and lifestyle of the participants.

Chapter four: Results

This chapter describes the participant's, demographic characteristics, the prevalence of ID and IDA within the samples, different factors (such as dietary) that influence iron status and general health and lifestyle practices. Results are presented in tables and figures.

Chapter five: Discussion

The section discusses the results in the context of the wider literature, providing comparisons with other relevant research.

Chapter six: Summary, Conclusions & Recommendations

This chapter summarises the main findings of this study, outlines the concluding statements and provides recommendations based on the study results.

Chapter 2: Literature review

2.1. Introduction

Iron deficiency can severely compromise women's health and pregnancy outcomes, and is therefore a significant health problem. The Global Burden of Disease (GBD) 2000 project reported that ID ranks ninth among 26 major factors that contribute to global disease rates (Stoltzfus, 2003) and is considered to be one of the eminent risk factors for disability, maternal and perinatal mortality (Zimmermann & Hurrell, 2007; Stoltzfus, 2003). Iron deficiency anaemia (IDA) is more prevalent in women and children of developing countries than of developed countries (McLean et al., 2008). The number of non-pregnant women reported to have IDA was 468 million globally (de Benoist et al., 2008). Furthermore, IDA contributes to 115,000 maternal deaths per year and 0.4% of total global disability-adjusted life years (DALYs) (Black et al., 2008). These figures demonstrate that ID and IDA can have serious consequences for women of reproductive age if not identified and treated early.

This literature review will describe different forms of iron and its functions, recommended iron requirements for non-pregnant women, dietary sources of iron, ID and IDA and their causes and consequences, and factors that can influence the iron status of women in both developed and developing countries. Evidence will be drawn from human and animal studies on ID and IDA from developed and developing countries. Nutritional issues that affect immigrants from undeveloped countries living in Western countries, including NZ, will also be explored.

This literature review will also include the profile of Pacific Islanders in NZ, as some of the issues have the potential to influence the iron status of Solomon Islands women living in NZ. Lastly, the review will describe the nutritional issues faced by Solomon Islands women in their native country, which led to the rationale behind this study.

2.2. Iron and its functions

Iron, a trace mineral, was identified as an essential nutrient over a century ago and presents as ferric (Fe^{3+}) and ferrous (Fe^{2+}) forms. Since then, many advances have been made in the study of iron metabolism and ID, but further understanding of its absorption mechanisms is still needed (Bernuzzi & Recalcati, 2006). Although the body only requires small amounts of iron,

it is an essential nutrient for human health. Iron has a distinctive characteristic: it is positively charged, allowing it to lose and gain electrons and therefore alternate between its oxidized Fe^{3+} and Fe^{2+} forms (Papanikolaou & Pantopoulos, 2005; Dunn, Rahmanto & Richardson, 2006). Another essential character of iron is its ability to bind to negatively charged components such as oxygen, nitrogen and sulphur, which significantly contributes to the functionality of iron within the body (Beard, 2001; King, 1996). It is vital that adequate iron levels are maintained to the degree that they meet physiological needs, but they should not be so high as to cause iron toxicity and oxygen radicals that harm cellular constituents (Papanikolaou & Pantopoulos, 2005; Miret, Simpson & Mckie, 2003).

The human body has two major iron body pools: functional iron in Hb, myoglobin and enzymes, and stored iron in ferritin, hemosiderin, and transferrin (Table 2.1) (Edison, Bajel & Chandy, 2008; Mahan & Escott-Stump, 2004). Adequate iron in each pool enables iron to engage in crucial cellular metabolic processes within the human body and facilitate proper physiological functioning (Clark, 2008; Hunt, 2005).

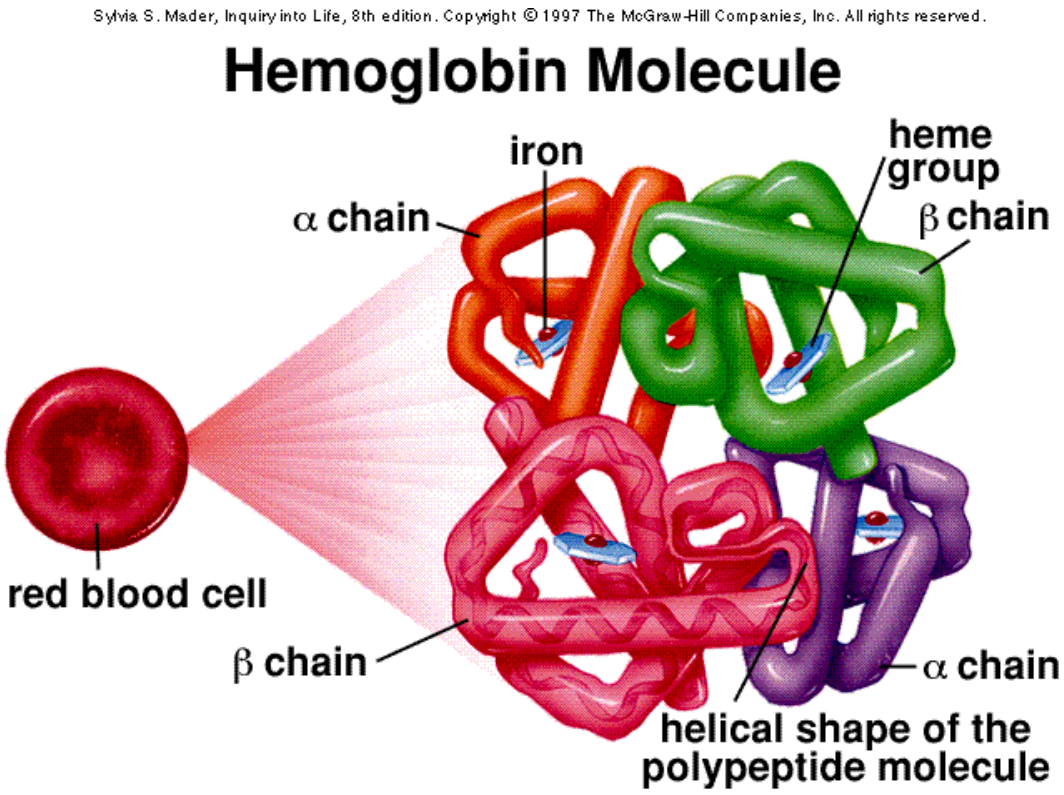
Table 2.1: Major iron pools and distribution in adults (Gropper, Smith & Groff, 2009)

Major iron pools	Women (mg/kg)	Men (mg/kg)
Functional iron		
Haemoglobin	28	31
Myoglobin	4	5
Haem enzymes	1	1
Non-haem enzymes	2	1
Transport iron		
Transferrin	0.05	0.05
Storage iron		
Ferritin and hemosiderin	4	12
Total iron	39.05	50.05

Source: Adapted from Gropper, Smith & Groff (2009)

Functional body iron is primarily found in haem protein complexes in Hb within circulating red blood cells, as well as in myoglobin of muscle tissues (Anderson & Vulpe, 2009; Beard, 2001). Both Hb and myoglobin aid iron transportation (Munoz, Villar & Garcia-Erce, 2009). Haemoglobin is the most important haem protein, consisting of four globin chains each binding

a haem molecule (Figure 2.1). The structure of Hb enables it to hold four iron atoms, which means it can efficiently transport more than one oxygen atom at a time to tissues (Lynch, 2003).



Source: (Mader, 1997)

Figure 2.1: Haemoglobin molecule from a red blood cell (Mader, 1997)

To carry oxygen to the tissues, iron binds with metalloproteins (Andrews & Schmidt, 2007). This occurs via the transfer of electrons to and from the iron atom as it varies between the different states of oxidation. Iron operates as a shuttle by binding with oxygen from the environment and delivering it to the tissues (Thompson et al., 2011; Aisen, Enns, & Wessling-Resnick, 2001).

Myoglobin is another functional haem molecule with a similar structure to Hb. It is found within muscles, but unlike Hb, its single globin chain and haem complex means it is only capable of transporting a small amount of oxygen per molecule. Myoglobin's role is to store oxygen and ensure sufficient delivery from erythrocytes to cellular mitochondria in the muscle cytoplasm

(Schechter, 2008; Lynch, 2003). Myoglobin makes up 10% of the body's functional iron (Lynch, 2003).

2.2.1. Iron regulation

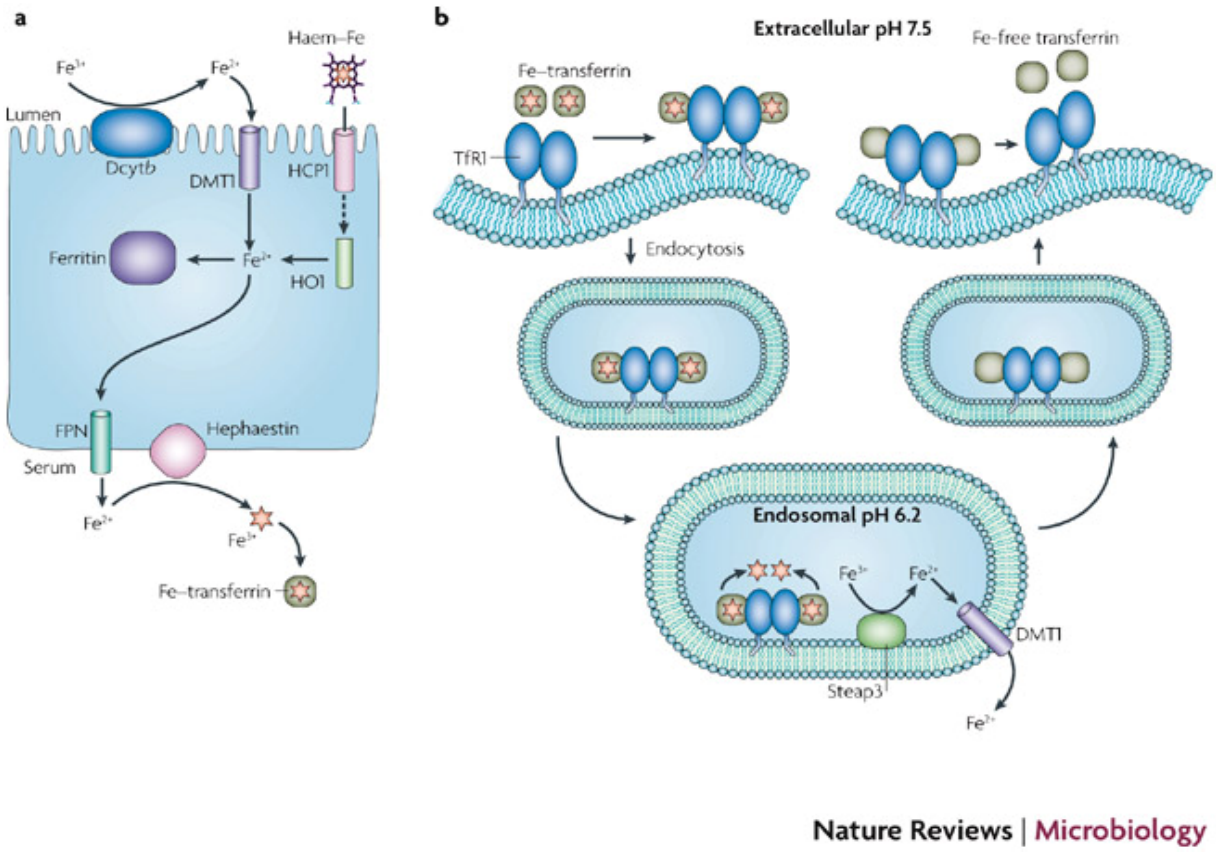
Iron is an indispensable nutrient for life, yet excess iron may cause toxicity in the body and can result in cardiac problems and cancer (Gropper et al., 2009; Papanikolaou & Pantopoulos, 2005). Therefore, physiological regulatory mechanisms are in place to maintain an ideal concentration of iron in the cells. The genes required for co-ordinating these mechanisms are regulated by iron responsive elements (IREs) and iron regulatory proteins (IRPs) (Recalcati, Minotti & Cairo, 2010). This homeostasis process primarily occurs through absorption, transport, storage and excretion of iron (Andrews & Schmidt, 2007; Dunn et al., 2006).

2.2.2. Iron absorption

There are two major types of iron in the diet, haem and non-haem iron (Lynch, 2003; Sharp & Srai, 2007). The mechanisms required for iron absorption are different for each form, but both involve a multistep process beginning with uptake of iron from the intestinal lumen and transport across the basolateral membrane to the plasma (Geissler & Singh, 2011; Sharp & Srai, 2007) as shown in figure 2.2. Prior to haem iron absorption, it needs to be hydrolysed from the globin portion of the haemoglobin or myoglobin, which requires the presence of gastric secretions such as hydrochloric acid and proteases in the stomach and the small intestine (Edison et al., 2008; Miret et al., 2003). Ferrireductases are the major players in the reduction process of Fe^{3+} to Fe^{2+} iron in the duodenum (Frazer & Anderson, 2005; Papanikolaou & Pantopoulos, 2005; Pantopoulos, 2004). Ascorbic acid has shown to be an influential factor necessary for the reductase activity (Hurrell & Egli, 2010; Trinder et al., 2002; Bothwell, 1995).

In its reduced state, ferrous iron is bound to divalent metal transporter 1 (DMT1), which acts as a proton symporter by allowing iron to cross the luminal membrane of the duodenum and be absorbed (Gropper et al., 2009; Zimmermann & Hurrell, 2007; Dunn et al., 2006). In the cytoplasm, iron is either stored as ferritin or released into the serum for circulation (Drakesmith & Prentice, 2008; Papanikolaou & Pantopoulos, 2005). Figure 2.2 illustrates the iron

absorption process, but the actual mechanism of haem iron absorption is yet to be identified (Trinder et al., 2002).



Source: Drakesmith & Prentice (2008)

Figure 2.2: Iron absorption in the duodenal cell and the iron transferrin cycle (Drakesmith & Prentice, 2008)

The absorption of dietary iron as Fe^{3+} begins with uptake from the intestinal lumen (Figure 2.2). It is then reduced from Fe^{3+} to Fe^{2+} by ferrireductase duodenal cytochrome b (Dcyt*b*) and transported into the cytoplasm via DMT1. Haem iron from food is absorbed via haem carrier protein 1 (HCP1), where it is converted to Fe^{2+} by oxygenase 1 (HO) (Drakesmith & Prentice, 2008; Zimmermann & Hurrell, 2007; Frazer & Anderson, 2005). Iron is released from enterocytes via ferroportin (FPN) under the action of ferric oxidase hephaestin, after which it binds to transferrin and is transported to tissues (Drakesmith & Prentice, 2008).

Iron transferrin has a strong affinity for transferrin receptor 1 (TfR1) at extracellular pH 7.5. Once inside the endosome, a pH of 6.2 causes ferric iron to be discharged from transferrin. It is then reduced by ferri- and cupric-reductases to Fe^{2+} iron and transferred to the cytoplasm by DMT1 (see Figure 2.2) (Drakesmith & Prentice, 2008; Mckie et al., 2001). Plasma transferrin is then incorporated into haemoglobin for erythropoiesis and release back into the circulation (Drakesmith & Prentice, 2008; Zimmermann & Hurrell, 2007).

The regulation of iron absorption can be influenced by certain factors such as the amount of iron consumed, the rate of erythropoiesis, hypoxia, pregnancy and inflammation, as well as dietary factors such as ligands and iron chelators that may inhibit or reduce its absorption (Thompson et al., 2011; Frazer et al., 2005; Miret et al., 2003; Bothwell, 1995). The amount of plasma iron absorbed by the enterocytes is equal to levels in the body; therefore the iron level of these cells reflects the body stores. Crypt cells express TfR1 which facilitates the uptake of transferrin bound iron (TBI) (Arneson & Brickell 2007; Trinder et al., 2002).

2.2.3. Recycling of iron

The normal human body contains 3 to 4 grams of iron, of which 75% is present as active metabolic compounds and about 10% remains as reservoir (Lynch, 2003; Miret et al., 2003; Bothwell, 1995). When the dietary iron supply is low or the body has undergone large losses, iron is mobilised from storage to maintain adequate blood levels. Once iron balance has been restored, the body will gradually boost the iron stores to ensure optimal reserves are available in times of demand. About 90% of daily iron needs are obtained from endogenous sources, whereby older red blood cells are broken down and recycled back into the iron pool (Figure 2.3) (Hurrell & Egli, 2010). The remaining 10% of iron comes from the diet as haem iron from animal sources and non-haem iron from plant sources (Hurrell & Egli, 2010; Harvey et al., 2000).

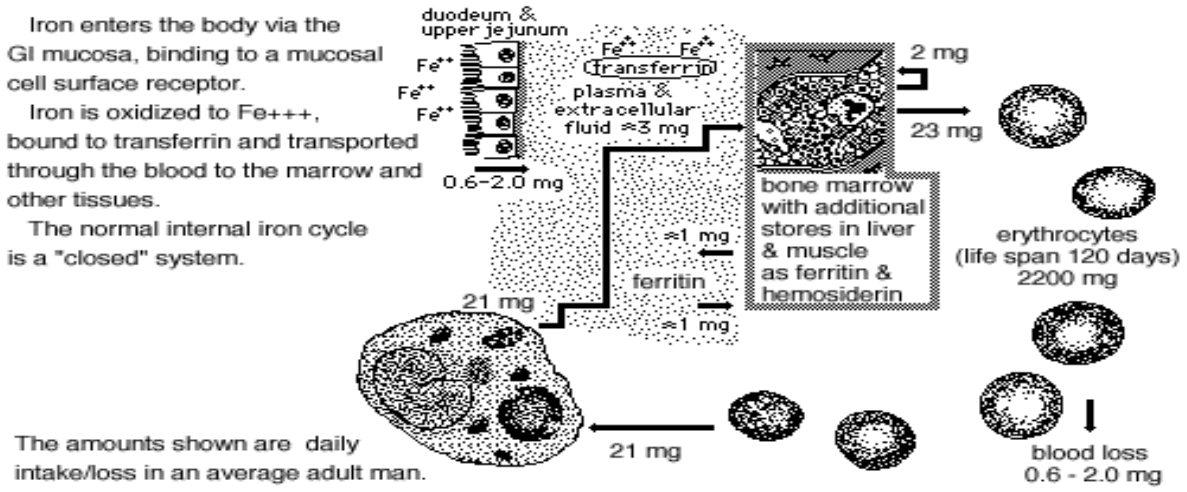


Figure 2.3: Iron regulation and recycling in the body

Source: School of Medicine, University of Virginia, (n.d.).

2.2.4. Iron transportation

Iron is transported from the iron pool through enterocyte membranes by FPN, an important iron carrier that aids the regulation of intestinal iron absorption and release (Frazer, et al., 2005). In the interstitial fluid, iron is in its ferrous form, which may be rapidly converted to ferric form by hepaetin or ceruloplasmin in the blood. Ferric iron must bind with transferrin in order to reach the cells, and each transferrin molecule can bind a maximum of two Fe^{3+} (Thompson et al., 2011; Papanikolaou & Pantopoulos, 2005; Dunn et al., 2003). Transferrin is a glycoprotein, the principal iron transporter in the blood. It is synthesised in the liver and has a life span of 8 to 12 days (Wick, Pinggera & Lehmann, 1994).

2.2.5. Iron storage

There are two forms of stored iron, ferritin and haemosiderin. Stored iron is supplied to the body iron when it is needed (Papanikolaou & Pantopoulos, 2005). Iron storage sites in the body are the liver, bone marrow and spleen (Fleming & Britton, 2006). Iron is normally stored as ferritin, whereas haemosiderin storage usually occurs during iron overload. If there is an iron overload and the excess iron still remains as haemosiderin in the heart and liver, serious complications can occur and there is a significant risk of organ damage (Papanikolaou & Pantopoulos, 2005). Normally, women store between 300 - 1000 mg of iron, which is less

than the 500 - 1500 mg usually stored by men (Thompson et al., 2011; Bothwell, 1995). Amounts of stored iron outside of these ranges can be treated as an abnormality.

2.2.6. Iron losses

The major route of iron loss is via the turnover of gut enterocytes, which involves gut cells being discarded into the intestinal lumen every three to six days (Figure 2.3). Ferritin stores in the enterocytes are also cycled back to the lumen (Figure 2.2 & 2.3). Iron regulation is controlled in such a way that it drastically decreases the likelihood of excess iron infiltrating the system, regardless of its source (Thompson et al., 2011). The body also loses iron through urine, faeces, sweat, menses and pathological loss (Miret et al., 2003; Bothwell, 1995).

2.2.7. Functions of iron

Iron has been referred to as a precious metal due to its numerous biological roles (Bernuzzi & Recalcati, 2006). Iron is a co-factor in many enzyme systems, energy generation proteins and deoxyribonucleic acid (DNA) synthesis, as well as being an important component of Hb and myoglobin which transport and metabolise oxygen (Ma et al., 2011; Bernuzzi & Recalcati, 2006; Minihane & Rimbach, 2002; Lombard, Chua & O'Toole, 1997). Iron is crucial for the daily production of approximately 200 billion erythrocytes, which occurs in bone marrow (Thompson et al., 2011).

2.2.8. Oxygen transport

Oxygen is necessary for the survival of all living creatures (Dunn, et al., 2006). This highlights the critical role of Hb, which transports oxygen throughout the body and requires iron to do so (Minihane & Rimbach, 2002). The efficient transport of oxygen also requires an optimal pH environment; Hb and oxygen are thought to bind more easily in an acidic environment (Means, 2012; Jensen, 2004; Nikinmaa, 1997). When pH rises, such as in the presence of CO_2, oxygen binds less frequently to Hb and more is released into the cells for utilization (Means, 2012; King, 1996).

2.2.9. Energy production

Iron plays a role in energy metabolism as part of its many vital roles in the body. Iron is a component of cytochromes, which are electron-carrying respiratory chain proteins that are

responsible for energy production and associated with the metabolism of macronutrients (Minihane & Rimbach; 2002; Frazer & Anderson, 2005). Inadequate iron levels may affect cytochrome function resulting in decreased energy production, especially during periods of increased energy requirements. Table 2.2 shows the iron compounds involved in oxidative metabolism and energy production (Mahan & Escott-Stump, 2004; Haas & Brownlie, 2001).

Table 2.2: Iron compounds in oxidative metabolism and energy production

Name of protein	Functional site	Major biological functions in energy production
Haemoglobin	Red blood cell	Oxygen transport
Myoglobin	Cytoplasm of muscle cells	Facilitate diffusion of oxygen towards the mitochondria
Oxidative enzymes such as; Dehydrogenase	Mitochondria inner membrane and matrix	Oxidation of substrate (acetyl-CoA) to produce NADH and $FADH_2$
Respiratory chain proteins such as cytochromes	Mitochondria inner membrane	Electron (electrochemical energy) transfer from O_2 molecule to NADH or $FADH_2$

Note: NADH-Nicotinamide adenine dinucleotide plus Hydrogen
$FADH_2$-Flavin adenine dinucleotide (hydroquinone form)

Sources: Haas & Brownlie (2001).

2.2.10. Iron in enzymes

Iron plays an important role in some of the key enzymes in the tricarboxylic acid (TCA) cycle, as well as enzymes involved in amino acid and lipid metabolism (Tong & Rouault, 2006). Iron is also part of the antioxidant enzyme system that combats free radicals. However, excess amounts of iron in the body can be pro-oxidative (Rouault, 2006; Mahan & Escott-Stump, 2004; Minihane & Rimbach, 2002).

Iron is a co-factor for ribonucleotide reductase, an important enzyme for DNA synthesis. Although DNA enzymes comprise very little of the total body iron (Pinero & Connor, 2000), ID has been found to inhibit both DNA synthesis and cell division, leading to severe consequences (Kawabata et al., 2000; Mahan & Escott-Stump, 2004).

A review of experimental studies showed that ribonucleotide reductase from calf thymus has an activity span of only 10 minutes when iron is removed (Thelander, Eriksson & Akerman, 1980) and there was a marked decline in the levels of DNA in the thymus and spleen of iron deficient rats compared to well-nourished rats (Kochanowski & Sherman, 1985). The importance of iron for DNA synthesis has been further confirmed by studies in humans which show that deferoxamine, a chelator of iron, inhibits DNA production in T- and B-lymphocytes. When deferoxamine was removed, iron levels were restored and DNA production resumed (Lederman et al., 1984).

2.2.11. Cognitive development

The brain has a huge demand for iron because of its high energy requirements. Iron is a critical factor for normal cognitive development and neurological functioning, due to its roles as a co-factor for tyrosine hydroxylase (norepinephrine), tryptophan hydroxylase (serotonin) and dopamine (DA), which are necessary for neurotransmitter synthesis (Beard, 2003; Pinero & Connor, 2000). A decline in brain iron levels as a result of poor dietary intake is correlated with a reduced concentration of D_2 and D_1 receptors which in turn distorts DA neurotransmission in striatum leading to poor cognitive function (Beard, 2003). Several studies have shown that ID reduces neuronal metabolism in all brain regions, and hampers the myelination process and affects the development of neurotransmitters thus impairing the brain functions (de Ungria et al., 2000; Lozoff, 2011). Table 2.3 shows the adverse effects of ID on the functions of some important neurochemicals in the brain and the damage that could occur during the brain development. It also indicates that some of the setbacks caused by ID during brain development were permanent while other damages could be corrected with early and appropriate treatment (Yager & Hartfield, 2002).

Table 2.3: Effects of ID on neurochemical functions

Neurochemical	Metabolic Effect	Clinical Effect	Reversibility
GABA	+/- GABA decreases GAD, GABA-T	Impaired neurotransmitter regulation of hypothalamic-hypophyseal hormones involved in behavioural regulation	Irreversible in gestational ID
Dopamine	Decreased D_2 receptor binding sites	Decreased motor activity and learning processes	Irreversible
Phenylalanine	Increased phenylalanine secondary to decreased phenylalanine hydroxylase activity	Decreased learning secondary to "PKU-like" effect	Reversible
Serotonin	Decreased 5-HT via decreased tryptophan or tyrosine hydroxylase activity or decreased 5-HT via decreased degradation by aldehyde oxidase	Impairs neurodevelopment or increases drowsiness, decreases attention and learning due to serotonergic effect	Irreversible or reversible
Abbrev; GABA- γ aminobutyric acid 5- HT - 5-Hydroxytryptophan GAD- Glutamate decarboxylase PKU – Phenylketonuria.			

Source: Adapted from Yager & Hartfield, (2002).

This information supports the importance of adequate iron levels in women of reproductive age, even before pregnancy. In a blinded, placebo-controlled intervention study involving cognitive assessment and iron supplementation in women of reproductive age, women without ID/IDA performed better in cognitive assessments and were able to complete tasks faster than the IDA group. After 16 weeks of supplementation, a five to seven-fold improvement in their cognitive tasks performance was seen in women with increased SF, and women whose Hb levels had improved completed cognitive tasks more quickly (Murray-Kolb & Beard, 2007). Similarly, Conlon et al. (2009) reported a positive correlation between ID without anaemia and

reduced working memory and processing speed in female students (n=52) who did not speak English as their first language compared to those with normal iron status (n=42). This shows that the impact of ID/IDA on cognition is not limited to the developing brain alone (Murray-Kolb & Beard, 2007), and adequate iron levels are necessary for healthy cognitive function into adulthood.

2.2.12. Iron and Immunity

Iron can influence the course of infection in two ways. Firstly, iron is a critical component of many immunological proteins, such as the enzymes responsible for peroxide and nitrous oxide generation that support proper functioning of the immune cells (Beard, 2001). Therefore, immune function can be compromised in a state of ID. A reduction in both T-lymphocyte numbers and T-lymphocyte blastogenesis and mitogenesis in various mitogens has also been observed in ID, and both were corrected with repletion of iron (British Nutrition Foundation, 1995). This demonstrates that iron is an important part of the immune response to infection.

2.3. Daily iron requirements for non-pregnant, non-lactating women of reproductive age

According to the Australia and NZ Nutrient Reference Values (MoHNZ, 2006), women of reproductive age need about 18 mg of iron per day to meet physiological needs and replenish iron losses. Women's iron requirements are higher than the recommendation according to their physiological needs for instance during pregnancy and lactation (Picciano, 2003; Bothwell, 2000; Hallberg & Rossander-Hulten, 1991).

2.3.1. Dietary sources of iron

Dietary iron is found in both animal and plant sources. Haem iron from animal foods is of high biological value compared to non-haem iron from plant and animal sources. The best sources of iron are animal organs (liver, kidney and heart) and meat and seafood (lean meat, poultry, fish and oysters as well as egg yolk). Other sources are plant foods such as dried beans and vegetables, dried fruits, dark molasses, whole grain, enriched breads, and cereals (Mahan & Escott-Stump, 2004). The major sources of iron in NZ are bread, breakfast cereals, vegetables, grains and pasta, potato, kumara and taro, bread based dishes and non-alcoholic drinks (MoHNZ, 2011). Dietary sources of iron in the Solomon Islands are not well documented. However, cooked cassava leaves, wing bean leaves, kangkong (Ipomoea

aquatic) or swamp cabbage and fern are reported to be high in iron (French, 2010). However, cassava and wing bean leaves are not commonly consumed by Solomon Islanders although these are available in the Solomon Islands (anecdotal source).

Table 2.4 presents iron food sources that are commonly consumed in NZ and the Pacific Islands according to the food composition tables from NZ and from the Pacific Islands (MoHNZ, 2006; Food Agriculture Organization, 2004). The food items were placed under their iron content categories as moderate-high and very high adapted from Beck et al. (2011).

Table 2.4: Dietary sources with moderately high to high iron content

Foods	Moderate - high (2 - 4 mg)	Very high (mg) (> 6 mg)	Sources
Meat/fish/shell fish/poultry			
Beef cooked – 1 cup		7.0	NZ
Beef organ stew – 1 cup		11.9	NZ
Chicken cooked – 1 cup	2.2		NZ
Lamb cooked – 1 cup	4.4		PI
Lamb organ (liver) – 100g		11.1	NZ
Pork cooked -1 cup		11	NZ
Mackerel fried – 134g		6.3	PI
Salmon pink canned – 1 can	3.8		PI
Shell fish cooked – 1 cup	2.0		NZ
Mussel green steamed- 1 cup		17	PI
Clam – 1 serve		25	PI
Cockles – 1 cup		22.4	PI
Seaweed dried – 100g		21.7	PI
Turtle cooked – 100g	4.9		PI
Starch staples/Vegetables/Fruits			
Cassava baked – 1 cup	4.5		NZ
Sweet potato baked (earth oven) 213g (1serve)	4.5		PI
Taro boiled – 260g (1 serve)	2		PI
Yam boiled – 209g (1 serve)	3.1		PI
Amaranth boiled – 100g	2.2		PI
Choke leaves boiled -100g		7.2	PI
Drumstick leaves boiled – 100g	2.0		PI
Nightshade leaves- 100g		18.6	PI
Silver beet – 1 cup (168g)	2.1		PI
Asparagus cooked – 1 cup	3.6		NZ
Cabbage Chinese cooked- 1 cup	2.8		NZ
Cabbage white inner and outer layer- 1 cup	3.6		NZ
Cabbage red – 1 cup	5.7		NZ
Parsley leaves raw- 1 cup	5.1		NZ
Taro leave cooked – 1 cup	3		NZ
Spinach, tropical leaves boiled- 88g (1 serve)	2.0		PI
Foods	Moderate - high (2 - 4 mg)	Very high (mg) (> 6 mg)	Sources
Watercress raw – 100g	3.0		PI

Peas green boiled – 1 cup		8.4	PI
Vegetable mixed European boiled – 1 cup	3.0		PI
Apricot dried – 1 cup	4.2		PI
Current dried – 1 cup	3.5		PI
Date dried- 10 dates	2.2		PI
Fig ficus carioca dried- 1 cup	2.9		PI
Lychee dried – 100g	4.4		PI
Pandanus paste – 100g		5.7	PI
Raisin – 1 cup		6.5	PI
Prune – 100g	4.2		PI
Rambutan – 100g	2.5		PI
Tamarin flesh – 100g		11.0	PI
Nuts and seeds – 100g	1.4 - 10		PI
Legumes – 100g	1.3 – 9.0		PI
Bakery foods			
Biscuit ANZAC home made – 100g	2.2		NZ
Biscuit chocolate base, wheat – 100g	2.4		NZ
Bread 9 grain, tip top fortified – 100g		6.1	NZ
Cracker, well grain, vita life Griffins – 100g		8.3	NZ
Cracker whole meal sesame – 100g	2.4		NZ
Lamington chocolate (1 slice)	2.1		NZ
Breakfast cereals			
All breakfast cereal	3.0 – 10		NZ
Drinks			
Complan powder – 100g		6.6	NZ
Milo powder – 100g	4.5		NZ
Chocolate drinking powder – 100g	2.4		NZ
Cocoa powder – 100g		10.5	NZ
Coffee instant powder – 100g	4.4		NZ
So good, soy drink – 100g	2.3		NZ
Other foods			
Tofu – 1 cup		14.1	NZ
Tempeh (fermented soy bean)		7.8	NZ
Fast food			
Beef with cashews – 1 cup		8.1	NZ
Beef satay – 1 cup		7.6	NZ
MacDonald - 1 burger	3.9		NZ
Burger bacon -1	4.6		NZ
Burger cheese- 1	4.3		NZ
Chicken with garlic &chilli sauce – 1 cup	2.5		NZ
Chopsuey pork – 1cup	3.3		NZ
Curry, Indian beef takeaway – 1 cup		6.2	NZ
Curry, Indian butter chicken – 1 cup	4.6		NZ
Curry, Indian chicken masala – 1 cup	5.4		NZ
Curry, Indian dhal – 1 cup		14.5	NZ
Curry lamb – 1 cup		11.2	NZ
Omelette egg, Foo young –I serve		9.0	NZ
Mince pie - 1		9.5	NZ

Sources: MoHNZ, (2006) & Food Agriculture Organization, (2004)

Note: Some other foods that contain iron have not been included in Table 2.4 due to their low iron content or limited availability and consumption.

2.4. Iron deficiency

Iron deficiency is often described as a condition that progresses from one stage to the next without early detection and treatment. ID is the stage in which iron stores are depleted but with a normal concentration of haemoglobin. Iron deficiency anaemia is the advance stage of ID where the haemoglobin concentrations fall below 120 g/L in women and can seriously affect health (Hercberg, Preziosi & Galan, 2001). Figure 2.4 illustrates the developmental stages of ID to IDA.

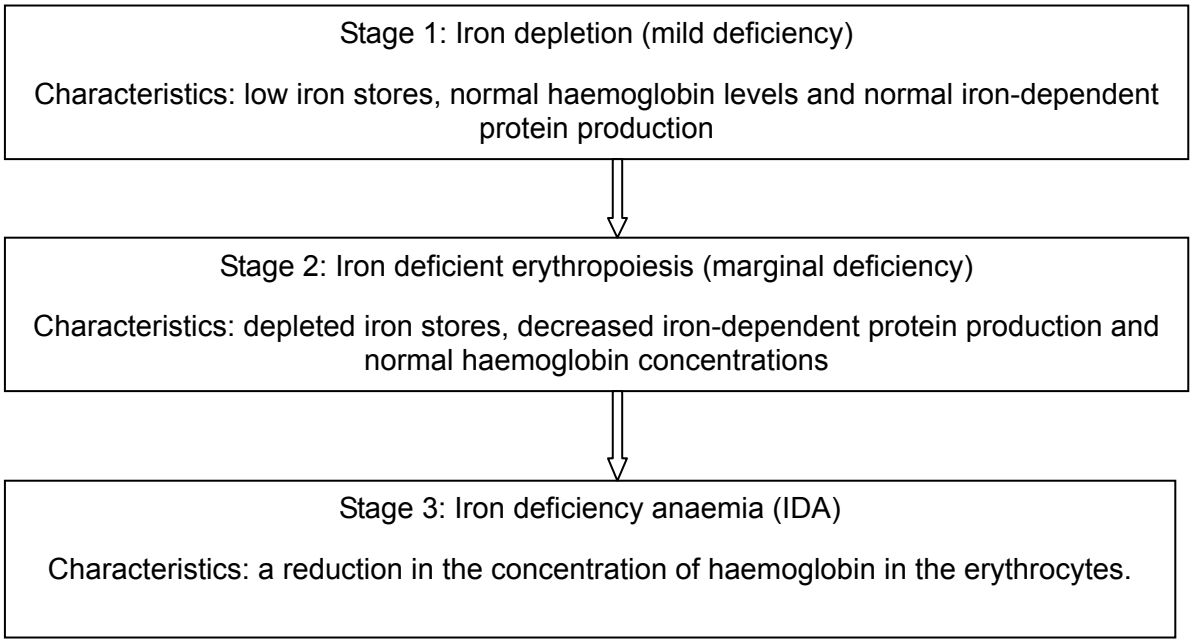


Figure 2. 4: Developmental stages of iron deficiency

2.4.1. Assessment of iron deficiency and iron deficiency anaemia

Assessment of iron status requires the measurement of a combination of biomarkers for increase sensitivity, better diagnosis and treatment as ID/IDA may occur due to different causes and may require different management approaches (Pollitt, 1993; Clark, 2009). According to the WHO (2011a), serum ferritin (SF) concentration is the preeminent marker of iron status. This is supported by a meta-analysis of nine randomised iron intervention trials, which found that SF showed a larger and more consistent response to iron intervention than the other biomarkers that were assessed (Mei et al., 2005). Haemoglobin and SF were measured in all nine studies, alongside a range of other iron indicators such as mean cell volume (MCV), erythrocyte protoporphyrin and transferrin receptors. The results of the meta-

analysis suggested that Hb and SF are the most useful combination of indicators for monitoring change in the iron status of a population (Mei et al., 2005).

Serum ferritin

Ferritin is a protein which stores iron for use when the body requires it (Remacha, et al., 1998). The measurement of ferritin in the serum has been identified as the best diagnostic test for ID because it is a measurement of iron stores in the body. Iron deficiency is indicated by a SF concentration < 20 μg/L (Beck et al., 2011). However, as an acute phase reactant, SF can also be influenced by the presence of infection or inflammation such as in rheumatoid arthritis, liver disease or malignancies (e.g. myeloma, lymphoma) (Krol & Cunha, 2003). In a state of inflammation, a person's SF may appear normal or increased even if they are deficient in iron; this has been noted in haemodialysis patients (Kalantar-Zadeh et al. 2004) and in those with systemic lupus erythematosus (Lim et al., 2001). Oral contraceptive and iron supplement use can also increase SF; therefore caution must be taken if measuring SF in isolation as this could lead to an underestimation of the presence or prevalence of ID (Arneson & Brickell, 2007; Remacha et al., 1998).

C-reactive protein

The WHO (2011a) recommends that measurement of SF should be accompanied by the analysis of one or more acute phase proteins (APPs), namely C-reactive protein (CRP) and α_1 - acid glycoprotein (AGP) to verify SF in the diagnosis of ID. This is based on the information from a review of 32 studies involving healthy participants from different population groups to estimate the increase in SF associated with inflammation (Thurnham et al., 2010). An increased amount of AGP and CRP are released into the blood when infection, inflammation or tissue damage is present in the body (Hochepied et al., 2003; Reeves, 2007), and thus these measurements can indicate whether the SF concentration may be falsely elevated. A value outside of the normal ranges (CRP > 5 mg/L and/or AGP > 1g/L) warrants extensive investigation (Arneson & Brickell, 2007) as this is a sign of infection.

Haemoglobin

Haemoglobin is a protein comprising globin and haem, and its primary function is to transport oxygen from the lungs to tissues throughout the body. A reduction in red blood cell Hb

concentration results in IDA (Remacha et al., 1998), which is indicated by Hb < 120 g/L (WHO, 2001). However, Hb is not always a reliable biomarker, as it lacks specificity for categorising iron status (Mei et al., 2005). Haemoglobin concentrations can be affected by other factors; therefore, it is best to assess Hb together with another iron biomarker such as SF (Mei et al., 2005). Despite its limitations, Hb is still the most commonly used biomarker for assessing iron status in circumstances where resources are limited, such as in developing countries like the Solomon Islands (Yip & Ramakrishnan, 2002; SPC, 2009b).

2.5. Consequences of iron deficiency and iron deficiency anaemia in women

There are a number of adverse consequences of ID and IDA in women of reproductive age, including increased risk of maternal mortality (WHO/UNICEF, 2004). A WHO analysis on global causes of maternal death found that IDA is responsible for 12.8% of maternal deaths in Asia and 3.7% in Africa (Khan et al., 2006).

Women with ID/IDA also have a higher risk of infection, poor pregnancy outcomes (such as low birth weight (LBW; < 2500 g) neonates, poor foetal neuro-cognitive development, preterm delivery, haemorrhage and death), impaired cognitive function, impaired thermoregulation, immune dysfunction, and reduced work capacity and symptoms such as irritability, fatigue, depression, less concentration and apathy (de Benoist et al., 2008; Conlon et al., 2009; Zimmermann & Hurrell, 2007; Lozoff et al., 2006; Beard et al., 2005; WHO/UNICEF, 2004; World Bank, 2004; Rasmussen, 2001; Steer, 2000).

Some of the effects caused by ID may have negative effects on maternal quality of life, and may cause permanent damage and disability to their offspring (Lozoff et al., 2006). As IDA can have major adverse implications for maternal health, and can have effects on foetal health that persist into adulthood, adequate iron status of women of reproductive age is vital (Mora & Nestel, 2000).

More than 50% of LBW cases in developing countries are related to maternal nutritional status before and during pregnancy (Ramakrishnan, 2004). Approximately half of LBW infants in developed countries are born preterm (< 37 weeks gestation) and others are affected by intrauterine growth restriction (Ramakrishnan, 2004). A study of Pakistani women found those

with IDA had a 4-fold increase in the risk of preterm delivery, and a 1.9-fold increase in the risk of LBW (Lone, Qureshi & Emanuel, 2004). The neonates of women with IDA had a 1.8-fold increased risk of an APGAR score < 5 at one minute, and a 3.7-fold increased risk of being stillborn (Lone et al., 2004).

A longitudinal study in Chile found that the strongest indicator of poor iron status for infants at birth and during infancy was maternal iron status prior to pregnancy (Lozoff et al., 2006). In addition, infants of mothers with moderate to severe IDA were reported to have significantly lower cord SF levels at birth (Singla et al., 1996), which can be detrimental to their early growth and development. There is strong evidence that ID delays psychomotor development and impairs cognitive performance in infants (WHO, 2001). Further, analysis of cognitive test scores from a Costa Rican longitudinal study found that those who had chronic ID during infancy still had reduced cognitive ability by 19 years of age compared to those who had maintained normal iron status during infancy, at 19 years, these young adults still experience difficulties in inhibitory control, set-shifting, planning and recognition memory tests (Lukowski, 2010; Lozoff et al., 2006). The significance of ID for maternal and infant health stresses the importance of preventing IDA in women. Ensuring adequate iron levels is especially important prior to pregnancy, as iron supplements during pregnancy may have only limited benefit for the mother and neonate (Scholl, 2005; Meier et al., 2003; Gibson et al., 2002).

Adequate intake of all nutrients, including iron, is crucial for the health, fertility, and healthy pregnancy of women of reproductive age (Black et al., 2008). Poor nutrition during pregnancy contributes to 4 million stillbirths and 4 million neonatal deaths each year and 98% of these deaths occur in developing countries (Tinker & Ransom, 2002). Studies have shown that a large number of these deaths could be prevented with adequate nourishment and good quality of care during pregnancy, delivery and the postpartum period (Tinker & Ransom, 2002; Steer, 2000).

The consequences of IDA also create an additional cost burden on health and the economy (Clark, 2008; Zimmerman & Hurrell, 2007). An analysis of the value of physical productivity losses per year in ten developing countries showed the median value of losses due to ID to be about US$0.32 cent per person, or 0.57% of GDP (Zimmermann & Hurrell, 2007). The effects

of IDA for Pacific Islands' women, including the Solomon Islands, have not been well documented even though IDA is a huge problem affecting women of reproductive age. The current data on IDA from most of the Pacific Islands including the Solomon Islands were from national survey reports and they were on the assessment of haemoglobin alone.

2.6. Causes of iron deficiency and iron deficiency anaemia

Multiple factors can lead to ID and IDA in women of reproductive age. The causes are attributed to: (1) increased iron requirements according to physiological needs, such as menstruation, pregnancy and lactation; (2) inadequate iron intake from the diet; (3) increased iron loss through menstruation, regular blood donation and/or chronic blood loss as the result of other diseases; and (4) decreased iron uptake due to consumption of iron-inhibiting substances such as phytate, polyphenols, tannin and calcium, or due to the presence of other micronutrient deficiencies such as vitamin A, Vitamin B_{12}, folate, riboflavin or copper (Hurrell & Egli, 2010; Backstrand et al., 2002; Menon et al., 2010; Pe'neau et al., 2008; Clark, 2008; de Benoist et al., 2008; Baynes & Bothwell, 1990).

2.6.1. Dietary factors influencing iron status

The body's ability to digest and absorb dietary iron can be manipulated by numerous factors. The major factors are: individual iron status, dietary iron consumption, type of dietary iron, amount of digestive acid present and the presence of other dietary factors that can enhance or inhibit iron absorption (Hurrell & Egli, 2010; Morgan & Oates, 2002; Hurrell et al., 1999). Poor iron status leads to increased iron absorption rates compared to those with adequate iron levels, with up to 40% of dietary iron able to be absorbed (Gropper et al., 2009). In contrast, absorption of non-haem iron is influenced by stomach acids, with pepsin and hydrochloric acid reducing ferric iron to its ferrous form during digestion (See section 2.2.2).

2.6.2. Enhancers of iron absorption

Vitamin C (ascorbic acid)

Ligands are dietary enhancers of iron absorption, ascorbic acid, citric, lactic and tartaric acids are examples of reduction agents that aids with non-haem iron (Fe^{3+}) at an acidic pH, increasing its absorption (British Nutrition, Foundation, 1995; Gropper et al., 2009).

Fruit and vegetables are good sources of vitamin C which is vital for enhancing iron absorption by reducing ferric to ferrous iron for mucosal cell uptake and prevents the formation of insoluble complexes that cannot be absorbed at the intestinal pH (Hallberg et al., 1989). Heath et al. (2001b) found that having both vitamin C food and haem iron while reducing phytate food sources improves iron status. In addition, adding ascorbic acid with non-haem iron meal have shown to increase iron absorption by 25% in iron depleted premenopausal women (Hunt et al., 1990).

Similarly, Beck et al. (2011) revealed that consuming kiwifruit (high in vitamin C) with breakfast cereal improves iron absorption in women with low iron stores. Backstrand et al. (2010) study in Mexican women also confirmed that adding ascorbic acid to non-haem iron improved iron status in women. The amount of non-haem iron that is available for absorption can be estimated from the quantity of vitamin C, meat, poultry, and fish that has been eaten alongside the non-haem iron source as these were found to be dose dependent (Hurrell & Egli, 2010; Gropper et al., 2009). In support of vitamin C iron absorption effect, Peneau et al. (2008) study identified positive correlations between serum ferritin (SF) and fruit and vegetable juice intake, haemoglobin (Hb) and fruit, vegetable juice and ascorbic acid intake with a low fibre diet (Peneau et al., 2008).

Similar results were shown by Heath et al. (2001b), in a 16 week randomised placebo controlled intervention in women (n=75) using supplements and diets. It was identified that vitamin C, animal food sources, haem iron and foods cooked in cast iron cookware significantly increased serum ferritin levels by 95% and 26% in the supplementary group and diet groups respectively (Heath et al., 2001b). Vitamin C was suggested to have the latent over powering effect on iron absorption inhibitors such as phytate, polyphenols, calcium and milk proteins, but, cooking, processing and storage may diminish the enhancing effects of ascorbic acid by reducing the ascorbic acid content of food (Hurrell & Egli, 2010).

Meat (muscle tissues)

Studies in the past have shown having meat, poultry and fish (Meat factor) with non-haem iron food sources increased iron absorption. This was suggested to be the result of animal tissues high in the contractile proteins actin and myosin and the action of the amino acids cysteine

and histidine from animal flesh by invigorating intestinal secretions (Reddy, Hurrell & Cook, 2000; Sharp & Srai, 2007; Salovaara, Sandberg & Andlid, 2002). However, the actual mechanism by which the meat, poultry and fish (Meat factor) enhances the absorption of non-haem iron is still unclear (Sharp & Srai, 2007).

Low intake of meat/fish/poultry was found to be an associated risk factor to mild ID in women of reproductive age (Heath et al., 2001a). Studies in India and Nepal reported that diets with less ascorbic and animal meat led to a reduction in iron absorption (Menon et al., 2010; Nair & Lyenge, 2009). A study by Young et al. (2010) in premenopausal non pregnant women reported that iron absorption was greater from a diet of animal products compared to ferrous sulphate. This was confirmed by Hunt (2003), using a 12 weeks experimental study on high and low iron bioavailability diets which identified that premenopausal women absorbed more iron from diets with high bioavailable iron contents compared to diet with low bioavailable iron (Hunt, 2003).

Furthermore, according to Haidar & Pobocik (2009), ID and IDA was significantly high ($p< 0.05$) among Ethiopian women age 31 to 49 years, with the main contributing factors probably inadequate intake of iron-rich food sources.

2.6.3. Inhibitors of iron absorption

Phytate and polyphenols

Phytate (myo-inositol hexakisphosphate) in plant based diets were known to be the main inhibitor of iron uptake (Hurrell & Egli, 2010 and), are found in legumes, oilseeds, rice and whole grains cereals (Hurrell & Egli, 2010; Minihane & Rimbach, 2002). Phytates and oxalates may use oxygen to bind with many minerals, and therefore interfere with iron absorption (Thompson et al., 2011). Several studies in the past showed the adverse effect of phytate on iron uptake. A study on maize found that maize bran containing phytate phosphorus was inversely associated with iron absorption compared to ordinary maize (Siegenberg et al., 1991). The inhibition effect of phytate on iron absorption was claimed to be dose dependent beginning from low levels as 2 – 20 mg/meal (Hurrell & Egli, 2010). However, Eklund-Jonsson et al. (2008) reported that iron absorption was increased by 94% from a barley meal when the phytate content of meal was reduced by tempe fermentation. The

inhibition effects of phytate on iron uptake can also be reduced by other preparation processes such as milling, soaking and heat treatment (Hurrell & Egli, 2010).

Polyphenolic compounds such as phenolic acids and flavonoids were found in foods such as fruit, vegetables, chilli, turmeric, tea, coffee and red wine (Tuntipopipat et al., 2006; Samman et al., 2001; Brune et al., 1989). These polyphenolic compounds act as antioxidants and metal chelators in the human body (Samman et al., 2001) and bind to ferric iron to form a complex that cannot be digested (Minihane & Rimbach, 2002).

A review of the factors affecting iron status in women of reproductive age in developing countries identified inadequate intake of dietary iron and low bioavailability iron as two of the major contributors to IDA (Massawa et al., 2002). In Karachi, where the prevalence of IDA among women of reproductive age is alarmingly high at 44.5% (n=89), out of the 89 women who had IDA 84% (n= 75) drank four cups of tea per day (Ansari et al., 2009). High consumption of tea and low intake of iron rich food sources are thought to be the leading causes of the high IDA rates in Karachi (Ansari et al., 2009).

Studies in India and Nepal also revealed IDA caused by low iron absorption as a major problem among women of reproductive age. Indian and Nepalese diets have a high content of phytate and polyphenols, low intakes of ascorbic acid and animal meat. It was reported that one or two cups of black tea reduced iron absorption by 49% and 67% respectively (Menon et al., 2010; Nair & Lyenge, 2009; Bharati et al., 2008). Other studies also confirmed the effects of polyphenol beverages such as tea and coffee as inhibitors of iron uptake (Thankachan et al., 2008; Nelson & Poulter, 2004; Samman et al., 2001). Kruger et al. (2009) also confirmed that low iron status was associated with coffee intake at meal times. A study in Mexican women further reiterates that phytate and polyphenol reduced iron uptake Backstrand et al. (2010).

Cook et al. (1995) revealed that when the alcohol content of red wine was removed, there was a 28% reduction in non-haem iron absorption as the effect of high phenolic content of red wine compared to white wine Cook et al. (1995). Also, the phenolic effect from chilli was reported

by Tuntipopipat et al. (2006) experimental study to reduced iron uptake by 38% from the meal. These findings clearly emphasised the inhibitory effect of polyphenol compounds in the diet.

Calcium

Dairy products are rich sources of calcium in the diet and calcium was suggested to adversely affect both haem and non-haem iron absorption (Hurrell & Egli, 2010). Studies in the past found contradicted results on the effect of calcium on iron uptake. Rangan, et al. (1997) reported calcium as an inhibitor to iron uptake which was also highlighted by Kruger et al. (2009) that, low iron status was associated with milk consumption at meal times. Backstrand et al. (2010) also supported the inhibitory effect of calcium on iron uptake. On the other hand, Heath et al. (2001a) study, reported that calcium or dairy product intake showed no negative implication on mild iron deficiency. This was also supported by Roughead et al. (2002) that, adding calcium as cheese (127 mg) to a meal high in both forms of iron did not affect the absorption. Also, calcium intake with meals composed of a variety of foods had no effect on iron absorption (Hurrell & Egli, 2010; Grinder-Pedersen et al., 2004). The effect of calcium on iron absorption is still in controversy thus needs further investigation to qualify the inhibitory effect of calcium on iron uptake.

2.6.4. Blood Loss

There are several causes of blood loss, including menstruation, losses through urine, faeces or sweat, and through gastrointestinal bleeding from underlying infections (Hurrell & Egli, 2010; Frewin et al., 1997; McIntyre & Long, 1993). Parasites such as hookworms, which are common in developing countries due to poor hygiene and sanitation, can also cause intestinal blood loss (Urbani & Palmer, 2001; Stolzfus et al., 1997). Past studies have shown that blood loss through menstrual periods was one of the major determinants of ID/IDA in women (Zimmermann & Hurrell, 2007; Harvey et al., 2005; Heath et al., 2001a).

For every millilitre of blood lost through menstruation, 0.5 mg of iron is also lost (Zimmermann & Hurrell, 2007). During heavy menstrual bleeding the estimated loss per month is > 80 ml, and these losses notably escalate the risk of ID (Zimmermann & Hurrell, 2007). High parity and use of intrauterine devices are other risk factors for women of reproductive age (Zimmermann & Hurrell, 2007). According to epidemiological studies in European countries,

10 – 30% of iron depletion and 1.5% to 14% of IDA occur among menstruating women (Herchberg et al. 2001).

Research in Australia and NZ has also identified menstrual loss as one of the factors contributing to ID in teenage girls (Gibson et al., 2002). A study on blood loss and diet in relation to ID in 384 pre-menopausal women by Heath et al. (2001a) found that 23% had mild iron deficiency (MID) with Hb > 120 g/L and SF < 20 µg/L. Four percent had iron deficiency erythropoiesis (IDE) with SF of < 20 µg/L and zinc protoporphyrin ≥ 40 mmol zinc protoporhyrin/mol haem, 2% had IDA (Hb < 120 g/L and SF < 12 µg/L) and 4% had anaemia without ID. Heath et al. (2001a), also identified dietary intake and blood loss as important determinants of ID. Women who were classified as having MID had a significantly (p<0.01) lower intake of meat, fish and poultry compared to those who had sufficient intake. The risk factors associated with increased risk of MID were recent blood donation, high menstrual blood loss, nose bleeds and low BMI (Heath et al., 2001a). Pathological blood loss (haemorrhoids, gynaecological bleeding) were also highlighted as well as blood donation (Milman et al., 1993; Hercberg, et al., 2001).

Adequate iron intake is necessary to replenish iron lost through menstruation and other causes. An experimental study in pre-menopausal women aged 18 to 45 years identified a significant correlation (p=0.004) between iron losses via menstruation and iron status (Harvey et al., 2005), showing that menstrual blood loss leads to poor iron status in women. The women were divided into three different dietary groups: red meat, lacto-ovo vegetarian and poultry/fish. Low SF (10 µg/L) was found in 60% of women in the red meat, 40% in the lacto-ovo vegetarian and 20% in the poultry/fish groups. However, it was suggested that menstrual blood loss (p=0.001) and dietary groups (p=0.040) were the main predictors of iron status (Harvey et al., 2005).

The studies mentioned above used different methods to assess menstrual blood loss. For instance, the recent studies on blood loss in NZ have used the recall method, which is a validated tool for use in NZ (Heath et al., 2001a). European studies on menstrual blood loss used a method by Hallerg & Nilsson (1964) and further modified it by Newton, et al. (1997) cited in Harvey et al. (2005) in which sanitary products were collected and returned to the researchers for analysis using a method called the “Alkaline haemotion” (Harvey et al., 2005),

therefore, the results are not comparable. According to Haidar & Pobocik, (2009) study in Ethiopian women, ID and IDA was also related to chronic illness and in a few cases parasitic infestation.

2.6.5. Other factors influencing iron status of Pacific Islands women

Factors leading to high rates of IDA in Pacific countries are similar to those in other developing countries, and include low socio-economic factors like high food prices, poverty, natural disasters and political instability (Menon et al., 2010; Nair & Lyenge, 2009; SPC, 2009a; Thankachan et al., 2008; Bharati et al., 2008; UNICEF, 2008; Chandyo et al., 2006; Thaman, 2003). However, poverty in the Pacific Islands context does not generally mean hunger or destitution, but the daily struggles to meet essential expenses such as school fees, basic food items and bills. These hardships are a burden largely experienced among low income earners in urban centres, leaving them little alternative but to purchase highly processed imported food items with limited nutritional value like white rice, flour, oil, and noodles (Unicef, 2008; SI statistic office, 2006; Thaman, 2003). Poor dietary quality is therefore a major contributing factor to IDA in the Pacific Islands as are parasitic infections due to poor sanitation, women's education (illiteracy) and low socio-economic status (SPC, 2009a; Stoltzfus et al., 1997). Women's level of education and socio-economic factors were also identified as determinants of anaemia in Indian and Bangladeshi women (Bharati et al., 2008; Bhargave, Bouis & Scrimshaw, 2001). Another contributing factor to iron status of women highlighted in some studies is contraceptive use (Hercberg et al., 2001; Heath, 2001a; Milman, Clausen & Byg, 1998). It was stated that hormonal or oral contraceptive pills reduces menstrual blood loss thus supports iron status compared to IUD (intrauterine device) which was suggested to increase menstrual blood loss (Milman et al., 1998).

2.6.6. Overweight/obesity and ID

An inverse association between iron status and adiposity has been identified, with women who are overweight or obese having a higher risk of ID/IDA (Wenzel et al., 1962). The association was first noted by Wenzel et al., (1962), who found that serum iron was significantly lower in obese adolescents than in their non-obese counterparts. Moderate ID had also been reported among obese women of reproductive age (Lecube et al., 2006; Yanoff et al., 2007 & Micozzi et al., 1989). Furthermore, Eftekhari et al. (2009) also found a high prevalence of anaemia

(34.1%) in overweight iron deficient Iranian girls aged 13-20 years. Likewise, a recent study in Mexican women identified that obese women had 2 to 4 times the risk of developing ID due to the effect of obesity related inflammation affecting iron uptake (Cepeda-Lopez et al., 2011). As obesity is a global epidemic, this association has important implications for the iron status of people worldwide.

2.7 Prevalence of ID and IDA in developed and developing countries

2.7.1 Prevalence of ID and IDA in developed countries

Both ID and IDA are health issues in the developed world. Approximately 12% of non-pregnant women with IDA are from developed countries (WHO, 1992). In the United Kingdom (UK), the prevalence of ID in women aged 16 to 64 years was 18%. These figures are slightly lower in the United States (US), where ID occurs in 9 to 11% of non-pregnant females aged 16 to 49, and IDA is present in 2 to 5% (Zimmermann & Hurrell 2007). The US Preventive Services Task Force Centre for Disease Control and Prevention, and the American College of Obstetrics and Gynaecology consider ID to be an important public health issue, and have estimated that 6 million women of reproductive age in the US are iron deficient (Ford, 2008). Approximately 2 million of these cases are thought to be caused by heavy menstrual bleeding (Ford, 2008). In the US, ID is most common among the poor, less educated and minority populations (Zimmermann & Hurrell, 2007).

Iron deficiency is also one of the major nutritional deficiency disorders among women of reproductive age in Europe, affecting 8 to 33% of young women across the continent (Grondin et al., 2008; Hercberg et al., 2001). Table 2.5 shows the prevalence of ID and IDA from different countries of Europe.

Table 2.5: Prevalence of ID and IDA in European countries

Country	% ID*	% IDA**
Sweden	33	7
Finland	22	-
Denmark	21	3
Norway	22	4
Northern Ireland	18	13
UK	15	9
Holland	16	-
France	23	4

Source: Adapted from Herchberg et al. (2001)
*ID – Iron deficiency
**IDA – Iron deficiency anaemia

Note: In Table 2.5, prevalence rates are a total of the figures from different areas of each country as reported in the review by Herchberg et al. (2001).

The estimated prevalence of IDA among non-pregnant women in Australia is 29% (Hughes, 2006). A population-based survey in Queensland area alone reported 10.6% ID in female's age 25 - 50 years and another 10% with marginal ID. Anaemia in the study population was low at only 3.8%. In this survey, low SF was associated with higher levels of education and a BMI < 25 kg/m^2, whereas those with basic education and BMI of > 25 kg/m^2 were less likely to have low SF levels (Ahmed et al., 2008).

In NZ, the latest Health survey (MoH, 2011) showed an increase in the prevalence of ID among women from 2.9% reported during the 1997 NZ NNS to 7.2% in the recent survey (MoHNZ, 2011). Iron deficiency was identified in 7.2 % and IDA in 3.5% among women of reproductive age. Others studies in NZ also revealed that rates of ID were considerably higher in a sample of premenopausal NZ women (Heath, et al., 2001a) in which 23% had ID and 2% had IDA (Heath et al., 2001a). In addition, 23% of a sample of 148 women in a study by Kruger et al. (2009) had low iron stores, and this was associated with milk and coffee intake at meal times.

2.7.2. Prevalence of ID and IDA in the Pacific Islands and other developing countries

Before European contact, most Pacific Islands were self-sufficient in food production. Pacific people were generally healthy and free of “diseases of affluence” such as cardiovascular diseases, diabetes, hypertension, some form of cancers and conditions like obesity and gout (Coyne, 2000), with their major health concern being infectious diseases. However, like other developing countries, many Pacific Islands also now face diseases caused by unsatisfactory nutrition; they have some of the fastest increasing rates of nutrition-related, non-communicable diseases and micronutrient deficiencies in the world (Thaman, 2003).

Anaemia is prevalent in most Pacific countries, especially among women of reproductive age. Recent surveys revealed high rates of anaemia (Hughes, (2006); de Benoist et al. (2008); SPC, (2009a); MoH (Kiribati) & WHO, (2009); WHO, (2003) & Knowles, (2007). There is no data on the prevalence of mild ID among women of reproductive age in Pacific Island countries, as no studies in the region have specifically investigated ID. This is partly due to a lack of available resources for assessing biomarkers that represent iron stores, such as SF.

Table 2.6 shows some statistics on anaemia collected from different surveys reports for the Pacific Islands.

Table 2.6: Prevalence of anaemia among women of reproductive age from some of the Pacific Islands' countries

Countries	% Anaemia
Western Samoa	56
Fiji	40
Papua New Guinea	40
Federated States of Micronesia	40
Tokelau	36.6
Nauru	32.2
Republic of Marian Islands	26
Tuvalu	25.3
Kiribati	22
Tonga	21.7
Palau	21
Vanuatu	20
Cook Islands	20
American Samoa	20

Sources: Adapted from Hughes, (2006); de Benoist et al. (2008); SPC, (2009a); MoH (Kiribati) & WHO, (2009); WHO, (2003) & Knowles, (2007).

There is also a high prevalence of IDA among women of reproductive age in other developing countries. In countries like Africa, ID/IDA may be attributed to multiple factors for example deficiency of iron, folate, low animal protein intake, genetic abnormalities leading to haemolytic anaemia and infections inclusive of malaria (Fleming, 1982). In Dar-es-salaam, Tanzania, 49% of women of reproductive age were anaemic (Hb < 12 g/dl), and 1.6% were severely anaemic (Hb < 7 g/dl) (Massawa et al., 2002). Eighty-seven percent of anaemic women were also iron deficient according to Massawa et al. (2002). In South Benin, the prevalence of ID and IDA in menstruating women was 33% and 21% respectively, and these were mostly attributable to insufficient iron intake and malaria infection (Hercberg et al., 1988). In Mexico, a study investigating IDA among women of reproductive age found that 16.1% had IDA (Monarrez-Espino et al., 2001).

2.8. Nutritional situation among immigrants in developed countries

Dietary acculturation is an issue encountered by many people who relocate from their countries of origin to other countries. Dietary acculturation according to Satia-Abouta (2003) "is the process by which immigrants adopt the dietary practices predominant in their new environment". It was further define as "multidimensional, dynamic, complex and differs according to personal, cultural and environmental characteristics" (Satia-Abouta, 2003).

Studies on immigrants in developed countries have reported an increase in body weight, BMI and changes in dietary intake compared to those from the host countries (Drummond et al., 2010; Guerin et al., 2007; Burns, 2004; Bell et al., 1999). Dietary assessment of a Samoan church community in Auckland found a new dietary pattern, resulting in increased energy intake compared to a traditional Samoan diet (Bell et al., 1999). Macronutrient intake was also different to a traditional diet, with most energy coming from fat and sugar (takeaways, soft drinks, snacks and dairy products) and a lower amount from protein (Bell et al., 1999).

Vitamin and mineral intake is also low in the NZ Pacific Island community (Bell et al., 1999). A high school-based study in NZ female adolescents reported low dietary intakes of iron and zinc among Pacific Islands students compared to their European peers, and ID was found to be two to three times more common in Asian (15.4%) and Pacific Island (20.9%) students compared to their European counterparts (Schaaf et al., 2000).

Studies in Somali populations of NZ and Australia have found an increase in obesity rates as a result of dietary and lifestyle changes (Burns, 2004; Guerin et al., 2007). In Australia, immigrant and refugee populations also have a high prevalence of obesity and cardiovascular disease. A recent study among a sample of 51 West African female immigrants and 100 Australian women found that 80% of the immigrant women were overweight/obese compared to 49% of Australian women. The high rate of overweight reported in this study was associated with dietary changes, limited knowledge of Western foods, sedentary lifestyles and misconceptions about participating in physical activities (Drummond et al., 2010).

A review of the dietary intake of immigrant populations in Europe found inconsistencies between ethnic groups and variations in nutritional problems. However, increased risk factors

for non-communicable diseases were common, and minority groups had insufficient intakes of nutrients like vitamin D, calcium, iron, and folate (Ngo et al., 2009). Another review of nutrition-related diseases in relation to immigration in the UK showed variations in mortality risk factors among different ethnic groups. However, the second generation offspring of migrants had adopted British dietary patterns; they had increased fat intake and reduced vegetable, fruit and pulse intake compared to the first generation migrants (Landman & Cruickshank, 2001).

Some studies in immigrants have pointed out the difficulties associated with adapting to new foods and maintaining their previous dietary practices. In the UK, Somalian immigrant diets were influenced by cultural factors. The traditional Somalian diet is low in fruit and vegetables, with less than two portions of fruit and vegetables typically consumed per day. It also includes large amounts of rice, pasta and red meat (McEwen et al., 2009). A review of dietary practices among Northern African and Southern European immigrants in France has shown low rates of chronic diseases and long life expectancies. This was hypothesised to be the result of improved dietary intakes, which were consistent with the typical Mediterranean diet (Darmon & Khlat, 2001). Also, the diet of West African (Bubi) immigrants in Madrid is protective because the majority of the participants in this study still follow their native diet, which includes high intakes of fish, fruits, vegetables and monosaturated fat (olive oil) (Delisle et al., 2009).

A recent Italian study involving 821 immigrant female outpatients aged 14 to 60 years revealed 20.5% had anaemia (due to other causes), 11.5% had IDA and 22.5% had ID (Morrone et al., 2010). Anaemia was most common in the 14 to 44 year age group. Amongst the different ethnicities in this study, female African immigrants had the highest risk of anaemia (Morrone et al., 2010). According to Morrone et al. (2010), education, occupation, pathological factors, vegetable and milk intake with the country of origin were reported as the important determinants of IDA in these migrants with an OR of 84.1 ($p<0.0001$). Skipping lunch was also identified as a significant determining factor ($P < 0.05$). Morrone et al. (2010), found similar results to studies of immigrant women in the US, which found ID in 19% of African American and in 22% of Mexican participants (Zimmermann & Hurrell, 2007; Morrone et al., 2010).

In Canada, dietary intake and iron biochemical indices were assessed among immigrants from Eastern India. The results showed a high prevalence of 33% for ID in females, and this was found to be associated with low intake of bioavailable iron, and high intakes of dietary fibre, phytates and tannins (Bindra & Gibson, 1986). There is little mention in the literature about the impact of migration on dietary changes, particularly for Pacific Island women living in NZ, or about how the dietary changes of immigrants might affect their iron status.

2.9. Demographic profile of the Pacific Islanders in NZ

The population of Pacific people in NZ has been steadily increasing over recent years. The 2006 NZ census reported 26,600 Pacific Islanders, which is an increase of 15% from the 2001 census (Tukuitonga, 2011). The life expectancy of Pacific women living in NZ is 78.1 years compared to 73.9 years for their male counterparts and this is lower than the average life expectancy in NZ (Tukuitonga, 2011; Callister & Didham, 2007). At the time of the census, the Pacific population was among the fastest growing in the country, which is probably the result of high birth rates and increasing life expectancy (Tukuitonga, 2011).

2.9.1. Socio-economic and health situation of Pacific Islanders in NZ

Compared to other New Zealanders, there is an over-representation of Pacific Islanders in low socio-economic groups. A large proportion of Pacific people leave school without gaining a formal qualification and the median income for Pacific people ($20,500) is lower than that of other New Zealanders ($24,400) (Callister & Didham, 2007; Tukuitonga, 2011). Low socio-economic status is associated with adverse health status. Other major social and public health issues faced by Pacific Islanders are overcrowding and poor quality housing (Tukuitonga, 2011; Callister & Didham, 2007). Other major risks to the health of Pacific Islanders in NZ are irregular exercise and being overweight; the latter being the case for 75% of the NZ Pacific population (Tukuitonga, 2011; Callister & Didham, 2007).

Non-communicable diseases are the leading causes of morbidity and mortality in the adult Pacific population. The prevalence of type 2 diabetes mellitus in Pacific Islanders is three to four times higher than in European New Zealanders. Rates of respiratory infections, infectious and parasitic diseases, burns and unintentional injuries are also higher in Pacific Islanders than the national average. These increased rates are thought to be a result of poverty, poor housing and inadequate health care (Tukuitonga, 2011; Callister & Didham, 2007). Pacific

Islanders in NZ are affected by many other health and social issues that are not highlighted in this review. The suggested barriers to better health and a good standard of living for Pacific Islanders in NZ are socio-economic difficulties, language and cultural factors (Tukuitonga, 2011).

2.10. Health and nutrition of women in the Solomon Islands

Results of the Solomon Islands National Nutrition survey 1989/90 (NNS) showed that IDA affected 23% of women aged 15 to 45 years (MoHSI, 1990). By the time the National Demographic and Health Survey (DHS) was completed in 2006/07, the prevalence was 44.3% - a 21% increase (SPC, 2009b). Inadequate intake of iron-rich foods and low levels of education among women are thought to be the major determinants of IDA in the Solomon Islands (SPC, 2009b). Further investigation into other factors influencing iron status of women such as dietary habits, blood loss, birth intervals, poverty and parasitic infections should be done in future studies in the Solomon Islands.

The prevalence of overweight and obesity has remained similar over time. The NNS reported 33% of women as overweight (BMI ≥ 25 – 30 kg/m^2) and 11% obese (BMI ≥ 30 kg/m^2) (MoHSI, 1989/1990), and 17 years later, the DHS reported 30% overweight and 14% obesity among women (SPC, 2009b). In both the NNS and the DHS, Hb was the only biomarker used to determine the presence of IDA. Serum ferritin and CRP could not be assessed due to the costs involved, as well as a lack of available resources. However, even with limited data, the above studies have shown anaemia was highly prevalent in women aged 15 to 49 years living in the Solomon Islands. There are currently no data available regarding ID and the factors affecting iron status (e.g. iron enhancers/inhibitors, blood loss, previous health history etc.) in these women. Furthermore, dietary data was collected using only a single 24 hour dietary recall (SPC, 2009b). Therefore, more research is needed in this area in the Solomon Islands.

2.11. Importance of the study for the Solomon Islanders in living in New Zealand

As there is a high prevalence of IDA among Solomon Island women in their native country, it is important to determine if migration to NZ has any effect on iron status. To date, no studies have been done among Solomon Island women living in NZ to determine whether there is a similar prevalence of IDA to the Solomon Islands, or whether ID is also of concern. Many

studies on Pacific Islanders in NZ have not been representative of those from minority Pacific countries. This leaves a knowledge gap about the health and nutritional profile of minority Melanesian groups such as Solomon Islanders, including the iron status of women.

This study will be the first to address whether ID is a problem for women from the Solomon Islands living in NZ, and to assessing factors contributing to their iron status. Therefore, this research will provide us with important data on which to base future interventions within this minority group living in NZ.

Chapter 3: Methodology

3.1. Study design

This was a cross sectional study comparing the iron status and factors influencing iron nutrition between Solomon Islands and Caucasian women aged 18 to 45 years living in and around Auckland, New Zealand (NZ). One hundred and twenty participants (80 Caucasian and 40 Solomon Islands women) were initially recruited to take part in the study. Six participants were excluded from the analysis (incomplete data (n=2) and (CRP > 10 mg/L (n=4). A total of 114 women's data were included in the final analysis. For classification into iron status categories, only 107 participants were analysed as seven women were excluded due to low haemoglobin (Hb < 120 g/L) and normal serum ferritin (SF > 20 µg/L (as these were outside of the parameters used to define iron status in this study). However, their data were used in all other analysis.

3.2. Recruitment

Solomon Islands women living in Auckland and Hamilton were invited to participate in this project using a variety of different strategies. An important recruitment strategy was through the Aotearoa Solomon Islands Wantoks Association (ASIWA) email network. The ASIWA is an organised body based in Auckland bringing together Solomon Islanders and promoting the unique 'Solo' culture and heritage. Within the Solomon Islands community in NZ different networks were formed through church groups, sporting activities and community events. Through these networks it was possible to make contact and undertake recruitment. Specific examples include email invitations (Appendix D) sent to the St. Andrew Parish in Auckland, seeking women church members and to the President of Solomon Islands community in Hamilton. Whenever possible, the lead researcher who is a Solomon Islands female promoted the research by undertaking short presentations and distributing flyers (Appendix E) explaining the study to the community groups.

The study was also promoted on ASIWA's face book page (social networking site). Word of mouth (phone calls and/or face to face at sporting events), was a major form of invitation among the Solomon Islands community by the researcher and the participants themselves. Besides the above promotional activities, radio announcements (Appendix D) were also made

through the “voice blo yumi” programme via the “Radio 531pi”. This is a radio station specifically targeting audiences from the main Pacific Island cultural groups in NZ. Announcements/promotions (Appendix D & E) were written in English and translated into the Solomon Islands Pijin language. However, all the announcements were communicated in Pijin, a preferred language amongst Solomon Islanders.

3.2.1. Participant selection for the Solomon Islands women cohort

Women who were interested to participate in this study contacted the researcher and were screened using the eligibility criteria (Appendix F). The study criteria were:

- Solomon Islands females (born in the Solomon Islands and living in New Zealand (NZ) and women of Solomon Islands descent (who may have been born in NZ or in another country)
- Non-pregnant,
- Aged from 18 to 45 years old and
- without any blood condition that might affect the iron biomarkers (e.g. blood clotting disorders)

Women who met the above eligibility criteria were sent the study information sheet (Appendix A). The information sheet fully explained the purpose and benefits for participating in this research, the amount of time the participant would have to commit to the research and the procedures involved in this study. Upon the confirmation of their voluntary participation, the women were booked in for their appointments.

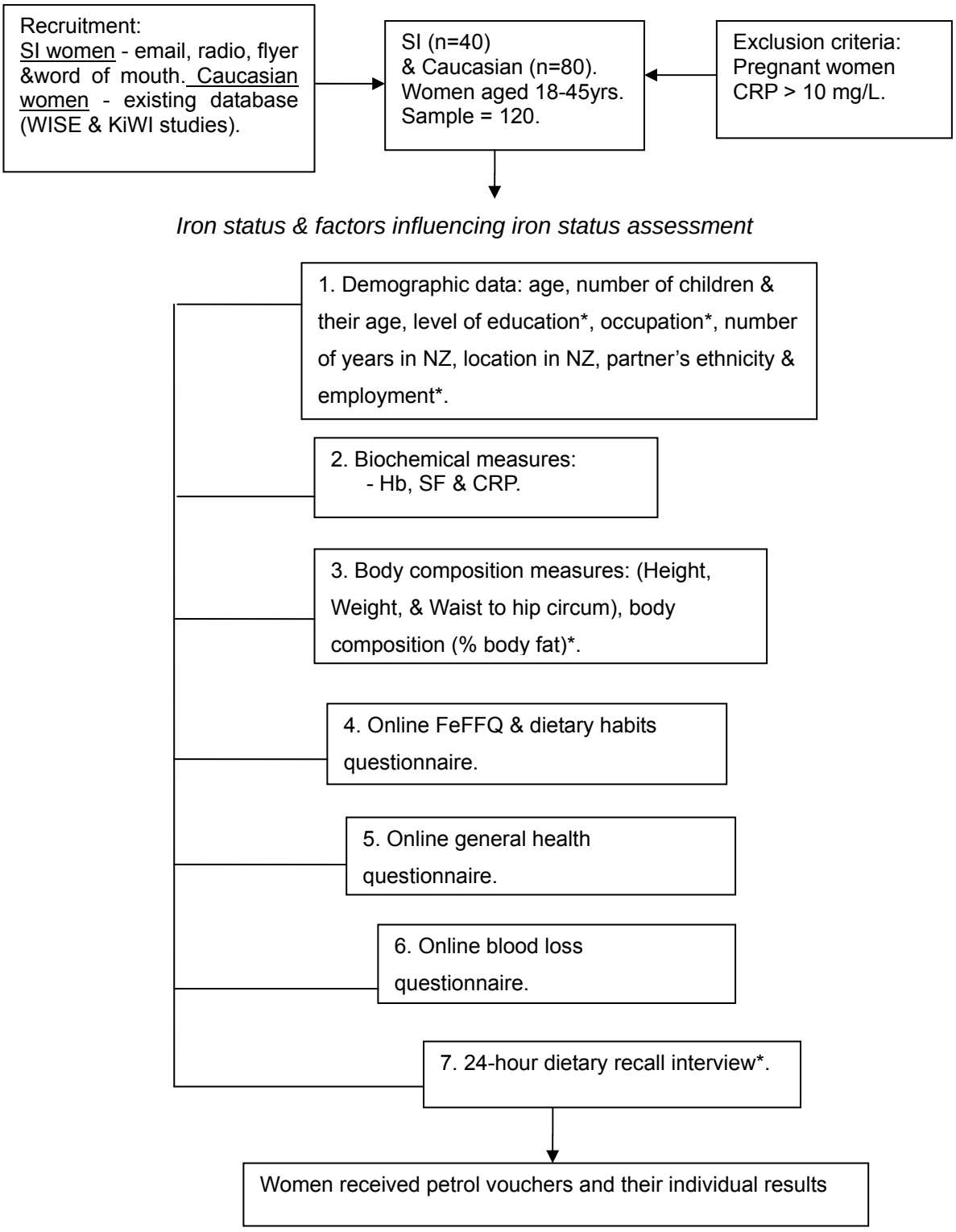
3.2.2. Participant selection for the Caucasian women cohort

Caucasian women who participated in two other studies were randomly selected. These were the Women’s Iron Status in Education (WISE) study investigating iron status in female university students (Beck et al., 2008), and from screening women in the general population for participation in a randomised controlled trial known as the Kiwi Women’s iron (KiWI) study investigating the effect of a dietary intervention on iron status (Beck et al., 2010). From the existing databases of women who had participated in these two recent studies, Caucasian women were selected and age matched (+ 1 or/ – 1 year) with the Solomon Islands women. Eighty women were randomly selected from the Caucasian women’s database by spinning a dice while being blind to the women’s iron status or any other data.

Data from two Caucasian women were used to compare with one Solomon Islands woman. The reason for using this comparative method was because the Solomon Islands population in NZ is small compared to the Caucasian population who may include immigrants from other countries. Therefore, greater between subject variation was expected in the Caucasian group and two Caucasian women were used for every Solomon Islands woman. The methodologies employed to collect data for the WISE and KiWI studies were the same with the methods currently used with the Solomon Islands women except for the biochemical analyses which were completed by two different laboratories.

3.3. During the visit

Participants were welcomed to the Human Nutrition Research Unit on their arrival. Before undertaking the study, all the general procedures were explained and the participants were asked if they had any questions about the study prior to signing the written consent form (Appendix B). The study procedures are illustrated in the study flow chart (Figure 3.1)



*Assessed in SI (Solomon Islands) women only, Hb (haemoglobin), SF (serum ferritin), CRP (C-reactive protein), NZ (New Zealand), FeFFQ (iron food frequency questionnaire), WISE (women's iron status in education), KiWI (Kiwi women's iron study)

Figure 3.1: Study setting and procedures

The study was conducted at the Human Nutrition Research Unit, Massey University, Albany, Auckland. Each participant was given a unique identifier to be used on all questionnaires and data forms. All the questionnaires were completed in English language but an interpreter was available if required. The data forms were kept in a safe and secure storage in a locked office within the Human Nutrition Department which is a restricted access building. The electronic data was also stored on computers and servers, which were protected by passwords within the same facility.

3.4. Study approval and funding support

This project was approved by the Massey University Human Ethics Committee (Southern A), ethics application reference No. 10/62 (Appendix C). This study was financially supported by the Post Graduate Research Support grant from the Institute of Food, Nutrition and Human Health, at Massey University. Transport costs for the Solomon Islands participants to travel to the research centre were provided by the NZ Aid Programme (open category post graduate scholarship).

3.5. Measurements used in this study

The data were collected through various methods such as a demographic questionnaire, an iron food frequency questionnaire (FeFFQ) including a dietary habit questionnaire (Appendix I) (computerised iron habit assessment tool), a general health questionnaire, a blood loss questionnaire, and a 24-hour dietary recall interview with Solomon Islands participants only. All the questionnaires were self-administered online, except for the demographic questionnaire which was manually filled and the 24-hour dietary recall which was conducted through face to face interview.

All online questionnaires, using SurveyMonkey (www.surveymonkey.com;California, USA), were completed in the computer suite during the participant's visit to the Human Nutrition Research Unit. Both written and verbal instructions were given to them on how to complete the online questionnaires. Participants were advised to seek assistance if they were unsure about any aspects of the questionnaire or if they were having any difficulties. A trained researcher was available in the room to assist by ensuring the participants understood the

questions and give appropriate responses. Body composition measurements and blood sample analysis were also conducted by trained researchers.

3.5.1. Demographic questionnaire

The purpose of this questionnaire was to collect data on participant's age, where they were born, number of years which they have lived in NZ, participant's educational background and their occupations (Appendix G & H). Educational background and occupation information were gathered for the Solomon Islands women only.

3.5.2. Dietary Assessment

Dietary assessment was undertaken using three different methods, a FeFFQ to assess the foods rich in iron and foods that may affect iron uptake, including a dietary habit questionnaire to assess eating habits of women in both groups and a single 24-hour dietary recall interview to assess usual dietary intake of Solomon Islands women.

3.5.3. Iron food frequency questionnaire

This study used a semi quantified computerized self-administered iron food frequency questionnaire (FeFFQ) to collect data on food sources of iron and foods that influences iron uptake by the body (Appendix I). This questionnaire comprised 144 food items and was specifically designed and developed by the research team at the Human Nutrition Research Unit for use in NZ (Beck et al., 2012).

The FeFFQ has been validated and successfully used in similar studies in the past (Beck et al., 2009; Beck et al., 2011), this tool was used to obtain data on the frequency of consumption of foods rich in iron and the foods that influence iron absorption over a month. Foods were listed according to categories such as meat and chicken, prepared meat, fish and sea food, egg, nuts, legumes, dairy products, milk, medium to high vitamin C fruits, fruits, medium to high vitamin C vegetables, green leafy vegetables, breakfast cereals, grains, breads (cakes, biscuits & crackers), alcoholic drinks, non-alcoholic drinks and miscellaneous foods and snacks (Appendix I). Participants were given clear written and verbal instructions on how to complete the FeFFQ online. The FeFFQ has an associated set of frequency of use response categories to assess the consumption of foods over the past month. The participants were

asked to click on the frequency of use response categories such as “Never” or “less than once per month”, “1 to 3 times per month”, “once per week”, “2 to 3 times per week”, “4 to 6 times per week”, “once per day”, “2 to 3 times per day” or “4 plus times per day”. Frequency of average intake per week was calculated as follows;

Never or less than once per month = 0 times per week
1 to 3 times per months = (1+3)/2/4 weeks =0.5 times per week
1 time per week = 7/7=1 time per week
2 to 3 times per week = (2 + 3)/2=2.5 times per week
4 to 6 times per week = (4 + 6)/2=5 times per week
Once a day = 7 times per week
2 to 3 times per day = (2+3)/2 x 7 = 17.5 times per week
4 plus times per day = 4 x 7 = 28 times per week.

The dietary sources of iron were allocated to identifiable groups such as, haem iron rich foods (including the meat, fish, poultry factors), non-haem iron rich foods, and iron fortified foods. In this study, the FeFFQ tool was also used to assess the frequency of intake of foods which may affect the intake and/or absorption of dietary iron such as vitamin C rich foods, phytate rich foods, calcium rich foods and foods containing polyphenols (Beck et al., 2009).

3.5.4. Dietary habit questionnaire

This questionnaire was used to gather information about the participants’ pattern of eating that may have contributed to their iron status (Appendix J). Questions were asked to find out; if there were differences in their dietary pattern between weekdays and weekends, types of foods and drinks they usually have for each of their meals. They were also asked if they had any drinks or fluids one hour before or after the meal and what types of drinks or fluids were consumed. This questionnaire was also used to investigate the servings of fruit and

vegetables during weekdays and weekends, alcohol consumption, eating out from home and consumption of products with added iron.

3.5.5. Single 24-hour dietary recall interview

The 24-hour dietary recall interview was designed to capture the usual dietary intake of Solomon Islands women. In this study, the macronutrients, iron, vitamin C, calcium and fibre were assessed. A four stage multiply pass interviewing method was used to obtain this data (Gibson, 2005). Participants were asked to recall all the foods and drinks they had in the past 24-hour. A simple 24-hour dietary recall record sheet was used to record the information collected from the participants (Appendix K). Photographs of foods and different portion sizes, common household measures such cups, spoons, bowls and food models were used as memory aids to estimate portion sizes.

Pass one

The interviewer asked the participants to give a quick list of everything they have eaten and drunk on the day prior to their visit from waking up (morning) to midnight (before bed time). The interviewer recorded the list of all the foods and drinks reported by the participants. Information collected included everything they ate and drank at home and away from home – take away food, snacks, coffee and alcoholic beverages.

Pass two

The interviewer asked the participants to describe each food and drink consumed, how each food item was prepared and the brand names of the foods and the beverages. At this stage, the interviewer probes for details on the products or food items.

Pass three

The interviewer asked the participants to estimate the amount of food or beverage consumed at the different meals during the day, for example before breakfast, breakfast, mid-morning, lunch, mid-afternoon, dinner and before bed time. The ingredients of mixed dishes were also gathered at this stage. The interviewer used food portion pictures, household measures (cups, spoons and bowls) and food models to help the participant estimate the amount of food

or beverage consumed. Various units of measure were used to estimate the different foods and drinks for example grams, millilitres, litres, cup sizes, spoon sizes or number of serves.

Pass four

The interviewer reviewed the list of foods and beverages recorded under different meals, the amounts or portion sizes and probe for additional eating occasions that they have not reported. Any new foods or drinks mentioned were included on the list.

Data from the 24-hr recall were manually entered into the Foodworks 2009 software programme (Xyris Software, Pty Ltd, Queensland, Australia) and checked several times to ensure accuracy before exporting nutrient data to SPSS 17.0 version for statistical analysis. The data were checked after entry into Foodworks to ensure the types or brand of foods and beverages, the amounts and the right unit of measure were accurately entered. The data was checked again by investigating the energy intake (in kilojoules) (KJ) of each participant. Participants with very low or high energy (KJ) intake were thoroughly checked against their original food records to identify any faults. Errors identified were corrected as soon as they were discovered.

3.5.6. General health and lifestyle questionnaire

This questionnaire had four sections to obtain data on the participants' previous health and lifestyle history that might have an effect on their iron status (Appendix L).

Section one (Personal questions)

Questions were asked to acquire information on number of pregnancies, parity, and ages of their children, contraception use and methods and the length of contraception use.

Section two (Lifestyle)

Questions were asked about smoking and number of cigarettes per day, who prepared most of the food at home and who did most of the food shopping for their households. They were also asked to describe their eating pattern, if they had followed any diet for cultural or religious reason and if they had dieted strictly in the last year.

Section three (Previous health history)

Questions were focused on identifying any past illnesses/conditions that might have an adverse effect on their iron status. Participants were asked if they had suffered any acute or chronic illness, had suffered any illness that affected their iron status, had low iron stores, ID or IDA before and if they have ever been treated for ID or IDA or had any medical condition that resulted in blood loss. Questions also addressed blood transfusions in the last year and any other means of blood losses experienced, excluding losses through menstrual periods or nose bleeds. Questions in this section also sought to find out if the participants were on any medication (excluding nutritional supplements) and if they had breastfed within the last year.

Section four (Nutritional supplements)

Participants were asked if they were taking any nutritional supplements (vitamin and/or mineral capsules/tablets) and any other dietary supplements (unprocessed bran, breakfast cereal, fibre tablets, noni juice lecithin etc.) any time in the past year.

3.5.7. Blood Loss

Menstrual blood loss is a major factor causing ID in women (Heath et al., 2001a). In this study blood loss was estimated using the adapted version of the recall method developed by Heath et al. (1998). Due to the expansion of brands of sanitary products available since the development of the recall method, it was necessary to update the list (to incorporate all possible brands currenlt available) as one component of the blood loss questionnaire asked about the brands of sanbitary product used. The participants were asked at what age they had their first menstrual period and the number of days of their last menstrual cycle, length of their menstrual period and the number of heavy and light bleeding days. The type (brand) of pads or tampons normally used, their absorbency levels (Table 3.1) and the number of pads or tampons used during heavy and light bleeding days was determined. Blood loss questionnaire (Appendix M).

Table 3.1: Absorbencies for pads and tampons used to estimate the menstrual blood loss

Products	Absorbency levels	Values
Tampax tampons	Regular	1
	Super	2
	Super plus	3
Libra tampons (Slim and designs)	Mini	1
	Regular	2
	Super	3
Carefree (Applicator and non-applicator) tampons	Light	1
	Regular	2
	Super	3
Signature range tampons	Mini	1
	Regular	2
	Super	3
Other brands (Tampons):		
OB from Germany	Regular	2
	Super	3
Playtex	Super	3
Cotton	Regular	1
	Super	2
Pam	Regular	2
	Super	3
Natracare organic	Regular	1
	Super	2
Home brand	Regular & super	2.5
Libra pads	Regular	2
	Super	3
Carefree pads (Liners)	Liner/Mini	1
Signature range	Regular	2
	Super	3
Stayfree pads	Regular	2
	Super	3
Other bands (Pads):		
Freestyle	Regular	2
Organic cotton	Regular & super	2.5
Always	Regular	2
Whisper	Regular	2
	Ultra	3
Laurier	Regular	2
Poise	Liner/Mini	1
Budget	Regular	2

Source: Adopted from Beck et al. (2011)

Menstrual loss calculation instructions according to Heath et al., (1998) were used to estimate menstrual Loss = HD x (HP x Abs + HT x Abs) + LD x (LP x Abs + LT x Abs)

KEY:
HD = number of 'heavy' days during an average period
HP = number of pads on a 'heavy' day
HT = number of tampons on a 'heavy' day
LD = number of 'light' days during an average period
LP = number of pads on a 'light' day
LT = number of tampons on a 'light' days
Abs = absorbency

Source: Heath et al. (1998)

The absorbency levels of different pads or tampons were determined by level of absorbency of different brands or products and the values were assigned accordingly. Higher values represent high absorbency and the low values represent materials that absorb less amount of blood during menstrual period.

Blood loss was measured in units and categorised using the formula given above. The categories in blood loss unit (BLU) according to Beck et al. (2010) & Heath et al. (2001a) were: menstrual loss of less than 35 BLU (low menstrual blood loss), 35 – 71 BLU (medium menstrual blood loss) and more than 71 BLU (high menstrual blood loss). The length of menstrual period (days) were also categorised as: less than 4 days (shorter period days), 4 - 6 days (short-medium period days) and more than 6 days (Longer period days) Beck et al. (2010). Questions were also included on blood donation, number of times they had donated blood in the previous year, nose bleeds, how often and how heavy those nose bleeds were. Other losses through coughing, urine and stool were also investigated as part of the general health questionnaire.

3.5.8. Body composition measurements

Weight, height, waist and hip circumference measurements were taken using the International Society for the Advancement of Kin-anthropometry standard techniques (ISAK). BODPOD® measurements were done according to the Institute of Food, Nutrition and Human Health

(IFNHH) SOP. Trained researchers in Anthropometric measurement conducted the body composition measurements during the study.

Height (cm)

Height was measured using a portable stadiometer (Holtain Ltd). The participants were asked to remove their shoes and hair bands (if any) before stepping on to the flat base of the stadiometer. Participants were asked to stand up straight with feet and heels together, against the board and look straight ahead. In the upright position, upward pressure was applied to the jaw to have the lower edge of the eye socket in alignment with the horizontal plane (notch superior to the tragon of the ear). While the head remained in the Frankfort plane, the participants were asked to take a deep breath in. An attached piece of head board was lowered down firmly on the head, crushing the hair as much as possible before the measurements were taken at the end of the deep inward breath. Height was recorded to the nearest 0.1cm. The participants were asked to step off the stadiometer and then a repeat measure was taken using the same procedure. If the first two measurements were different by more than 0.4cm a third measurement was recorded. Values from the first two measurements were recorded as mean and if there were three measurements the median was recorded.

Weight (kg)

The participant's weights (wt) were measured using the electronic scale (Model number: EC 240 & EI 200) as part of the BOD POD® with light clothing on, no jewellery and shoes. The scale was calibrated each day using two weight 10 kilo gram (kg) objects according to the manufacturer's instruction manual. The calibration process was repeated till all the parameters were reached for accurate measurement. Weight was recorded to the nearest 0.1kg.

Body mass index (kg/m^2)

The Quetelet's body mass index (BMI) was calculated from the height and weight values according to the formula; wt (kg)/ ht^2 (m^2). The WHO (2000) cut-off points were used to classify the participants' BMI as underweight, normal healthy weight, overweight and obese (Table 3.2).

T**able 3.2: BMI cut off values and classification**

Classification	BMI (kg/m^2) Principal cut - off points
Underweight	< 18.50
Severe thinness	< 16.00
Moderate thinness	16.00 – 16.99
Mild thinness	17.00 – 18.49
Normal range	18.50 – 24.99
Overweight	≥ 25.00
Pre-obese	25.00 – 29.99
Obese	≥ 30.00
Obese class I	30.00 – 34.99
Obese II	35.00 – 39.99
Obese III	≥ 40.00

Source: Adapted from (WHO, 2000).

For the Solomon Islands women the Pacific Islands/Maori BMI cut off values for overweight (> 26 kg/m^2) and obese (> 32 kg/m^2) (MoHNZ, 2011) were also used with the WHO international standards to classify the proportion of overweight/obese in Solomon Islands women.

Waist and hip circumference (cm)

Waist and hip circumferences were measured using a non-stretch measuring tape (Lufkin tape). Waist and hip circumferences were measured according to the ISAK (International Society for the Advancement of Kin-anthropometry) standard protocols. Waist was measured from the smallest part of the abdomen between the lower costal border and the top of the iliac crest perpendicular to the long axis of the trunk. The hip measurement was measured as the circumference of the buttocks at the level of their greatest posterior protuberance to the long axis of the trunk, from the hip between the waist and thigh (Peltz et al., 2010).

The participants were asked to put their feet together, stand up straight with arms folded across the thorax and the abdomen relaxed. The tape was placed at the participant's natural waist (smallest part of the upper body) as explained earlier. Participants were told not to

breathe in while taking the measurement. The measurement steps were repeated at the widest point of the participants' hips and buttocks. Both measurements were repeated twice, if the first two measurements differed by 0.1cm then a third measurement was taken. The mean from the first two or the median of all three measurements were recorded to the nearest centimetre.

Per cent of body fat

Percentage of body fat was measured in women from the Solomon Islands, but was not a variable measured in the Caucasian women as part of the WISE and KiWI studies.

Body composition was assessed in this study using the BOD POD® (Life Measurement, Inc - Concord, California, USA) to determine the total per cent (%) of body fat. The BOD POD® is an instrument which assesses body composition by air displacement plethysmography. The BOD POD® was auto calibrated at the same time of the day prior to use. The calibration curve for the BOD POD® was checked by the trained operator to ensure that the calibration testing was within the normal parameters. If a system failure occurred then the calibration testing was repeated until all parameters were passed satisfactorily. Participants were nil by mouth prior to this measurement in order to minimise fluid that might cause an increase in the per cent of body fat results. An intake of 1 litre fluid can increase per cent body fat significantly ($P < 0.001$) according to Heiss et al. (2009).

Also, as part of the BOD POD® procedures all participants wore prescribed tight fitting clothes without padding or wiring and a swim cap (Appendix N). Tight fitting clothing and cap is necessary to minimize errors resulting from air trapping on the clothes or in the hair while in the chamber. They were also instructed to, empty their bladder and removed any jewellery or glasses before getting into the BOD POD®. The participant's body volume was measured inside the enclosed chamber of the BOD POD®. The percentage body fat was automatically calculated using the participants' volume, age, gender, height and weight captured on computer software used to operate the BOD POD machine and rated and categorised automatically (Table 3.3).

Table 3.3: Categories and cut off values for total body fat percentage for female

Body Fat Rating	Female
Risky (high body fat)	≥ 40%
Excess Fat	31 - 40%
Moderately Lean	23 – 30%
Lean	19 – 22.9%
Ultra Lean	15 – 18%
Risky (low body fat)	< 15%

Source: McArdle, Katch & Katch, (2006); Life Measurement, Inc - Concord, CA, USA.

3.5.9. Blood sample collection and processing

Venipuncture was carried out by certified phlebotomists according to a standard operating procedure (Appendix O) to draw a fasted blood sample from the participants. The participants were fasted overnight to undertake this measurement. Procedures were fully explained to the participants and they were also given advice on care of the puncture site and any risks associated with the procedure. Fasting blood samples were collected into 10ml red top tubes which were free of anticoagulant and labelled with the participant's study identification number, their date of birth date and time of collection.

Immediately, after the blood was collected a single drop of blood was withdrawn from the sample for the analysis of haemoglobin concentration. The rest of the blood sample was left at room temperature (20°C - 26°C) and protected from sunlight for at least 30 minutes for clotting to occur. Then, the clotted blood samples were placed in an upright position in the Labofuge 400R (Heraeus) for centrifugation to obtain the serum. The centrifugation process took 10 minutes at 2000 rpm, 4°C. Serum was extracted for the analysis of SF and CRP concentrations.

Aliquots of 0.5 mls from the serum were transferred into an eppendorf tube using a transfer pipette. Each 0.5 mls eppendorf tube was labelled with the participant's identification number, date of birth and sample codes. Serum aliquots were coded as (a) serum CRP, (b) serum ferritin and (c) serum spare. These eppendorf tubes were stored at – 80°C until the end of the data collection period (October 2010 – May 2011) when the samples were sent for analysis by International Accreditation New Zealand (IANZ) laboratories.

3.5.10. Biochemical analysis

Haemoglobin (Hb)

The analysis of haemoglobin was to done to identify participants with anaemia. This was done in the Human Nutrition Research laboratory, Albany Campus. A Hemocue analyzer, Hb 201^{+} (HemoCue, Inc, Cypress, California) was used to perform the analysis. Before performing the analysis each day, quality controls were measured to ensure the Hemocue analyzer was operating optimally.

A single non coagulated drop of blood large enough to fill the microcuvette in one continuous process was taken from the sample. The microcuvettes were checked for any air bubbles, samples with the presences of air bubbles in them were discarded and the sample repeated for accurate results. After checking, microcuvettes were placed in the cuvette holder immediately and the cuvette holder was pushed to its measuring position. The Hb value of the sample in g/L was displayed after 15 to 60 seconds.

The Hb concentrations for the Caucasian women were carried out by Diagnostic Medlab, Auckland using the SLS-Hb (sodium lauryl sulphate-Hb) method using an automated haematology analyzer XE-2100 (Systemex Corporation, Auckland, NZ).

Haemoglobin values in this study were categorised according to the WHO (2011) cut off points for anaemia in non-pregnant women (Table 3.4).

Table 3.4: Haemoglobin values and its classifications for iron status in non-pregnant women

Iron biochemical marker	Cut off values (g/L)	Classification
Haemoglobin	≥ 120 g/L	Normal
	110 - 119 g/L	Mild anaemia
	80 - 109 g/L	Moderate anaemia
	≤ 80 g/L	Severe anaemia

Source: Adapted from WHO (2011b)

Serum ferritin and C-reactive protein

The analysis of serum ferritin (SF) was to determine the level of iron stores in the body. For the Solomon Islands women, the analysis for SF and serum C-reactive protein (CRP) were carried out by LabPlus, Auckland City Hospital. The principal method used to test for SF concentration was particle enhanced immunoturbidimetric assay and reagents (Roche Ferritin GEN 4 kit, Cat. No. 04885627190). In this study IDA is indicated by a decrease in SF concentration < 20 µg/L. Table 3.5 presents the SF values and cut off points for women aged 15 – 40 plus years (LabPlus, 2009).

Table 3.5: Serum ferritin reference intervals for women aged 15 – 40 plus years

Iron biomarker	Age	Cut off values (µg/L)	Classifications
Serum ferritin	15 – 19 years	15 – 170	
	20 – 29 years	20 – 170	Iron replete
	– 40 years	20 – 190	
	>40 years	20 – 380	
		< 20 µg/L*	Iron deficiency

Source: Adapted from LabPlus, Auckland City Hospital (2011)
*SF cut off value used to indicate IDA in this study.

Serum ferritin (SF) can be influenced by the presence of infection or inflammation. Therefore, CRP, an acute phase protein, was assessed to verify SF biomarker for the confirmation of iron status. The principal method used to test for CRP was particle enhanced immunoturbidimetric assay and reagents (Roche CRPLX kit, Cat. No.03002055). Participants with CRP > 10 mg/L (Beck et al., 2008) were excluded from this study as this indicates a bacterial or viral infection or an inflammation (Gabay & Kushner, 2001; Reeves, 2007) that may cause a false rise in SF.

The SF and CRP analysis for the Caucasian women were carried out by Diagnostic Medlab, Auckland. The method used to test for SF was immunoturbidmetric test (Roche Diagnostics, Indianapolis, Cat. No. 1661400) and the principal method used to test for CRP was particle enhanced immunoturbidmetric test (Roche Diagnostics, Indianapolis, Cat. No.03002039) (Beck et al., 2010).

3.6. Data processing and statistical analysis

Upon completion of the data collection, data were exported from the Surveymonkey and Food works software to Microsoft Excel for processing. Data were checked for accuracy by checking the number of participants completing each questionnaire, questionnaires were checked for completion and missing data before analysis. Data from the two groups were checked to ensure the necessary data were included. After processing, data from both groups were given matching titles and merged into one dataset in SPSS 17.0 version (SPSS, Inc., Chicago, IL, USA) for analysis.

Descriptive statistics were used to describe the findings from this study. All variables were explored to determine the appropriate distribution and measures to use. Mean ± SD (for normally distributed data), median (25^{th}, 75^{th} percentiles) (for non-normally distributed data), frequency (%) (for categorical data) and geometric mean (95% CI) (anti-logs of logarithmically transformed data) were used to present the results. Differences between the two groups were analyzed using independent Student *t* test for parametric data, Mann Whitney *U* test for non-parametric data and Pearson's Chi square test for all the categorical variables. A *p value* (< 0.05) indicates a significant difference between the two groups.

Chapter 4: Results

4.1. Characteristics of participants

This study aims to assess and compare the iron status and the factors influencing iron status of Solomon Islands with Caucasian women living in New Zealand (NZ). One hundred and twenty non pregnant women (40 Solomon Islands women and 80 Caucasian women) aged between 18 and 45 years completed the study. Six women were excluded from the analysis due to (incomplete data (n=2) and C-reactive protein (CRP) > 10 mg/L (n=4) (Refer to methods 3.5.10) and seven women were excluded from the iron status biomarkers data due to being anaemic (Hb < 120 g/L) but having normal iron stores (SF > 20 µg/L) indicative of an unknown cause of the anaemia.

The mean age for this group was 33.5 years. Most of the Solomon Islands women who participated in this study were born overseas before migrating to NZ and the majority of them had lived in NZ for more than 5 years (Table 4.1). A large proportion of Solomon Islands women had attained NZ NCEA L3 or an overseas high school qualification and most of them were either homemakers or students at the time of this study. There was a significant difference (p=0.011) between the Caucasian and Solomon Islands women for self-reported acute or chronic diseases (Table 4.1). A large proportion of Caucasian women reported to have acute or chronic diseases as opposed to the Solomon Islands women. Ulcerative proctitis was reported by the Solomon Islands participants and the following conditions were reported by Caucasian women: depression (anxiety disorders), epilepsy, bronchial pneumonia, kidney infection, gestational diabetes, asthma, hyperthyroidism, anaemia, hiatus hernia and thyroid disorder (cured diseases were not included). A small number of women in both groups reported smoking. Table 4.1 compares the demographic characteristics between the two groups.

Table 4.1: Demographic characteristics of Solomon Islands and Caucasian women*

Characteristics	Solomon Islands women (n=39)	Caucasian women (n=75)	*p* Value**
Age (years)	33.5 ± 6.83	33.5 ± 6.58	.972
Born in NZ	2 (5.1)	55 (73.3)	0.001**
Years in NZ			
> 5 years	23 (59)	63 (84)	0.003**
Highest qualification		NM	
No qualification	5 (12.8)		
NZ NCEA L3 and overseas high school qualification	14 (35.9)		
Diploma/trade/technical certificate	5 (12.8)		
Graduate qualification	11 (28.2)		
Post graduate qualification	4 (10.3)		
Occupation		NM	
Administrator/Manager	2 (5.1)		
Professional	4 (10.3)		
Clerk	1 (2.6)		
Plants & machinery operator	1 (2.6)		
Home maker	13 (33.3)		
Unemployed	3 (7.7)		
Student	12 (30.8)		
Other	3 (7.7)		
Acute or chronic diseases	1 (2.6)	15 (20)	0.011**
Smoking	3 (7.7)	4 (5.3)	NA

NM: Not measured, NA – Not applicable (assumptions for statistical test not met due to few subjects in some cells), NCEA L3 – National certificate of educational achievement level 3
*mean ± SD or frequency (%)
***p* values using either Independent sample *t* test or Pearson Chi-Square test, significant differences between the 2 groups ($p<0.05$).

4.2. Body composition

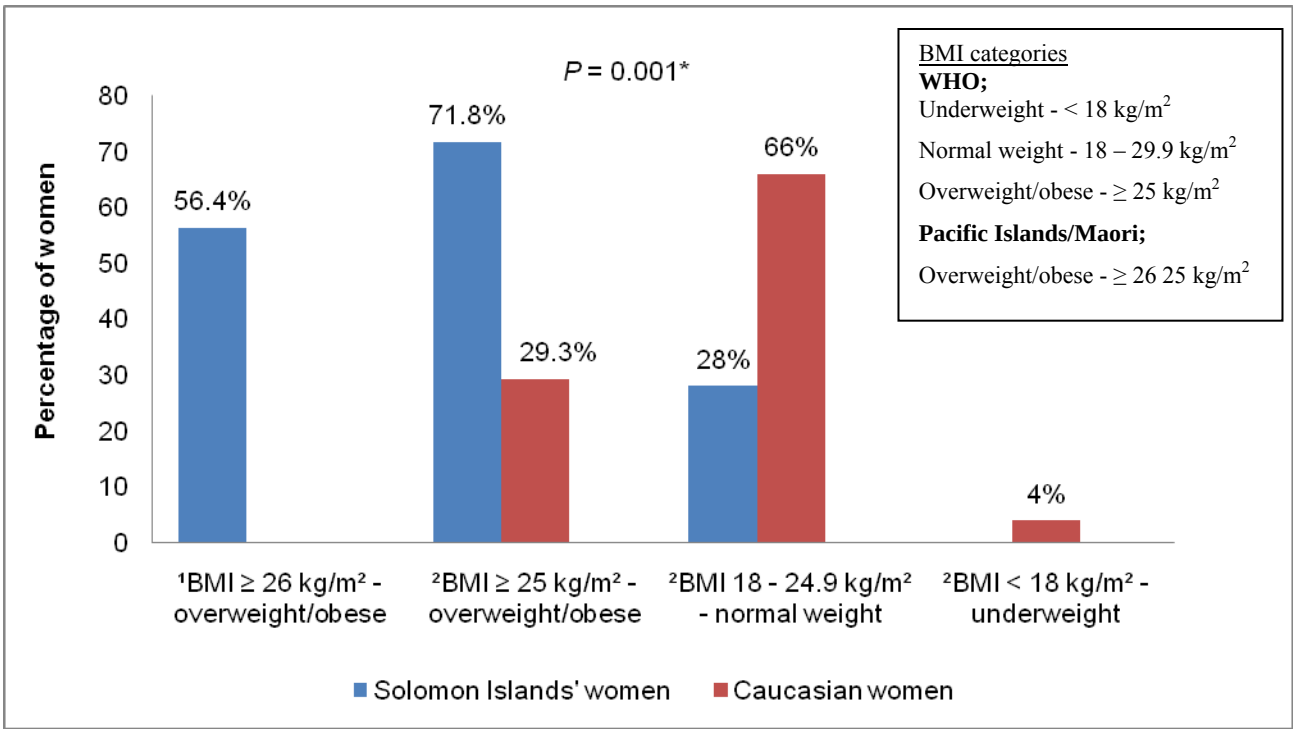
A range of body measurements were carried out to calculate the participants' body mass index (BMI), waist circumference and percentage of body fat. Table 4.2 shows the measurement outcomes for the two groups.

Table 4.2: Anthropometric measurement and percentage body fat results for Solomon Islands and Caucasian women

Characteristics	Solomon Islands women (n=39)	Caucasian women (n=75)	*p* value*
BMI (kg/m^2) **	28 (24.0, 33.0)	23 (21.4, 25.9)	0.001*
Height (cm) **	159 (154, 165)	165.5 (154.9, 170.4)	0.043*
Waist circumference (cm)***	83.1 (79.8, 87.4)	74.4 (72.2, 75.9)	0.001*
Waist circumference categories, n (%)			
High risk ≥ 80 cm	22 (56.4)	16 (21.3)	0.001*
Low risk < 80 cm	17 (43.6)	59 (78.3)	
Percentage body fat†	34.8 (32 , 37.4)	NM	
Body fat percent categories, n (%)			
High risk > 40%	12 (30.8)	NM	
Excess fat 30 – 39.9%	19 (48.7)		
Moderately lean 22 – 29.9%	5 (12.8)		
Lean 19 - < 22%	3 (7.7)		

BMI- Body mass index, NM- Not measured,
**p* values using either Independent student *t* test, Mann-Whitney U test or Pearson Chi-Square test, significant difference between 2 groups ($p<0.05$)
**Median (25^{th}, 75^{th} percentile)
***Geometric mean (95% CI)
†Mean (95% CI)

Solomon Islands women had a significantly higher waist circumference (p=0.001) and BMI (p=0.001) than the Caucasian women (Table 4.2). Classification of BMI (kg/m^2) was done according to the WHO cut off values (2000). Women with a BMI of less than 18 kg/m^2 were classified as underweight, between 18 to 24.99 kg/m^2 as normal weight, ≥ 25 kg/m^2 as overweight and ≥ 30 kg/m^2 as obese. The Pacific Islands/Maori BMI cut off value (≥ 26 kg/m^2) (MoHNZ, 2011) was also used to classify overweight/obesity among the Solomon Islands women (Figure 4.1).



BMI – Body mass index, WHO – World Health Organisation
[1]BMI – Pacific Islands/Maori cut off value (MoHNZ, 2011)
[2]BMI – World Health Organisation cut off values (WHO, 2000)
*p value using Pearson Chi-Square test, significant difference between 2 groups (p<0.05)

Figure 4.1: Percentage of Solomon Islands and Caucasian women classified as overweight/obese, normal BMI or underweight

The different BMI cut off values used for the Solomon Islands women was to determine if the high prevalence of overweight/obesity among Solomon Islands women could be reduced when the Pacific Islands/Maori cut off values were applied. In Figure 4.1 a reduction in the proportion of Solomon Islands women in the overweight/obese category was observed when the Pacific Islands/Maori cut off value was applied (71.8% (WHO cut off values) to 56.4%

(Pacific Islands/Maori cut off values). Despite the reduction of 15.4% in the prevalence of overweight/obesity with the Pacific Islands/Maori cut off value, more than half the proportion (56.4%) of Solomon Islands women was still overweight/obese.

4.3. Iron status

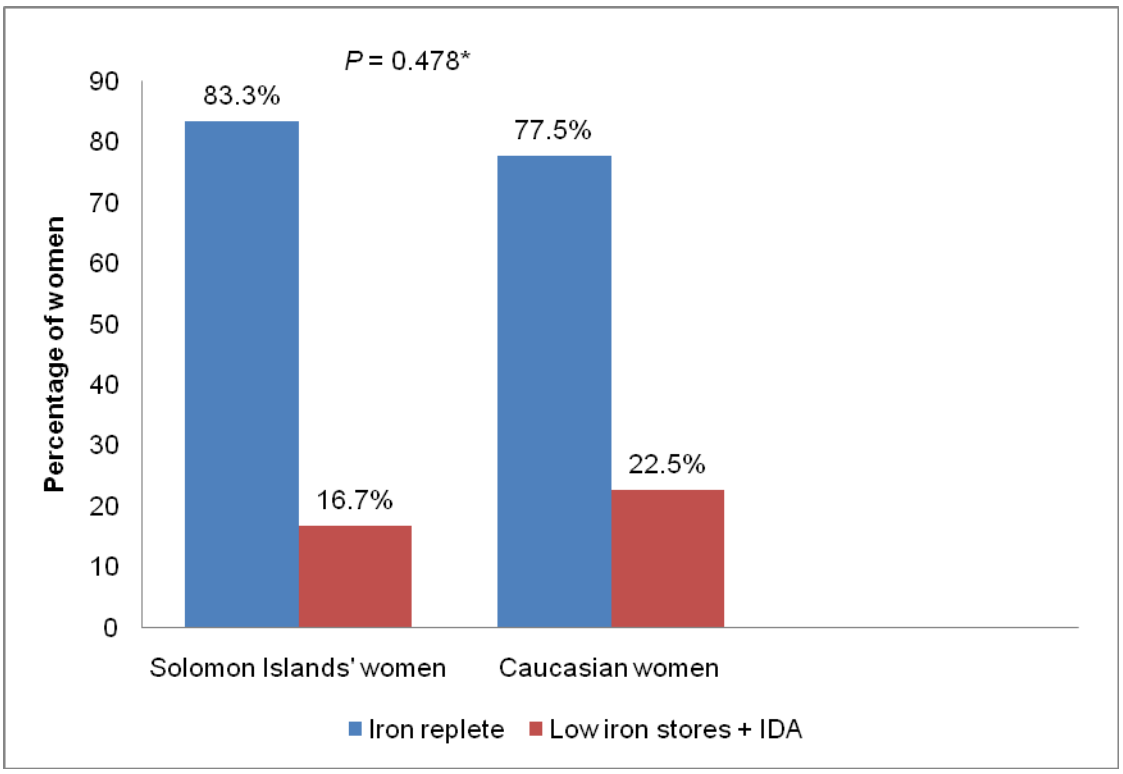
Iron status was assessed through the measurement of the biomarkers haemoglobin (Hb) and serum ferritin (SF) concentrations in the participants. Seven women were excluded from this biochemical data due to low Hb and normal SF results. Table 4.3 shows the iron status of Solomon Islands and Caucasian women.

Table 4.3: Haemoglobin and serum ferritin concentrations of Solomon Islands and Caucasian women

Characteristics	Solomon Islands women (n=36)	Caucasian women (n=71)
Hb (> 120 g/L)*	133.2 ± 14.3	129.50 ± 8.86
Hb < 120 g/L**	2 (5.6)	4 (5.6)
SF (> 20 µg/L)†	64.5 (25.5, 122.3)	36 (20, 51)
SF < 20 µg/L**	6 (16.7)	16 (22.5)

Note: No comparison is made because the samples were analyzed by different laboratories and different methods were used.
*Mean ± SD
**Frequency (%)
†Median (25^{th}, 75th percentile)

Mean Hb and median SF results for women in both groups were shown to be in the normal ranges (Table 4.3). The proportion of women with low iron stores + IDA is illustrated in figure 4.2.



*P value using Pearson Chi-Square test, no significant difference between 2 groups (p> 0.05)
Note: Iron status is defined as; Haemoglobin (Hb) > 120 g/L + SF > 20 µg/L (iron replete), Hb > 120 + SF < 20 µg/L (low iron stores), Hb < 120 g/L + SF < 20 µg/L (Iron deficiency anaemia (IDA)

Figure 4.2: Proportion of Solomon Islands and Caucasian women who were iron replete or iron deficient and anaemic

This study shows no significant difference (p=0.478) in the proportion of women who were iron replete or iron deficient and anaemic between the two groups (Figure 4.2). Iron deficiency anaemia was identified in a very small number of women (n=6) and in equal proportions between the two groups Solomon Islands (5.6%) and Caucasian (5.6%) (Table 4.3).

4.4: Factors influencing iron status of the participants

The women in this study were all of reproductive age. Many factors such as having a history of iron deficiency, blood loss from menstruation, the types of contraception used and taking iron supplements are known to influence iron status (Table 4.4).

Table 4.4: Factors influencing iron status of Solomon Islands and Caucasian women*

Factors	Solomon Islands women (n=39)	Caucasian women (n=75)	*p* value**
Had children	27 (69.2)	47 (62.7)	0.49
Breastfed within the last year	4 (10.3)	7 (9.3)	NA
Previous history of ID/IDA	7 (17.9)	45 (60)	0.001**
Low iron during pregnancy	6 (15.7)	8 (10.7)	NA
Other times	0 (0)	27 (36)	
Never	33 (84.7)	13 (17.3)	
Missing data	none	27 (36)	
Estimated menstrual blood loss (Blood Loss Unit)†	22 (16.5, 47)	32 (20, 52)	0.190
Length of menstrual period (days)†	4 (3, 5)	5 (4, 6)	0.014**
Blood donation > 6 months ago	4 (10.3)	15 (20)	0.324
Has nose bleeds in the past year	2 (5.1)	5 (6.7)	NA
Blood transfusion in the past year	0 (0)	1 (1.3)	NA
Uses contraceptives	4 (10.3)	25 (33.3)	0.001**
Oral contraceptives	1 (2.6)	19 (25.3)	
Intra uterine device (IUD)	1 (2.6)	6 (8)	
Depo - provera	2 (5.1)	0 (0)	
Multivitamin/mineral use	5 (12.8)	50 (66.7)	0.001**
Iron supplements	1 (2.6)	12 (16)	NA
Other dietary supplements	0 (0)	33 (44)	0.001**

NA – Not applicable (assumptions for statistical test no met, due to few subjects in some cells)
ID/IDA – Iron deficiency/Iron deficiency anaemia
***p* values using either Mann-Whitney U test or Pearson Chi-Square test, significant difference between 2 groups ($p<0.05$), *Frequency, n (%),
†Median

More than half of the subjects in both groups in this study had children. A higher proportion of the Caucasian women (60%) reported to have a past history of ID/IDA. Despite the previous history of ID/IDA, only a small percentage of Caucasian women reported to have low iron status during their past pregnancies.

Estimated menstrual blood loss was low (< 35 Blood loss unit (BLU)) to medium (35 - 71 BLU) among women of both groups. However, there was significant difference (p=0.014) between the 2 groups in the length of menstrual periods. Caucasian women had more menstrual period days with a median of 5 (4, 6) vs. 4 (3, 5) days in the Solomon Islands group (Table 4.4). Ten percent of Solomon Islands and 20% of Caucasian women reported that they had donated blood, although, all of them donated blood more than six months ago. A few of the women in either group reported suffering from nose bleeds or having a blood transfusion (Table 4. 4). A significant difference (p=0.001) in contraceptive use between the two groups was identified. More Caucasian women reported using contraceptives than Solomon Islands women. The most commonly used method by the Caucasian women was oral contraceptive (Table 4.4).

Regarding nutrient supplement intake, there was a significant difference (p=0.001) observed between the two groups. More Caucasian women (66.7%) used either one or both multi vitamins and mineral supplements compared to Solomon Islands women (12.8%). Likewise, a larger proportion of Caucasian women (44%) reported taking other dietary supplements. The types of multi vitamins/mineral supplements used were divided in two groups, supplements with iron and those with vitamin C (Appendix R).

4.5. Lifestyle and dietary practices

The participants were asked a number of questions related to their dietary practices. The number of participants, who reported adherence to a special diet or dieting in the past year and adherence to different eating patterns, are reported in table 4.5.

Table 4.5: Responses to different dietary practices of Solomon Islands and Caucasian women*

Variables	Solomon Islands women (n=39)	Caucasian women (n=75)	*p* value**
Special diet	3 (7.7)	2 (2.7)	NA
Dieting in the past year	6 (15.4)	8 (10.7)	NA
Eating pattern;			NA
Eat a variety of all foods, including animal products	32 (82.1)	66 (88)	
Eat eggs, dairy, fish and chicken but avoid other meats	4 (10.3)	7 (9.3)	
Eat eggs and dairy products but avoid all meats and fish	0 (0)	2 (2.7)	
Eat eggs but avoid dairy products, all meats and fish	3 (7.7)	0 (0)	
Eating out at restaurant, food courts or cafes;			
Less or once per week	23 (59)	39 (52.7)	
More than Once per week	16 (41)	35 (47.3)	0.524
Eating fast foods (take away, fish and chips, McDonalds);			
Less than once per week	27 (69.2)	68 (91.9)	
Once or more times per week	12 (30.8)	6 (8.1)	0.002**

NA: Not applicable (assumption for statistical test not met due to few subjects in some cells)
*Frequency n (%)
***p* values using Pearson Chi-Square test, significant difference between 2 groups ($p<0.05$)

Women were asked about eating out and consumption of fast foods such as takeaways (Table 4.5). Although there were no significant differences in eating out at restaurants and cafes there was a significant difference in fast food per week between the two groups ($p=0.002$). More Solomon Islands women (30.8%) reported having fast food once or more times per week compared to the Caucasian women (8.1%) (Table 4.5). Women were also asked about their eating pattern and the common eating pattern identified among women in both groups was "eating a variety of all foods, including animal products" (Table 4.5).

Women were asked if they had knowledge about foods and drinks with added iron and if they had considered buying those items. A large proportion of Solomon Islands women did not know (35.9%) or did not consider buying (30.8%) foods or drinks which were fortified with iron. While more Caucasian women (88%) knew about those food items but about half (50.7%) of the women did not consider buying them. A question on using cast iron pan, wok or pot when preparing meals was also asked, 23% of Solomon Islands and 44% of Caucasian women reported that they had never used those cooking utensils. However, 31% and 17% of the proportion of women in both groups (Solomon Islands and Caucasian, respectively) reported using cast iron pan, wok or pot 2 - 3 times per week.

4.6. Dietary Assessment

A comprehensive dietary assessment was undertaken which include a food frequency questionnaire, a 24-hour dietary recall and a structured questionnaire on dietary habits. The different dietary assessments method were focused on foods rich in iron and foods containing factors known to enhance or inhibit iron absorption. Also, dietary habits that might contribute to poor or enhanced iron status among the two groups.

4.6.1. Results from the iron food frequency questionnaire

To identify the frequency of intake in a broader perspective of nutrients which influence iron absorption, single food items from the iron food frequency questionnaire (FeFFQ) were grouped. For example, foods with similar contents in iron, vitamin C, fibre and calcium were grouped together and items with polyphenols were grouped together (Table 4.6). The results from the FeFFQ food groups indicate that there were no significant differences between the Solomon Islands and Caucasian women in their frequency of intake of red meat intake, milk and polyphenol drinks. Fish and sea foods, medium to high vitamin C fruits and, grains and bread were consumed significantly more frequently by the Solomon Islands women (p=0.001, p=0.002 and p=0.001, respectively) whereas dairy products were more frequently consumed by the Caucasian women (p=0.001) (Table 4.6).

Table 4.6: Frequency of intake of groups of foods influencing iron status per week*

Food items	Solomon Islands women (n=39)	Caucasian women (n=75)	*p* value**
Red meat, prepared meat and offal	3.75 (2.5, 5.5)	3.5 (2.0, 5.0)	0.187
White meat	3 (2.0, 4.5)	3 (2.0, 5.5)	0.942
Fish and seafood	5 (3.0, 8.0)	1.5 (0.50, 2.5)	0.001**
Nuts and seeds	2.5 (1.0, 3.5)	2.5 (1.0, 7.5)	0.271
Legumes	2 (0.5, 3.5)	1 (0.5, 3.5)	0.381
Medium high vitamin C fruits	8.4 (3.35,14.8)	3.25 (1.5, 7.5)	0.002**
All other fruits	11.0 (5.50,19.5)	10.5 (6.0,19.5)	0.794
Medium high vitamin C vegetables	10.4 (3.4, 17.8)	8 (5.0, 8.0)	0.162
All other vegetables	24 (16.0,37.25)	21 (15.0, 28.0)	0.156
All other breakfast cereal	4 (1.0, 6.0)	2.5 (0.50, 5.5)	0.368
Grains and breads	18.4 (12.8, 32.9)	10.5 (8.0, 16.0)	0.001**
Cakes, biscuits and crackers	4 (2.5, 7.0)	4.5 (1.5, 7.0)	0.788
Tofu and soy milk	0.0 (0.0, 0.50)	0.0 (0.0, 0.50)	0.810
Milk	5 (1.0, 9.5)	6 (2.5, 7.5)	0.975
All dairy products	3.5 (1.5, 6.4)	9 (6.0, 11.0)	0.001**
Alcohol group	0.0 (0.0, 1.0)	2 (0.5, 5.0)	0.001**
Coffee (all varieties)	1 (0.0, 7.0)	5 (0.5, 17.0)	0.124
Polyphenol drinks	7 (2.5, 21.0)	12.5 (2.5, 20.0)	0.872

*Median (25^{th}, 75^{th} Percentile)
***p* values using Mann Whitney U test, significant difference between 2 groups ($p<0.05$)

When individual food items were analysed, the frequency of consumption per week varied with different foods between the two groups. Median beef consumption was high among Caucasian women, whilst corn beef, soup meat and meat pies were more frequently consumed by the Solomon Islands women (Appendix P). Solomon Islands women had a higher frequency of intake of sea foods (fresh, frozen, canned and mussels), fruits (citrus fruits, kiwifruit, fruit salad and apple) and vegetables (kumara, cabbage, spinach and other

green leafy vegetables) compared to Caucasian women. However, the frequency of consumption of cheese, milk as in food and yogurt were higher among the Caucasian women compared to Solomon Islands women. Regarding the types of beverages, the median frequency of intake of tea (p=0.005) and Milo (p=0.001) were significantly higher among the Solomon Islands women. Refer to Appendix P for the complete result of iron food frequency questionnaire (FeFFQ).

4.6.2. Dietary Habits

Women were asked how many servings of fruit, vegetables and meat/fish/chicken they normally consumed on week days and weekend days. Table 4.7 presents the median servings of fruit, vegetable and meat/fish/chicken and the proportion of women who have reported to consume 2 or more servings of fruits, 3 or more servings of vegetables and 1-2 servings of meat/fish/chicken on week days and weekend days. The number of servings of fruit and vegetables used in this study was according to the five plus a day recommendation by the NZ Ministry of Health (MoHNZ, 2003). Servings of meat per day was according to the Medlineplus, American Cancer Society and American Heart Association (AHA) recommendations 2012 guidelines for meat, poultry and fish (AHA, 2012; Dugdale, 2010).

Table 4.7: Daily intake of servings of fruits, vegetables and meat by Solomon Islands and Caucasian women*

Week days/weekend	Solomon Islands women (n=39)	Caucasian women (n=75)	*p* value**
Servings of fruits per week days	2 (1.0, 3.0)	3 (3.0, 4.0)	0.001**
≥ 2 fruits per day	25 (64.1)	70 (93.3)	NA
Servings of fruits per weekend days	2 (1.0, 3.0)	3 (2.0, 4.0)	0.003**
≥ 2 fruits per weekend day	23 (59)	69 (92)	NA
Servings of vegetables per week days	2 (1.0, 2.0)	4 (3.0, 5.0)	0.001**
≥ 3 vegetables per week day	9 (23.1)	72 (96)	NA
Servings of vegetables per weekend days	2 (1.0, 2.0)	4 (3.0, 5.0)	0.001**
≥ 3 vegetables per weekend day	21 (53.8)	64 (86.4)	NA
Servings of meat/fish/chicken per week days	1 (1.0, 2.0)	2 (2.0, 4.0)	0.001**
1 – 2 servings of meat/fish/chicken per week day	33 (84.6)	45 (60)	NA
Servings of meat/fish/chicken per weekend days	2 (1.0, 2.0)	2.5 (2.0, 3.0)	0.001**
1 – 2 servings of meat/fish/chicken per weekend day	36 (92.3)	37(49.3)	NA

NA- Not applicable (assumption for test not met due to few subjects in some cells),
*Median (25^{th}, 75^{th} percentile) or frequency (%)
***p* values using Mann Whitney U test, significant difference between 2 groups ($p<0.05$)

Note: Description of servings in this study:

One serving fruit = one apple, pear, banana, orange, two small apricots or plums, half a cup of fruit salad or stewed fruit, one cup of juice, two tablespoons of raisins or three dates.

One serving vegetables = one medium potato or kumara, one tomato, half a cup of cooked vegetables or salad vegetables.

One serving meat = two slices of cooked meat, one medium steak, ¾ cup of mince or casserole, one medium fillet of fish, two chicken drumsticks or one chicken leg.

As shown in table 4.7, there was a significant difference between the two groups in servings of fruit both on week days and weekend days (p=0.001 and p=0.003 respectively). The study revealed that median intake of fruit servings per day during a week was significantly higher among the Caucasian women, although a fair proportion of Solomon Islands women (64%) reported to consume 2 or more servings of fruit per day. Servings of vegetables during the week and weekend days were significantly lower among the Solomon Islands women (p=0.001 and p=0.001 respectively). The median intake of meat/fish/chicken servings on week days and weekend days was significantly higher among Caucasian women (p=0.001 and p=0.001, respectively). However, a large proportion of Solomon Islands women consumed 1 -2 servings of meat/fish/chicken per day both on week days and on weekend days (Table 4.7).

Participants were asked what meals of the day they frequently ate and which foods they consumed. Table 4.8 describes the frequency of meals usually consumed in a day.

Table 4.8: Frequency of meals consumed during the day*

Meal times	Solomon Islands women (n=39)	Caucasian women (n=75)	*p* value**
Before breakfast			
Always	5 (12.8)	11 (14.7)	
Sometimes	17 (43.6)	8 (10.7)	0.001**
Never	17 (43.6)	55 (73.3)	
Breakfast			NA
Always	22 (56)	57 (76)	
Sometimes	15 (38.5)	12 (16)	
Never	2 (5.1)	5 (6.7)	
Between breakfast and lunch			
Always	5 (12.8)	31 (41.3)	0.006**
Sometimes	28 (71.8)	37 (49.3)	
Never	6 (15.4)	6 (8)	
Lunch			NA
Always	20 (51.3)	64 (85.5)	
Sometimes	19 (48.7)	9 (12)	
Never	0 (0)	1 (1.3)	
Between lunch and evening meals			
Always	8 (20.5)	41 (54.7)	0.002**
Sometimes	26 (66.7)	28 (37.3)	
Never	5 (12.8)	5 (6.7)	
Evening meal			NA
Always	29 (74.4)	70 (93.3)	
Sometimes	8 (20.5)	2 (2.7)	
Never	2 (5.1)	2 (2.5)	
After evening meal			
Always	7 (17.9)	15 (20)	0.860
Sometimes	23 (59)	45 (60)	
Never	9 (23.1)	14 (18.7)	
Other times (e.g. midnight)			
Always	3 (7.7)	15 (20)	0.001**
Sometimes	12 (30.8)	45 (60)	
Never	24 (61.5)	14 (18.7)	

NA: Not applicable (assumption for statistical test not met due to few subjects in some cells)
*Frequency n (%)
***p* values using Pearson Chi-square test, significant difference between 2 groups ($p<0.05$).

Note: Definitions; Always (5 to 7 times per week), sometimes (2 to 4 times per week), never (0 to 1 time per week).

The study shows a significant difference between the two groups in the in-between meals (snacks). More Caucasian women reported that they ate between main meals than the Solomon Islands women. Nonetheless, large proportions of women in both groups reported that they always eat their three main meals of the day (Table 4.8).

The women were also asked if they normally drink beverages up to an hour before or after meals and what type drinks they frequently consumed. Participants' responses are shown in table 4.9. This is purposely to identify the enhancers and inhibitors of iron uptake.

Table 4.9: Percentage of participants who usually drink beverage between 1 hour before or after meal time*

Meal times	Solomon Islands women (n = 39)	Caucasian women (n=75)
Breakfast	37 (94.9)	64 (85.3)
Lunch	39 (100)	73 (97.3)
Evening meal	39 (100)	73 (97.3)
Snacks	39 (100)	73 (97.3)

*Frequency n (%)

As shown in table 4.9, the majority of women in both groups frequently drank a beverage one hour before or after their meals. Water is shown to be the most consumed drink prior to or after all of the meals in both groups (Table 4.10). However, there was a significant difference between the two groups in fruit and vegetable juices and tea (all varieties), coffee and chocolate based drinks intake. More Solomon Islands women reported consuming fruit and vegetable juices and tea prior to or after evening meals (p=0.03 for fruit and vegetable juices and p=0.005 for tea), snack (p=0.004 for fruit and vegetable juices and p=0.005 for chocolate based drinks) and supper (p=0.001 for fruit and vegetable juices, p=0.03 for tea and p=0.017 for coffee) (Table 4.10).

Drinks were ranked according to the Solomon Islands women's intake. The first five drinks were ranked as the most commonly consumed drinks. Table 4.10 gives the summary of the types of drinks usually consumed one hour before or after each meal.

Table 4.10: The five top drinks usually consumed by the Solomon Islands and Caucasian women 1 hour before and after meals *

Type of drinks	Solomon Islands women (n=39)	Caucasian women (n=75)	*p* value**
Prior to/after breakfast;			
Water (all varieties)	26 (66.7)	35 (46.7)	0.463
Tea (all varieties)	23 (59)	31 (41.3)	0.531
Coffee (all varieties)	12 (30.8)	25 (33.3)	0.737
Chocolate based drinks, (e.g. Milo)	9 (23.1)	6 (8)	0.082
Milk or milk based drinks	8 (20.5)	6 (8)	0.152
Lunch;			
Water (all varieties)	31 (79.5)	48 (64)	0.109
Fruit and vegetable juices	15 (38.5)	17 (22.7)	0.131
Tea (all varieties)	14 (35.9)	23 (30.7)	0.787
Milk or milk based drinks	9 (23.1)	7 (9.3)	0.069
Coffee (all varieties)	6 (15.4)	19 (25.3)	0.150
Evening meal;			
Water (all varieties)	29 (74.4)	52 (69.3)	0.912
Fruit and vegetable juices	18 (46.2)	18 (24)	0.034**
Tea (all varieties)	16 (41)	12 (16)	0.005**
Coffee (all varieties)	8 (20.5)	8 (10.7)	0.210
Milk or milk based drinks	7 (17.9)	5 (6.7)	NA
Snack;			
Water (all varieties)	33 (84.6)	58 (77.3)	0.505
Tea (all varieties)	25 (64.1)	33 (44)	0.057
Fruit and vegetable juices	19 (48.7)	16 (21.3)	0.004**
Coffee (all varieties)	16 (41)	34 (45.3)	0.574
Chocolate based drinks, e.g. Milo	14 (35.9)	10 (13.3)	0.005**
Supper;			
Water (all varieties)	26 (66.7)	43 (70.5)	0.687
Tea (all varieties)	26 (66.7)	27 (44.3)	0.029**
Fruit and vegetable juices	14 (35.9)	4 (6.6)	0.001**
Chocolate based drinks, e.g. Milo	12 (30.8)	27 (68.2)	0.385
Coffee (all varieties)	11 (28.2)	6 (9.8)	0.017 **

NA: Not applicable (assumption for statistical test not met due to few subjects in some cells)
*Frequency n (%)
***p* values using Pearson Chi-Square test, significant difference between 2 groups ($p<0.05$)

As part of the eating habit assessment, the women were asked to report the types of foods and drinks they usually consumed at each meal. The items were ranked according to the

Solomon Islands women's intake. Water has been excluded from the list to show variation in food and beverage intake more appropriately.

From the ranked food items for breakfast, there was a significant difference (p=0.013) observed for bread or toast between the two groups. Ninety two percent of Solomon Islands women reported having bread or toast for breakfast. Fruit consumption was also shown to be high by the Solomon Islands women for breakfast. Although there is no significant difference in breakfast cereals and milk products, a large proportion (71.9%) of Caucasian women reported having those foods for breakfast (Table 4.11).

The intake of bread (e.g. sandwiches, rolls, etc.) for lunch was high in both groups, Solomon Islanders (92.3%) and Caucasian (94.5%). Meats (e.g. meat, fish, chicken, seafood, ham) intake at lunch time was significantly different (p=0.001) between the groups. A larger percentage of Solomon Islands women (89.7%) ate meat at lunch time than Caucasian women (54.3%). Meats (e.g. meat, fish, chicken, seafood, and ham), starchy foods and vegetables (including salad) were consumed by almost all women in both groups during the evening meals (Solomon Islands 92% vs. 91% Caucasian women, 87% vs. 83% and 87% vs. 97% respectively). Items that were consumed by high proportions of women in both groups as snack were fruits, crackers and tea (all varieties). At supper, fruit, fruit and vegetable juices, crackers and tea (all varieties) were ranked higher by the Solomon Islands women. Table 4.11 summarises the top five ranked items consumed at each meal category. The complete list of items frequently consumed is presented in Appendix Q.

Table 4.11: The five top foods/drinks frequently consumed at each meal during the day*

Food items ranked as top five (5) in each meal	Solomon Islands women (n=39)	Caucasian women (n=75)	*p* value**
Five top foods/drinks usually eaten at breakfast;			
Bread or toast	36 (92.3)	46 (61.3)	0.013**
Fruits	27 (69.2)	34 (53.1)	0.107
Milk products (e.g. yoghurt, dairy foods, ice cream)	25 (64.1)	49 (76.6)	0.173
Breakfast cereals	24 (61.5)	46 (71.9)	0.276
Tea (all varieties)	23 (59)	31 (41.3)	0.531
Five top foods/drinks usually eaten at lunch;			
Bread (e.g. sandwiches, rolls, etc)	36 (92.3)	69 (94.5)	0.645
Meats (e.g. meat, fish, chicken, seafood, ham)	35 (89.7)	40 (54.3)	0.001**
Fruits	25 (65.8)	40 (54.3)	0.265
Vegetables (including salad)	24 (61.5)	39 (53.4)	0.410
Starchy foods (e.g. Pasta, rice, potato)	20 (51.3)	23 (31.5)	0.040**
Five top foods/drinks usually eaten at dinner;			
Meats (e.g. meat, fish, chicken, seafood, ham)	36 (92.3)	68 (91.9)	0.938
Starchy foods (e.g. pasta, rice, potato)	34 (87.2)	62 (82.7)	0.685
Vegetables (including salad)	34 (87.2)	73 (97.3)	0.029**
Fruits	21 (53.8)	11 (14.9)	0.001**
Fruit and vegetable juices	18 (46.2)	18 (26.1)	0.034**
Five top foods/drinks usually eaten as snack;			
Fruits	32 (84.2)	53 (72.6)	0.171
Tea (all varieties)	25 (64.1)	33 (45.2)	0.057
Biscuits or cakes	23 (59)	31 (42.5)	0.096
Crackers	22 (78.8)	41 (56.4)	0.04**
Fruit and vegetable juices	19 (48.7)	16 (21.9)	0.004**
Five top foods/drinks usually eaten at Supper;			
Tea (all varieties)	26 (66.7)	27 (44.3)	0.029**
Fruits	20 (51.3)	19 (31.1)	0.044**
Biscuits or cakes	14 (35.9)	19 (31.1)	0.62
Crackers	14 (35.9)	2 (3.3)	0.001**
Fruit and vegetable juices	14 (35.9)	4 (5.3)	0.001**

*Frequency n (%)
***p* values using Pearson Chi-Square test, significant difference between 2 groups ($p<0.05$)

4.6.3. 24-hour dietary recall

Daily nutrient intake for the Solomon Islands women was assessed using a 24-hour dietary recall to obtain the average daily intake of iron and other nutrients associated with iron status. The 24-hour dietary recall results showed that the mean ± SD of energy (KJ) intake was 6839.8 ± 2295.7 (KJ), the median (25^{th}, 75th) of protein, vitamin C and fiber intake were 64.8 g (50.02, 84.6), 57.7 mg (29.3, 107.9) and 14.6 g (11.5, 18.7) respectively. The mean (95% CI) for calcium and iron intake were 391.5 mg (320.5, 473.4) and 8.94 mg (7.6, 10.6) respectively. This result identified that the daily intake of all the nutrients associated with iron status was low except for protein, while iron intake was only half of the recommended daily intake (Table 4.12).

Table 4.12: Average daily nutrient intake of the Solomon Islands women from the 24-hour dietary recall

Nutrients	Dietary intake	RDI for women age 18 – 45yrs (NZ & Australian reference values)
Energy (KJ)*	6839.8 ± 2295.7	7701 - 8783 KJ/day
Protein (g)**	64.8 (50.02, 84.6)	45 - 46 g/day (0.75 g/kg)
Carbohydrate (g)*	195.3 ± 80.1	214 g/day
Total fat (g)*	61.6 ± 33.3	72 g/day
SFA (g)	21.9 ± 13.2	
PUFA (g)	10.5 ± 6.89	
MUFA (g)	22.9 ± 13.4	
Fiber (g)**	14.6 (11.5, 18.7)	28 g/day (SDT)
Vitamin C (mg)**	57.7 (29.3, 107.9)	190 mg/day (SDT)
Calcium (mg)***	391.5 (320.5, 473.4)	1,000 - 1,300 mg/day
Iron (mg)***	8.94 (7.6, 10.6)	18 mg/day
Percentage of Energy (KJ) from macronutrients		AMDR
Fat *	30.7 ± 11.2	20 - 35
Carbohydrate*	47.2 ± 13.2	45 - 65
Protein*	17.5 ± 7.3	15 - 25
SFA*	11.2 ± 5.01	<10
PUFA*	5.5 ± 2.7	6 – 10
MUFA*	11.8 ± 4.8	Difference

RDI (Recommended daily intake), AMDR (Acceptable Macronutrient distribution range), SFA (Saturated fatty acids), PUFA (Polyunsaturated fatty acids), MUFA (Monounsaturated fatty acids), SDT (Suggested dietary target).
*Mean ± SD,
**Median (25^{th}, 75th),
***Mean (95% CI)

To supplement the fruit and vegetable data (Table 4.7), we extracted the number of fruit and vegetable servings that the Solomon Islands women reported in the 24-hour dietary recall. The results showed that the median (25^{th}, 75^{th}) servings of fruit and vegetables consumed the day before their visit to the research centre were 1 (0.0, 2.0) and 2 (1.0, 3.0) servings respectively. The median (25^{th}, 75^{th}) total number of vegetables consumed (thus, not servings, but the total number of different types of vegetables including those from mixed dishes which may be more reflective of the frequency data) the previous day was 3 (2.0, 4.0).

Chapter 5: Discussion

This study aimed to assess and compare the iron status and factors influencing iron status of Solomon Islands' with Caucasian women living in NZ. To our knowledge this is the first study to look at women of the Solomon Islands living in NZ. The participants were non-pregnant Solomon Islands women aged between 18 and 45 years living in and around Auckland and age matched randomly selected Caucasian women.

5.1. Characteristics of Solomon Islands women

A substantial proportion of women from the Solomon Islands who took part in this study reached overseas' high school qualification or NZ NCEA L3. With only a few engaged in paid employment the vast majority were either homemakers or students at time of this study. The majority of these women were born in the Solomon Islands before migrating to NZ. Furthermore, this study identified a higher prevalence of overweight/obesity and greater waist circumferences among Solomon Islands women as opposed to Caucasian women, and a large number of women in the Solomon Islands group were found to have an excess percentage of body fat.

5.2. Iron status and factors influencing iron status of Solomon Islands' and Caucasian women

This study found no significant difference in the proportion of women with ID and IDA between Solomon Islands and Caucasian women, but, some variation in the dietary intake and practices were found between the two groups. Processed meat and fish/sea food, medium – high vitamin C fruits and grain and cereals, milk as in drink and black tea were consumed more frequently by Solomon Islands women than the Caucasian women. Also more Solomon Islands women reported consuming fruits and vegetable juices and tea an hour prior to or after meals/snacks. However, beef, dairy products such as cheese, yogurt and milk as in food and nutrient supplement intake were significantly lower in Solomon Islands women compared to Caucasian women. Solomon Islands women also reported shorter menstrual periods and their contraceptive usage was significantly lower than the Caucasian women. Other factors such as blood donation (6 months prior to study), past

history of ID/IDA and chronic diseases were also reported by greater numbers of Caucasian women compared to Solomon Islands women.

5.2.1. Prevalence of iron deficiency and iron deficiency anaemia

Mean SF and Hb were within the normal ranges for women in both groups and the percentage of women with ID and IDA was low in both groups. This was possibly due to the participants' frequent intake of iron-rich foods such as meat and fish, as well as foods that enhance iron absorption such as those rich in vitamin C as identified in past studies (Hunt, 2003; Heath et al., 2001b). Also another contributing factor to the low prevalence of ID and IDA may have been education as most of these women were well educated, as lack of education was suggested to be associated to high prevalence of IDA (SPC, 2009b).

5.2.2. Protective dietary factors for adequate iron status

According to the results of the FeFFQ, fish and seafood were consumed more frequently by Solomon Islands women than Caucasian women. Like red meat and chicken, fish also has a an enhancing factor as alluded to by many studies namely the meat, fish and poultry factor (MFP or meat factor) that aids iron absorption (Sharp & Srai, 2007; Reddy, Hurrell & Cook, 2000). This could be a contributing factor to the low prevalence of ID and IDA among Solomon Islands women despite eating less beef. In addition, the frequent intake of processed meat such as canned corn beef, meat pies and soup meat by Solomon Islands women could contribute to adequate iron stores, even though these were not healthy choices of meat (Micha, et al., 2010). Consumption of these products could be due to the higher cost of fresh meat or a preference for processed meat as they are also quick and easy to prepare. These choices may also contribute to the higher prevalence of overweight/obesity identified in this study among Solomon Islands compared to Caucasian women.

This high frequency of fish/seafood consumption reflects past reports on seafood consumption of Solomon Islanders, which show that the Solomon Islands has one of the highest rates of seafood consumption in the world. The annual estimated intake of fish is

45.5kg of fish per capita, with 36.7% consumed as fresh fish, 31% as frozen fish and 32.3% as canned fish (Richards et al., 1994). In Honiara, 31% of households eat fresh fish every day, and 82.4% of meals contain fish as a source of protein (Crossland & Philipson, 1993, as cited in Richards et al., 1994). A recent survey by the Solomon Islands National Statistics Office & United Nations Development Program Pacific (2008) found that canned tuna is the top animal food source consumed in Honiara. Eason 1985 cited in WHO (2003b) also noted that fresh fish was the main source of protein in rural Solomon Islands communities. Therefore, the frequency of intake of fish/seafood by Solomon Islands women in NZ is reflective of the pattern of consumption of their original country.

The results from the habitual dietary intake in this study also found that a substantial percentage of Solomon Islands women reported having one to two servings of meat, fish and chicken while a larger proportion of Caucasian women usually had two or more servings of meat, fish and chicken in a week (Table 4.7). This is also reflected in the FeFFQ results although meat, fish and chicken were analysed for the frequency of consumption per week and each item was assessed separately. According to the World Cancer Research Fund International/American Institute for Cancer Research 2007, eating red meat one to two times a week is considered a moderate intake, as more than five servings per week has been associated with increased risk of colon cancer. The current recommendation per week for red meat intake is 300 – 500 grams (World Cancer Research Fund International, 2007; Byer et al., 2001). This does not include other meat, such chicken and fish. Despite a difference in the number of servings of meat, fish and chicken per week between the two groups, there was no variation in iron status.

The FeFFQ also showed that Solomon Islands women consumed medium- to high-vitamin C fruits and vegetables more frequently than Caucasian women, and this could be another protective factor against low iron levels in Solomon Islands women in this study. Solomon Islands women more frequently consumed cabbage, kumara, spinach and other green leafy vegetables, compared to Caucasian women (Table 4.6). Moreover, fruit and fruit & vegetable juice intake was reported by significant numbers of Solomon Islands

compared to Caucasian women in the dietary habits questionnaire. Beck et al. (2011) found that consumption of fruit high in vitamin C (kiwifruit) with a fortified breakfast cereal improved iron status compared to a fruit low in vitamin C (banana). Fruits that were reported to be consumed more frequently by Solomon Islands women were apples, citrus fruits and green and gold kiwifruit. Previous studies have confirmed that vitamin C enhances iron absorption by reducing ferric to ferrous iron for mucosal cell uptake and preventing the formation of insoluble complexes that cannot be absorbed at intestinal pH (Reddy et al., 2000; Hallberg et al., 1989).

Fruit and vegetable intakes by Solomon Islands women were reported to be considerably higher in the FeFFQ compared to the dietary habit questionnaire and 24-hour recall. The dietary habit and 24-hour recall showed that the number of servings of fruit and vegetables consumed per day by Solomon Islands women was below the recommended minimum of three vegetable and two fruit servings per day for adults (Byer et al., 2001; MoHNZ, 2003). This is in line with the results of the recent STEPS survey in the Solomon Islands which suggest that fruit and vegetable intake in Solomon Islanders might be low, as 94% of the surveyed population consumed less than five servings per day (MoHSI & WHO, 2010). Also, several NZ-based studies have found that Pacific Islanders and Asians consumed fewer servings of fruit and vegetables compared to NZ Europeans (MoHNZ, 2008; Metcalf et al., 1998 & Bell et al., 1999). Therefore, the high frequency of fruit and vegetable consumption reported by Solomon Islands women in this study could be due to an overestimation from the FeFFQ, which has been the case for other studies that have used FFQs (Bell et al., 1999; Krebs-Smith et al., 1995). However, despite different intakes of fruit and vegetables between Solomon Islands and Caucasian women, there was no significant difference in iron status between the two groups.

According to the 24-hour recall data, the geometric mean (95% CI) intake of iron was just 8.94 (7.6, 10.6) mg/d, much lower than the 18 mg/d, which is the recommended daily intake of iron for women of reproductive age in NZ (MoHNZ, 2006). This is similar to Ferguson et al.'s (2001) finding on daily iron intake of 9.6 mg/d amongst Pacific Islands' women in NZ. Also, the Adult Nutrition Survey (MoHNZ 2011) reported an average daily

intake of iron to be 9.9 mg/d in women. As shown by the above NZ based studies, the average daily intake of iron by women in NZ was lower than the daily recommended intake, despite the abundance of food sources of iron. However, the FeFFQ and dietary habit questionnaire both showed meat, fish and poultry consumption to be adequate, and there is a high percentage of Solomon Islands women with normal iron status. Therefore, the daily iron intake identified in this study may be due to under-reporting in the 24-hour recall interview and may not truly represent actual iron intake of Solomon Islands women.

Intake of multivitamins/mineral and dietary supplements was significantly higher in Caucasian women compared to Solomon Islands women. As consumption of nutritional supplements may be a protective factor against ID/IDA, this may be a contributing factor to Caucasian women's adequate iron status in this study. Low intake of nutrient supplements in Solomon Islands women may be due to lack of affordability, or possibly due to preference as nutritional supplements are rarely consumed in the Solomon Islands (SPC, 2009b). As there was no difference in iron status between the two groups despite a disparity in supplement consumption, this could indicate that Solomon Islands women had adequate intake of other iron-promoting foods and nutrients such as meat, fish, chicken, vitamin C and perhaps less intake of iron uptake inhibitors (Zijp, Korvor & Tijburg, 2000).

5.2.3. Non- protective dietary factors for adequate iron status

In this study, Solomon Islands women consumed more cereal and grains compared to Caucasian women. Cereals and grains are sources of fibre and phytate, which are known to inhibit iron absorption (Hurrell & Egli, 2010). However, of all cereal and grains, only consumption of white rice and white bread was significantly higher in Solomon Islands compared to Caucasian women. These foods are highly refined and contain less fibre than other cereals and grains (MoHNZ & New Zealand & Plant and Food Research, 2009), therefore, their consumption may not have had a significant negative effect on iron absorption. This is supported by the substantial percentage of Solomon Islands women with normal iron status in this study. The high intake of white rice and bread is consistent with an emerging dietary pattern in the Pacific Islands (including the Solomon Islands),

where imported foods such as rice and wheat flour products are frequently consumed in place of local foods (Foley et al., 2011).

Milk as a source of dietary calcium has been suggested to inhibit iron absorption (Hallberg et al., 1991; Hallberg et al., 1992; Kruger et al., 2009). Solomon Islands women in this study consumed dairy products such as cheese, yoghurt and milk (as in food) less frequently, and milk (as a drink) more frequently than Caucasian women. From the dietary habit results of this study, intake of milk products at breakfast was reported by high percentages of women in both groups (64% Solomon Islands vs. 77% of Caucasian women). Also, milk or milk based drinks were among the five top drinks usually consumed an hour prior or after meals. However, regular consumption of milk with meals appears to have not adversely affected iron status, as shown by the large proportions of women in both groups with normal iron stores.

Previous studies regarding calcium intake and iron absorption have found contradictory results. Heath et al. (2001a) and Roughead et al. (2002) found no inhibitory effect of calcium on iron absorption, whilst the results of Rangan et al. (1997) and Kruger et al. (2009) indicated that calcium posed a risk to poor iron absorption if consumed at meal times. Our study only considered the frequency of consumption of food sources of calcium, but did not investigate whether there was a correlation between calcium and iron uptake.

There was no significant difference in total consumption of polyphenol non-alcoholic beverage between the two groups (Table 4.6). But, when individual items were assessed, consumption of Milo and black tea was significantly higher in Solomon Islands women compared to Caucasian women. This was supported by the dietary habit results, which identified four beverages in addition to water that the Solomon Islands women commonly consumed within one hour of meals: tea, coffee, chocolate-based drinks and milk (Table 4.10). Tea was also shown to be one of the top five items consumed alongside the evening meal and supper by Solomon Islands women.

The consumption of beverages containing polyphenols for example black tea within an hour of the evening meal by a large proportion of Solomon Islands women is a concern, as iron uptake may be affected (Kruger et al., 2009; Thankachan et al., 2008; Nelson & Poulter, 2004; Samman et al., 2001). Although the inhibitory effects of these beverages were not assessed in relation to iron absorption in this study, such practices could increase the risk of ID/IDA. No studies in the Solomon Islands have investigated the consumption of polyphenol non-alcoholic beverage intake in women in the past, but it is likely to be one of the factors contributing to high rates of IDA among women living in the Solomon Islands.

This study also assessed alcohol intake, and found that the Caucasian women drank alcohol more frequently than Solomon Islands women (Table 4.6). Although the frequency of alcohol consumption was low in Solomon Islands women, results from the dietary habit questionnaire showed that 15% Solomon Islands women usually drank alcohol with their evening meal, and 10% with their supper. Because the dietary habit questionnaire does not assess quantities, the amount of alcohol consumed by women in this study cannot be compared with results from the Solomon Islands STEP survey, which found that 20% of women consumed four or more standard alcoholic drinks per day in the week prior to the interview (MoHSI & WHO, 2010). Low alcohol consumption by Solomon Islands women in this study could be one of the protective factors against ID/IDA. The protective factor of low alcohol intake against ID/IDA was also reported by Whitfield et al. (2001).

5.2.4. Dietary habits influencing iron status

There were no differences in the frequency of eating, or of consuming beverages with main meals (breakfast, lunch & dinner) between the two groups. However, there was a significant difference in the frequency of eating or drinking between meals or snacks, with more Caucasian women consuming food or drink between meals than Solomon Islands women (Table 4.9). A study in European, Maori, Pacific and Asian adults in Auckland, NZ, reported that different ethnic groups often have different patterns of eating (Metcalf et al., 2008), therefore, this variation in eating patterns between groups was expected. Solomon Islanders traditionally eat only two main meals a day, one in the morning and one in the

evening (Anecdotal source). In this study, almost all Solomon Islands women also ate or drank at lunch time. The traditional meal pattern is not formalised, and there are no set menus for each meal; rather, people eat whatever food and drink is available at that meal time (Anecdotal source). No studies in the Solomon Islands have investigated eating practices. Thus, this is the first study to assess frequency of eating and drinking at main meal times. Missing meals is not a healthy practice and can lead to inadequate nutrient intake, especially of essential micronutrients such as iron (Nande et al., 2009).
Apart from consumption of tea within an hour of meal times, the foods usually consumed for main meals by the women in this study generally pose no risk to iron status. However, drinking fruit and vegetable juice with main meals is a protective factor, which could minimise the negative effect of tea on iron absorption (Zijp, Korver & Tijburg, 2000) and contribute to the adequate iron status of Solomon Islands women in this study.

It is interesting to compare the dietary intake of women living in the Solomon Islands to that of those living in NZ, and determine the main influences on their iron status. The results of the Solomon Islands 2005/06 Household Income and Expenditure Survey identified the top ten foods consumed by urban and rural dwellers. In the city of Honiara, these were rice, canned tuna, noodles, kumara, breads, cabbage (slippery – also known as Island cabbage), fresh tuna, other fish, cabin biscuits and cassava. In rural communities, kumara, rice, cassava, taro, cooking banana, cabbage (slippery), noodles, coconut (dry nut) and reef fish were most frequently consumed (SI National Statistics & UNDP, 2008). Foods from the top ten items frequently consumed in the Solomon Islands such as rice, canned tuna, bread, noodles, fish, kumara and biscuits were also frequently consumed by Solomon Islands women living in NZ. Animal foods such chicken and meat as well as fruits (vitamin C sources) are lacking in the Solomon Islands top ten foods which could be a contributing factor to the high prevalence of IDA in the Solomon Islands.

A small number of women in each group were on some type of diet, mainly for weight reduction, but this probably had no effect on their iron status. The most common eating pattern in each group was “eating a variety of all foods including animal products” and only 10.3% Solomon Islands and 9.3% Caucasian women avoided red meat. Studies

involving vegetarians and participants with minimal meat intake have found that a diet low in meat is a risk factor for ID/IDA (Harvey et al., 2005; Gibson & Ashwall, 2002; Heath et al., 2001a; Bindra & Gibson, 1986). Those who had reported to avoid red meat in this study may have other animal products and iron food sources that adequately maintain their iron stores. In this study no hypothesis could be drawn about the effect of avoiding red meat and iron status as this was not assessed, but avoiding red meat as the major source of haem iron is a risk to ID/IDA as shown by Heath et al. (2001a). In this study it was also identified that a substantial proportion of Solomon Islands women (31%) compared to Caucasian women (8%) had fast or take-away foods once or more times per week. Although this may not have an effect on their status, it is a risky behaviour for obesity which is a risk factor for ID (Cepeda-Lopeza et al., 2011).

5.3. Other factors influencing iron status

5.3.1. Blood loss

One of the major determinants of ID/IDA in women is blood loss through menstruation (Zimmermann & Hurrell, 2007; Harvey et al., 2005 & Heath et al., 2001a). Women in this study had low to medium blood loss, and although Solomon Islands women had shorter periods than Caucasian women, there was no significant difference in estimated menstrual BLU between groups. This is in line with the lack of difference in iron status between groups. A low to medium level of menstrual blood loss may therefore be protective against ID/IDA. No women in this study reported donating blood within the previous six months, which is another major risk factor for ID in women of reproductive age (Heath, et al., 2001a). Although only a small number of women in each group donate blood regularly, it is an important factor relating to ID as blood loss through blood donation, nose bleeds or secondary to other infections increases the risk of ID/IDA in women (Hercberg et al., 2001; Heath et al., 2001a; Gibson et al., 2002).

5.3.2. Contraceptive use

A significantly lower number of Solomon Islands women used contraceptives compared to Caucasian women. However, none of the Caucasian women used an intra-uterine device

(IUD), which has been known to contribute to heavy menstrual blood loss (Zimmermann & Hurrell, 2007) and thus may increase the risk of ID/IDA. Oral contraceptives were the most commonly used method of contraception by Caucasian women, which is in line with the high oral contraceptive usage in Caucasian women reported by Heath et al. (2001a). As oral contraceptives decrease menstrual blood loss (Callard et al., 1966 as cited in Heath et al., 2001a), their use could be a protective factor for the iron status of Caucasian women. Although the rate of contraceptive usage among Solomon Islands women was lower there was no significant difference in menstrual blood loss unit, both groups had low - medium menstrual blood loss. Thus low BLU is a protective factor on iron status for women in both groups, despite the variation in contraceptive use.

5.3.3. Past history of iron deficiency/anaemia

Women with a previous history of ID/IDA are at increased risk of these conditions. A significantly greater percentage of Caucasian women (60%) reported a previous experience of ID/IDA compared to Solomon Islands women (18%). However, tests for ID/IDA are not usually performed in the Solomon Islands health surveys, or even during pregnancy (Anecdotal source). Therefore, the difference in history of ID/IDA between groups is probably due to Solomon Islands women being unaware of their previous iron status. However, having a history of ID/IDA was not reflected in the iron status of Caucasian women in this study, as most of them were iron replete.

5.3.4. Chronic diseases

Some health and lifestyle practices could also be seen as risk factors contributing to iron status in women. The result showed only one woman (2.6%) of Solomon Islands women had ulcerative proctitis (a severe form of inflammatory bowel condition) compared to a higher proportion of Caucasian women (20%) reported having acute or chronic diseases (e.g. kidney infections, diabetes, thyroid disorder, pneumonia). Iron deficiency and anaemia was reported by many studies as a complication in inflammatory bowel diseases (Wilson, Reyes & Ofman, 2004; Gasche et al., 2004). Conditions such as kidney infection (Astor et al., 2002; McClellan et al., 2004) and diabetes (Thomas, 2008; Perrous et al., 2000) may be associated with the risk of ID/IDA and autoimmune thyroid disorders were

reported to be associated with pernicious anaemia (Perrous et al., 2000). The study of Haidar & Pobocik, (2009) in Ethiopian women reported pneumonia, acute febrile diseases and tuberculosis were some of the major factors leading to IDA. In this study, none of the conditions reported was assessed in relation to IDA in these participants.

5.3.5. Body Mass Index

High BMI is another possible risk factor for ID (Cepeda-Lopeza et al., 2011; Efthekari et al., 2009; Yanoff et al., 2007; Lecube et al., 2006). In this study, a significantly higher percentage of Solomon Islands women were overweight/obese compared to Caucasian women and their average waist circumference was also greater. However, the correlation between BMI and iron status was not assessed in this study due to the small sample size and the small numbers of women with ID and IDA in both groups. The problem of elevated BMI and large waist circumference is prevalent among Pacific Islanders in NZ, especially compared with NZ Europeans (Metcalf et al., 2000). This problem is also common amongst immigrants in developed countries, and is probably a consequence of altered lifestyle and dietary habits (Burns, 2004; Guerin et al., 2007; Drummond et al., 2010; Fitzgerald et al., 2006; & Bell et al., 1999), which is also reflected in this study where Solomon Islands women consumed fast foods more frequently than Caucasian women. Despite the high rates of overweight/obesity reported among Solomon Islands women in this study, there was still only a small percentage with ID/IDA, and no significant difference in the percentage of women with ID/IDA between groups. The high BMI was also noted in the STEPS survey in the Solomon Islands, where 67% of women were overweight (BMI ≥ 25 kg/m^2) and 40% obese (BMI ≥ 30 kg/m^2) (MoHSI & WHO, 2010), but the link between overweight/obesity and ID/IDA was not assessed.

5.4. Iron status of Solomon Islands women living in New Zealand and Solomon Islands

The high proportion of Solomon Islands women with normal iron status in this study could be an indication that Solomon Islands women living in NZ have better iron stores compared to their counterparts in the Solomon Islands. The dietary differences between

Solomon Islands women in this study and in their native country support the hypothesis of SPC (2009b) that the high prevalence of IDA in the Solomon Islands is primarily due to the unavailability of animal sources of iron in the diet (SPC, 2009b). Unlike in Solomon Islands-based studies, this study assessed iron status and factors influencing iron status in women of reproductive age using robust methods of assessment. It is vital that any future studies in the Solomon Islands that investigate iron status measure not only haemoglobin, but other iron biomarkers and factors influencing iron status. This will enable the risks factors for ID/IDA in this population to be established, which are required to plan interventions to reduce the prevalence of IDA. This study identified various risk factors for ID/IDA that could also exist for Solomon Islands women living in their native country.

In spite of the variation identified in dietary intake, there was no significant difference in iron status identified in the proportions of women from both groups. The primary factors that appeared to support adequate iron status in Solomon Islands women in NZ were sufficient intake of meat/fish/poultry, high dietary consumption of vitamin C rich foods, low to medium menstrual blood loss and low rates of blood donation and nose bleeds. The factors that could potentially increase the risk of ID in this group were the consumption of black tea within an hour before or after main meals, low frequency of intake of red meat (beef) and high prevalence of overweight/obesity. As there were limited numbers of women with ID/IDA, no assessment of the relationship between these factors and ID/IDA could be undertaken. However, by comparing these factors in Solomon Islands women with Caucasian women and evidence from other research, protective factors, as well as some risk behaviours for ID/IDA, could be identified.

Strengths and limitations

This is the first study of the Solomon Islands population in NZ. Due to the small population, random sampling was impossible; therefore, only a convenience sample of Solomon Islands women living in NZ could be recruited. The findings of this study cannot be generalised for this population in NZ, future studies may need a random sample to fairly represent the population. Another limitation encountered during this study was the

long length of time required to recruit participants. There was a very slow response from the women, despite the wide promotion of this study among the Solomon Islands community in and around Auckland. To further delay the progress of this study, most of the women who volunteered to participate could not drive and thus arrangements had to be made to bring them to the Research Unit whenever convenient. Regardless of the long waiting time, we were unable to recruit as many Solomon Islands women as initially intended.

Our control sample of Caucasian women was randomly selected from an existing database of previously conducted studies with similar natures and aged-matched with the Solomon Islands group. The sample of Caucasian women was double the size of the Solomon Islands sample, which allows for the variability between groups and allows fair representation of the Caucasian group. The comparison of Caucasian with Solomon Islands women is seen as strength of this study, even though, the results relating to Caucasian women cannot be generalised to all Caucasian women in NZ.

Within this study dietary data was collected using three dietary assessment methods; the FeFFQ which assessed the frequency of intake of foods which may contribute to iron status due to either being high in haem iron or factors enhancing/inhibiting iron absorption. Dietary habitual intake questionnaire used to assess the practices and types of foods and beverages usually consumed at different meal times that could hamper or support iron status of women, in addition, the 24-hour dietary recall interview which was conducted to collect data on the daily average nutrient intake of Solomon Islands. Thus, using different methods of dietary assessment in this study bestow strength to the dietary data reported by this study.

Chapter 6: Summary, conclusion & recommendation

6.1. Summary

Iron deficiency (ID) and iron deficiency anaemia (IDA) are common among women of reproductive age worldwide, and are of even greater concern in developing countries. Past surveys in the Solomon Islands identified IDA (Hb < 120 g/l) as a widespread problem among women of reproductive age. It was hypothesized that rich food sources of iron, such as meat, is lacking in the Solomon Islands diet, leading to a high prevalence of IDA. However, nothing is known about the iron status of Solomon Islands women living in NZ. This cross-sectional study aims to compare iron status and factors affecting iron status of Solomon Islands women with Caucasian women living in and around Auckland. A convenience sample of 40 Solomon Islands women was age-matched with 80 randomly selected Caucasian women. The participants were non-pregnant women aged between 18 and 45 years.

It is important to investigate if Solomon Islands women living in NZ have better iron status than women in the Solomon Islands, and identify the factors influencing their iron status. Therefore, this study assessed ID and IDA in each group, as well as the potential determinants of iron status such as dietary iron intake, dietary practices, consumption of iron uptake inhibitors/enhancers, blood loss, health history and demographic characteristics. Past nutrition surveys in the Solomon Islands did not have the capacity to carry out such a detailed analysis. This is the first study to investigate ID/IDA and factors influencing iron status among Solomon Islands women living in NZ.

This study found no significant difference in the proportion of Solomon Islands and Caucasian women with ID/IDA. A small but equal proportion of women in both groups were identified as having IDA. The factors that appeared to positively influence the iron status of Solomon Islands women in this study were sufficient consumption of meat from the diet and high intake of vitamin C rich fruits and vegetables, which enhance iron absorption. However, this study also identified factors that might increase the risk of ID/IDA among the Solomon Islands women. Consumption of tea an hour before or after

mains meals, a low frequency of meat (beef) intake and a high prevalence of overweight/obesity were the potential risk factors for ID/IDA identified in this study.

6.2. Conclusion

The iron status of Solomon Islands women and Caucasian women did not differ, but the intake of foods influencing iron status varied. From the results of this study, it can be hypothesized that adequate intake of meat/fish/poultry and vitamin C from the diet were the protective factors contributing to adequate iron status of the Solomon Islands women in NZ. It is likely that a different combination of factors will influence iron status in other groups. From the results of this study and from past research, we also suggest that the prevalence of IDA is lower in Solomon Islands women living in NZ, a developed country, compared to living in the Solomon Islands, a developing country. This is possibly due to the adoption of different dietary habits and accessibility to animal food sources of iron in NZ compared to those living in their native country.

6.3. Recommendation

- To conduct nutrition programmes for Solomon Islands women in Auckland/Hamilton to promote healthy eating practices and lifestyles in prevention of overweight/obesity.

- To repeat this study in the future looking at a representative sample of women from all the Pacific Islands living in Auckland, NZ.

- To do a similar study in the Solomon Islands to assess more than one iron biomarker to identify the magnitude of both ID and IDA in women of reproductive age. And to thoroughly investigate factors influencing iron status of women by adjusting the methods and tools used in this study to suit the Solomon Islands context.

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Appendices

Appendix – A

Study information sheet

MASSEY UNIVERSITY
COLLEGE OF SCIENCES
TE WĀHANGA PŪTAIAO

Institute of Food Nutrition and Human Health
Massey University, Private Mail Bag 102-904
North Shore Mail Centre
Albany, Auckland.

Iron status of Solomon Islands women living in New Zealand

INFORMATION SHEET

We would like to invite you to take part in a University research project to assess iron status and to investigate factors which may affect iron status.

Introducing the Researchers
The research is being undertaken by Rosemary Kafa who is from the Solomon Island and currently studying for her Masters in Science (Human Nutrition). The project will be under the supervision of Dr Cathryn Conlon, Associate Professor Welma Stonehouse & Dr Rozanne Kruger at the Institute of Food Nutrition and Human Health, Massey University, Albany, Auckland.

Why is this research important?
In the Solomon Islands iron deficiency anaemia is a huge problem affecting many women of child bearing age. Iron deficiency is not just a problem for developing countries such as the Solomon Islands but is also found in countries such as New Zealand. Iron deficiency can cause tiredness, depression and affect pregnancy outcome. However, once identified, treatment of iron deficiency is simple and effective. Factors that can affect a women's iron status include diet and blood loss from menstruation. To date no research has been done to assess whether iron deficiency is an issue for women of Solomon Islands descent currently living in or around Auckland, New Zealand.

Therefore, this study will assess the iron status of women from the Solomon Islands living in or about Auckland and also investigate factors which may contribute to iron deficiency in women. Information gathered from this study will provide the basis for health care providers to design appropriate interventions to improve the nutritional well being of this group in New Zealand. Also, participants will be given individual feedback on their results and a summary of the findings of the study. It is an excellent opportunity for you to find

out your iron status which will be done by measuring markers in your blood. We will also look at dietary factors that affect iron status and measure your body composition.

Who we are looking for?

We are looking for 50 Solomon Islands women volunteers to participant in this study. To take part in this study you should be:

between 18 – 45 years of age,
female,
Solomon Islander (both born in the Solomon Islands and living here and women of Solomon Islands descent)
not pregnant,
healthy (have no known medical condition such as cancer or any blood condition)

What is going to happen?
After you have read the information provided in this information sheet and you decided to take part in this study we will ask you a few questions to ensure you meet the criteria for the study. If you are eligible to join the study we will arrange for you to visit the Nutrition Research Unit at Massey University in Albany, Auckland at a time which is convenient to you. If you agree to participate, you will be asked to sign a consent form before starting the study.

On the day of your visit to the project site:

You will be asked to complete a health questionnaire, demographic questionnaire, online food frequency questionnaire, dietary habit questionnaire and the research student will conduct an interview with you to assess your usual diet. Our data collection from the questionnaires is an important aspect of our research and we will allow plenty of time (1 hour) during your visit to complete these.

1 x 10mls of fasting blood sample will be collected by an experienced phlebotomist to assess your iron status (haemoglobin as a marker of anaemia, serum ferritin as a marker of iron stores and C - reactive protein as a marker of inflammation which can affect the measurement of iron stores).

Your height, weight and waist and hip circumferences will be measured. Your body composition (lean body mass and percentage body fat) will also be measured using the BODPOD. This will require you to change into your swim suit or tight fitting clothes such as bike pants and wearing a swimming cap (which will be provided). This measurement will take place in a private, enclosed room.

Please do not eat any food on the morning of your visit. You may drink water up until 2 hours before your visit. After collection of blood samples and the anthropometric measurements you be given a breakfast (or you are welcome to bring your own breakfast).

What are the benefits and risks of taking part in this study?
The procedures to be used are safe and there are no personal risks to your health. All tests will be free of charge e.g. the blood tests for your iron status and, percentage of your body fat. You will receive feedback on your individual results and a petrol voucher worth of $20.00 upon completion of the study to help meet the cost of your travel.

Description of discomforts or risks to participants as a result of participation

Some people will have fear of having their blood samples taken or experience discomfort when the blood samples are taken. A slight bruising will result and usually disappears within a day or two. Social and cultural discomfort from having a blood sample taken or anthropometric measures taken may occur. Trained and experienced personnel will be conducting the blood sampling to minimize risks associated with the procedures. The researcher will ask permission to touch participants if required during the anthropometric measurements.

Project Procedures

You are allowed to bring someone if you are not comfortable being alone during physical or biochemical measurement procedures. All risks associated will be minimized as possible by the experienced personnel who will be undertaking the measurements and the blood samples.

A member of the research team will be available during the study to answer any questions or queries. So please feel free to ask, if you need help.

Data Management

Data collected will be used only for the purposes of this study and no individual will be identified. Data will be analyzed and the results written up in a Master's Thesis.

You will be given a unique identifier and that will be used on all questionnaires and data forms. The data forms will be kept in a safe and secure storage in a locked filing cabinet in a locked office within the Human Nutrition Research Unit which is a restricted access building. The electronic data will be stored on computers and servers, which are protected by passwords within the same facility. Your contact details will be kept separately from all other data in a locked filing cabinet. Data will be transferred in an official secure archive (Crown Records Management) after 5 years and destroyed by them after 10 years period following the permission of the supervisors. The data stored at this archive is identified by barcode and is accessible by nominated people who have pin numbers.

Summary of the project findings
Upon completion of this study, the summary of the results will be sent to all participants. Individuals will also get their blood results. The results will be published in the Pacific

Health Dialogue or the Asian Pacific Journal of clinical nutrition, presentations during one of the Solomon Islands community gatherings and/or at the New Zealand Melanesian annual forum. Also a copy of the research report will be sent to the New Zealand's International Aid & Development Agency (NZAID).
Due to the small community of women living in New Zealand from the Solomon Islands, if you share your results with other women it is likely that they will not remain confidential.

Participant's Rights
You are under no obligation to accept this invitation. If you decide to participate, you have the right to:
decline to answer any particular question;
withdraw from the study at any stage between recruitment and before the completion of study.
ask any questions about the study at any time during participation;
provide information on the understanding that your name will not be used unless you give permission to the researcher;
be given access to a summary of the project findings when it is concluded.

Project Contacts
If you have any further queries or concerns about the study, please contact Rosemary Kafa or Cathryn Conlon.

Rosemary Kafa	Dr Cathryn Conlon
Research Student	Lecture Human Nutrition
Massey University	Institute of Food Nutrition and Human health
Email:rosemary_kafa@yahoo.co.nz	Massey University
Phone: (09) 476 3266 or 0212928676	Email: C.Conlon@massey.ac.nz
	Phone: (09) 443 9748

Committee Approval Statement

Select the appropriate statement:

This project has been reviewed and approved by the Massey University Human Ethics Committee: Southern A, Application _10/62. If you have any concerns about the conduct of this research, please contact Professor Julie Boddy, Chair, Massey University Human Ethics Committee: Southern A, telephone 06 350 5799 x 2541, email humanethicsoutha@massey.ac.nz.
Compensation for Injury

If physical injury results from your participation in this study, you should visit a treatment provider to make a claim to ACC as soon as possible. ACC cover and entitlements are not automatic and your claim will be assessed by ACC in accordance with the Injury Prevention, Rehabilitation and Compensation Act 2001. If your claim is accepted, ACC must inform you of your entitlements, and must help you access those entitlements. Entitlements may include, but not be limited to, treatment costs, travel costs for rehabilitation, loss of earnings, and/or lump sum for permanent impairment.

Compensation for mental trauma may also be included, but only if this is incurred as a result of physical injury.

If your ACC claim is not accepted you should immediately contact the researcher. The researcher will initiate processes to ensure you receive compensation equivalent to that to which you would have been entitled had ACC accepted your claim.

Appendix – B

Participant consent form

MASSEY UNIVERSITY
COLLEGE OF SCIENCES
TE WĀHANGA PŪTAIAO

Institute of Food Nutrition and Human Health
Massey University, Private Mail Bag 102-904
North Shore Mail Centre
Albany, Auckland.

Iron status of Solomon Islands women living in New Zealand

CONSENT FORM

I have read the Information Sheet and have had the details of the study explained to me. My questions have been answered to my satisfaction, and I understand that I may ask further questions at any time.

I agree to participate in this study under the conditions set out in the Information Sheet.

Signature: ..... **Date:** .....

Full Name - printed .....

Appendix – C

Ethics application

Massey University
Te Kunenga ki Pürehuroa

Application No: 10/62
This number is assigned when your application is accepted.
Quote on all documentation to participants and the Committee.

Human Ethics Application

FOR APPROVAL OF PROPOSED RESEARCH/TEACHING/EVALUATION

INVOLVING HUMAN PARTICIPANTS

(All applications are to be typed and presented using language that is free from jargon and comprehensible to lay people)

SECTION A

1 Project Title Iron status of Solomon Islands women living in New Zealand

Projected start date for data collection September 2010 **Projected end date** September 2011

(In no case will approval be given if recruitment and/or data collection has already begun).

2 Applicant Details *(Select the appropriate box and complete details)*

ACADEMIC STAFF APPLICATION (excluding staff who are also students)

Full Name of Staff Applicant/s

School/Department/Institute

Campus *(mark one only)* **Albany** ☐ **Palmerston North** ☐ **Wellington** ☐

Telephone **Email Address**

STUDENT APPLICATION

Full Name of Student Applicant ROSEMARY KAFA

Employer (if applicable)

Telephone *09 476 3266 (Mb) 0212928676* **Email Address** rosemary_kafa@yahoo.co.nz

Postal Address **26 John Jennings Drive, Unit 12/10, Albany, NorthShoreCity, Auckland.**

Full Name of Supervisor(s) Dr Cathryn Conlon (main supervisor), A/Prof. Welma Stonehouse & Dr Rozanne Kruger

School/Department/Institute Institute of Food Nutrition and Human Health

Campus *(mark one only)* **Albany** [X] **Palmerston North** ☐ **Wellington** ☐

Telephone *09 443 9748* **Email Address** C.Conlon@massey.ac.nz

GENERAL STAFF APPLICATION

Full Name of Applicant						
Section						
Campus *(mark one only)*	**Albany**		**Palmerston North**		**Wellington**	
Telephone		**Email Address**				
Full Name of Line Manager						
Section						
Telephone		**Email Address**				

3 Type of Project *(provide detail as appropriate)*

Staff Research/Evaluation:		**Student Research:**	**X**	**If other, please specify:**
Academic Staff		**Specify Qualification**	**MSc (Human Nutrition)**	
General Staff		**Specify Credit Value of Research**	**120**	
Evaluation		**(e.g. 30, 60, 90, 120, 240, 360)**		

4 Summary of Project

Please outline in no more than 200 words in lay language why you have chosen this project, what you intend to do and the methods you will use.

(Note: All the information provided in the application is potentially available if a request is made under the Official Information Act. In the event that a request is made, the University, in the first instance, would endeavour to satisfy that request by providing this summary. Please ensure that the language used is comprehensible to all.)

Iron deficiency anaemia (IDA) is highly prevalent in women (44.3% of women aged 15-49 years) living in the Solomon Islands. However, only limited data is available regarding iron deficiency and the factors affecting iron status (e.g. dietary data, blood loss) in these women. Currently nothing is known about the iron status of women from the Solomon Islands living in New Zealand. This study will be the first to address whether iron deficiency is a problem for women from the Solomon Islands living in NZ as well as assessing factors contributing to iron status. This will provide us with important data on which to base future interventions if iron deficiency is a problem for this minority group living in New Zealand. It will also provide the student undertaking the project with the research training to undertake research and use tools/techniques relevant to her home country.

Women aged 18 to 45 years from the Solomon Islands living in Auckland will be recruited through the Solomon Islands Aotearoa Wantoks Association (ASIWA). Women who express an interest in taking part in the study and meet the screening criteria will be invited to attend the nutrition research unit on the Albany campus. During this visit the women will have a blood sample taken to assess iron status, undertake a dietary assessment and have body composition measured using the BODPOD.

5 **List the Attachments to your Application**, e.g. Completed "Screening Questionnaire to Determine the Approval Procedure" (compulsory), Information Sheet/s *(indicate how many*),Translated copies of Information Sheet/s, Consent Form/s *(indicate of how many),* Translated copies of Consent Form/s, Transcriber Confidentiality Agreement, Confidentiality Agreement *(for persons other than the researcher / participants who have access to project data)*, Authority for Release of Tape Transcripts, Advertisement, Health Checklist, Questionnaire, Interview Schedule, Evidence of Consultation, Letter requesting access to an institution, Letter requesting approval for use of database, Other *(please specify).*

Complete "Screening Questionnaire to determine the Approval Procedure" (1)
Information sheet (1)
Consent form (1)
Advertisement –
Flyer (1)
Email, radio (1)
Questionnaires
Screening questionnaire for study (1)
Demographics (1)
Participants personal information form (1)
Health Questionnaire
Blood Loss Questionnaire (1)
General wellbeing questionnaire (1)
Dietary Assessment:
- CIHAT – Computerized iron habits assessment tool- hard copy provided (1)
- Dietary habit Questionnaire (1)
- 24 hour dietary recall sheet (1)

Standard operation procedure for BODPOD (1)
Standard operation procedure for blood sampling (1)
Evidence of Consultation

Applications that are incomplete or lacking the appropriate signatures will not be processed. This will mean delays for the project.

Please refer to the Human Ethics website (http://humanethics.massey.ac.nz) for details of where to submit your application and the number of copies required.

SECTION B: PROJECT INFORMATION

General

6	**I/We wish the protocol to be heard in a closed meeting (Part II).** *(If yes, state the reason in a covering letter.)*	**Yes**		**No**	X
7	**Does this project have any links to previously submitted MUHEC or HDEC application(s)?** **If yes, list the MUHEC or HDEC application number/s (if assigned) and relationship/s.**	**Yes**		**No**	X
8	**Is approval from other Ethics Committees being sought for the project?** **If yes, list the other Ethics Committees.**	**Yes**		**No**	X
9	**For staff research, is the applicant the only researcher?** **If no, list the names and addresses of all members of the research team.**	**Yes**		**No**	

Project Details

10 **State concisely the aims of the project.**

- To assess the prevalence of iron deficiency and iron deficiency anaemia in a sample of women from the Solomon Islands aged 18- 45 years living in New Zealand
- To investigate the potential factors affecting iron status (e.g. diet, blood loss, number of births, previous health history)
- To assess if there is any relationship between body composition (weight, height, BMI, % body fat) and iron status

11 **Give a brief background to the project to place it in perspective and to allow the project's significance to be assessed.** *(No more than 200 words in lay language)*

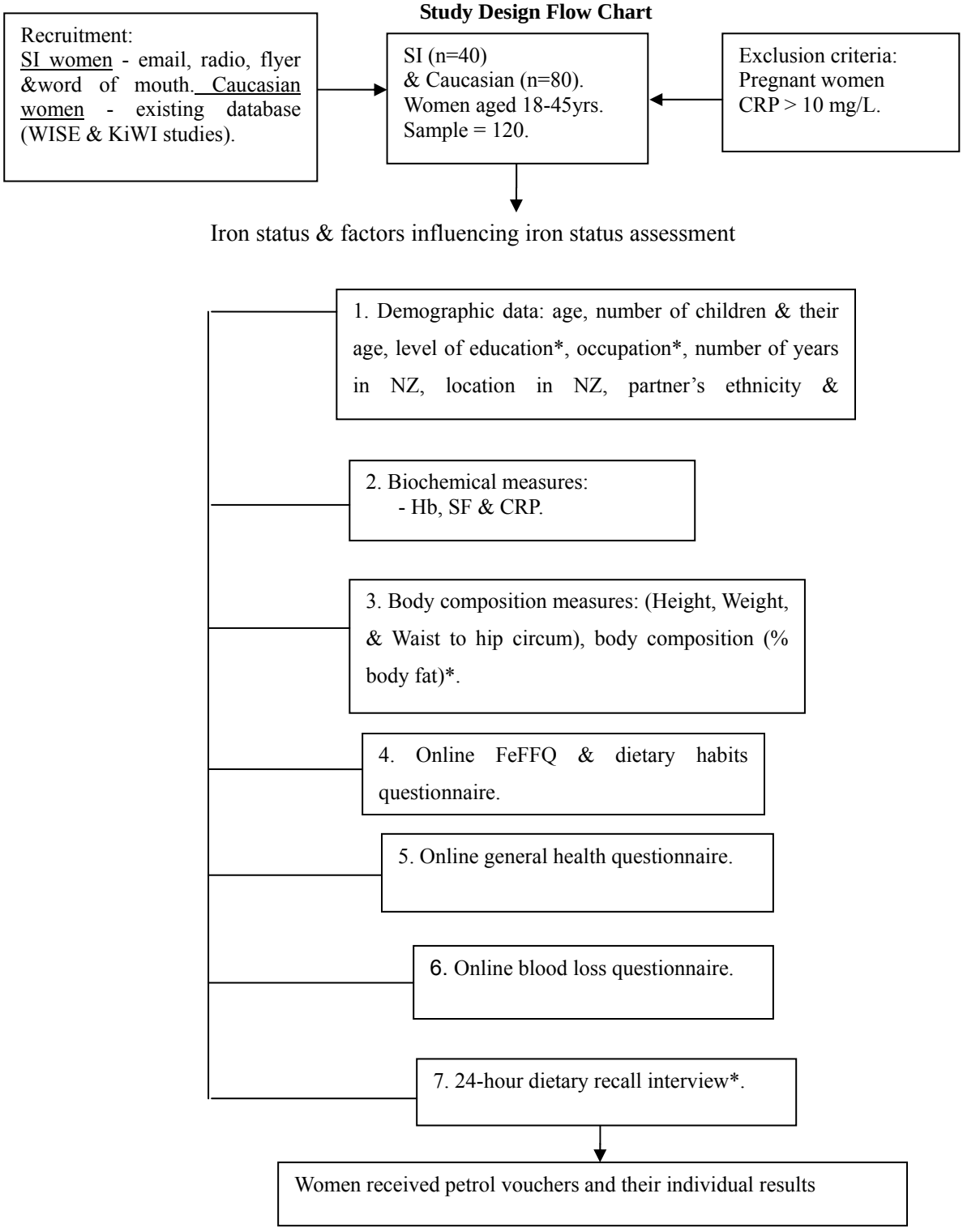
Iron Deficiency (ID) is a common nutritional disorder worldwide. A complete depletion of iron stores and reduction in the levels of haemoglobin in the red blood cell results in Iron Deficiency Anaemia (IDA). Women are vulnerable to IDA, particularly during reproductive years. The New Zealand National Nutrition Survey 1997 reported low iron stores (6%), ID (3%) and IDA (2%) among women aged 15-44 years. Whilst an even higher prevalence of iron deficiency anaemia has been reported (44.3%) among women aged 15-45 years in the Solomon Islands from the National Demographic and Health Study.

Women with IDA are at a higher risk of infection, maternal mortality, poor pregnancy outcomes (i.e. Low birth weight babies, poor neurocognitive development of foetus, preterm delivery, haemorrhage and death), impaired cognitive function, tiredness, depression, and reduced work capacity. Solomon Islanders, from a Melanesian Pacific country, form a small growing population in New Zealand. To date no studies have been done among this minority group to determine whether iron deficiency is a significant problem. Therefore, this study aims to provide baseline information about the iron status of a sample of Solomon Islands women living in New Zealand and find out if ID is an issue for these women. Information from this study will inform us as to whether interventions to improve the iron status are required in this group.

12 **Outline the research procedures to be used, including approach/procedures for collecting data. Use a flow chart if necessary.**

Study design: Thesis an observational study. Solomon Islands female aged 18 – 45 years living in New Zealand will be invited to participate. Women will be screened to ensure they are between 18-45 years, are from the Solomon Islands and currently not pregnant (screening questionnaire). The recruitment of volunteers (n=50) for this study will be done through the Solomon Islands Aotearoa Wantoks Association (ASIWA), radio announcement, flyers, email and word of mouth.

Study Design Flow Chart



Iron Status assessment – biochemical measures: Fasting blood samples will be collected by an experienced phlebotomist on site. The sample will be immediately processed and stored at – 80°C until analysis by LabPlus, Auckland City Hospital in Auckland. A single blood sample will be drawn to analyse serum ferritin - to identify deficient iron stores, C- reactive protein (CRP) - to screen for inflammation which may indicate an underlying infection that may influence the measurements of iron status. A single blood drop will be taken from the sample for analysis of haemoglobin to determine the identification of anaemia using the Hemocue analyser in the Human Nutrition Research laboratory, Albany Campus, Auckland.

Potential factors affecting iron status: The following tools will be used to undertake dietary assessment with the women:

(1) Computerised habits assessment tool (CIHAT) to assess the frequency of intake of the different iron rich components in the diet. Dietary sources will be allocated to identifiable groups e.g. haem iron rich foods (including the Meat-Fish-Poultry (MFP) factor), non-haem iron rich foods, and iron fortified foods.
(2) The frequency of intake of foods which may affect the intake and/or absorption of dietary iron e.g. vitamin C- rich foods, phytate- rich foods, calcium –rich foods, tea/coffee intake will also be assessed.Dietary habits questionnaire will assess patterns of dietary intake for example frequency of meals/snacks, types of drinks and snack foods.
(3) A single 24 hour dietary recall will be use to determine the usual food intake of the women.

Blood loss will be estimated by the menstrual recall method (questionnaire attached) as it is most applicable and feasible for this group. It has been shown to be sufficiently valid in distinguishing between high and low blood loss which is sufficient for this research. Blood loss through nose bleeds and blood donation will also be recorded.

Height, weight, waist and hip circumferences will be measured in duplicate during their visit to the Human Nutrition Research Unit (HNRU) in Albany by a trained researcher using the International Society for the Advancement of Kinanthropometry (ISAK) standards. Quetelet's Body Mass Index (BMI) will be calculated from height and weight. Percentage body fat and lean body mass will be measured using the BODPOD.

Demographic information including level of education, occupation and number of years in NZ will be obtained from a demographic questionnaire (attached). Medical history, number and ages of children and factors likely to influence iron status will be assessed using the Health Questionnaire (Attached). The women's age will be determined from their date of birth (Personal contact details form (attached).

Data on general well being and fatigue will be collected using the Fatigue and general well being questionnaire.

Data Capturing: Participants will complete paper and computer-based questionnaires. The computer-based questionnaires will provide an easy means of recording data while minimizing errors such as survey bias, interpretation and coding errors. Student researcher will be present toassistin thecompletion of all questionnaires.

Statistical analysis: Statistical analysis will be done with the SPSS software version 18 (SPSS Inc., Chicago, IL, USA). Descriptive analyses will be done to give a first overview of the different variables. Univariate and multivariate analysis will be carried out to determine the association between the levels of iron status and the influencing factors. A generalized linear model will be used for the multivariate analyses.

Participant feedback: Individual blood test results (either within a normal range or not) will be posted to each participant with an explanation of the findings. Individuals with abnormal test results will be given a copy of their results and letter recommending that they visit their medical practitioner. Alternatively, this letter will be sent directly to the participant's practitioner at the participant's request. Key findings from study will be made known to the participants.

Dissemination of results: A summary of the results will be published in the Pacific Health Dialogue, Asian Pacific Journal of Clinical Nutrition and will be presented during the Solomon Independence anniversary July 2011. Also to all participants and the New Zealand International Aid Assistance Programme (NZAID).

Where will the project be conducted? Include information about the physical location/setting.

The study will be conducted at Massey University on the Auckland campus utilising the Human Nutrition Research Unit. The Human Nutrition Research Unit is a purposely designed building for undertaking human research with clinical rooms for blood sample collection, anthropometry and a computer suite set up for online data collection. The computer suite consists of individual booths with computers set up. Within the unit there are waiting areas, bathroom facilities and a small kitchenette. The Human Nutrition Research Unit has an onsite laboratory for processing, analysis and storage of blood samples. Outside these facilities are reserved free parking spaces for research participants.

The unit has appropriate space to provide the participants with privacy body composition measurements such as height and weights. We also have an onsite first aid kit and first aider. The Nutrition Research Unit is located on the Oteha Rohe side campus. We have ongoing support from Student Health & Counselling who are also located on the same side of campus within 5 minutes walk from the Nutrition Research Unit. To organise the project the research team request permission to set up a study linked Massey email address, namely solomon@massey.ac.nz

If the study is based overseas:

i) Specify which countries are involved;

ii) Outline how overseas country requirements (if any) have been complied with;

iii) Have the University's Policy & Procedures for Course Related Student Travel Overseas been met? *(Note: Overseas travel undertaken by students – refer to item 5.10 in the document "Additional Information" on the MUHEC website.)*

N/A

Describe the experience of the researcher and/or supervisor to undertake this type of project?

This study will be conducted by a student as the principal investigator under the supervision of three research expert supervisors at the Albany campus. These supervisors possess a wealth of knowledge and experiences in different study designs. All the supervisors have undertaken their own studies in the past and they are well equipped to provide guidance on the procedures involved in this study.

Describe the process that has been used to discuss and analyse the ethical issues present in this project.

The ethical issues in this project have been discussed with the expert supervisors in this field. Questionnaires have been tested and evaluated and peer reviewed by a group of experts who have carried out a similar study in the past. For this research, modification, testing and evaluation of the questionnaire will be done via consultation withRosemilly Piasi and Jillian Sebastian representatives of the Solomon Islands community in New Zealand for the wording and cultural appropriateness of the questions. The research student will be trained to carry out the anthropometric measurements and quality control measures required when taking these measurements. Participants' right to privacy and discretion will be maintained at all times during these procedures.

Describe the intended participants.

Solomon Islands female aged between 18 and 45 years (both born in the Solomon Islands and living here and women of Solomon Islands descent).

How many participants will be involved?

50

What is the reason for selecting this number?

(Where relevant, attach a copy of the Statistical Justification to the application form)

SolomonIsland community in New Zealand is very small, thus 50 is about half the female population aged 18 to 45 years living in New Zealand. This sample will provide excellent data on the iron status of SolomonIsland women living in New Zealand.

Describe how potential participants will be identified and recruited?

Potential participants are all Solomon Islands women aged 18-45 years living in or around Auckland NZ. Identification of women for recruitment will be done through the Solomon Islands Aotearoa Wantoks Association (ASIWA). Women will receive an invitation via the ASIWA radio programme take part in this study. Women who express interest will be followed up by email or telephone. The Solomon Islands community in New Zealand is very small so word of mouth will be an important strategy. Also the study will be advertised through the ASIWA radio programme, posters will be distributed via church groups and events hosted by ASIWA inviting volunteers to participate.

Does the project involve recruitment through advertising?	**Yes**	X	**No**	

(If yes, attach a copy of the advertisement to the application form)

Flyer/poster and copy of radio advertisement attached

Does the project require permission of an organisation (e.g. an educational institution, an academic unit of Massey University or a business) to access participants or information?	**Yes**		**No**	X

If yes, list the organisation(s).

(Attach a copy of the draft request letter(s), e.g. letter to Board of Trustees, PVC,HoD/I/S, CEO etc to the application form. Include this in your list of attachments (Q5). Note that some educational institutions may require the researcher to submit a Police Security Clearance.)

Who will make the initial approach to potential participants?

Student researcher

Describe criteria (if used) to select participants from the pool of potential participants.

Solomon Islander, Female, aged 18 - 45 years, except for those women who are pregnant who will not be asked to participant.

How much time will participants have to give to the project?

1 hour for online questionnaires

30-40 minutes for anthropometric, BODPOD

10-15 minutes for blood sample

15-20 minutes for 24 hour recall

In total the whole process should require about 2 hours from the participants

Does the project include the use of participant questionnaire/s?	**Yes**	X	**No**	

(If yes, attach a copy of the Questionnaire/s to the application form and include this in your list of attachments (Q5))

Copy of questionnaires attached:

Screening questionnaire

Demographic questionnaire

Health questionnaire

Blood loss questionnaire

Fatigue and well being questionnaire

If yes:	**i) indicate whether the participants will be anonymous (i.e. their identity unknown to the researcher).**	**Yes**		**No**	X
	ii) describe how the questionnaire will be distributed and collected.				

(If distributing electronically through Massey IT, attach a copy of the draft request letter to the Director, Information Technology Services to the application form. Include this in your list of attachments (Q5) – refer to the policy on "Research Use of IT Infrastructure".)

All questionnaires will be completed during the appointment time for each participant. The online questionnaires will be set up on computers located in the Human Nutrition Research Unit on the Auckland campus. The nutrition technician will be responsible for setting up, maintaining and backup of the questionnaire on these computers. The computers are located in a secure place and can only be accessed by appropriate staff from the research study. Privacy for participants completing the questionnaire will be provided with the use of screens. The researcher will be available at all times to answer any questions or queries of the participants as they complete the questionnaire. Questionnaires will be identified with subject numbers only and held securely either in a locked room or held electronically with password protection on secure computers.

Does the project involve observation of participants? If yes, please describe.	**Yes**		**No**	X

Does the project include the use of focus group/s?	**Yes**		**No**	X

(If yes, attach a copy of the Confidentiality Agreement for the focus group to the application form)

If yes, describe the location of the focus group and time length, including whether it will be in work time. *(If the latter, ensure the researcher asks permission for this from the employer).*

Does the project include the use of participant interview/s?	**Yes**	X	**No**	

(If yes, attach a copy of the Interview Questions/Schedule to the application form)

All participants will be asked if they understand the study, given the opportunity to ask questions and asked to sign a consent form. A 24 hour dietary recall interview will be conducted with participants.

If yes, describe the location of the interview and time length, including whether it will be in work time. *(If the latter, ensure the researcher asks permission for this from the employer)*

Working women and students will be seen on weekends at the Nutrition Research Unit, Massey University, Albany campus, Auckland.

Does the project involve sound recording?	**Yes**		**No**	X
Does the project involve image recording, e.g. photo or video?	**Yes**		**No**	X

If yes, please describe. *(If agreement for recording is optional for participation, ensure there is explicit consent on the Consent Form)*

If recording is used, will the record be transcribed?	**Yes**		**No**	

If yes, state who will do the transcribing.

(If not the researcher, a Transcriber's Confidentiality Agreement is required – attach a copy to the application form. Normally, transcripts of interviews should be provided to participants for editing, therefore an Authority For the Release of Tape Transcripts is required – attach a copy to the application form. However, if the researcher considers that the right of the participant to edit is inappropriate, a justification should be provided below.)

Does the project involve any other method of data collection not covered in Qs 25-31?	**Yes**	X	**No**	

If yes, describe the method used.

Anthropometric measures (height, weight) and body composition (% of body fat) will be taken by the student researcher. Training will be provided by the supervisors on the standard operation procedures to conduct the measurements. Blood sample collection will be done by a licensed phlebotomist on site at Massey University, Auckland and LabPlus, AucklandcityHospital will undertake the analysis. A single blood drop will be taken from the sample to assess for haemoglobin levels using the HemoCue Analyzer on site.

Does the project require permission to access databases?	**Yes**		**No**	X

(If yes, attach a copy of the draft request letter/s to the application form. Include this in your list of attachments (Q5). Note: If you wish to access the Massey University student database, written permission from Director, National Student Relations should be attached.)

Who will carry out the data collection?

The research student (applicant) under the supervision of Dr Cathryn Conlon, A/Prof. Welma Stonehouse & Dr Rozanne Kruger.

SECTION C: BENEFITS / RISK OF HARM (Refer Code Section 3, Para 10)

35 What are the possible benefits (if any) of the project to individual participants, groups, communities and institutions?

Participants will receive their individual blood test results on their iron status, BMI and their percentage of body fat. If participants are found to have abnormal results they will be informed of these results and given a referral letter to take to their Medical Practitioner. The benefit to Solomon Islands community members is to provide information for health care providers to plan appropriate nutrition interventions to address their needs. Additionally one Master's thesis will be produced from this research work, and at least one peer-reviewed research article will be written and submitted for publication.

36 What discomfort (physical, psychological, social), incapacity or other risk of harm are individual participants likely to experience as a result of participation?

Some people will have fear of having their blood samples taken or experience discomfort when the blood samples are taken. A slight bruising may result and usually disappears within a day or two. Social and cultural discomfort from having a blood sample taken or anthropometric measures taken.

37 Describe the strategies you will use to deal with any of the situations identified in Q36.

All procedures will be fully explained to the participants. A licensed phlebotomist will carry out all venipuncture and analysis be completed by LabPlus, AucklandCityHospital. Subjects will be given advice on care of the puncture site and any risks associated with the procedure. The research student will be trained to undertake anthropometric measures (height, weight) and body composition using the BODPOD machine and will ask permission to touch participants if required. Participants will be treated with care and respect and the body composition measurement will be done in a separate room. The research student who will be taking the anthropometric measures is a female Solomon Islander.

38 What is the risk of harm (if any) of the project to the researcher?

The licensed phlebotomist may at risk of contamination. However, all precaution measures will be taken to minimised risks of contamination through contact with blood or needle stick injury during the finger prick procedure. Protective gloves will be worn to protect from blood contact.

39 Describe the strategies you will use to deal with any of the situations identified in Q38.

Protective gloves will be worn when performing blood sampling and there will be a designated, enclosed area for all blood measurements within the confines of the Nutrition Laboratory.

There will be sharps bin for proper needle disposal and yellow hazard bags for soft material disposal. All of these procedures adhere to Massey OSH guidelines. All staff working in the laboratory and with human tissue has signed a document stating that they have studied the IFNHH Safety & Health procedure.

40 **What discomfort (physical, psychological, social) incapacity or other risk of harm are groups/communities and institutions likely to experience as a result of this research?**

None

41 **Describe the strategies you will use to deal with any of the situations identified in Q40.**

N/A

42 **Is ethnicity data being collected as part of the project?** **Yes** [ ] **No** [X]

If yes, will the data be used as a basis for analysis? If so, justify this use in terms of the number of participants.

If no, justify this approach, given that in some research an analysis based on ethnicity may yield results of value to Maori and to other groups.

(Note that harm can be done through an analysis based on insufficient numbers)

All participants will be Solomon Islands females.

43 **If participants are children/students in a pre-school/school/tertiary setting, describe the arrangements you will make for children/students who are present but not taking part in the research**.

(Note that no child/student should be disadvantaged through the research)

N/A

SECTION D: INFORMED & VOLUNTARY CONSENT (Refer Code Section 3, Para 11)

44 **By whom and how, will information about the research be given to potential participants?**

Research student (applicant). Information about this study will be given to the potential participants through the Solomon Islands community Sunday radio programme, flyers, email and word of mouth to women.

45 **Will consent to participate be given in writing?** **Yes** [X] **No** [ ]

(Attach copies of Consent Form/s to the application form)

If no, justify the use of oral consent.

46 **Will participants include persons under the age of 16?** **Yes** [ ] **No** [X]

If yes: i) indicate the age group and competency for giving consent.

ii) indicate if the researcher will be obtaining the consent of parent(s)/caregiver(s). **Yes** [ ] **No** [ ]

(Note that parental/caregiver consent for school-based research may be required by the school even when children are competent. Ensure Information Sheets and Consent Forms are in a style and language appropriate for the age group.)

47 **Will participants include persons whose capacity to give informed consent may be compromised?** **Yes** [ ] **No** [X]

If yes, describe the consent process you will use.

48 **Will the participants be proficient in English?** **Yes** [X] **No** [ ]

If no, all documentation for participants (Information Sheets/Consent Forms/Questionnaire etc) must be translated into the participants' first-language.

All participants are proficient in English, however, they will be welcomed to the Human Nutrition Research Unit in Solomon Islands Pijin which is their common language. Advertisement messages will be given in both English and Pijin. Communication with participants during the data collection process will be in English and questionnaires will remain in English because they are all proficient in English.

(Attach copies of the translated Information Sheet/Consent Form etc to the application form)

SECTION E: PRIVACY/CONFIDENTIALITY ISSUES (Refer Code Section 3, Para 12)

49	**Will any information be obtained from any source other than the participant?**	**Yes**		**No**	X

If yes, describe how and from whom.

50	**Will any information that identifies participants be given to any person outside the research team?**	**Yes**		**No**	X

If yes, indicate why and how.

51	**Will the participants be anonymous (i.e. their identity unknown to the researcher?)**	**Yes**		**No**	X

If no, explain how confidentiality of the participants' identities will be maintained in the treatment and use of the data.

The participants name and contact details are collected on the personal details form so that appointments can be made and results can be sent to the participants. This form will be stored separately from all other forms. Participants will be given a unique identifier and all data forms, computer database and samples will use the identifier.

52	**Will an institution (e.g. school) to which participants belong be named or be able to be identified?**	**Yes**		**No**	X

If yes, explain how you have made the institution aware of this?

53 Outline how and where:

i) the data will be stored, and

(Pay particular attention to identifiable data, e.g. tapes, videos and images)

Each participant's unique identifier will be used on all questionnaires and data forms. The data forms will be kept in a safe and secure storage in a locked filing cabinet in a locked office within the Human Nutrition Research Unit which is a restricted access building. The electronic data will be stored on computers and servers, which are protected by passwords within the same facility. Participants contact details will be kept separately from all other data in a locked filing cabinet.

ii) Consent Forms will be stored.

(Note that Consent Forms should be stored separately from data)

Consent forms will be stored in a locked filing cabinet in a locked office in a separate building to the Human Nutrition Research Unit.

54 i) Who will have access to the data/Consent Forms?

The research student and supervisors will have access to participants contact details for sending out results.

ii) How will the data/Consent Forms be protected from unauthorised access?

All data collection forms and consent forms will be stored in a locked filing cabinet in a locked office. The electronic data will be stored on computers and servers, which are protected by passwords. All data will be stored in locations with restricted access and in buildings that are locked.

55 How long will the data from the study be kept, who will be responsible for its safe keeping and eventual disposal? (Note that health information relating to an identifiable individual must be retained for at least 10 years, or in the case of a child, 10 years from the age of 16).

(For student research the Massey University HOD Institute/School/Section / Supervisor / or nominee should be responsible for the eventual disposal of data. Note that although destruction is the most common form of disposal, at times, transfer of data to an official archive may be appropriate. Refer to the Code, Section 4, Para 24.)

Data will be transfer in an official secure archive (Crown Records Management) after 5 years and destroy by them after 10 years period following the permission of the supervisors. The data stored at this archive is identified by barcode and is accessible by nominated people who have pin numbers.

SECTION F: DECEPTION (Refer Code Section 3, Para 13)

56	**Is deception involved at any stage of the project?**	**Yes**		**No**	X

If yes, justify its use and describe the debriefing procedures.

SECTION G: CONFLICT OF ROLE/INTEREST (Refer Code Section 3, Para 14)

57	**Is the project to be funded in any way from sources external to Massey University?**	**Yes**	X	**No**	

If yes: i) state the source.

This projected will be supported by NZAID and Massey University.

ii) does the source of the funding present any conflict of interest with regard to the research topic?

None

58	**Does the researcher/s have a financial interest in the outcome of the project?**	**Yes**		**No**	X

If yes, explain how the conflict of interest situation will be dealt with.

59 Describe any professional or other relationship between the researcher and the participants? (e.g. employer/employee, lecturer/student, practitioner/patient, researcher/family member). Indicate how any resulting conflict of role will be dealt with.

Participants and the research student are from the Solomon Islands. All results from the study will be kept confidential.

SECTION H: COMPENSATION TO PARTICIPANTS (Refer Code Section 4, Para 23)

60	**Will any payments or other compensation be given to participants?**	**Yes**	X	**No**	

If yes, describe what, how and why.

Petrol vouchers worth of $20.00 will be given to participants upon completion of the visit to the Human Nutrition Research Unit. To help meet the cost of their travel to the project site.

(Note that compensation (if provided) should be given to all participants and not constitute an inducement. Details of any compensation provided must be included in the Information Sheet.)

SECTION I: TREATY OF WAITANGI (Refer Code Section 2)

61	**Are Maori the primary focus of the project?**	**Yes**		**No**	X

If yes: Answer Q62 – 65

If no, outline:i) what Maori involvement there may be, and

Only Solomon Islands females aged 18- 45 years are eligible to take part in this study.

ii) how this will be managed.

N/A

62	**Is the researcher competent in te reo Maori and tikanga Maori?**	**Yes**		**No**	

If no, outline the processes in place for the provision of cultural advice.

N/A

63 Identify the group/s with whom consultation has taken place or is planned and describe the consultation process.

(Where consultation has already taken place, attach a copy of the supporting documentation to the application form, e.g. a letter from an iwi authority)

N/A

64 Describe any ongoing involvement of the group/s consulted in the project.

N/A

65 Describe how information resulting from the project will be shared with the group/s consulted?

N/A

SECTION J: CULTURAL ISSUES(Refer Code Section 3, Para 15)

66	**Other than those issues covered in Section I, are there any aspects of the project that might raise specific cultural issues?**	**Yes**		**No**	X

If yes, explain. Otherwise, proceed to Section K.

67 What ethnic or social group/s (other than Maori) does the project involve?

The study will only involve Solomon Islands women living in and around Auckland

68	**Does the researcher speak the language of the target population?**	**Yes**	X	**No**	

If no, specify how communication with participants will be managed.

69 Describe the cultural competence of the researcher for carrying out the project.

(Note that where the researcher is not a member of the cultural group being researched, a cultural advisor may be necessary)

The research student is a Solomon Islander herself and is knowledgeable of their culture and, the supervisors are experienced in carrying out research with people from different ethnicities.

70 Identify the group/s with whom consultation has taken place or is planned.

(Where consultation has already taken place, attach a copy of the supporting documentation to the application form)

Representatives of Solomon Islands Aotearoa Wantoks Association (Jillian Sebastian and Rosemilly Piasi)

71 Describe any ongoing involvement of the group/s consulted in the project.

Consultation with the above names is ongoing regarding the potential participants listing and identification of common Solomon Islands foods to be included in the dietary questionnaire. Consultation will be ongoing with respect to any issues raised during the implementation of this study.

72 Describe how information resulting from the project will be shared with the group/s consulted.

The overall results from this study will be communicated back to the individual participants and to the Solomon Islands Wantoks Association (ASIWA) for information purposes.

73 If the research is to be conducted overseas, describe the arrangements you will make for local participants to express concerns regarding the research.

N/A

SECTION K: SHARING RESEARCH FINDINGS (Refer Code Section 4, Para 26)

74 Describe how information resulting from the project will be shared with participants and disseminated in other forums, e.g. peer review, publications, and conferences.

(Note that receipt of a summary is one of the participant rights)

Upon completion of this study, the summary of the results will be sent to participants. Individuals will also get their blood results. The results will be published in the Pacific Health Dialogue or the Asian Pacific Journal of Clinical Nutrition, presentation during one of the Solomon Islands community gatherings and/or at the New Zealand Melanesian annual forum. Also a copy of the research report will be sent to the New Zealand International Aid Assistance Programme (NZAID).

SECTION L: INVASIVE PROCEDURES/PHYSIOLOGICAL TESTS (Refer Code Section 4, Para 21)

75	**Does the project involve the collection of tissues, blood, other body fluids or physiological tests?** *(If yes, complete Section L, otherwise proceed to Section M)*	**Yes**	X	**No**	

If yes, are the procedures to be used governed by Standard Operating Procedure(s)? If so, please name the SOP(s). If not, identify the procedure(s) and describe how you will minimise the risks associated with the procedure(s)?

SOP's attached

76 Describe the material to be taken and the method used to obtain it. Include information about the training of those taking the samples and the safety of all persons involved. If blood is taken, specify the volume and number of collections.

1x 15ml of blood will be taken during the visit by a licensed phlebotomist on the project site. Participants will be fasted overnight prior to the sample collection and physical measurements in the morning. Breakfast will be provided to the participants.

77	**Will the material be stored?**	**Yes**	X	**No**	

If yes, describe how, where and for how long.

Blood samples will be processed on site and then immediately stores at -80ºC (if appropriate for specimen) until the end of data collection when they will be delivered to LabPlus for analysis.

78 **Describe how the material will be disposed of (either after the research is completed or at the end of the storage period).**

(Note that the wishes of relevant cultural groups must be taken into account)

Sharps, cotton wools and microvettes used will be disposed in the bins and/or bags provided by the Nutrition Research unit, soon after taking the readings on the same day. Blood samples will be disposed of according the procedures of LabPlus who will be doing the blood analysis.

79	**Will material collected for another purpose (e.g. diagnostic use) be used?**	**Yes**		**No**	X
	If yes, did the donors give permission for use of their samples in this project? *(Attach evidence of this to the application form).*	**Yes**		**No**	

If no, describe how consent will be obtained. Where the samples have been anonymised and consent cannot be obtained, provide justification for the use of these samples.

80	**Will any samples be imported into New Zealand?**	**Yes**		**No**	X

If yes, provide evidence of permission of the donors for their material to be used in this research.

81	**Will any samples go out of New Zealand?**	**Yes**		**No**	X

If yes, state where.

(Note this information must be included in the Information Sheet)

82 **Describe any physiological tests/procedures that will be used.**

Blood samples will be collected by experienced licensed phlebotomists from the participants on the project site. Samples will be analysed at LabPlus, AucklandcityHospital. A single blood sample will be obtained for analysis. Haemoglobin will be analysed to determine the identification for anaemia. Serum ferritin will be analysed to determine for identification of deficient iron stores and C-reactive protein will be analysed to screen for any inflammatory disease and infection that might influence measurements. Height and weight will be measured using standardized techniques and body composition will be measured using BODPOD.

83	**Will participants be given a health-screening test prior to participation?** *(If yes, attach a copy of the health checklist)*	**Yes**	X	**No**	

It will be identified that all the women are from the Solomon Islands, aged between 18 to 45 years, not currently pregnant and have no known medical condition such as a clotting disorder likely to be affected by procedures conducted during the study.

Reminder: Attach the completed Screening Questionnaire and other attachments listed in Q5

SECTION M: DECLARATION (*Complete appropriate box)*

STUDENT RESEARCH
Declaration for Student Applicant

I have read the Code of Ethical Conduct for Research, Teaching and Evaluations involving Human Participants and discussed the ethical analysis with my Supervisor. I understand my obligations and the rights of the participants. I agree to undertake the research as set out in the Code of Ethical Conduct for Research, Teaching and Evaluations involving Human Participants.

The information contained in this application is to the very best of my knowledge accurate and not misleading.

Student Applicant's Signature ..... Date: .....

Declaration for Supervisor

I have assisted the student in the ethical analysis of this project. As supervisor of this research I will ensure that the research is carried out according to the Code of Ethical Conduct for Research, Teaching and Evaluations involving Human Participants.

Supervisor's Signature ..... Date: .....

Print Name .....

Appendix – D

Study announcement

MASSEY UNIVERSITY
COLLEGE OF SCIENCES
TE WĀHANGA PŪTAIAO

Institute of Food Nutrition and Human Health

Iron status of Solomon Islands women living in New Zealand
Advertisement

Email, radio invitation & word of mouth invitation

Hello everyone

My name is Rosemary Kafa and I'm a nutritionist from the Solomon Islands currently studying for my masters at Massey University. I would like to invite you to take part in an interesting study looking at the iron status of women between 18 to 45 years. As part of my work in the Solomon Islands we found that iron deficiency was a huge problem for women but we don't know whether it is a problem for women once they are living in New Zealand. I would like to invite all eligible Solomon Islands women to be part of my research at Massey University, Albany Campus Auckland.

Solomon Islands female age between 18 and 45 years are eligible to take in this study. Except for those who are pregnant and anyone with a known medical condition that might affect the procedures involved.

If you are interested, I will send you an information sheet about the study and a consent form to sign if you decided to participate.

What will happen during the study;
You will be booked to come to the Nutrition Research Unit, Massey University, Albany, Auckland, Oteha Rohe side. Instructions on what to expect during the study and how to get to the project site will be given to you. Questionnaires will be completed by the participants, body measurements will be taken and a phlebotomist will collect blood samples to test for iron levels in the body. It will take 2 hours the most to complete all the procedures involved, depending on how fast you will answer the questions.

What you will gain from this study:
Free tests and individual results of your blood tests, waist and hip circumferences, Body Mass Index and percentage of body fat.
$20.00 petrol voucher

The information that you will provide will be confidential and your name will represented by unique codes. Your participation is voluntary and you can decline to answer any question.

If you have any questions or concerns about this study please contact Rosemary Kafa on email:rosemary_kafa@yahoo.co.nz or phone: (09) 476 3266(H)/ or 0212928676 or my supervisor Dr Cathryn Conlon email:C.Conlon@massey@ac.nz or phone:(09) 443 97
Thank you

.....

Advertisement in Solomon Islands Pidgin

Halo oketa wantok

Name blo mi Rosemary Kafa. Mi wanfala nutritionist from Solomon Islands wea mi duim masters studi distaem lo Massey University. Mi like invaetim iu fo teke part lo wanfala intaresting studi wea by luk lo iron status blo olketa mere aged from 18 ieas go kasem 45 ieas. From waka blo mi lo Solomon Islands mifala findim " no enuf iron or condition oketa callem lo Anaemia" hem wanfala big problem lo oketa mere and pikinini lo Solomon Islands. But distaem iu mi no savi, if disfala problem hem still stap lo olketa mere from Solomon Islands wea olketa come stap lo New Zealand. Disfala problem hem hapen evri wea lo world, olketa mere lo NZ too garem. This wan bae wanfala interesting studi bikos hem olsem wanfala first studi aboutim pipol lo Solomon Islands stap lo New Zealand. Result blo disfala studi by oketa pipol wea providem health kare fo iufala bae savi usem fo planim nutrition programmes wea bae fitim need blo Solomon pipol.

Evri Solomon Islands mere wea age blo olketa from 18 go kasem 45 savi teke part lo disfala studi, only if iu babule or garem ani siki lo blud bae iu no teke part.

Sapose iu interest fo teke part, bae mi sendim you infomeison about disfala witim wanfala consent form fo iu signed bifo iu teke part.

Wat bae hapen na olsem:

Bae mi bookim iu fo kam lo Massey University lo Albany Campus, Auckland one time nomoa. Olketa instrakson about wat fo iu duim an hao fo kam lo ples fo duim studi bae mi sendim kam lo iu. Taem Taem iu kam bae iu fillim ap questionenias, bae mi measarim body blo iu and wanfala officer wea waka blo hem na fo tekem blud (phlebotomist) bae kollectim lelebet blud from han blo iu fo mifala usim fo test fo iron levels lo bodi blo iu. Evri ting lo studi yea shud tekem 2 aoas fo finisim, bat hem depen lo hao fast iu savi ansewerim olketa online questens.

Wat bae iu gainim out lo disfala studi:

Free cheks and bae iu tekem result lo blud test blo u, weist an hip circumferences, Bodi mass index wetim pasent lo fat insaed lo bodi. $20.00 petrol voucher fo helpim iu lo transport

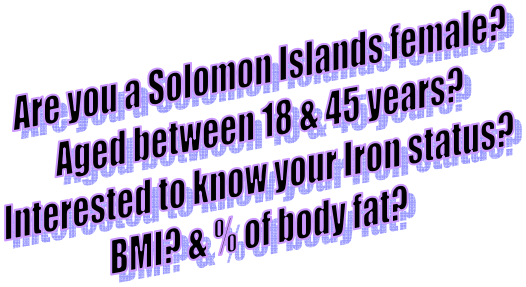
Sapose iu interested or garem any questen about disfala studi? Kontactim mifala: Rosemary Kafa lo email:rosemary_kafa@yahoo.co.nz or phone: (09) 476 3266 or 0212928676 or main supervisor blo mi Dr Cathryn Conlon lo email:C.Conlon@massey@ac.nz or phone:(09) 443 9748

Tagio Tumasi

Appendix – E

Study promotion flyer

Study Promotional Flyer



If you answered YES to the above questions

Then you must be the one we are looking for!!!

A Massey University's student from the Solomon Islands is doing a study on the iron status of Solomon Islands women living in New Zealand. Iron deficiency is a problem for many women and can cause tiredness, depression and affect pregnancy outcomes. This will be the first study to look at the iron status of women from the Solomon Islands living in New Zealand. If you are female aged between 18 to 45 years and from the Solomon Islands we would appreciate your help. If you do not meet the criteria but know women from the Solomon Islands please pass this information on.

This study will involve:
*A blood test to look at your iron status
*Physical body measurements such as height, weight, waist & hip circumferences and body composition
*Questionnaires on your diet and other factors affecting iron status

This study will be the first to specifically looking at the Solomon Islanders living in New Zealand. We will report back your individual results and a summary of the findings of the study.

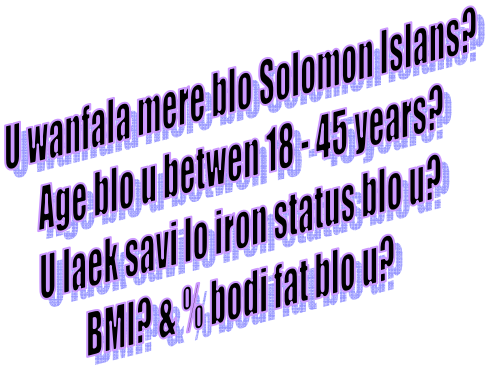
Benefits for participants:
*Individual results of your blood tests, and body composition.
*$20.00 petrol voucher

Study location:
Nutrition Research Unit, Massey University, Albany, Oteha Rohe side, Gate 4, Albany High way.

For further information Contact:

Rosemary Kafa
Research Student
Email: rosemary_kafa@yahoo.co.nz
Phone: 09 476 3266(H)/0212928676

Dr. Cathryn Conlon (Supervisor)
Lecturer
Email:C.Conlon@massey.ac.nz
Phone:09443 9748



Sapose IU ansa YES lo olketa questens antap?

Den IU mas bi wanfala lo wea mifala lukoutim!!!

Wanfala studen lo Solomon Islans lo Massey Universiti hem duim wanfala studi lo Iron status blo olketa mere blo Solomon Islan wea stap lo New Zealand. No enuf iron lo bodi hem wanfala big helt problem lo olketa mere wea lo age fo garem pikinini. Taem olketa mere no garem enuf iron, olketa savi easi tumasi fo casem any siki, incresim chanse fo oketa bonem unhelti baby, brain no waka gud, bodi tired olowei and depresson.

Disfala studi bae duim:
*Blud tests fo iron status
*Mesarim bodi weit, hait & bodi fat
* Questionnaire about kaikai
*Questionnaires about olketa samting wea affectim iron status lo bodi

Disfala study hem first wan fo lukluk long health blo olketa Solomon pipol stap lo New Zealand. Result blo disfala studi bae mifala givim kam lo iu.

Olketa tings wea olketa teke part lo disfala studi bae receivem:
*results lo blud tests, BMI & bodi composition
*$20.00 petrol voucher

Pelesi blo studi:
Nutrition Research Unit, Massey University, Albany, Oteha Rohe side, Gate 4, Albany High way.

Sapose IU laek savi moa contactim:

Rosemary Kafa
Research Student
Email: rosemary_kafa@yahoo.co.nz
Phone: 09 476 3266(H)/0212928676

Dr. Cathryn Conlon (Supervisor)
Lecturer
Email:C.Conlon@massey.ac.nz
Phone:09443 9748

Appendix – F

Participant's screening criteria

Subject Number:

MASSEY UNIVERSITY
COLLEGE OF SCIENCES
TE WĀHANGA PŪTAIAO

Solomon Island Women's Iron Study

SCREENING QUESTIONNAIRE

Check prior to making appointment for the study:

Female		Yes	□	No	□
Aged between 18 and 45 years	Yes	□	No	□	
From the Solomon Islands	Yes	□	No	□	

If the answer is yes to all of the above then continue with screening. If any answer is no thank the participant for their time but inform them that unfortunately they are not eligible

Currently pregnant	Yes	□	No	□

If the participant is currently pregnant then they are not eligible for the study. If not pregnant continue with screening

Any medical conditions (iron deficiency or iron deficiency anaemia ok)

Yes □ No □

Check details of medical condition. Any medical condition such as a clotting disorder means the participant should not take part in the study. If the participant answers no to this question they are eligible for the study

Your Date of Birth: __ __/__ __/__ __

Appendix – G

Personal details

Subject Number:

MASSEY UNIVERSITY
COLLEGE OF SCIENCES
TE WĀHANGA PŪTAIAO

Solomon Island Women's Iron Study

PARTICIPANT PERSONAL DETAILS

First name:

Family name:

Preferred name:

Street address:

Suburb:

Phone (home): _____ Phone (mobile):

Email:

Medical Practitioner:

Address:

Phone:

I am willing to be contacted about future research projects within the Institute of Food, Nutrition and Human Health:
Yes □
No □

Appendix – H

Demographic questionnaire

Subject Number:

MASSEY UNIVERSITY
COLLEGE OF SCIENCES
TE WĀHANGA PŪTAIAO

Iron Status of Solomon Islands women

Demographics Questionnaire

Are you from the Solomon Islands/Solomon island descent?

Yes ☐ No ☐

Your date of birth: __ __/__ __/__ ___

Which country were you born in?

☐ Solomon Islands

☐ New Zealand

☐ Other (Please state which country) _____

If you born outside of New Zealand, how long have you been in New Zealand?
_____

Where do you live in New Zealand?_____

What is your husband/partner's ethnicity (if you are married):

_____
State Not applicable (N/A) if you are single.

Go to question no. 8, if you are single or do not have a partner

Is your husband/partner:

☐ A full time employee

☐ A part- time employee
☐ Self- employed
☐ Unemployed
☐ Student
☐ Other please specify_____

What is your highest secondary school qualification? *(Single response)*

☐ NZ School Certificate in one or more subjects, or National Certificate Level 1
☐ NZ Sixth Form Certificate in one or more subjects, or National Certificate Level 2
☐ NZ University Entrance before 1986 in one or more subjects
☐ NZ Higher School Certificate, or Higher Leaving Certificate
☐ University Entrance qualification from NZ University Bursary
☐ NZ A or B Bursary, Scholarship, or National Certificate Level 3
☐Other NZ secondary school qualification.*(Please specify)*
_____
☐ Overseas secondary school qualification
☐ None or only up to primary school level

Apart from secondary school qualifications, do you have another qualification?
Yes ☐ No ☐

If yes please name it by identifying your highest qualification from the list below (Do not count incomplete qualifications or qualifications that take less than 3 months of full-time study to obtain. *Only one response should be marked the highest qualification e.g. BSc, PhD, etc.)*

☐Bachelors degree, e.g. BA. BSc. LLB
☐Bachelors degree with honours
☐ Masters degree, e.g. MA, MSc
☐ PhD
☐ Diploma (not Post Graduate)
☐ Diploma - Post Graduate
☐ Trade or technical certificate which took more than 3 months full time study
☐ Professional qualifications like ACA, teachers, nurses
☐ Other *(Specify)* _____
☐ No qualification beyond secondary school

What is your current occupation (the type of job you work the most hours in)?

☐ Administrator/Manager

☐ Professionals
☐ Technicians & Associate Professionals
☐ Clerks
☐ Service & Sales Workers
☐ Agriculture and Fishing
☐ Trade Workers
☐ Plant & Machinery Operators
☐ Labourers/Unskilled Work
☐ Self-employed
☐ Homemaker/house wife
☐ Unemployed
☐ Student
☐ Other *(Specify)* _____

Appendix – I

Iron food frequency questionnaire

Subject Number:

MASSEY UNIVERSITY
COLLEGE OF SCIENCES
TE WĀHANGA PŪTAIAO

Iron Food Frequency Questionnaire

When answering this questionnaire consider your intake of food over the past month. To help you do this, please think of an event in your life that happened one month ago and think about your eating patterns since that date. For seasonal fruit and vegetables consider monthly intake when the food is in season.

Example

Consider if you have sugar in all your drinks during the day as well as added to other food items and indicate how many times in the day you are consuming sugar. E.g. drinking 2 cups of coffee with sugar and 4 cups of tea with sugar, one bowl of cereal with sugar and sugar on pancakes at dinner resulting in choosing the category (4 Plus times per day). Consider if you have pineapple and indicate how many times you are consuming pineapple. E.g. eating pineapple slices with a hamburger meal once a week at lunch and eating carrot and pineapple salad once a week at dinner (2 to 3 times per week)

Food items	Never or less than once a month	1-3x per month	Once per week	2-3x per week	4-6x per week	Once per day	2-3x per day	4+ per day
Sugar								X
Pineapple				X				

In the past month I have eaten this food?								
Meats and chicken	**Never or less than once a month**	**1 to 3 times per month**	**Once per week**	**2 to 3 times per week**	**4 to 6 times per week**	**Once per day**	**2 to 3times per day**	**4 plus times per day**
Beef (e.g. roast, steak, chops, schnitzel, silverside, casseroles, stir fry, curry, hamburger meat, mince dishes)								
Chicken, turkey or duck (e.g. roast, fried, steamed, BBQ, casseroles, stir fry, curry, fried takeaway chicken)								
Lamb, hogget or mutton (e.g. roast, steak, chops, BBQ, casseroles, stir fry, curry)								

Pork (e.g. roast, chops, steak, casserole, casseroles, stir fry, curry)								
Veal								
Liver, kidney, other offal (including pate)								
other offal(including pate) Ham, bacon								
Corn beef, canned								
Prepared meat								
Beef Jerky/Biltong								
Sausages, Frankfurters, savory								
Luncheon sausage, salami, brawn, pastrami								
Black Pudding								
Meat pies								

In the past month I have eaten this food?								
Fish and Seafood	**Never or less than once a month**	**1 to 3 times per month**	**Once per week**	**2 to 3 times per week**	**4 to 6 times per week**	**Once per day**	**2 to 3times per day**	**4 plus times per day**
Fresh and frozen fish (e.g. snapper, tarakihi, gurnard, flounder, hoki, salmon, white bait, shark, eel)								
Battered and crumbed fish (e.g. fish fingers, fish cakes)								
Canned and bottled fish (e.g. tuna, salmon, herrings, sardines)								
Mussels, pipi, paua, cockles, oysters								
Scallops, crab sticks, crab, squid, crayfish, kina								
Prawns, shrimps								

Egg	**Never or less than once a month**	**1 to 3 times per month**	**Once per week**	**2 to 3 times per week**	**4 to 6 times per week**	**Once per day**	**2 to 3times per day**	**4 plus times per day**
Eggs – boiled, fried, poached, scrambled, raw and egg based dishes including quiche, soufflés, frittatas, omelettes								

Nuts	**Never or less than once a**	**1 to 3 times per month**	**Once per week**	**2 to 3 times per week**	**4 to 6 times per week**	**Once per day**	**2 to 3times per day**	**4 plus times per day**

	month							
Peanuts, mixed nuts, macadamias, pecan, hazelnuts, brazil nuts, walnuts, cashews, pistachios								
Almonds								
Pumpkin seeds, sunflower seeds, peanuts								
Sesame seeds, tahini								

Legumes	**Never or less than once a month**	**1 to 3 times per month**	**Once per week**	**2 to 3 times per week**	**4 to 6 times per week**	**Once per day**	**2 to 3times per day**	**4 plus times per day**
Tofu, soybeans, tempeh								
Beans in sauce (e.g. baked beans, chilli beans) Beans (canned or dried) (e.g. black beans, butter beans, haricot beans, red kidney beans, white kidney beans, refried beans)								
Lentils								
Peas (e.g. chick peas, hummus, falafels, split peas, cow peas)								
Dahl (all varieties)								

Dairy Products	**Never or less than once a month**	**1 to 3 times per month**	**Once per week**	**2 to 3 times per week**	**4 to 6 times per week**	**Once per day**	**2 to 3times per day**	**4 plus times per day**
Cheese (e.g. Cheddar, Colby, Edam, Tasty, blue vein, camembert, parmesan, gouda, processed)								
Cottage cheese, ricotta cheese								
Cream, sour cream, cream cheese, cheese spreads, Fromage frais (all varieties)								
Milk (cow's milk) **as a drink** (e.g. flavored milk, milk shakes)								
Milk (cow's milk) (all varieties) **added to drinks** (e.g. in tea, coffee)								
Milk (cow's milk) (all varieties) **added to food** (e.g. cereals, dishes such as macaroni cheese, milk puddings such as rice pudding, custard, semolina, instant puddings,								

dairy food)								
Soy Milk								
Coconut milk								
Yoghurt								
Ice cream								

Fruits	**Never or less than once a month**	**1 to 3 times per month**	**Once per week**	**2 to 3 times per week**	**4 to 6 times per week**	**Once per day**	**2 to 3times per day**	**4 plus times per day**
Apples								
Bananas, green bananas (plantain)								
Citrus fruits (e.g. orange, tangelo, tangerine, mandarin, grapefruit, lemon)								
Green kiwifruit								
Zespri gold kiwifruit								
Pears, nashi pears								
Stone fruit (e.g. apricots, nectarines, peaches, plums, lychees)								
Avocadoes, olives								
Feijoas, persimmon, tamarillos								
Grapes								
Mango								
Watermelon								
Pawpaw (papaya), other melons (e.g. honey dew, rock melon)								
Pineapple								
Rhubarb								
Fruit salad, canned								
Strawberries, blackberries, cherries, blueberries, boysenberries, loganberries, cranberries, gooseberries, raspberries								
Sultanas, raisins, currants, figs								
Dried apricots, prunes, dates, mixed dried fruit								

Vegetables	**Never or less than once a month**	**1 to 3 times per month**	**Once per week**	**2 to 3 times per week**	**4 to 6 times per week**	**Once per day**	**2 to 3times per day**	**4 plus times per day**

Potato (e.g. boiled, mashed, baked, roasted, fried, chips)								
Kumara (e.g. boiled, mashed, baked, roasted, fried, chips)								
Green beans, broad beans, runner beans, asparagus								
Broccoli (all varieties)								
Red cabbage								
Cabbage (all varieties), Brussels sprouts								
Capsicum, peppers (all varieties)								
Carrots								
Cauliflower								
Corn (all varieties)								
Courgette, zucchini, cucumber, jerkins or marrow (all varieties)								
Beetroot								
Radishes (all varieties)								
Lettuce								
Mushrooms								
Onions (all varieties), leeks, celery, shallot								
Tomatoes (all varieties)								
Peas, green								
Spinach, silver beet, Swiss chard (all varieties)								
Other green leafy vegetables (e.g. **watercress**, puha, Whitloof, chicory, kale, chard, collards, Chinese kale, Bok Choy, water spinach)								
Pumpkin, squash, yams								
Parsnip								
Taro leaves (palusami)								

Breakfast cereal or porridge	**Never or less than once a month**	**1 to 3 times per month**	**Once per week**	**2 to 3 times per week**	**4 to 6 times per week**	**Once per day**	**2 to 3times per day**	**4 plus times per day**
Porridge, rolled oats, oat bran, oat meal								
Muesli (all varieties)								
Weetbix (all varieties)								
Cornflakes or rice bubbles								

Bran based cereals (all varieties e.g. All Bran, Sultana Bran)								
Light and fruity cereals (e.g. Special K, Light and tasty)								
Chocolate based cereals (e.g. Milo cereal, Coco Pops)								
Sweetened cereals (e.g. Nutrigrain, Fruit Loops, Honey Puffs, Frosties)								
Breakfast drinks (e.g. Up and Go)								

Grains	**Never or less than once a month**	**1 to 3 times per month**	**Once per week**	**2 to 3 times per week**	**4 to 6 times per week**	**Once per day**	**2 to 3times per day**	**4 plus times per day**
White rice								
Brown rice								
Instant noodles								
Pasta, noodles (white)								
Pasta, noodles (whole wheat)								
Couscous, polenta								
Bulgur wheat (e.g. tabbouleh)								
Wheat germ, wheat bran (flakes)								

Breads, cakes, biscuits and crackers	**Never or less than once a month**	**1 to 3 times per month**	**Once per week**	**2 to 3 times per week**	**4 to 6 times per week**	**Once per day**	**2 to 3times per day**	**4 plus times per day**
White bread and rolls (including specialty breads such as foccacia, panini, pita, naan, crumpets, pizza bases, tortilla's, burrito, roti)								
Brown bread and rolls (including multigrain, wholegrain, whole meal breads)								
Breads fortified with iron (e.g. Mighty White Tip Top bread)								
Fruit and currant bread / buns								
White flour muffins (all varieties)								
Whole meal muffins (all varieties)								
Cakes (all varieties excluding chocolate and fruit cake)								

Chocolate cake								
Fruit cake								
Biscuits, plain sweet								
Biscuits, chocolate or chocolate covered								
Crackers (e.g. crisp bread, water crackers, rice cakes, cream crackers, Cru skits, Meal mates								
Iron fortified crackers (e.g. Vita wheat)								

Miscellaneous foods and snacks	**Never or less than once a month**	**1 to 3 times per month**	**Once per week**	**2 to 3 times per week**	**4 to 6 times per week**	**Once per day**	**2 to 3times per day**	**4 plus times per day**
Marmite								
Chocolate spread (e.g. Nutella)								
Peanut butter								
Butter or margarine								
Cooking oil (all varieties)								
Soup, vegetable based, homemade or canned								
Soup, meat based, homemade or canned								
Sugar (all varieties) added to food / drinks								
Jam, marmalade, honey or syrups								
Muesli or cereal bar (all varieties)								
Chocolate covered Muesli or cereal bar (all varieties)								
Potato crisps								
Milk chocolate								
Dark chocolate								
White chocolate								

Alcohol	**Never or less than once a month**	**1 to 3 times per month**	**Once per week**	**2 to 3 times per week**	**4 to 6 times per week**	**Once per day**	**2 to 3times per day**	**4 plus times per day**
Beer, cider (all varieties)								
Red wine								
White wine								

Spirits (all varieties)								
Ready to drink alcoholic beverages								
Non- Alcoholic Drinks	**Never or less than once a month**	**1 to 3 times per month**	**Once per week**	**2 to 3 times per week**	**4 to 6 times per week**	**Once per day**	**2 to 3times per day**	**4 plus times per day**
Complan, Sustagen (all varieties)								
Milo								
Hot chocolate, drinking chocolate, Cocoa, Oval tine, Nesquik								
Coffee (all varieties)								
Black tea								
Herbal tea, fruit tea								
Cordials (including syrups, powders) (e.g. Blackcurrant, orange)								
Fruit and vegetable juices (all varieties)								
Sports drinks (e.g. Powerade)								
Energy drinks (e.g. Red Bull, V)								
Water (including tap water or bottled water)								

Are there any other food items that you can think of that you consume on a regular basis that were not covered by this questionnaire?
Please list these, including the frequency of consumption.

Food items	**Never or less than once a month**	**1 to 3 times per month**	**Once per week**	**2 to 3 times per week**	**4 to 6 times per week**	**Once per day**	**2 to 3times per day**	**4 plus times per day**

Appendix – J

Habitual Dietary Intake Questionnaire

Subject Number:

MASSEY UNIVERSITY
COLLEGE OF SCIENCES
TE WĀHANGA PŪTAIAO

Iron Status of Solomon Islands women

Dietary habits questionnaire

When answering this questionnaire consider your intake of food over the past month. To help you do this, please think of an event in your life that happened one month ago and think about your eating patterns since that day.

1. At which of the following time periods do you eat or drink during weekdays? (Tick as many as apply)

	Always (4-5x/week)	Sometimes (2-3x/week)	Never (0-1x/week)
Before breakfast			
Breakfast			
Morning tea			
Lunch			
Afternoon tea			
Dinner/Supper			
Late night snack			
Other eating periods (please specify)			

2. If you eat *breakfast* what types of food do you usually eat? (Tick as many as apply)

Breakfast cereals	
Porridge	
Bread or toast	
Noodles or rice	
Milk products (including milk on cereal or milk as a drink; yoghurt; cheese)	
Fruit	
Meats (e.g. Bacon, sausages)	
Baked beans or eggs	

3. Do you usually have a drink up to 1 hour before, with, or up to 1 hour after your breakfast?

YES	
NO	

4. If yes, what drinks do you usually have with you breakfast? (Tick as many as apply)

Fruit or vegetable juices	
Milk or milk-based drinks (all varieties)	
Soy-based drinks	
Chocolate-based drinks (e.g. milo)	
Coffee (all varieties)	
Tea (all varieties)	
Water (all varieties)	
Other	

5. If you eat lunch, what types of food do you usually eat? (Tick as many as apply)

Bread (e.g. Sandwiches, rolls)	
Starchy food (e.g. Pasta, rice, potato)	
Milk products (including milk on cereal or milk as a drink; yoghurt; cheese)	
Fruit	
Meats (e.g. Meat, fish, chicken, seafood, ham, salami)	
Legumes, nuts, eggs	
Vegetables (include salad)	
Fruit juice	

6. Do you usually have a drink up to 1 hour before, with, or up to 1 hour after your lunch?

YES	
NO	

7. if yes, what drinks do usually have at lunch? (Tick as many as apply)

Type	**Number of cups or glasses during the week**
Fruit or vegetable juices	
Milk or milk-based drinks (all varieties)	

Soy-based drinks	
Chocolate-based drinks (e.g. milo)	
Coffee (all varieties)	
Tea (all varieties)	
Water (all varieties)	
Other	

8. If you eat evening meal, what types of food do you usually eat? (Tick as many as apply)

Bread (e.g. Sandwiches, rolls)	
Starchy food (e.g. Pasta, rice, potato)	
Milk products (including milk on cereal or milk as a drink; yoghurt; cheese)	
Meats (e.g. Meat, fish, chicken, seafood, ham, salami)	
Legumes, nuts, eggs	
Vegetables (include salad)	
Dessert or pudding	
Fruit	

9. Do you usually have a drink up to 1 hour before, with, or up to 1 hour after your evening meal?

YES	
NO	

10. If yes, what drinks do usually have at lunch? (Tick as many as apply)

Type	**Number of cups or glasses during the week**
Fruit or vegetable juices	
Milk or milk-based drinks (all varieties)	
Soy-based drinks	
Chocolate-based drinks (e.g. milo)	
Coffee (all varieties)	
Tea (all varieties)	
Alcohol	
Water (all varieties)	
Other	

11. If you eat or drink *between meals*, what types of food or drinks do you usually have? (Tick as many as apply)

Bread based snacks (e.g. sandwiches)	
Breakfast cereal	
porridge	
Biscuits or cakes	
Crackers	
Milk based, snacks (milk-based drinks, yoghurt, dairy food, cheese)	
Fruit	
Potato chips	
Cereal bars, muesli bars	
Chocolate or sweets	
Vegetables	
Fruit or vegetable juices	
Milk or milk-based drinks (all varieties)	
Soy-based drinks	
Chocolate-based drinks (e.g. milo)	
Coffee (all varieties)	
Tea (all varieties)	
Water (all varieties)	
Other	

12. If you eat or drink *after your evening meal* what types of food or drink do you usually eat? (Tick as many as apply)

Bread based snacks (e.g. sandwiches)	
Breakfast cereal	
porridge	
Biscuits or cakes	
Crackers	
Milk based, snacks (milk-based drinks, yoghurt, dairy food, cheese)	
Fruit	
Potato chips	
Cereal bars, muesli bars	
Chocolate or sweets	
Vegetables	
Fruit or vegetable juices	
Milk or milk-based drinks (all varieties)	
Soy-based drinks	
Chocolate-based drinks (e.g. Milo)	
Coffee (all varieties)	
Tea (all varieties)	
Water (all varieties)	
Other	

13. Do you drink alcohol?

YES	
NO	

14. If you drink alcohol on week days, how many days would you drink alcohol? (Please drink). Weekdays include Monday to Friday.

One	
Two	
Three	
Four	
Five	

15. If you drink alcohol how many glasses of wine, cans of beer, ready to Drinks, or nips of spirits do have in total during week days?

1-2	
3-4	
5-6	
7-8	
9-10	
11-12	
13-14	
15-16	
17-18	
19-20	
>21	

16. If you drink alcohol on weekends, how many days would you drink alcohol? (Please drink). Weekends include Saturday and Sundays.

One	
Two	

17. If you drink alcohol how many glasses of wine, cans of beer, ready to Drinks, or nips of spirits do have in total during week days?

1-2	
3-4	
5-6	
7-8	
9-10	

11-12	
13-14	
15-16	
17-18	
19-20	
>21	

18. During the entire week (including weekdays and weekends) how many times would you eat out (for example, at a restaurant, food court or a cafe)?

Never	
Once	
Twice	
Three times	
4 to 5 times	
6 to 7 times	
8 to 9 times	
10 to 11 times	
12 to 13 times	
14 plus times	

19. During the week how many times would you eat take away food (for example, fish and chips, McDonalds, Chinese)?

Never	
Once	
Twice	
Three times	
4 to 5 times	
6 to 7 times	
8 to 9 times	
10 to 11 times	
12 to 13 times	
14 plus times	

20. How many servings of fruit do you usually eat per day (One serving = one apple, pear, banana, orange, two small apricots or plums, half a cup of fruit salad or stewed fruit, one cup of orange juice, two table spoons of raisins or three dates)?

Type	Number of serves per day during the week (Monday to Friday)	Number of serves per day at the weekends (Saturday and Sunday)
Fruit		

21. How many serving of vegetables do you usually eat per day? (One serving = one medium kumara or potato, half a cup of cooked vegetables or salad vegetables, one tomato)

Type	Number of serves per day during the week (Monday to Friday)	Number of serves per day at the weekends (Saturday and Sunday)
Vegetable		

22. How many servings of meat, fish, chicken or seafood do you usually eat per day? (one serving two slices of cooked meat, one medium steak, ¾ cup of mince or casserole, one medium fillet of fish, two cooked drumsticks or one chicken leg)

Type	Number of serves per day during the week (Monday to Friday)	Number of serves per day at the weekends (Saturday and Sunday)
Meat, fish, chicken or seafood		

23. Some foods and drinks have iron added to them (e.g. some breakfast cereals). When you are choosing foods and drinks, how often do you choose the product with added iron instead of the product without?

Whenever I can	
Usually	
Sometimes	
Never	
I don't know or I don't consider whether foods are iron fortified or not	

24. How often do you use a cast-iron fry pan, work or pot when preparing your meals?

Never or less than once a month	
1-3x per month	
Once per week	
2-3x per week	

4-6x per week	
Once per day	
2-3x per day	
4+x per day	
I don't know	

Appendix – K

Multiple pass 24-hour dietary recall sheet

Subject Number:

MASSEY UNIVERSITY
COLLEGE OF SCIENCES
TE WĀHANGA PŪTAIAO

24 hours Dietary Recall Sheet

I would like you to tell me everything you had to eat or drink yesterday; tell me everything you ate from the time you woke up to the time you went to sleep. This includes eating at home and away from home, and it includes mealtimes and eating or drinking between meals.

Meals times	Foods, drinks, snacks (Brand names, description and preparation methods e.g. boiling, frying, microwave, recipes)	Amounts/volume
Before B/Fast **< 6 am**		
Breakfast **6 – 9 am** _____		
Mid- morning **9-12** _____		

Lunch **12- 2 pm** _____		
Mid-Afternoon **3-5 pm** _____		
Dinner **5- 8 pm** _____		
Before Bed time **After 8 pm** _____		

Appendix – L

General health and lifestyle questionnaire

Subject Number:

MASSEY UNIVERSITY
COLLEGE OF SCIENCES
TE WĀHANGA PŪTAIAO

Iron Status of Solomon Islands women living in New Zealand

Solomon Islands women's Health Questionnaire

General instructions

Please fill in Section 1 of this questionnaire. If you require any help please ask one of the researchers.

1) **Do you have children?** Yes ☐ No ☐

If answered yes

How many children do you have? _____

How old are they?1.___2.___3. ___ 4.___ 5.___ 6.___ 7.___

2) **Are you currently taking any contraception such as?**

	Yes	No
Oral contraception (Pill)?	☐	☐
Or		
Patch contraception?	☐	☐
Or		
Contraception by injection (Depo Provera)?	☐	☐
Or		
Intra-uterine device (Loop)?	☐	☐

Or

Contraception implants, e.g. Jadelle

and "Other hormonal methods of contraception? ☐ ☐

If yes, how long have you been using this contraceptive method?

_____

3) **Have you been pregnant recently?** Yes ☐ No ☐

Section 2: Lifestyle

1. **Do you smoke?** Yes ☐ No ☐

If yes, how many cigarettes do you smoke a day _____

2. **At home who prepares <u>most</u> of the food?**

I do ☐ My mother ☐ My relative ☐ My partner ☐

Other ☐ *Please state who* _____

---

3) Who does <u>most</u> of the food shopping for your household?

I do ☐ My parents ☐ My Partner ☐ My relative ☐

Other ☐ *Please state who* _____

4) How would you describe your eating pattern?

☐ Eat a variety of all foods, including animal products

☐ Eat eggs, dairy, fish and chicken but avoid other meats

☐ Eat eggs and dairy products but avoid all meats and fish

☐ Eat eggs but avoid dairy products, all meats and fish

☐ Eat no animal products

☐ Other, *Please specify*_____

5) Do you follow any diet for cultural or religious reason? Yes ☐ No ☐

*If yes, what type of diet do you follow?*_____

6) **Have you dieted strictly in the last year?** Yes ☐ No ☐

*Please comment*_____

Section 3: Health

1) **Do you have or have you ever suffered from any acute or chronic illness?**
Yes ☐ No ☐

Diagnosis Date Diagnosed by Any further details

_____ _____ _____ _____

---

2) Do you have or have you ever suffered from any acute or chronic illness which may affect your iron status? Yes ☐ No ☐

Diagnosis Date Diagnosed by Any further details

_____ _____ _____ _____

_____ _____ _____ _____

3) **Have you ever suffered from low iron stores, iron deficiency or iron deficiency anaemia?** Yes ☐ No ☐

Diagnosis Date Diagnosed by Any further details

_____ _____ _____ _____

_____ _____ _____ _____

_____

4) **Have you ever been treated for iron deficiency or iron deficiency anaemia in your most recent pregnancy?**

N/A ☐ Yes ☐ No ☐

Type of treatment duration any further details

_____ _____ _____

_____ _____ _____

5) **Do you have or have had any medical condition which has resulted in blood loss?** Yes ☐ No ☐

If yes, please describe and give approximate dates

_____

6) **Have you had a blood transfusion in the last year?** Yes ☐ No ☐

If yes, do you know why you receive the transfusion?

_____

7) **Have you had any blood loss (other than your periods or nose bleed) such as wounds, regular scratches from contact sports, blood in stools or urine in the past year?** Yes ☐ No ☐

If yes, please describe

_____

_____

8) **Are you currently taking any medication (excluding nutritional supplements)**
Yes ☐ No ☐

If yes, please state what medication you are taking and why

_____
_____
_____

9) **Have you breastfed a baby within the last year?**

N/A ☐ Yes ☐ No ☐

Section 4: Supplements

1) **Did you take any vitamin and/or mineral capsules/tables at any time during the past year?** Yes ☐ No ☐

If yes, please list the brand name of the supplement, the type of supplement, the number taken and the frequency of intake and the dose (including units)?

Note, it is important to obtain the amounts and types of iron, vitamin C and calcium in any supplement if that is available

eg. Healtheries Iron & vitamin C, 1 taken every 2nd day, ferrous gluconate(170mg) providing element iron (20mg) and vitamin C (40mg)

If participant is not able to remember details please ask them to send an email with the details

Email requested ☐ **Email received** ☐

_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____

1) **Did you take any other dietary supplements such as plain wheat bran(unprocessed bran, not 'All Bran, or breakfast cereal), fibre tablets, Noni juice, lecithin, evening primrose oil, performance enhancers, protein supplements, etc at time during the past year?**

Yes ☐ No ☐

If yes, please list the brand name of the supplement, the type of supplement, the number taken and the frequency of intake and the dose (including unit)?

eg. Nutralife evening primrose oil, 3 capsules take per day, contains 1000mg evening primrose oil

_____
_____
_____
_____
_____
_____
_____
_____
_____

Appendix – M

Blood loss questionnaire

MASSEY UNIVERSITY
COLLEGE OF SCIENCES
TE WĀHANGA PŪTAIAO

Blood Loss Questionnaire

Adapted with permission from a questionnaire designed by Dr Anne-Louise Heath: 23Nov07

ID number ☐☐☐☐☐☐☐

Section 1: Blood Donation

1. Do you donate blood? ☐ No ☐ Yes

2. When did you last donate blood?

   If you cannot remember the day please put 01 and then complete the month and year

   DD MM YYYY
   ☐☐/☐☐/☐☐☐☐

3. How many times have you donated blood in the past year?
   Times in the past year ☐☐☐☐☐☐☐

Section 2: Nose bleeds

1. Do you have nose bleeds? ☐ No ☐ Yes (if you get nose bleeds)
2. How often do you get a nose bleed?
   Times a month ☐☐☐☐☐☐☐
   OR times a year ☐☐☐☐☐☐☐

3. How heavy are yours nose bleeds? ☐ Light ☐ Medium ☐ Heavy

Section 3: Your periods

1. How old were you when you had your first menstruation period?
   Years old ☐☐☐☐☐☐☐

2. Have you had a period in the last 6 months? ☐ No ☐ Yes
   If NO please tell us why

Section 4: Current periods

1. How regular are your periods? ☐ Regular ☐ Irregular

For the next questions you may need to use the calendar at the bottom of the page

2. When did your last period start?

	DD	MM	YYYY
Day/Month/Year	☐ /	☐ /	☐
OR the week starting Day/Month/Year	☐ /	☐ /	☐
If you don't know the date please enter 00/00/0000	☐ /	☐ /	☐

3. How many days do you usually have between periods? (For instance, counting from the first day of your last period to the day you expect your next period to start)

Days ☐

4. How many days does your period usually last?

Days ☐

5. We need to ask the following questions to help us estimate how heavy your periods are:

How many 'heavy' days do you have during a period? ☐

How many 'light' days do you have during a period? ☐

6. On a 'heavy' day please complete the following:

	How many do you use?	What absorbency level are they?
On a 'heavy' day, how many PADS do you use? And what Absorbency level are they? (E.g. super plus, super, regular, mini or light)	☐	☐
On a 'heavy' day, how many TAMPONS do you use? And what Absorbency level are they? (E.g. super plus, super, regular, mini or light)	☐	☐

7. On a 'light' day please complete the following:

	How many do you use?	What absorbency level are they?
On a 'light' day, how many PADS do you use? And what Absorbency level are they? (E.g. super plus, super, regular, mini or light)	☐	☐
On a 'light' day, how many TAMPONS do you use? And what Absorbency level are they?	☐	☐

(E.g. super plus, super, regular, mini or light)

8. If you use tampons, which brand of tampons do you usually use?

- ☐ Tampax Applicator
- ☐ Tampax Tampets
- ☐ Carefree
- ☐ Libra
- ☐ Signature
- ☐ Moxie
- ☐ Natracare
- ☐ Pams
- ☐ Kotek
- ☐ home brand

Other (please specify)

9. If you using PADS which brand of pad do you usually use?

- ☐ Stayfree
- ☐ Libra
- ☐ U Ultra
- ☐ Home brand
- ☐ Signature

Other (please specify)

10. Other blood loss?

Please describe any other sources of blood loss such as coughing up blood, blood in stools or urine

11. Any comments

Instructions for calculating estimated menstrual loss

(Heath et al., 1998)

Estimated Menstrual Loss =HD x (HP x Abs + HT x Abs) + LD x (LP x Abs + LT x Abs)

KEY:

HD = number of 'heavy' days during an average period

HP = number of pads on a 'heavy' day

HT = number of tampons on a 'heavy' day

LD = number of 'light' days during an average period

LP = number of pads on a 'light' day

LT = number of tampons on 'light' days

Abs = absorbency (see table below)

Table of relative absorbencies for tampons and pads:

Products	Absorbency levels	Values
Tampax tampons	Regular Super Super plus	1 2 3
Libra tampons (Slim and designs)	Mini Regular Super	1 2 3
Carefree (Applicator and non-applicator) tampons	Light Regular Super	1 2 3
Signature range tampons	Mini Regular Super	1 2 3
Other brands (Tampons): OB from Germany Playtex Cotton	 Regular Super Super Regular Super	 2 3 3 1 2

Pam	Regular	2
	Super	3
Natra care organic	Regular	1
	Super	2
Home brand	Regular & super	2.5
Libra pads	Regular	2
	Super	3
Carefree pads (Liners)	Liner/Mini	1
Signature range	Regular	2
	Super	3
Stayfree pads	Regular	2
	Super	3
Other bands (Pads):		
Freestyle	Regular	2
Organic cotton	Regular & super	2.5
Always	Regular	2
Whisper	Regular	2
	Ultra	3
Laurier	Regular	2
Poise	Liner/Mini	1
Budget	Regular	2

Adopted from; Beck et al. (2011).

This questionnaire has been trialed and used in previous studies. Thus, no alterations have been made to it.

References

Beck, K., Conlon, A.C., Kruger, R., Coad, J & Stonehouse,W. (2011). Gold kiwifruit consumed with an iron-fortified breakfast cereal meal improves iron status in women with low iron stores: a 16-week randomised controlled trial. *British Journal of Nutrition,* 105, 101 - 109.

Heath A-LM, Skeaff CM, Williams S, Gibson RS (2001).The role of blood loss and diet in the aetiology of mild iron deficiency in premenopausal adult New Zealand women. *Public Health Nutrition* 4:197-206.

Heath AL, Skeaff CM, Gibson RS (1998).Validation of a questionnaire method for estimating extent of menstrual blood loss in young adult women. *Journal of Trace Elements in Medicine and Biology* 12:231-235.

Appendix – N

Bod Pod standard operation procedure

Institute of Food, Nutrition and Human Health

Standard Operative Procedure (SOP)

Name: BODPOD to measure body composition

Code: IFNHH-SOP-005 v.01 Supersedes: NA (new)

Revision date due (two years from Approval): 15/02/2012

Purpose: This SOP describes the method to obtain percentage of body fat with the use of the BOPBOD.

Background

Body composition is a vital component of many research studies. Only trained personnel are allowed to operate the BODPOD.

Equipment and Consumables

1. BODPOD
2. Breathing tube
3. Swim cap
4. Appropriate clothing

Procedure

5. Ensure calibration of BODPOD is undertaken on a daily basis when in use. Scales should be calibrated weekly[1].
6. Prepare BODPOD for first participant. Enter the average height into the BodPod (round up to nearest 0.1) Ask subject to get changed and empty bladder (swimwear / tight clothing, remove jewellery, participants should remove glasses as no breathing procedure will be required but may keep them on if required) [1].
7. Put details into BODPOD and start calibration process[1]
8. Whilst doing calibration process ask participants to put swim cap on. Do not open the room door as this will affect the air pressure in the room
9. Explain procedure to participant – Don't forget to show green button[1].

10. Also tell participant that light ear pressure may be felt and that they will hear some clicking noises
11. Follow on-screen instructions[1]

References

[1] BODPOD Manual in IFNHH 2008.

Changes Control

10. New Format with header and footer.

11. Full description of Operation and Maintenance.

12. Method updated to current practice.

13. Prepared, Checked and Approved by.

14. Two years of Revision date from Approval.

15. References and Changes Control.

Prepared by:	Checked by:	Approved by:
Cath Conlon Date: 15/10/10	Rozanne Kruger Date: 08/02/10	Cath Conlon Date: 15/02/10

Appendix – O

Massey laboratory standard operation procedure

Massey University
COLLEGE OF SCIENCES

Institute of Food Nutrition and Human Health
Te Kura Hangarau o Kai-orangā-ā-tāngata
Human Nutrition & Health

HUMAN NUTRITIONAL STUDIES LABORATORY PROCEDURE

Obtaining a Venous Blood Sample

BACKGROUND
The purpose of obtaining venous blood samples in a safe and effective manner to assist in the diagnosis and ongoing management of an adult patient.

SCOPE
Applies to all medical practitioners, staff, who perform peripheral intravenous cannulation on trial participants of adult age.

AUTHORITIES AND RESPONSIBILITIES

It is expected that all staff performing venipuncture should have undertaken suitable training and have been evaluated as competent to perform this procedure by a registered health professsional. MidCentral Health have trained HN&H staff.

At IFNHH, the laboratory clinician, laboratory manager and associated research scientists who hold certification in peripheral intravenous cannulation may perform this procedure. From time to time, qualified nursing staff and phlebotomists will be contracted to perform this procedure in trial participants.

Each trial participant must be assessed prior to venipuncture. If the venipuncture is judged as being too complex for the level of skill of the person performing the procedure, then the patient must be referred to a more experienced health professional,.

The laboratory's scientific staff are responsible for ordering the blood tests required and which are according to the parameters of the particular study being conducted, and in accordance with MUHEC.

PREREQUISITES

The following key points must be considered prior to venipuncture:

Vigorous hand exercise or "pumping" by the trial participant in order to distend the vein can cause the test results to be inaccurate and therefore must be avoided. Having the trial participant make a fist is adequate to achieve this result.

HUMAN NUTRITIONAL STUDIES LABORATORY PROCEDURE

If the tourniquet is left on for more than one minute, the results of some tests may be abnormally high. If there is difficulty or delay in drawing blood, the tourniquet should be loosened for approximately a minute, and then tightened again before entering the vein.

Careful assessment of the trial participant should be made prior to venipuncture to identify whether the proposed site is suitable. Sites that should not be used include:

- Veins which have extensive scarring or a haematoma present.
- If a patient has lymphedema, the affected limb should not be used for venipuncture as the lymphedema could be exacerbated.

PROCEDURE

Equipment

- Vacutainer
- Size 20 or 21g vacutainer needle OR Syringe with 20g or 21g needle OR size 20/21g
- Winged infusion device.
- Sharps container
- Blood tube(s)
- Tourniquet
- Alcohol swabs
- Non-sterile gloves
- Gauze swabs
- Adhesive plaster dressing i.e. Airstrip.
- 18 gauge needle (if syringe and needle method is used).

Health and Safety:

Staff:

1) Apply standard precautions when dealing with human blood samples. See IFNHH Safety Manual.

2) This is an aseptic procedure, and aseptic technique should be followed.

3) Disposable latex gloves should be worn. Before using these gloves, check whether the trial participant is allergic to latex and where necessary use non-latex gloves (e.g. nitrile)

4) Vacutainer evacuated blood collection system is the preferred method to reduce the incidence of needlestick injuries and blood spillage

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Te Kura Hangarau o Kai-orangā-ā-tāngata
Human Nutrition & Health

HUMAN NUTRITIONAL STUDIES LABORATORY PROCEDURE

5) Needles should be placed in a sharps container once venipuncture is performed.

6) If a needlestick injury occurs refer to the IFNHH safety manual and follow procedure

7) Identify and plan safe actions/stance e.g. Semi-squat.

Trial Participant

1) If venipuncture is unsuccessful on the third consecutive attempt, the procedure should be stopped and the trial participant referred to a more experienced health professional.

2) To ensure that disinfection occurs, the insertion site must be cleaned well using an alcohol swab and the area left to dry prior to venipuncture. This will also reduce the risk of haemolysis of any specimen collected and prevent a burning sensation to the trial participant when the venipuncture is performed.

3) To prevent preservative contamination, the recommended sequence for blood tubes is:

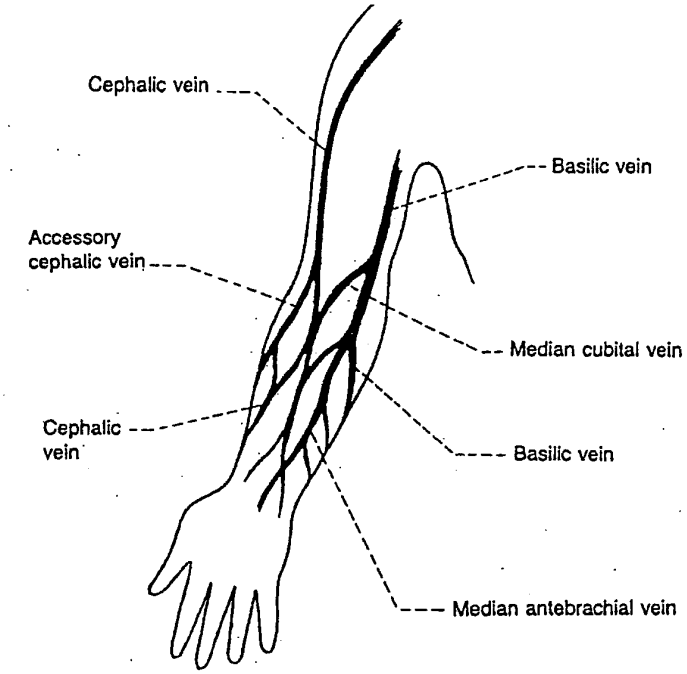
- Blood cultures (sterile samples)
- Plain - red top (glass)
- Citrate - blue
- SST-II Gel - red top (with clot activator)
- PST-II Gel - green top
- EDTA - pink top
- EDTA - lavender top
- Fluoride - grey top
- ESR - black

4) For restless or very apprehensive trial participants arrange to have an assistant to help you. The assistant will focus on the person's needs and safety during the procedure.

HUMAN NUTRITIONAL STUDIES LABORATORY PROCEDURE

Venipuncture Sites

For adults, blood is usually drawn from a vein in or around the antecubital fossa (refer to the diagram below).



Veins in antecubital region

Performing the Procedure

1) Accurately identify the trial participant. Immediately after taking a sample the identification details of the trial participant and the date and time of the collection must be written onto the sample. The minimum information required on all specimens is the trial participants surname, first name(s), and date of birth. Explain the procedure and reassure the trial participant.

2) Position the trial participant with his/her arm extended and supported on a pillow and extends the arm to form a straight line from the shoulder to the wrist.

3) Wash hands.

HUMAN NUTRITIONAL STUDIES LABORATORY PROCEDURE

4) Put on gloves.

5) Apply tourniquet around the arm 8-10cm above the venipuncture site. Allow vein to fill and distend ensuring that the flow of blood is not stopped for more than a minute before the blood is drawn.

6) Select the venipuncture site. Ask the trial participant to clench their hand into a fist. If a vein is still not apparent, ask the trial participant to hang their arm downward. Firm tapping of the vein site with the index and second finger a few times will cause the vein to dilate. Applying a warm damp cloth to the site for five minutes may have the same result.

7) Clean the venipuncture site with an alcohol swab. Allow the skin to dry. Do not touch the site after cleaning it. If you have to relocate the vein with a finger before puncturing the skin, ensure that asepsis is maintained.

8) Grasp the trial participant's arm near the venipuncture site using the thumb to draw their skin tight.

9) With the needle bevel facing up, line the needle with the vein, penetrating the skin and entering the vein at an angle of approximately 10-20 degrees. Hold the barrel firmly, to prevent movement of the needle in the trial participant's arm, and push the tube stopper over the needle. Keep the tube below the puncture site while the needle is in the vein. Ask the trial participant to open his/her fist when the blood starts to flow into the tube.

10) Release the tourniquet slowly.

11) When the last tube has been filled, remove it from the holder and gently remove the needle from the venipuncture site. Tubes containing an anticoagulant, e.g. blue, lavender – need to be inverted several times in order to mix the anticoagulant. If using a syringe instead of a vacutainer, ensure sufficient blood is withdrawn for the required tests. Replace existing needle with 18 gauge needle. Gently pierce the rubber top of the blood tube with the needle to minimise the risk of haemolysis.

12) Apply a gauze swab or cotton wool to the venipuncture site for 2-3 minutes. Do not bend the elbow as sufficient pressure cannot be applied in this position and bruising may occur.

13) Dispose of the needle directly into sharps container. If using a steel butterfly needle cut needle off into the sharps container, taking care to prevent injury. Do not recap needles. Dispose of equipment into designated containers in approved manner.

14) Record collection details on requisition form and label blood tubes immediately after collection.

15) Carefully check the site to ensure the bleeding has stopped and apply an adhesive over the site. Instruct the trial participant to leave the adhesive in place for at least 15 minutes. If the trial participant is allergic to an adhesive, apply gauze and tape.

Massey University
COLLEGE OF SCIENCES

Institute of Food Nutrition and Human Health
Te Kura Hangarau o Kai-orangā-ā-tāngata
Human Nutrition & Health

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16) Forward specimen to laboratory in a biohazard bag after placing form into side pocket.

17) Wash hands.

REFERENCES

MedLab Central: SUPP; Procedure for Vein Selection and Collection of Blood Samples.

Weinstein, S.M. (2001). Plummer's Principles and Practice of Intravenous Therapy. (7th ed.). Lippincott Raven Publishers; Philadelphia

Appendix – P

Complete FeFFQ result

Frequency of intake of foods influencing iron status*

Food items	SI women (n=39)	Caucasian women (n=75)	*P*-value**
Red meat, white meat, prepared meat and offal			
Beef	1 (0.5, 2.5)	2.5 (1.0, 2.5)	0.006**
Lamb	0.5 (0.0, 1.0)	0.5 (0.0, 0.5)	0.932
Pork	0.5 (0.0, 1.0)	0.0 (0.0, 0.5)	0.242
Ham	0.5 (0.0, 1.0)	0.5 (0.5, 1.0)	0.068
Veal	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)	0.471
Liver	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)	0.012
Game meat	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)	0.974
Beef Jerky	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)	0.001
Black pudding	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)	0.166
Chicken	2.5 (1.0, 2.5)	2.5 (1.0, 2.5)	0.577
Corn beef (canned)	0.5 (0.0, 0.5)	0.0 (0.0, 0.0)	<0.001**
Luncheon meat	0.0 (0.0, 0.5)	0.0 (0.0, 0.5)	0.171
Meat pies	0.5 (0.0, 0.5)	0.0 (0.0, 0.5)	0.001**
Soup meat	0.5 (0.0, 0.5)	0.0 (0.0. 0.5)	0.011**
Fish and sea food			
Fresh frozen fish	0.5 (0.5, 1.0)	0.5 (0.0, 1.0)	0.007**
Canned/bottled fish	2.5 (0.5, 2.5)	0.5 (0.0, 1.0)	<0.001**
Battered crumb fish	0.0 (0.5, 0.5)	0.0 (0.0, 0.5)	0.021**
Mussels	0.5 (0.0, 0.5)	0.0 (0.0, 0.0)	<0.001**
Scallop	0.0 (0.0, 0.5)	0.0 (0.0, 0.0)	0.039**
Prawn	0.0 (0.0, 0.5)	0.0 (0.0, 0.0)	0.002**
Egg	1.0 (0.5, 2.5)	1.0 (0.5, 2.5)	0.331
Nuts and seeds			
Peanut	1 (0.5, 2.5)	1 (0.5, 2.5)	0.929

Almond	0.5 (0.0, 1.0)	0.5 (0.0, 2.5)	0.714
Pumpkin seed	0.0 (0.0, 0.5)	0.5 (0.0, 1.0)	0.044
Sesame seed	0.0 (0.0, 0.0)	0.0 (0.0, 0.5)	0.032**
Legumes			
Bean in sauce	0.5 (0.0, 1.0)	0.5 (0.0, 0.5)	0.136
Bean canned	0.0 (0.0, 0.5)	0.0 (0.0, 0.5)	0.982
Lentils	0.0 (0.0, 0.5)	0.0 (0.0, 0.5)	0.326
Peas	0.0 (0.0, 1.0)	0.5 (0.0, 1.0)	0.188
Dhal	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)	0.048
Dairy products			
Cheese	0.5 (0.0, 2.5)	2.5 (2.5, 5.0)	<0.001**
Cottage cheese	0.0 (0.0, 0.5)	0.0 (0.0, 0.5)	0.877
Cream	0.5 (0.0, 0.5)	0.5 (0.0, 1.0)	0.748
Milk as drink	1 (0.0, 1.0)	0.0 (0.0, 1.0)	0.002**
Milk in food	1.75 (0.5, 5.0)	5 (1.0, 7.0)	0.047**
Yoghurt	0.5 (0.0, 2.5)	2.5 (1.0, 5.0)	0.009**
Ice cream	0.5 (0.37, 1.0)	0.5 (0.0, 1.0)	0.127
Coconut cream	0.5 (0.5, 1.0)	0.0 (0.0, 0.5)	0.001**
Fruits			
Apple	2.5 (1.0, 7.0)	1 (0.5, 5.0)	0.007**
Citrus fruits	2.5 (1.0, 7.0)	2.5 (0.5, 5.0)	0.025**
Green kiwifruit	2.5 (1.0, 7.0)	0.5 (0.0, 2.5)	<0.001**
Gold kiwifruit	0.5 (0.0, 2.5)	0.0 (0.0, 0.5)	<0.001**
Pear	0.5 (0.5, 2.5)	0.0 (0.0, 1.0)	0.223
Stone fruit	0.5 (0.0, 1.0)	0.5 (0.0, 1.0)	0.930
Avocado	0.5 (0.0, 1.0)	0.5 (0.5, 1.0)	0.443
Feijoa	0.0 (0.0, 0.5)	0.0 (0.0, 1.0)	0.689

Grape	0.5 (0.5, 2.0)	0.5 (0.0, 1.0)	0.059
Mango	0.0 (0.0, 0.5)	0.0 (0.0, 0.0)	0.007**
Watermelon	0.5 (0.0, 1.0)	0.0 (0.0,0.0)	0.000**
Pawpaw	0.0 (0.0, 1.0)	0.0 (0.0, 0.0)	0.013**
Pineapple	0.5 (0.0, 0.5)	0.5 (0.0, 0.5)	0.989
Fruit salad	0.5 (0.0, 1.0)	0.0 (0.0, 0.5)	0.001**
Straw berries	0.5 (0.25, 1.0)	0.0 (0.0, 1.0)	0.034**
Sultana	0.5 (0.0, 0.5)	0.5 (0.0, 2.5)	0.004**
Dried apricot	0.0 (0.0, 0.5)	0.5 (0.0, 2.5)	0.012 **
Vegetables			
Potato	2.5 (0.5, 5.0)	2.5 (1.0, 2.5)	0.852
Kumara	1 (0.5, 2.5)	0.5 (0.5, 2.5)	0.018**
Green bean	0.75 (0.0, 1.0)	1.0 (0.5, 2.5)	0.460
Red cabbage	0.0 (0.0, 0.5)	0.0 (0.0, 0.5)	0.269
Cabbage	2.5 (0.75, 5.0)	0.0 (0.0, 0.5)	<0.001**
Capsicum	0.75 (0.37, 5.0)	0.5 (0.5, 2.5)	0.448
Cauliflower	1.0 (0.0, 5.0)	0.5 (0.5, 2.5)	0.195
Corn	0.5 (0.0, 1.0)	0.5 (0.0,1.0)	0.932
Courgette	0.75 (0.00, 2.5)	1.0 (0.5, 2.5)	0.779
Carrot	2.5 (2.5, 5.0)	2.5 (1.0, 5.0)	0.372
Lettuce	2.5 (1.0, 7.0)	2.5 (0.5, 5.0)	0.055
Tomato	5.0 (1.0, 7.0)	2.5 (1.0, 5.0)	0.214
Mushroom	0.5 (0.0, 2.5)	1.0 (0.0, 2.5)	0.509
Onion	5.0 (2.5, 7.0)	2.5 (2.5, 5.0)	0.080
Peas green	1.0 (0.0, 2.5)	1.0 (0.5, 2.5)	0.505
Spinach	1 (0.0, 2.5)	0.5 (0.0, 1.0)	0.012**
Pumpkin	0.5 (0.0, 1.0)	0.5 (0.0, 1.0)	0.675

Parsnips	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)	0.836
Other green leafy vegetables	0.7 (0.5, 2.5)	0.0 (0.0, 0.5)	<0.001**
Vegetable soup	1.0 (0.0, 2.5)	0.5 (0.0, 1.0)	0.255
Cereals and grains			
Porridge	0.0 (0.0, 0.8)	0.0 (0.0, 2.5)	0.535
Cornflakes	0.5 (0.0, 2.5)	0.0 (0.0, 0.0)	<0.001**
Weetbix	0.0 (0.0, 0.5)	0.0 (0.0, 1.0)	<0.001**
Muesli	0.5 (0.0, 1.0)	0.5 (0.0, 2.5)	0.808
Light and fruity cereal	0.0 (0.0, 1.0)	0.0 (0.0, 0.5)	0.054
Choc based cereal	0.0 (0.0, 0.5)	0.0 (0.0, 0.0)	<0.001**
Sweetened cereal	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)	0.001**
Breakfast drink	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)	0.090
Brown rice	0.0 (0.0, 0.5)	1.0 (0.5, 2.5)	0.155
White rice	5 (2.5, 7.0)	1 (0.5, 2.5)	<0.001**
Instant noodle	1 (0.5, 2.5)	0.0 (0.0, 0.0)	<0.001**
Pasta white	1 (0.5, 2.5)	1 (0.5, 2.5)	0.786
Pasta whole	0.0 (0.0, 1.0)	0.0 (0.0, 0.0)	0.001**
Couscous	0.0 (0.0, 0.0)	0.0 (0.0, 0.5)	0.001**
Bulgur wheat	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)	0.669
Wheat germ	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)	0.177
Fruit bread	0.5 (0.0, 1.0)	0.0 (0.0, 0.5)	<0.001**
Fortified bread	0.0 (0.0, 1.0)	0.0 (0.0, 0.0)	0.002**
White bread	2.5 (1.0, 7.0)	1 (0.5, 2.5)	0.006**
Brown bread	2.5 (1.0, 7.0)	5 (2.5, 7.0)	0.502
Cakes, crackers and biscuits			
Cakes	0.5 (0.5, 1.0)	0.0 (0.0, 0.5)	0.004**
Whole meal muffin	0.0 (0.0, 0.5)	0.0 (0.0, 0.0)	0.013**

Fruit cake	0.0 (0.0, 0.5)	0.0(0.0,0.0)	0.002**
Chocolate cake	0.5 (0.5, 1.0)	0.0 (0.0, 0.5)	<0.001**
Biscuit chocolate	0.0 (0.5, 1.0)	0.5 (0.5, 1.0)	0.921
Crackers fortified	0.0 (0.0, 0.5)	0.0 (0.0, 0.5)	0.301
Crackers	1 (0.5, 2.5)	2.5 (0.5, 2.5)	0.416
Spreads			
Marmite	0.0 (0.0, 1.0)	1 (0.0, 2.5)	0.070
Chocolate spread	0.0 (0.0, 0.5)	0.0 (0.0, 0.0)	0.020**
Peanut butter	1 (0.0, 2.5)	0.5 (0.0, 2.5)	0.220
Butter	5 (2.5, 7.0)	5 (1.0, 7.0)	0.734
Sugar	7 (2.5, 7.0)	2.5 (0.5, 7.0)	0.042**
Potato crisps	0.5 (0.0, 1.0)	0.5 (0.0, 1.0)	0.533
Dark chocolate	0.0 (0.0, 0.5)	0.5 (0.0, 0.5)	0.034**
White chocolate	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)	0.542
Beverages			
Milo	2.5 (0.5, 7.0)	0.0 (0.0, 0.5)	<0.001**
Hot chocolate	0.0 (0.0, 2.5)	0.0 (0.0, 1.0)	0.581
Coffee	1 (0.0, 7.0)	5 (0.5, 17.5)	0.124
Black tea	1 (0.0, 7.0)	0.0 (0.0, 2.5)	0.005**
Herbal tea	0.5 (0.0, 5.0)	0.5 (0.0, 2.5)	0.180
Fruit juice	1 (0.5, 2.5)	1 (0.0, 5.0)	0.697
Alcohol			
Beer	0.0 (0.0, 0.0)	0.0 (0.0, 0.5)	0.225
Red wine	0.0 (0.0, 0.5)	0.0 (0.0,0.5)	0.008**
White wine	0.0 (0.0, 0.0)	0.5 (0.0, 1.0)	<0.001**
Spirit	0.0 (0.0, 0.0)	0.0 (0.0, 0.5)	0.010**

*Median (25^{th}, 75^{th} percentile)

**P values using Mann Whitney U test, significant difference between 2 groups (P<0.05)

Appendix – Q

Complete list of foods and drinks frequently consumed

The type of foods and drinks usually consumed at each meal time*

Food items	SI women (n=39)	Caucasian (n=75)
Breakfast		
Bread or toast	36 (92.3)	46 (61.3)
Fruit	27 (69.2)	34 (45.3)
Milk products (e.g. milk on cereal, yoghurt, dairy food, cheese)	25 (64.1)	49 (65.3)
Breakfast cereal	24 (61.5)	46 (61.3)
Tea (all varieties)	23 (59)	31 (41.3)
Baked beans or eggs	21 (53.8)	15 (20)
Coffee (all varieties)	12 (30.8)	25 (33.3)
Noodles or rice	10 (25.6)	1 (1.3)
Porridge	11 (28.2)	25 (33.3)
Chocolate-based drinks (e.g. Milo)	9 (23.1)	6 (8)
Milk or milk-based drinks (all varieties)	8 (20.5)	3 (4)
Meats (e.g. bacon, sausages)	7 (17.9)	3 (4)
Vegetables	7 (17.9)	3 (4)
Fruit or vegetable juices	7 (17.9)	15 (20)
Soy-based drinks	2 (5.1)	6 (8)
Lunch		
Bread (e.g. sandwiches, rolls)	36 (92.3)	69 (92)
Meats (e.g. meat, fish, chicken, seafood, ham, salami)	35 (89.7)	40 (53.3)
Fruit	25 (64.1)	40 (53.3)
Vegetables (including salad)	24 (61.5)	39 (52)
Starchy food (e.g. pasta, rice, potato)	20 (51.3)	23 (30.7)
Lunch - Legumes, nuts, eggs	19 (48.7)	13 (17.3)
Fruit or vegetable juices	15 (38.5)	17 (22.7)
Tea (all varieties)	14 (35.9)	23 (30.7)
Milk products (e.g. yoghurt, dairy food, cheese)	11 (28.2)	43 (40)
Milk or milk-based drinks (all varieties)	9 (23.1)	7 (9.3)
Coffee (all varieties)	6 (15.4)	19 (25.3)
Chocolate-based drinks (e.g. Milo)	5 (12.8)	3 (4)
Soy-based drinks	2 (5.1)	1 (1.3)
Evening meal		
Meats (e.g. meat, fish, chicken, seafood, ham)	36 (92.3)	68 (90.7)
Starchy food (e.g. pasta, rice, potato)	34 (87.2)	62 (82.7)
Vegetables (including salad)	34 (87.2)	73 (97.3)
Fruit	21 (53.8)	11 (14.7)

Fruit or vegetable juices	18 (46.2)	18 (24)
Tea (all varieties)	16 (41)	12 (16)
Milk products (e.g. yoghurt, dairy food, cheese, custard, ice cream)	15 (38.5)	21 (28)
Bread (e.g. sandwiches, rolls, etc)	11 (28.2)	8 (10.7)
Coffee (all varieties)	10 (25.6)	22 (29.3)
Legumes, nuts, eggs	8 (20.5)	8 (10.7)
Milk or milk-based drinks (all varieties)	7 (17.9)	5 (6.7)
Evening meal - Chocolate-based drinks (e.g. Milo)	6 (15.4)	3 (4)
Alcohol	6 (15.4)	26 (34.7)
Soy-based drinks	2 (5.1)	0 (0)
Snacks		
Fruit	32 (82.1)	53 (70.7)
Tea (all varieties)	25 (64.1)	33 (44)
Biscuits or cakes	23 (59)	31 (41.3)
Crackers	22 (56.4)	41 (54.7)
Fruit or vegetable juices	19 (48.7)	16 (21.3)
Potato crisps	16 (41)	13 (17.3)
Chocolate or sweets	16 (14)	34 (45.3)
Coffee (all varieties)	15 (38.5)	21 (28)
Bread based snacks (e.g. sandwiches)	15 (38.5)	7 (9.3)
Vegetables	14 (35.9)	16 (21.3)
Chocolate-based drinks (e.g. Milo)	14 (35.9)	10 (13.3)
Milk products (e.g. yoghurt, dairy food, cheese, ice cream)	12 (30.8)	22 (29.3)
Milk or milk-based drinks (all varieties)	11 (28.2)	9 (12)
Cereal bars, muesli bars	9 (23.1)	38 (50.7)
Breakfast cereal	8 (20.5)	2 (2.7)
Soy-based drinks	4 (10.3)	1 (1.3)
Porridge	2 (5.1)	1 (1.3)
Supper		
Tea (all varieties)	26 (66.7)	27 (36)
Fruit	20 (51.3)	19 (25.3)
Biscuits or cakes	14 (35.9)	19 (25.3)
Crackers	14 (35.9)	2 (2.7)
Fruit or vegetable juices	14 (35.9)	4 (5.3)
Chocolate or sweets	12 (30.8)	23 (30.7)
Milk products (e.g. Yoghurt, dairy food cheese, ice cream)	12 (30.8)	15 (20)
Chocolate-based drinks (e.g. Milo)	12 (30.8)	14 (18.7)
Potato crisps	11 (28.2)	3 (4)

Coffee (all varieties)	11 (28.2)	6 (8)
Vegetables	9 (23.1)	1 (1.3)
Milk or milk-based drinks (all varieties)	8 (20.5)	8 (10.7)
Cereal bars, muesli bars	8 (20.5)	1 (1.3)
Bread based snacks (e.g. sandwiches)	6 (15.4)	0 (0)
Breakfast cereal	4 (10.3)	4 (5.3)
Alcohol	4 (10.3)	12 (16)
Soy-based drinks	4 (10.3)	0 (0)
Porridge	2 (5.1)	0 (0)

*Frequency n (%)

Appendix – R

Multivitamins/minerals usually consumed

Multivitamin and minerals used by participants

Multivitamins/minerals with Iron + Vitamin C	Multivitamin/minerals containing vitamin C + other nutrients
Iron tablets	Healtheries odorless garlic, vitamin C (250 mg) + zinc (5 mg) and Echinacea
Healtheries (multivitamins contains calcium, iron 10 mg and vitamin C)	Healtheries (vitamin C 5000mg)
Centrum (Vitamins/mineral supplements contains beta carotene, calcium, ascorbic acid, iron, zinc & other nutrients)	Black mores (multivitamins)
Herbal Life (Thermojection vitamin C, ferrous sulphate 5mg)	Healtheries (multivitamins)
Blackstrap molasses (vitamins/minerals)	Hi Spec antioxidant (500 mg vitamin C)
Herbal iron capsule	Executive B stress formula (Calcium ascorbate + calcium phosphate)
Healtheries women's multivitamins	Black mores (multi Bio Ace)
Cenovis women's iron plus (contains ferrous fumarate 5 mg (iron 5 mg)	Black mores (Executive B complex)
Ferrogradument C	Femmefort women's multivitamins
Iron melt (contains iron 5 mg + vitamin C)	Healtheries vitamin C, zinc and Echinacea
Healtheries iron supplement (contains ferrous sulphate)	Effergize (contains vitamin C, calcium + others not stated)
Iron capsules + vitamin C	Calcium ascorbate dehydrate + others not stated
Elevit	Healtheries B vitamins
Floradix (liquid iron supplement)	Berroca (contains B vitamins + Vitamin C)
Iron and vitamin C tablets	Real Nutrition multivitamins (contains vitamin C, magnesium and calcium)
Ascorbic acid and ferrogradument	Radiance vitamin B 100 complex
Thompsons multivitamin (contains vitamin C calcium and iron)	Boost (vitamin B complex + vitamin C)

Herbal iron capsule	Multi gel (B complex 50 mg)
Ferocarb plus (iron and vitamins)	Vitamin B and C supplements
	Black mores (Executive stress B vitamins)
	Nature's Own vitamin C
	Centrum multivitamin
	Nutra Life women's multivitamins (contains vitamin D, vitamin C + others not stated)
	Healtheries vitamin C (250mg)