A Situational Analysis of Iron Education in New Zealand Intermediate and Secondary Schools

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Abstract

Background: Iron deficiency is one of the most common nutritional deficiencies worldwide and is the leading cause of anaemia. Iron deficiency is disproportionately represented in the female population partially due to the significant blood loss experienced during menstruation. Increases in iron education may serve as a preventative method for reducing iron deficiency incidence in females in the general population and may aid in early diagnosis and treatment.

Objective: This study aimed to investigate the current level of iron education provided to 11-14-year-old females in New Zealand intermediate and secondary schools by Health, Physical Education (PE), and Nutrition teachers. The secondary objective was to investigate whether these teachers had access to iron education resources.

Methods: An anonymous online questionnaire was distributed to nutrition, physical education, and health teachers throughout New Zealand to gain their perspective on what iron (dietary and menstruation) education is provided within their schools.

Results: The results reflect a low level of iron education currently being provided, with 52% (26/50) of participants reporting that iron education was not part of their current curriculum. The delivery of iron education was affected by the subject the participant primarily taught ($\chi 2=12.641$, $p=0.002$). Health and physical education teachers were 5.07 times more likely to report they did not teach any iron-specific education compared to nutrition teachers. The primary reasons for not including iron education were lack of time (36%, 9/26) and iron education being too specific (28%, 7/26). Furthermore, the results of this study show only 28% (14/50) of the participants reported having access to iron-related resources.

Conclusions: Our findings indicate that there is limited iron education provided to 11-14-year-old female students in New Zealand intermediate and secondary schools. This low amount of iron education is due to a lack of time available for teachers to cover the specific topic in the health and nutrition curriculums. There is potential for an improvement in the provision of educational resources for the delivery of iron education in New Zealand intermediate and secondary schools to aid a more consistent and broad reach of education to students nationwide.

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List of Abbreviations

Abbreviation	Term
DMT	Divalent Metal Transporter
Hb	Haemoglobin
HBM	Health Belief Model
HMB	Heavy Menstrual Bleeding
HPO	Hypothalamic Pituitary Ovarian
ID	Iron Deficiency
IDA	Iron Deficiency Anaemia
MCV	Mean Corpuscular Volume
PE	Physical education
PRECEDE	Predisposing, Reinforcing, and Enabling Constructs in Educational Diagnosis and Evaluation
PROCEED	Policy, Regulatory, and Organizational Constructs in Educational and Environmental Development
RBC	Red Blood Cell
sTfR	Soluble Transferrin Receptor
TIBC	Total Iron Binding Capacity
TPB	Theory of Planned Behaviour
WHO	World Health Organisation

Chapter 1 Purpose

1.0 Introduction

Iron deficiency (ID) is one of the most common nutritional deficiencies worldwide, and according to the World Health Organisation (WHO), it is the leading cause of anaemia (Abbas et al., 2021; Coad & Pedley, 2014). ID is defined as having low levels of iron stores in the body in the form of serum ferritin (Coad & Pedley, 2014). The WHO range for normal ferritin levels in females aged 11-14 is 15-150µg/L. Below this indicates an ID (Dietitians New Zealand Inc, 2016), where there is insufficient iron to produce iron-dependent proteins such as haemoglobin (Hb). Thus the quality of red blood cells is impacted, and iron deficiency anaemia (IDA) may be diagnosed (Coad & Pedley, 2014).

Young adolescent females require adequate iron, among other nutrients, during the period of rapid physiological change and development that occurs from 10-14 years (Peddie et al., 2020; Wiafe et al., 2021). Iron is an essential component of Hb, the protein responsible for transporting oxygen around the body, and myoglobin in muscle tissue. As a result, it supports optimal cognitive function, physical performance, immunity, growth, and development in young children and adolescents (Ministry of Health NZ, 2006). During adolescence, a period of rapid physiological change and growth spurts, and in females, the commencement of menarche means that iron requirements are increased (Dominikus Raditya et al., 2020; Peddie et al., 2020). Despite this, female adolescents appear to have limited knowledge of iron and the prevention, causes, and consequences of ID and IDA (Jalambo et al., 2017). Increased iron requirements, a lack of nutritional knowledge, and additional iron loss via menstrual periods are likely to contribute to a negative iron balance (iron losses exceed iron intake), and an increased risk of ID (Seyoum et al., 2019).

Approximately 440.3-629.4 million females aged 15-49 years worldwide were diagnosed with IDA in 2011 (Alami et al., 2019). These high prevalence rates are likely due to blood/iron losses from menstruation, particularly those who experience heavy menstrual bleeding (Leonard et al., 2014; Ministry of Health NZ, 2003; Wang et al., 2013). The New Zealand National Children's Nutrition Survey published in 2002 found that the overall prevalence of ID among 11-14 year old females in New Zealand was 5.5%. This result showed that females within this age range were at a higher risk of iron deficiency than their

male counterparts. This prevalence is likely due to menstruating occurring at 11-14 years in females (Ministry of Health NZ, 2003). Furthermore, the prevalence of iron deficiency was higher in Māori and Pacific females aged 11-14 years (11.2%; 9.6%) compared to New Zealand European females of the same age (3.2%) (Ministry of Health NZ, 2003). This suggests that there is underlying inequity with regards to iron intake and potentially health education.

The iron status of females is also highly influenced by their dietary intake (Leonard et al., 2014). The total amount of iron consumed in the diet, in addition to the bioavailability of iron in the body (haem or non-haem), are important dietary factors to consider when treating or maintaining iron status. 25-35% of haem iron is absorbed in the body, whereas only ~2-15% of non-haem iron is absorbed (Leonard et al., 2014). Haem iron is found in animal sources such as red meat, whereas non-haem iron is found in plant sources such as green leafy vegetables and legumes. Plant-based dietary patterns, such as veganism and vegetarianism appear to be increasing (Peddie et al., 2020). A Colmar Brunton poll in 2019 showed that 1 in 3 (34%) New Zealanders had reduced their meat intake (Lichtenstein, 2020). These dietary patterns positively influence the environment and an individual's health (Peddie et al., 2020). However, vegetarian and vegan diets need to be planned carefully as individuals are likely to have increased nutrient requirements, including iron, due to the decreased bioavailability of these nutrients in non-animal products (Gibson et al., 2014; Peddie et al., 2020). Many young females miss the opportunity for education on maintaining an adequate iron intake while following a vegan or vegetarian diet, which may contribute to an increased risk of ID in this population.

Education has been found to have significant benefits in increasing nutrition knowledge and improving intentions and behaviours toward nutrition and eating (Alami et al., 2019; Alaofè et al., 2009; Bhutta et al., 2017; Hong & Hwang, 2003). Therefore, education focusing on iron intake and requirements could play a vital role in ensuring adolescent females have an adequate iron intake, regardless of dietary choices. An adequate iron intake improves cognitive and physical performance (Wiafe et al., 2021). Studies have found that ID and IDA put students at an academic disadvantage (Aquilani et al., 2011) due to its impact on their cognitive development, concentration, and work capacity. As well as this, the fatigue

experienced as a result of ID can negatively affect physical performance (Ibáñez-Alcalde et al., 2020; Leonard et al., 2014).

Numerous studies worldwide have investigated the benefit of nutrition education, including iron-specific education interventions on influencing knowledge, attitude, and behaviour towards nutrition and the diet (Abu-Baker et al., 2021; Alaofè et al., 2009; Hong & Hwang, 2003; Richa et al., 2021). However, none of these studies have been completed in New Zealand. To our knowledge, no research has been conducted on the iron education level provided in New Zealand intermediate and secondary schools. A gap in research and education is likely to contribute to the high prevalence of ID and IDA observed in the young New Zealand female population. Before iron education and health in New Zealand schools can be improved, the status quo needs to be identified.

1.1 Aims and Objectives

1.1.1 Research Aim:

The primary aim of this study is to investigate the level of iron education provided to young females in New Zealand intermediate and secondary schools.

1.1.2 Objectives

- To design and distribute an online survey to Health, Physical Education, and Nutrition teachers in intermediate and secondary schools New Zealand-wide investigating:
    - The perceived level of Iron education delivered to 11–14-year-old female students from a staff perspective.
    - The current resources on iron education available to staff and 11–14-year-old female students.

1.1.3 Hypotheses

- It is hypothesised that from the data collected in the online survey, there will be evidence of limited:
    - Education regarding iron requirements and losses for girls aged 11-14 in New Zealand intermediate and secondary schools.

- Resources available to New Zealand intermediate and secondary school staff for iron education for female students aged 11-14.

1.2 Structure of the Thesis

This thesis comprises four chapters, beginning with an introduction to the thesis topic, the research aims, and the hypotheses. The second chapter is a literature review of the current research on the prevalence of ID in young females and the effectiveness of iron education in influencing knowledge, attitudes, and behaviours toward iron intake. Throughout the review, gaps in this research area will be identified and discussed, highlighting the need for this study. The third chapter is a manuscript prepared for publication in a peer-reviewed journal. It outlines the abstract, introduction, methods, results, discussion, and conclusions of the research. The final chapter (chapter 4) provides the research's overall conclusions and recommendations. A complete list of references and the appendix can be found at the end of the thesis.

1.3 Research Contributions

Table 1.1: Summary of Researcher's Contributions

Researcher	**Contribution**
Jerushah Keightley	Primary Researcher and author of the thesis. Completed a research proposal, ethics application, survey design, data collection, statistical/data analysis, and wrote manuscript.
Renee Jansen	Co-researcher. Assisted in research study design, ethics application, data collection and statistical analysis.
Prof Pamela von Hurst	Main Supervisor and co-researcher. Assisted in study design, review of ethics application, review of the survey for data collection and reviewed the final manuscript.
Dr Claire Badenhorst	Co-Supervisor. Assisted in study design, review of ethics application, review of the survey for data collection and reviewed the final manuscript.
Dr Hajar Mazahery	Assisted in data analysis and reviewed results.

Chapter 2 Literature Review

2.0 Introduction

Iron deficiency (ID) is known to be the leading cause of anaemia worldwide according to the World Health Organisation (WHO) (Polin et al., 2013). Anaemia occurs when the number of red blood cells (RBC) is inadequate for meeting physiological requirements. ID contributes to this, as there are insufficient levels of iron to produce these RBC's (Abu-Baker et al., 2021). ID is disproportionately represented in the female population, and young female adolescents are at an increased risk of developing ID and iron deficiency anaemia (IDA) (Abu-Baker et al., 2021). This is likely due to blood loss during menstruation and increased requirements during the period of physiological development that occurs from the ages of 10-14 years upon the initiation of puberty (Peddie et al., 2020; Wiafe et al., 2021). Nutrition education interventions have been shown to positively influence attitudes and behaviours toward nutritional intake (Abu-Baker et al., 2021; Alaofè et al., 2009). Therefore, dietary iron education may help to raise awareness about ID and provide knowledge on how to prevent and treat it.

From the literature available, this review aims to highlight the prevalence of ID and IDA in the female adolescent population and the potential benefits of nutritional iron education in helping to reduce the development of ID in this population. The definition of iron deficiency is explored, followed by its prevalence in the 11-14-year-old female population. The review will then highlight the importance of adequate iron intake in this population and the various dietary sources available. This literature review also includes a summary of previous studies showing the effectiveness of nutrition education interventions in influencing attitudes and behaviour toward nutritional intake. Lastly, literature on the current iron education in New Zealand will be reviewed to highlight the need for this present study.

2.1 Iron Deficiency – Definition and Cut-offs

Iron is a micronutrient that can be found as a trace mineral in the diet. It is a component of haemoglobin (Hb), the protein responsible for transporting oxygen around the body, and myoglobin, the protein found in muscle tissues (Ministry of Health NZ, 2006). It also plays a role in both brain development and function. It is important for cognitive function, physical performance, immunity, erythropoiesis, growth, and development in young children and

adolescents (Abbas et al., 2021; Coad & Pedley, 2014; Ministry of Health NZ, 2006). The other primary source of iron, other than dietary intake, is the recycling of iron from senescent RBCs by macrophages. The body is very efficient at recycling and preserving iron due to the delicate balance required to maintain iron homeostasis and prevent ID and iron toxicity (Coad & Pedley, 2014; Dietitians New Zealand Inc, 2016; Florescu et al., 2016; Polin et al., 2013).

Disruptions to iron homeostasis from an inadequate iron intake, increased iron requirements, and increased iron excretion results in a negative iron balance. In this state, iron losses exceed iron intake, depleting the body's iron stores (serum ferritin), and increasing the risk of ID (Coad & Pedley, 2014; Heath et al., 2001). Increased iron requirements during periods of growth, such as during childhood and adolescence, can put individuals at an increased risk of deficiency, especially if these increased iron needs are not compensated for by increases in iron intake, which may occur through a low dietary intake of iron or low iron bioavailability of the diet (eg. Vegetarian diets). Blood loss from menstrual bleeding, intestinal bleeding, blood noses, or regular blood donation can also significantly contribute to the risk of ID and specific medical conditions that impair iron absorption (Heath et al., 2001).

There are three progressive stages of ID classified as (Coad & Pedley, 2014):

1. Mild ID which is defined as the normal production of iron-dependent proteins; however, iron stores are depleted.
2. Marginal ID is the second stage where the production of iron-dependent proteins is compromised due to progressively lower iron stores. However, Hb is normal, and erythropoiesis is maintained.
3. IDA occurs when iron stores are so low that the production of Hb has been compromised; therefore, Hb concentration is low. In IDA, erythrocytes are small (microcytic) and pale (hypochromic).

The haematological breakdown of the progressive stages of ID and the reference ranges for 11-14-year-old females are presented in Table 2.1.

Table 2.1 : Stages of ID and Biomarkers/Iron Studies Including Reference Ranges for 11-14-Year-old Females

	Normal	Mild ID	Marginal ID	IDA
Haemoglobin (Hb)	Normal 115-150g/L	Normal 115-150g/L	Normal 115-150g/L	Low <115g/L
Production of iron-dependent proteins	Normal	Normal/ Low	Low	Low
Plasma/Serum Iron (Iron Stores)	Normal 8.0 – 32µmol/L	Low <8.0µmol/L	Low <8.0µmol/L	Low <8.0µmol/L
Total Iron Binding Capacity (TIBC)	Normal 50-81µmol/L	Normal 50-81µmol/L	High >81µmol/L	High >81µmol/L
Transferrin Saturation	Normal 15-50%	Normal 15-50%	Low <15%	Low <15%
Serum Ferritin	Normal 15-150µg/L	Low <15µg/L	Low <15µg/L	Low <15µg/L
Soluble Transferrin Receptor (StfR)	Normal 1.9 - 4.4mg/L	High >4.4mg/L	High >4.4mg/L	Normal/High
Red Blood Cell (RBC)	Normal 4.00-5.35 E+12/L	Normal 4.00-5.35 E+12/L	Normal 4.00-5.35 E+12/L	Low <4.00 E+12/L
Mean Corpuscular Volume (MCV)	Normal 78-93 fL	Normal 78-93 fL	Normal 78-93 fL	Low <78 fL

(Dietitians New Zealand Inc, 2016, Coad and Pedley, 2014, Raymond and Morrow, 2021)

The biomarkers for iron status that are commonly used in New Zealand and research studies to identify ID and IDA (Coad & Pedley, 2014; Dietitians New Zealand Inc, 2016; Gibson et al., 2014; Raymond & Morrow, 2021) include Hb as a measure of anaemia, mean corpuscular volume (MCV) as an indication of abnormally small RBC that occurs in IDA, serum/plasma ferritin as a measure of iron stores in mild ID, and serum/plasma iron as a measure of the

quantity of iron bound to transferrin. Total iron-binding capacity (TIBC) is an indirect measure of transferrin, as transferrin accounts for over 95% of the iron-binding capacity of plasma. A high TIBC indicated ID. Transferrin saturation is a measure of the iron supply/availability to the tissues, and soluble transferrin receptor (sTfR) reflects iron depletion in the tissues. A high sTfR indicates an ID, however, this is not necessarily true in IDA, where sTfR may be normal. sTfR It is used to differentiate between IDA and anaemia of chronic disease (Koulaouzidis et al., 2009). It is worth noting that serum ferritin, an acute phase reactant, can disproportionately represent iron stores in conditions of inflammation. It is highly recommended when using serum ferritin to define iron status that an inflammatory marker such as C-reactive protein is measured alongside it, to ensure that inflammation is not masking an ID diagnosis (Coad & Pedley, 2014; Gibson et al., 2014).

In general, ID is defined as having low levels of iron stores in the body in the form of serum ferritin (Coad & Pedley, 2014). The WHO range for normal ferritin levels in girls aged 11-14 is 15-150µg/L. Once the ferritin concentration is less than 15µg/L in girls aged 11-14 years, this indicates an ID (Dietitians New Zealand Inc, 2016). At a serum ferritin level of <15µg/L, there is not enough iron in the body to produce iron-dependent proteins such as Hb. In these severe cases where iron stores are low enough to impact the quality of red blood cells produced, IDA may be diagnosed (Coad & Pedley, 2014; Koulaouzidis et al., 2009). The next section of this review will explore the prevalence of ID and IDA in the New Zealand female adolescent population.

2.2 Intake Requirements and Prevalence of ID in New Zealand Female Adolescents

ID is known to be the most common nutritional deficiency worldwide and disproportionately affects females, especially those of reproductive age (Abbas et al., 2021; Abu-Baker et al., 2021; Coad & Pedley, 2014). ID is also known as the leading cause of anaemia worldwide, with IDA affecting one-third of the world's population. Of the global population diagnosed with IDA, 15.5% are adolescent females aged 12-19 (Abu-Baker et al., 2021; Dominikus Raditya et al., 2020). This highlights the issue of ID ad IDA within the female adolescent population.

The most recent New Zealand children's nutrition survey from 2002 reported that ID and IDA was more prevalent in girls aged 11-14 than males of the same age. The prevalence of ID in females aged 11-14 was 5.5% compared to males aged 11-14 years being (0.7%). This prevalence is likely due to menstruating occurring at 11-14 years in females (Ministry of Health NZ, 2003), reflecting the impact of blood loss through menstruation on an individual's iron status. This pattern is also seen in countries worldwide. In the United States, 9% of female adolescents aged 12-15 years are diagnosed with ID, with 2% being diagnosed with IDA (Ibáñez-Alcalde et al., 2020). A study based in Norway found that IDA was more prevalent in female adolescents (19.9%) compared to male adolescents (2.9%) (Stabell et al., 2021). Within Indonesia, 18% of people with IDA are female adolescents (Dwi & Dono, 2020). This research highlights the need for an intervention of some form, such as education, to help reduce the prevalence of ID and IDA in the young female population. the prevalence of iron deficiency was higher in Māori and Pacific females aged 11-14 years (11.2%; 9.6%) compared to New Zealand European females of the same age (3.2%) (Ministry of Health NZ, 2003). This suggests that there is underlying inequity with regards to iron intake and potentially health education.

Iron intake requirements increase during periods of growth. However, there may not be enough iron ingested to compensate for the increased iron losses and the increased requirements experienced in this population (Coad & Pedley, 2014). The iron requirement for young females aged 9-13 is 8mg/day; this increases to 15mg/day at 14-18 and then again to 18mg/day for females aged 19-50 years. Iron requirements are higher in females than males above the age of 14 years, with a difference of 10mg between males and females from 19-50 years (Ministry of Health NZ, 2006).

Adolescents are at a higher risk of developing iron deficiencies due to increased needs during periods of rapid growth and development where lean body mass, blood volume, and red blood cell mass increase (Campisi et al., 2021; Dominikus Raditya et al., 2020; Gupta et al., 2012; Rahfiludin et al., 2021; Samson et al., 2022; Stabell et al., 2021; Thongprasert et al., 2018). In particular, the prevalence of ID increases in young adolescent females after puberty due to the initiation of menstruation and elevated iron loss during menstrual bleeding (Coad & Pedley, 2014; Khani Jeihooni et al., 2021). ID and IDA can impact young

females' cognitive performance and physical performance, as iron is an essential mineral for transporting oxygen around the body (Ibáñez-Alcalde et al., 2020; Leonard et al., 2014).

2.3 Importance of Iron for Female Adolescents

2.3.1 Puberty and Menstruation

Puberty and the initiation of menstruation contribute to the increased risk of ID in female adolescents. Iron requirements are increased with accelerated growth experienced during puberty and increased iron loss through the blood during monthly menstrual periods. They are likely to contribute to a negative iron balance. Around 1mg of iron is lost each day during menstrual bleeding, which can be 5-6 times higher in females with heavy menstrual bleeding (Napolitano et al., 2014). Heavy menstrual bleeding (HMB) is a loss of 80ml or more of blood in one menstrual cycle (Wang et al., 2013). It is a common diagnosis in adolescent females due to the immature hypothalamic-pituitary-ovarian (HPO) axis (Elmaogullan & Aycan, 2018). The mean age of menarche has been progressively declining since the 1990s and is now around 10-14 years of age (Kaplowitz, 2020; Peddie et al., 2020; Wiafe et al., 2021). This trend for a lower age of menarche has coincided with the prevalence of obesity (Campisi et al., 2021). Additionally, pubertal age is lower in those with better socioeconomic status and living conditions, likely related to access to food, with malnutrition most commonly associated with a delayed onset of puberty (Campisi et al., 2021).

A study that observed the relationship between nutrition and the onset of puberty in rural Pakistan found that the onset of menstruation in females was 11.9 years and the completion of puberty highlighted by menarche was 12.9 years (Campisi et al., 2021). Another study in India by Gupta et al. (2012) found that the average age of girls at their first period was 13.4 years, while the range was from 10 to 17 years of age. This study, however, did not find any correlation between IDA and the onset of menarche, with the results on the prevalence of anaemia among this school-age adolescent group being only 25%. It was considered that this was due to the school-based interventions that the Indian government had implemented. The results from these studies highlight the wide range of menarche onset among female adolescents. However, the main range appears to be from 11-14 years of age.

2.3.2 Cognitive Performance

Iron is essential for cognitive functioning, in particular for learning and memory. Neurons have a high requirement for iron. However, their ability to store iron is limited. Therefore, the brain is especially susceptible to fluctuations in iron availability; hence, ID can significantly affect the brain (Abbas et al., 2021; Coad & Pedley, 2014) by reducing concentration, work performance, and cognitive functioning (Coad & Pedley, 2014). Studies have found that ID, even without IDA, can impair cognitive functioning, student performance, and work capacity. This is due to the decreasing number of dopamine D2 receptors and norepinephrine synthesising, which can lead to abnormalities in sleep, memory, and learning ability (Dominikus Raditya et al., 2020; Ibáñez-Alcalde et al., 2020; Wang et al., 2013). In IDA, reduced immune function, depression, metabolism, and aerobic capacity can all contribute to increased fatigue and a lack of concentration in an acute setting (Coad & Pedley, 2014; Gosdin et al., 2021). Having IDA long-term has been associated with reduced overall work capacity and cognition, impacting the long-term academic potential and performance of adolescent students (Gosdin et al., 2021).

2.3.3 Physical Performance

Iron is also vital for the physical performance of young adolescent females, as one of its primary roles is delivering and storing oxygen around the body as a component of Hb and myoglobin (Ministry of Health NZ, 2006). Active females are at a higher risk of ID than their sedentary peers, particularly active females who follow a vegetarian or very restrictive diet, experience repetitive ground strike/ foot strike haemolysis, or undertake endurance training (Pedlar et al., 2018). In active females, ID alone is not associated with the oxygen-carrying capacity of the blood and therefore does not affect aerobic capacity. However, common symptoms still include decreased energy levels, athletic performance, muscle fatigue, aerobic adaption, and metabolic responses. If ID progresses to IDA, aerobic capacity will be affected due to the reduced oxygen-carrying capacity, secondary to low Hb levels (Coad & Pedley, 2014). Exercise has also been suggested to increase iron loss. As a result, individuals may increase the risk of being in a negative iron balance and more readily progress into an iron-deficient state. Therefore, educating active young adolescent females about iron requirements and exercise is important for potentially preventing ID (Wouthuyzen-Bakker & van Assen, 2015).

2.4 Dietary Sources of Iron

Iron requirements are predominantly met by Erythrophagocytosis (the recycling of iron). While dietary iron intake contributes towards only 5% of daily iron requirements. However, of the iron in our diet, only about 5-15% of this is absorbed, with haem iron (found in animal flesh, e.g. red meat and poultry) being more easily absorbed than non-haem iron (found in plant foods e.g., green leafy vegetables, grains, and legumes) (Coad & Pedley, 2014; Gibson et al., 2014). The absorption of non-haem iron is easily affected by other dietary components and is mainly found in the insoluble ferric form (Fe^{3+}). However, it must be reduced to ferrous iron (Fe^{2+}) to be transported across the gut wall. There are components of the diet that can aid in this reduction and act as reducing agents, including vitamin C. As a result, co-ingestion of non-haem iron with a vitamin C source can enhance its absorption (Coad & Pedley, 2014; Gibson et al., 2014; Rahfiludin et al., 2021). There are also components of the diet that can inhibit iron absorption, including phytates found in grains, cereals, legumes, nuts, and seeds, as well as polyphenols found in tea, cereal, and some fruits and vegetable (Coad & Pedley, 2014). The divalent metal transporter-1 (DMT-1) that transports iron across the gut wall is not specific to iron. Therefore, non-haem iron absorption can be inhibited by other divalent metals competing for DMT-1, such as zinc and manganese. As well as this, calcium can also inhibit non-haem iron absorption by affecting the proton gradient that drives DMT-1 (Coad & Pedley, 2014).

Results from the 2002 New Zealand children's nutrition survey show that breakfast cereals were the most significant contributor of iron in children's diet (18%). This was followed by bread (12%), with beef and some starchy vegetables contributing only 6% of dietary iron intake (Ministry of Health NZ, 2003). This suggests that the primary source of iron in New Zealand children's diets are non-haem, low-iron absorption foods from plant-based sources as opposed to haem iron from animal sources.

2.5 Vegetarian and Vegan Diets

The popularity of vegetarian and vegan diets appears to have been on the rise over recent years (Peddie et al., 2020). Anecdotally this has been related to increasing awareness about sustainability, ethical consideration for animals, and the health concerns raised with a diet high in meat (Peddie et al., 2020). Vegetarians have been found to have a 1-2kg/m2 lower

BMI than omnivores and gain less weight in adulthood. On top of this, they have also been found to have a lower risk of ischemic heart disease, likely due to a lower intake of cholesterol (Peddie et al., 2020).

When vegetarian and vegan diets are well-planned, they can be nutritionally adequate for people at all stages of life (Peddie et al., 2020). This has been made easier with the advances in nutrient fortification and increased availability of vegetarian/vegan products (Peddie et al., 2020). However, if not well-planned, vegetarian and vegan diets can result in nutritional deficiencies, one being iron. One study found that adolescents that ate meat less than four times a week were at an increased risk of ID (Ibáñez-Alcalde et al., 2020). This is likely the result of the bioavailability of iron being decreased in vegetarian diets due to the limited amount or removal of haem iron sources (animal products such as meat) and a higher presence of inhibitors such as phytates and polyphenols (found in plant-based foods) in the diet (Gibson et al., 2014).

To prevent ID in vegetarian individuals, iron bioavailability needs to be maximised by including fortified cereals and milk and increasing the consumption of whole grains and vitamin C-rich foods and drinks. Additional benefits for iron bioavailability can occur by reducing the amount of tea and coffee consumed, especially around iron-rich mealtimes. It is worth noting that in vegetarian diets, the consumption of non-haem iron sources (meat alternatives such as unrefined cereals, nuts, and legumes) often occurs in conjunction with these food being high in phytates, which act as inhibitors of iron absorption, therefore making the iron in the food sources less bioavailable (Gibson et al., 2014; Rahfiludin et al., 2021). As a counter to this inhibitory effect, it has been found that vegetarian diets are often higher in vitamin C, which enhances iron absorption by reducing the non-haem iron to its ferrous form so that it can be absorbed across the gut wall (Gibson et al., 2014; Peddie et al., 2020). However, supplements are sometimes still required for vegetarians and vegans, particularly those following a restrictive diet (Gibson et al., 2014).

It has been found that a high intake of bioavailable iron is positively associated with adequate Hb concentrations and can be beneficial in preventing IDA (Alaofè et al., 2009). In a meta-analysis by Gibson et al. (2014) that examined the effect of vegetarian diets on children's iron status from numerous studies, only minor differences were seen between vegetarians and omnivores in terms of Hb concentration, with the most significant

difference in a study involving children aged 7-11 years old, where the average Hb of vegetarians was lower (118.6g/L) than omnivores (124.1g/L) (*P <0.05)*. However, in some of the studies, a significant difference was seen in serum ferritin between these two groups, with vegetarians having significantly lower serum ferritin stores, with differences ranging from -1.4 to -12.1 between omnivores and vegetarians. These studies involved children from 1.5 years of age to 6 years of age; therefore, they may not be able to be directly related to the adolescents in this current study. However, the effect of a vegetarian diet on iron status is still evident. This difference is likely due to the reduced amount of the more bioavailable haem iron found in animal products (Gibson et al., 2014).

As mentioned, a well-planned vegetarian or vegan diet can be nutritionally adequate (Peddie et al., 2020). However, these diets have many factors to consider to ensure an adequate iron intake. If not planned well, vegetarian and vegan diets can put individuals at an increased risk of developing ID due to sources of iron being from non-haem iron, plant-based foods (Gibson et al., 2014). Education prior to the commencement of vegetarian and vegan diets may prove beneficial in ensuring these diets are well planned to ensure an adequate iron intake.

2.6 Impact of Iron Education on Iron Intake

It has been shown that nutritional knowledge is the first step in influencing behaviour and shaping nutritional habits (Stefani Verona Indi et al., 2021). Researchers from various studies have also found that health and nutrition education effectively improves knowledge and iron status (Abu-Baker et al., 2021; Hong & Hwang, 2003; Jalambo et al., 2018), suggesting that nutrition education is necessary for increasing awareness and influencing behaviour regarding dietary iron intake. Schools are an effective way of delivering nutritional interventions to adolescents. Teachers have been found to be one of the most important information sources in IDA education (Khani Jeihooni et al., 2021; Samson et al., 2022), with the WHO recommending that iron supplementation information be delivered through school-based platforms and the education sector (World Health Organizaion, 2017). In studies investigating the effectiveness of implementing nutrition supplementation initiatives, including iron in schools, the potential to reduce the risk of ID and IDA in adolescents has been demonstrated (Gosdin et al., 2021). A summary of these studies is provided below in Table 2.2.

One study on education and ID of female adolescent students in Jordan found that 54.5% had mild to moderate deficiency and only 52.4% reported adequate knowledge regarding IDA, showing a link between dietary iron knowledge and iron status. Therefore, this study highlights the need for more iron education and resources. The study also found that iron education positively impacted knowledge, attitudes, and practice regarding IDA, as there was a significant increase in total knowledge, attitude, and practice scores in the post-educational intervention group. In contrast, the control group showed no significant difference. Therefore, supporting the idea of developing policies and iron education programs, such as the national education curriculum (Abu-Baker et al., 2021).

Table 2.2: Summary of Findings from Studies Investigating Iron Education

Title of the Research and Type of Delivery	Number of Participants	Results of the Study	Limitations of the study
The impact of nutrition education on knowledge, attitude, and practice regarding iron deficiency anaemia among female adolescent students in Jordan (Abu-Baker et al., 2021). Delivered in four schools in Irbid, Jordan. Delivered by an external organisation.	N= 363 13-15 years olds with no chronic disease or involvement in any health education program. Intervention N = 194 Control N = 169	Following an educational intervention, adolescents had an increase in scores for knowledge, attitude and practice relating to IDA. The control group showed no significant increase in any of these scores. This study emphasised the effectiveness of delivering education in schools to reach as many students as possible at one time.	The study included participants from one city, therefore the data cannot be generalised. Self-reported questionnaires could create bias in participants, as they may accurately represent the types of food they have depending on what they think is more acceptable, this could create bias in the practice scores relating to IDA. Haematological measurements were not done before and after the study, therefore, could not see if iron levels had improved along with knowledge.
The effect of educational intervention on iron and vitamin D consumption based on the theory of planned behaviour in Iranian adolescent girls: A quasi-experimental	N=177 Adolescent girls aged 12-14 years old. Intervention N=85 Control N=92	A significant difference was seen in perceived behaviour control, subjective norms, intention and behaviour between the control group and the intervention group following education training. There was however, no significant difference seen between the two	Used a self-reported questionnaire. Focused on vitamin D and iron, not just iron in this study.

study (Alami et al., 2019). Delivered in schools within the city of Gonabad, Iran. Delivered by an external organisation.		groups for attitude, suggesting that the educational intervention did not improve the attitude of the adolescents towards using vitamin D and iron supplements.	
Education and improved iron intakes for treatment of mild iron-deficiency anaemia in adolescent girls in southern Benin (Alaofè et al., 2009). Delivered in two boarding schools (one intervention school, one control school) in South Benin. Delivered by and external organisation.	N = 68 Intervention N=34 Control N=34	Education improved the intake of vitamin C and dietary iron, including non-haem and haem iron within the intervention group. The intervention group had a decreased risk of inadequate iron and vitamin C intake than the control group (1% dietary iron, 31% absorbable iron post, 6% vitamin C post-intervention, compared to 8%, 60% and 32% respectively) pre-intervention. The prevalence of IDA was reduced by 74% in the intervention group.	Selection bias – the study was carried out in non—randomly selected boarding schools, therefore it may not be applicable to general public schools.
Dietary intake changes in adolescent girls after IDA diagnosis (Dominikus Raditya et al., 2020).	N=62 12-15-year-olds recently diagnosed with IDA.	Following a recent diagnosis of IDA, the dietary intake of the adolescent's changed, where they were more aware of their dietary intake and their intake of vitamin C, iron, and	This study only covered school-going females and not home-schooled females. Data came from mostly middle low-income families.

Delivered in two junior high schools in Wates, Kulon Progo. Delivered by an external organisation.		carbohydrates intake. However, subjects still drank coffee and tea following diagnosis.	The majority of students were from families with well-educated parents who had finished high school.
Effects of nutrition education and iron supplementation on iron nutrition and anaemia of middle school girls (Hong & Hwang, 2003). Delivered in schools in Ulsan City, Korea. Delivered by an external organisation.	N= 123 Middle school girls aged 11-15 with ID or IDA.	There was some improvement of dietary attitudes following nutrition education. The most significant being restricting tea and coffee after meals. Iron status improved following supplementation (Hb and ferritin levels significantly increased, TIBC significantly decreased). Treatment of IDA was correlated with improved academic performance.	There was no intervention group that received only education. Therefore, the true effect of nutrition education alone in this study cannot be concluded.
Effects of iron supplementation and nutrition education on haemoglobin, ferritin and oxidative stress in iron-deficient female adolescents in Palestine: Randomized control trial (Jalambo et al., 2018).	N= 131 15-19 year old female students in Gaza, Palestine who had ID and IDA. N=45 received iron supplements (group a).	Following 6 months of the intervention of weekly iron supplementation +/- nutrition education: Group a: Hb improved from 11.52 to 12.04g/dL. Ferritin improved from 9.92 to 13.94ug/L.	There was no intervention group that received nutrition education alone without iron supplementation, therefore this study does not completely support the idea that education alone can improve iron intake.

Delivered to ID and IDA females. Place of delivery unknown.	N=44 received iron supplements and education (group b) Control group (group c) N=42	Group b: Hb improved from 11.45 to 12.17g/dL. Ferritin improved from 9.19 to 15.73ug/L. Group c: Hb did not change. Ferritin improved from 9.70 to 10.14ug/L.	
The effect of nutrition education based on PRECEDE model on iron deficiency anaemia among female student (Khani Jeihooni et al., 2021). Delivered outside of schools to participants randomly selected in Fasa City, Fars Province, Iran.	N= 160 7-8th grade female students from 4 randomly selected public high schools. Intervention N=80 Control N=80	Experimental group (educational intervention) Knowledge increased, attitude increased, self-efficacy increased, preventative behaviours improved, enabling factors improved and reinforcing factors improved. All of which were significant. There were no changes in any of the measured variables in the control group. The only blood marker that improved and was found to be significant was ferritin, and this only occurred in the experimental group.	The self-reported questionnaire was performed before and after the intervention, however, there is no way of knowing if students had access to the internet when carrying out the questionnaire which could have influenced their responses.

Effectiveness of a nutritional education intervention focused on iron among school children in National Capital Region and Mumbai (Richa et al., 2021). Delivered in schools by Eat Right School program from Food Safety and Standards Authority of India.	N=34,550 8-14-year-old male and female students form Delhi, Gurgaon, Faridabad and Mumbai.	Students showed a significant increase in knowledge of - 32.2% in importance/role of iron - 25.82% in IDA - 26.5% in food sources of iron - 25.2% in iron absorption enhancers. - 21.5% in concept of fortification.	The success of the intervention was tested after a minimum of 7 days.

A study based on the PRECEDE (Predisposing, Reinforcing, and Enabling Constructs in Educational Diagnosis and Evaluation) – PROCEED (Policy, Regulatory, and Organizational Constructs in Educational and Environmental Development) model on IDA in female adolescents found that education has the potential to prevent IDA and increase serum ferritin levels in adolescent girls by improving their knowledge, self-efficacy and nutritional behaviours (Khani Jeihooni et al., 2021). Furthermore, numerous other studies have found that iron education increases knowledge of dietary practices related to iron intake (Abu-Baker et al., 2021; Alami et al., 2019; Leonard et al., 2014; Richa et al., 2021). The majority of studies also saw an improvement in attitude toward dietary iron intake practices and improved self-efficacy and intention (Abu-Baker et al., 2021; Hong & Hwang, 2003; Khani Jeihooni et al., 2021). However, one study found no significant improvement in attitude toward using iron supplements (Alami et al., 2019). This study, however, looked into both iron and vitamin D supplementation, not just iron. Studies have also shown that education not only improves knowledge and attitude regarding dietary iron, it also improves dietary practices relating to iron, such as improved iron intake and improved vitamin C intake (Alaofè et al., 2009; Dominikus Raditya et al., 2020). Other dietary factors that influence iron absorption, such as reducing coffee and tea intake, had conflicting results; where one study found that this was the most significant change following iron education (Hong & Hwang, 2003), while another study found that this was one of the only dietary factors that did not change (Dominikus Raditya et al., 2020).

Alongside influencing dietary iron knowledge, attitudes, and practices, iron education also has the potential to improve iron biomarkers, thereby improving/reducing the risk of ID and preventing IDA. One study found that the prevalence of IDA decreased by 74% following an educational intervention Field (Alaofè et al., 2009), while another study found that the only blood marker influenced was serum ferritin (Khani Jeihooni et al., 2021). Another study that investigated the effect of a 6-month intervention of both iron supplements alone and then iron supplements alongside education found that there were significant changes in both Hb and ferritin in both groups compared to the control group, with the most significant change seen in the group that had both education and supplements (Jalambo et al., 2018). This shows that education alongside iron supplementation reduces the risk of ID and IDA.

However, this study did not investigate the effectiveness of education alone on iron blood markers.

Although results from these studies vary in terms of the effectiveness of education in influencing attitudes and practices toward iron supplementation and reducing iron absorption inhibitors, they are all consistent in their findings supporting the benefit of education in influencing knowledge, attitudes, behaviours, and practices regarding dietary intake, including some focused specifically on iron. The effectiveness of educational interventions can be understood using different models, such as the theory of planned behaviour (TPB) and the health belief model (HBM).

2.7 Theory of Planned Behaviour and Iron Education

The TPB identifies that ability to follow a certain behaviour depends on the perceived ability and motivation of the individual (Alami et al., 2019). The TPB in educational interventions is effective in influencing perceived behaviour control. A study on adolescent girls and the effects of an educational intervention using the TPB and its impact on iron and vitamin D supplementation uptake, found that adolescent girls with higher self-efficacy and perception were more likely to take iron and vitamin D supplements regularly regardless of other barriers such as the taste of the supplements (Alami et al., 2019). This, therefore, suggests that the TPB model, combined with educational interventions, can influence adolescents' dietary intake of iron and thus contribute to preventing ID in this population. It would be beneficial for the TPB to be used in future studies looking into the effect of nutrition education on practices relating to nutrition.

2.8 Health Belief Model and Iron education

The HBM is based on the concept that an individual's behaviour changes upon them realising through education the significance of the problem as their motivation for change increases. There are several concepts that make up the HBM, including perceived severity, perceived benefit, perceived barriers, perceived susceptibility, and self-efficacy (Stefani Verona Indi et al., 2021). Studies have investigated the effectiveness of the HBM and its impact on dietary iron intake (Araban et al., 2017; Mekonnen et al., 2021; Stefani Verona Indi et al., 2021). These studies concluded that education based on the HBM can significantly influence treatment adherence and help prevent IDA. Therefore, the results

from these studies show that nutrition education based on the HBM is likely to be effective in influencing dietary behaviours and is likely to be beneficial for iron education.

The TPB and the HBM are effective ways of understanding and delivering educational interventions to influence dietary practices, including iron intake. Educational interventions are effective, particularly within the school setting. Therefore, it would be beneficial to include iron education in the New Zealand school curriculum to create awareness and influence dietary practices relating to iron intake to help reduce the development of both ID and IDA.

2.9 The New Zealand Curriculum

The New Zealand curriculum sets the foundation for a local curriculum design that reflects a meaningful learning program for the school's students, their whānau, local iwi, and the wider community. Therefore, the New Zealand curriculum acts as a framework, not a set plan. It encompasses eight principles: high expectations, Te Tiriti o Waitangi, cultural diversity, inclusion, learning to learn, community engagement, coherence, and future focus (Ministry of Education NZ, 2015). This means that schools can include what they feel is best for their school community in their education curriculum, so long as it reflects the New Zealand curriculum principles and students are provided with subjects from each of the eight learning areas. The eight learning areas are English, arts, health and PE, learning languages, mathematics and statistics, science, social sciences, and technology (Ministry of Education NZ, 2015). Within these learning areas, schools can provide whatever subjects they feel meet the needs of their students. Therefore, there is potential for differences in the provision of iron education across different schools throughout New Zealand.

2.10 Current Iron Education in New Zealand

There are yet to be any studies investigating the current level of dietary iron education provided in New Zealand intermediate and secondary schools for our at-risk population of adolescent females. However, there have been studies that have looked into how schools promote nutrition in general. For example, there has been recent research into the impact of missing breakfast on school students and the factors contributing to skipping breakfast. Research shows that skipping breakfast negatively impacts students' studies and academic ability (Wilson et al., 2018). There has also been evidence suggesting that providing milk in

schools helps children to meet the recommended intake of dairy and calcium for bone health (Wilson et al., 2018). This suggests that schools are an effective way of targeting and improving nutritional issues in New Zealand, such as malnutrition, missing breakfast, and inadequate dairy intake. Furthermore, the most effective way to ensure a broad reach of dietary iron education to young females is through the school curriculum, as in New Zealand, legally, every child under the age of 16 years is required to be enrolled in a school (Ministry of Education NZ, 2020). Therefore, it is likely that schools may serve as a beneficial location for providing iron education to help prevent the development of ID and IDA. Regardless, an investigation into the status of iron education in New Zealand schools would be beneficial to determine the current levels of nutritional iron education and areas that may require improvement.

2.11 Summary

Iron is an essential nutrient for the human body, and requirements increase in young female adolescents as they enter puberty, where their growth accelerates and menstruation commences. This increased iron requirement means that ID is more common in this population. Therefore, measures need to be taken to ensure that these individuals have the appropriate knowledge and skills to prevent them from developing ID and IDA. Education on iron, through schools, is an effective way of improving dietary iron intake in other countries. Therefore, there is the potential for this to be an effective intervention in New Zealand schools. However, the status of iron education provided in New Zealand schools needs to be investigated, as there needs to be current research on the topic. Determining the level of dietary iron education currently offered in New Zealand intermediate and secondary schools may facilitate changes and improvements to include more iron education in the New Zealand school curriculum, which may aid in reducing the prevalence of ID and IDA that is seen in adolescent females.

Chapter 3 Research Study Manuscript

Evidence of limited iron education provided to 11–14-year-old females in New Zealand schools †

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A Manuscript Prepared for Submission to a Peer-reviewed Journal

3.0 Abstract

Background: Iron deficiency is one of the most common nutritional deficiencies worldwide and is the leading cause of anaemia. Iron deficiency is disproportionately represented in the female population partially due to the significant blood loss experienced during menstruation. Awareness of the female's increased risk and symptoms associated with iron deficiency may aid in early diagnosis and treatment. Additionally, increases in iron education may serve as a preventative method for reducing iron deficiency incidence in females in the general population.

Objective: This study aimed to investigate the current level of iron education provided to 11-14-year-old females in New Zealand intermediate and secondary schools by Health, Physical Education (PE), and Nutrition teachers. The secondary objective was to investigate whether these teachers had access to iron education resources.

Methods: An anonymous online questionnaire was distributed to nutrition, physical education, and health teachers nationwide to gain their perspective on what iron (dietary and menstruation) education is provided within their schools. A total of 182 teachers were recruited via work email addresses, and 50 completed the questionnaire (response rate = 27%).

Results: The results reflect a low level of iron education currently being provided, with 52% (26/50) of participants reporting that iron education was not part of their current curriculum. The delivery of iron education was affected by the subject the participant primarily taught ($\chi 2=12.641$, $p=0.002$). Health and physical education teachers were 5.07 times more likely to report they did not teach any iron-specific education compared to nutrition teachers. The primary reasons for not including iron education were lack of time (36%, 9/26) and iron education being too specific (28%, 7/26). Furthermore, the results of this study show that there is limited access to iron education resources for both staff and students, with 72% (36/50) of the participants reporting that they do not have access to iron-related resources.

Conclusions: Our findings indicate that there is limited iron education provided to 11-14-year-old female students in New Zealand intermediate and secondary schools. This low amount of iron education is due to a lack of time available for teachers to cover the specific

topic in the health and nutrition curriculums. There is potential for an improvement in the provision of educational resources for the delivery of iron education in New Zealand intermediate and secondary schools to aid a more consistent and broad reach of education to students nationwide.

Keywords: iron; iron deficiency; dietary iron, education, anaemia.

3.1 Introduction

Iron deficiency (ID) is one of the most common nutritional deficiencies worldwide and is the leading cause of anaemia (Abbas et al., 2021; Coad & Pedley, 2014). Young adolescents are considered at a higher risk of iron deficiency due to increased requirements during the period of rapid physiological changes and the initiation of menstruation that occurs around 11-14 years of age (Leonard et al., 2014; Wang et al., 2013). According to the most recent New Zealand National Children's Nutrition Survey published in 2002, the prevalence of ID in children aged 11-14 was 5.5%. This prevalence is higher than males aged 11-14 years which was 0.7% (Ministry of Health NZ, 2003).

Iron is an important component of haemoglobin (Hb), the protein responsible for transporting oxygen around the body, and myoglobin found in the muscle tissue. It plays a crucial role in cognitive function, physical performance, immunity, growth, and development in young children and adolescents (Ministry of Health NZ, 2006). ID and iron deficiency anaemia (IDA) puts students at an academic disadvantage (Aquilani et al., 2011) due to its impact on their cognitive development, concentration, and work capacity. As well as this, the fatigue experienced as a result of ID can have a negative effect on physical performance (Ibáñez-Alcalde et al., 2020; Leonard et al., 2014).

Nutrition education interventions have been shown to positively affect individuals' knowledge and behaviour toward nutrition (Abu-Baker et al., 2021; Khani Jeihooni et al., 2021). This suggests that education at a young age could be beneficial in potentially preventing iron deficiency not only during adolescence but also into later life. The school curriculum is the most effective way to ensure a broad reach of dietary iron education for young females. In New Zealand, legally, every child under the age of 16 must be enrolled in a school (Ministry of Education NZ, 2020). There is a lack of research on the current iron education provided in New Zealand intermediate and secondary schools, with limited research on the topic worldwide (Abu-Baker et al., 2021). Therefore, there is no way of knowing whether young females are receiving dietary iron education.

This study aimed to investigate the current level of iron education provided to 11-14-year-old females in New Zealand intermediate and secondary schools by Health, Physical

Education (PE) and Nutrition teachers. The overall purpose was to identify any gaps in dietary iron education and the potential for developing iron education resources.

3.2 Methodology

This study was a cross-sectional observational study involving health, PE, and nutrition teachers from New Zealand intermediate and secondary schools. Data collection commenced in June 2022 and concluded in July 2022. A low-risk ethics notification was submitted to the Massey University Human Ethics Committee (MUHEC) before the commencement of data collection.

3.2.1 Participants and Recruitment

Fifty staff who currently teach health, PE, or nutrition to 11-14-year-old female students participated in this study. This was a convenience sample, as there was limited data from previous research to base the sample size on. It was predicted that this sample size would provide sufficient data to gain an understanding of what level of iron education is being provided in New Zealand schools, as the school curriculum in New Zealand is consistent concerning the subject requirements, although open to individual interpretation in how they are taught (Ministry of Education NZ, 2015).

Inclusion criteria included staff from public and private New Zealand intermediate and secondary co-educational and female-only schools who were currently teaching PE, health, and nutrition to female students aged 11-14 years old, as this is the general age for the onset of menarche (Kaplowitz, 2020; Peddie et al., 2020; Wiafe et al., 2021). Exclusion criteria included staff from single-sex schools that taught only male students health and nutrition, staff that did not teach at an intermediate or secondary school, staff from male-only schools, staff that only taught secondary school students above the age of 14 years, staff members that were not considered health, PE or nutrition teachers and therefore the scope of iron education was not within their teaching practice.

Staff were recruited via the New Zealand Nutrition Teachers' and New Zealand Health Teachers' Facebook pages. As well as by word of mouth and by work email addresses collected from school websites nationwide. An advertisement was created with a link to the information sheet, where participants could read more about the background and purpose of the study and were made aware of their rights as a participant. The questionnaire was

delivered online to willing staff members through a link at the bottom of the information sheet. They completed the questionnaire anonymously online via their personal devices (e.g., laptop, mobile, iPad).

3.2.2 The Questionnaire

The questionnaire was conducted on the online software Qualtrics. It included open and closed questions to assess schools' practices/curriculum from a staff point of view regarding education on menstruation, iron loss, dietary iron requirements, use of iron in the body, and foods that provide iron. Additional questions asked staff about what resources were available to them to use for iron education.

At the beginning of the questionnaire, there was a compulsory consent question that staff were required to complete before progressing to the rest of the questionnaire. The questionnaire was then broken down into four sections. The first section contained closed demographic questions regarding the type of school the participants work at (intermediate/secondary/composite), the age group they currently teach/have contact with, and what subject they teach. The second section included open and closed questions regarding their perception of what iron education is provided within their school, including whether they teach it in their subject. The third section involved open and closed questions about whether they provide education on female health and puberty within their subject. The final section included questions involving what resources they have/know of that are available to aid iron education in their school and what resources they would find helpful in the future.

The demographic questions at the beginning of the questionnaire acted as screening questions. If the participants did not meet the inclusion criteria with their responses, they were directed to the end of the questionnaire. Two people were excluded from the questionnaire because they did not teach at an intermediate, secondary, or composite school. One was excluded from the study because they did not teach the required age group.

3.2.3 Statistical Analysis

IBM SPSS Statistics 28.0.1 for windows (IBM Corporation, Armonk, NY, USA) was used for statistical analysis. Results were collated on the Qualtrics survey software and then

transferred to Microsoft Excel for Mac (version 16.58) where the data was organised, categorised, and coded. Responses to open questions were categorised before being analysed. Responses to closed questions were coded for analysis. Questions were determined as either categorical or ordinal variables.

Data was then transferred to IMB SPSS for statistical analysis. Categorical data was reported as frequencies, percentages, and bar charts, while ordinal data was reported as medians and percentiles. A Pearson's chi-square test was used to compare categorical data and to determine associations between iron education, the type of school, the subject taught, and the age of students. If > 20% of expected counts were < 5, the data was re-grouped, and Pearson's chi-square test was repeated to ensure < 20% of expected counts were < 5. Effect size as odds ratio was calculated for significant Pearson's chi-squared tests. A Kruskal Wallis test was completed for non-parametric comparisons between the level of education provided and the type of school. The significance for all tests was determined as $p < 0 .05$.

3.3 Results

3.3.1 Participant Characteristics

There were 50 teachers who participated in the online questionnaire; the demographic characteristics of participants are summarized in table 3.1. In total, 76% (38/50) of the teachers taught at a secondary school, compared to 14% (7/50) at intermediates and 10% (5/50) at composite schools. The majority (80%, 40/50) of participants taught Food and Nutrition, followed by Food Technology (74%, 37/50), while fewer participants taught health (30%, 15/50) and PE (30%, 15/50). Most participants also reported teaching 'other' subjects (90%, 45/50). The most common age group taught was 13-year-olds (84%, 42/50) and 14-year-olds (86%, 43/50) students, while it was less common that participants taught 12-year-olds (48%, 24/50) and 11-year-olds (24%, 12/50).

Table 3.1: Summary of Participant Characteristics

Characteristic		Frequency (n=50)
School	**Intermediate**	7 (14%)
	Secondary	38 (76%)
	Composite	5 (10%)
Subject	**Food and Nutrition**	37 (74%)
	Food Technology	40 (80%)
	Health	15 (30%)
	PE	15 (30%)
	Other*	45 (90%)
Age of Students Taught	**11-year-olds**	12 (24%)
	12-year-olds	24 (48%)
	13-year-olds	42 (84%)
	14-year-olds	43 (86%)
*Other includes hospitality, science, fitness, sports nutrition, and the whole curriculum.		

3.3.2 Level of Iron Education

When asked to rank the level of iron education provided within the school (0 = not taught at all, 10 = thorough iron education provided), the median [25th, 75th percentiles] score was 2 [1, 3], with the most common score reported being 1. The level of dietary iron education provided to 11-14-year-old females was not significantly affected by the type of school that the staff taught at (H (2) = 4.519, $p > 0.05$).

3.3.3 Iron Education: Comparison Between School, Subject, and Age of Students Taught

Approximately 50% (26/50) of participants reported that iron education was not part of their current curriculum. The delivery of iron education appeared to be affected by the subject that the participant primarily taught (table 3.2). Health and physical education teachers were 5.07 times more likely to report they did not teach any iron-specific education compared to nutrition teachers (χ^2=12.641, p=0.002). As well as this, the type of school that the participants taught at also appeared to affect whether or not iron education was delivered (table 3.2). Intermediate and composite teachers were 6.85 times more likely to report not teaching iron-specific education than secondary school teachers (χ^2=6.211, p=0.013). When asked why iron education was not provided within their curriculum, the primary reasons were lack of time (36%, 9/26) and iron education being too specific (28%, 7/26).

Table 3.2: Summary of Provision of Iron Education by Type of School, Subject Taught, and Age of Students

Characteristic		Iron education provided (n=24)	Iron education not provided (n=26)	P-value
School	**Intermediate/Composite (n=12)**	2 (17%)	10 (83%)	0.013
	Secondary (n=38)	22 (58%)	16 (42%)	
Subject	**Food Technology/ Nutrition (n=17)**	13 (76%)	4 (25%)	0.002
	Health/PE (n=36)	14 (39%)	22 (61%)	
Age of Students Taught	**11-year-olds (n=12)**	2 (17%)	10 (83%)	0.007
	12-year-olds (n=24)	9 (38%)	15 (62%)	
	13-year-olds (n=42)	22 (52%)	20 (48%)	
	14-year-olds (n=43)	23 (53%)	20 (47%)	
Values are represented as frequencies (row percentage)				

3.3.4 Type of Iron Education Provided

Of those who responded yes to whether iron education is a part of their curriculum, the most common topic taught was 'foods that are good sources of iron' (91.7%), followed by 'the consequence of not getting enough iron in your diet' (87.5%) and 'the main functions of iron in the body' (79.2%). There appears to be limited education on 'the difference between haem and non-haem iron' (33.3%) and 'foods/nutrients that decrease iron absorption' (25%). As shown below in table 3.3, these results appeared consistent in ranking with the knowledge of staff participants.

When asked if participants knew if iron education was provided to sports teams within their school, 40% (20/50) responded no, while 60% (30/50) responded unsure. 0% responded yes.

Table 3.3: Summary of Staff Iron Knowledge and the Type of Iron Education Provided

Type of Iron Education Provided	Staff Knowledge (n=50)	Education provided (n=24)
The main functions of iron in the body	39 (80%)	19 (79%)
The consequences of not getting enough iron in your diet	46 (94%)	21 (88%)
The importance of iron intake for females when they have their period	38 (78%)	12 (50%)
The difference between haem and non-haem iron	19 (39%)	8 (33%)
Foods that are good sources of iron	46 (94%)	22 (92%)
Vegetarian foods that are good sources of iron	33 (67%)	13 (54%)
Foods/nutrients that increase absorption (eg. Vitamin c)	31 (63%)	14 (58%)
Foods/nutrients that decrease absorption (eg. Tea and coffee)	25 (51%)	6 (25%)
The importance of iron for female athletes	32 (65%)	10 (42%)
Values represented as frequencies (column percentage)		

3.3.5 Evidence of Iron Deficiency

A significant 62% (31/50) of participants reported noticing symptoms of iron deficiency among students (fatigue, lethargy, pale skin, headaches/dizziness/light-headedness, or

being constantly cold compared to peers). While only 2% (1/50) reported no, and 36% (18/50) reported maybe or unsure.

3.3.6 Potential for Iron Education

Most participants (80%,40/50) believed that dietary education is important, and 20% (10/50) stated it might be or is not important or were unsure. Participants thought iron education would best fit under the subject of health (39%, 39/100), followed by nutrition (22%, 22/100), PE (17%, 17/100), and then food technology (11%, 11/100). This was an open question, where participants could select more than one option. Hence the frequencies are out of 100.

3.3.7 Puberty and Female Health Education

When participants were asked if they provide female health or puberty education, 72% (36/50) participants provided female health education and 73% (36/50) provided puberty education. Just under half of the participants reported that they have students approaching them with questions about puberty and menstruation (44%, 22/50). Of those that reported not teaching female health education (14/50), the reasons were (13 participants responded) that it was not part of the current curriculum (84.6%, 11/13) and it was being taught in other subjects (15.4%, 2/13). Similarly, of the 12 that reported not providing puberty education, the reasons were (8 participants responded) that it was not part of the curriculum (75%, 6/8) and it too was being taught in another subject (25%, 2/8).

3.3.8 Iron Resources

Most participants (72%, 36/50) reported that they did not have access to resources, while only 28% (14/50) reported that they did. Whether or not participants reported having access to iron education resources appears to be significantly affected by the subject that the participants teach (table 3.6). Health and PE teachers were 10.36 times more likely to report not having access to iron education resources compared to nutrition and food technology teachers (χ^2=27.268, p<0.001).

Table 3.4: Summary of the Comparison Between Staff Access to Resources and Subject Taught

		Access to Resources		P-value
		Yes (n=14)	No (n=36)	
Subject	**Health/PE (n=33)**	4 (12%)	29 (88%)	<0.001
	Food Technology/ Nutrition (n=17)	10 (59%)	7 (41%)	
Values represented as frequencies (row percentage)				

Of the 14 that reported having access to resources, 13 responded to the question about the types of resources available. The most common iron education resources were reported to be Beef and Lamb resources (27.8%, 5/13), Nutrition Foundation resources (27.8%, 5/13), and Ministry of Health (16.7%, 3/13) (figure 3.1). 16.7% (3/13) of the participants reported resources that were group into the 'other' category. These included menstruation booklets from suppliers of menstrual products, unspecified 'old paper resources', and from author Dr Libby Weaver (biochemist).

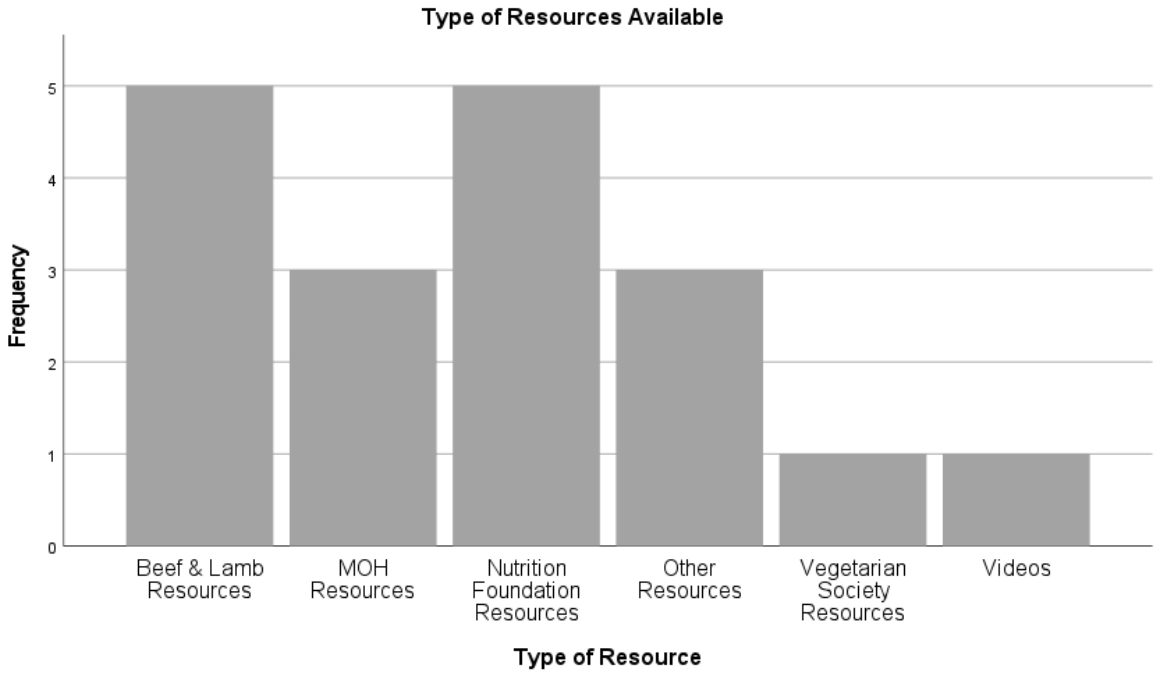

Figure 3.1: Graph Showing the Type of Resources Available to Staff

A large proportion of participants (of the 49 who responded to this question) stated that they would use iron education resources if they were available (76%, 30/49), while 20% (10/49) said they might use them, and 2% (1/49) were unsure.

The type of resources that participants (43 responded to this question) indicated that they would find useful were pamphlets/information sheets (41.9%, 18/43), followed by in-person

activities, videos (37.2%, 16/43), and then website/interactive online resources (27.9%, 12/43).

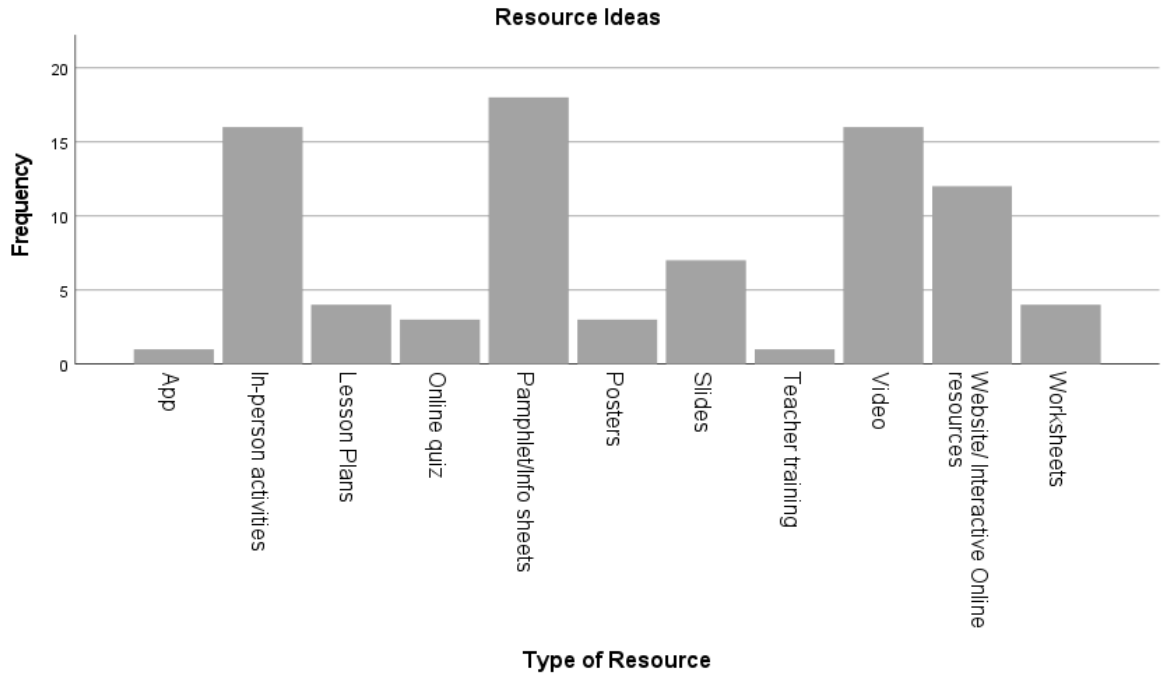

Figure 3.2: Graph Showing the Type of Resources Staff Would Find Useful

3.4 Discussion

This study was designed to assess the current level of iron education provided to 11-14-year-old females in New Zealand intermediate and secondary schools by nutrition, health, and PE teachers. The secondary aim of the study was to investigate the types of iron education resources available to students and staff in these schools. To our knowledge, this was the first study in New Zealand that examined the level of iron education provided in schools. Results from this study suggest a limited amount of iron education delivered within the school setting, with half of the participants reporting that iron education was not included as part of their taught curriculum. The results also show a limited availability of iron education resources for staff in New Zealand intermediate and secondary schools, with most participants reporting that they do not have access to these resources.

The subject taught by the participants appeared to be a significant determinant in whether iron education was provided. Health and PE teachers were five times more likely to report that they did not teach iron-specific education than nutrition and food technology teachers. A possible explanation for this is the specificity of iron education and the wide variety of

topics related to well-being covered under health and PE. As iron education, specifically dietary iron intake, is related to nutrition, it is more likely to be covered under nutrition and food technology. However, nutrition and food technology are not compulsory subjects for this age group. Schools are also not required to provide nutrition as a subject per the New Zealand education curriculum; they are only required to provide subjects under the heading of the eight learning areas (Ministry of Education NZ, 2015). Students who select this subject may be interested in food and nutrition; therefore, possible selection bias in subjects may contribute to a disproportional distribution of iron education knowledge for this age group.

There were two main reasons for iron education not being taught by teachers. These were 'lack of time,' and iron education is 'too specific'. The primary teachers to provide these reasons were health and PE teachers, as they were the main participants to report not providing iron education.

The New Zealand curriculum is based on a local curriculum design, where schools must include subjects under the eight learning areas, with health being one of them. Health and nutrition fall under the learning area of health, and within this learning area, there are specific achievement objectives on which teachers can base their topics. For example, achievement objective D is titled "Healthy communities and environments". This objective is broken down into smaller objectives, which may differ between levels/year groups (Ministry of Education NZ, 2015). This may explain why some health and PE teachers in our study reported that iron education is a part of their curriculum while others reported it was not. A local curriculum is essential to meet the needs of the students within a community. However, as the results from our study show, it can also reflect a need for more consistency within the New Zealand school curriculum. This may mean there are disparities in the education received between students in different schools across New Zealand.

Disparities within iron education can create inequalities relating to health and the prevalence of ID and IDA. Particularly with the evidence from previous studies showing the effectiveness of education in influencing knowledge, attitudes, and practices towards ID and IDA. For example, Alaofè et al. (2009) investigated the effect of education on iron intake for treating ID and IDA in adolescent females in Benin over a 26-week period in two schools. One school (n = 80 students) received an intervention involving four weeks of nutrition education followed by 22 weeks of an increase in iron content and bioavailability within the

school cafeteria menu. The second school (n = 100 students) acted as the control group, receiving no intervention. The study found that the intervention group had improved iron and vitamin C intake. As well as this, the prevalence of IDA was reduced by 74% in the intervention group. This study showed the effectiveness of iron education in increasing iron intake and reducing the prevalence of ID and IDA. When we relate this to the results from our research, where approximately half of our participants did not provide iron education, our results suggest a gap in iron education provided to some students throughout New Zealand, given the evidence of the benefit of iron education in improving iron intake and reducing ID and IDA (Alaofè et al., 2009). This gap means that those students receiving iron education from our participants are likely to benefit from the education and have reduced prevalence of IDA compared to those who do not receive this education.

In cases where the participants provided iron education, this education tended to cover foods that are good sources of iron, the consequences of not getting enough iron, and the main functions of iron in the body. These topics are important, as they are critical determinants of iron intake and bioavailability; thus, they can help to prevent the development of ID and IDA (Gibson et al., 2014; Rahfiludin et al., 2021). Similar topics were also covered in an education intervention from a study in Jordan by Abu-Baker et al. (2021). Participants received a nutrition education program broken down into four 45-minute sessions based on the WHO guidelines on 'Nutrition anaemia: Tools for effective prevention and control'. The education was presented through PowerPoint presentations and videos, with an information sheet handed out at the end of each session. The education intervention positively affected knowledge, attitudes, and practices relating to IDA. Therefore, this shows that even though only half of our participants provided iron education, those that do are on the right track with the topics they include.

Despite approximately half of the participants not including iron education within their curriculum, the results of this study show that 80% believed that iron education is important to include in the curriculum. This suggests that teachers are open to including iron education within their curriculum, implying that there are other barriers to them not providing the education other than a lack of interest in the topic. The reason some participants believe it is not important could be due to their own limited knowledge regarding iron. Therefore, they may need help understanding the importance of the topic.

The responses from the participants suggest that the best subject to include iron education under is health (39% (39/100), followed by nutrition (22% (22/100). This is supported by the requirements of the New Zealand education curriculum, as health is one of the eight learning areas and encompasses the subjects of both health, PE, and nutrition (Ministry of Education NZ, 2015). Furthermore, health and nutrition would be the best subjects to include iron education under, as iron intake has a direct link to health, with an inadequate iron intake potentially leading to ID or IDA, particularly within the female population (Abbas et al., 2021; Abu-Baker et al., 2021; Coad & Pedley, 2014). Given this, iron education would align with the achievement objective D of "Healthy communities and environments" which falls under the learning area of health (Ministry of Education NZ, 2015).

Although a school setting is most likely the best place to provide education on iron to ensure a broad reach of people (Alami et al., 2019; Ministry of Education NZ, 2020), there is a potential question regarding whether school teachers are the best people to provide this education, based on their background knowledge. Particularly as the type of iron education provided appears to match the participant's background knowledge (see table 3.4). This suggests that the participants only provide iron education when they feel confident and have adequate background knowledge. One way to overcome this barrier would be to provide appropriate resources for teachers to give students and for themselves to understand the topic of iron before they teach it. This has been shown to be effective in a previous study where they utilised PowerPoint presentations, videos, and pamphlets (Abu-Baker et al., 2021). Another way to approach it would be for schools to get an outside health professional, such as a dietitian or nutritionist, to come into the school at least once a year and provide this education in a large group setting. This was shown to be beneficial in a previous study that used nutrition and health experts, such as dietitians, to deliver nutrition education (Alami et al., 2019). This nutrition education method effectively increased perceived behaviour control, subjective norms, and intentions and behaviour toward iron consumption. However, this option would likely cost more money and wouldn't be as interactive in a larger group setting compared to a smaller classroom setting.

The provision of adequate educational resources is reported to assist in topic-specific education delivery (Alaofè et al., 2009; Edwards, 2014). In the previously mentioned study by Alaofè et al. (2009), the use of PowerPoint presentations and videos in the delivery of the

education intervention proved to be effective in improving iron intake and reducing the prevalence of IDA by 74%. This suggests that if teachers were to provide education on iron, it would be important for them to have the appropriate resources and prior knowledge. However, in our study, 70.8% of the participants reported that they did not have access to iron education resources. These results suggest the potential for new and updated resources to be developed. However, there may also be potential that some participants were unaware of possible iron education resources. This was seen in a study by (Edwards, 2014) that investigated teachers' knowledge and use of resources to support learners where English is their second language. This study found that staff were unaware of the educational resources; therefore, few participating teachers utilised the recommended resources. This may be true also for the participants in our study. However, there is no way of knowing without investigating the available resources; this is a potential area for future research.

Despite the above findings, 96% of our participants reported that they either might or would use iron education resources if made available; this highlights the potential for more awareness around the available resources and the need for more resources on iron to be developed. The types of resources participants reported would be useful were information sheets, videos, online resources, and PowerPoints. This was similar to the educational resources used in the intervention in the study based in Jordan by Abu-Baker et al. (2021), where they used PowerPoints and videos to deliver the education session and handed out pamphlets at the end. This study improved knowledge, attitudes, and practices toward iron and ID/IDA. Therefore, resources such as information sheets, videos, online resources, and PowerPoint slides would likely be beneficial in providing iron education to intermediate and secondary school students in New Zealand, with a positive outcome for teachers and students.

A significant number (31/50) of participants reported noticing symptoms of iron deficiency in their female students. These findings are also supported by the prevalence (5.5%) of iron deficiency that was seen within the 11-14-year-old menstruating female population in the most recent New Zealand children's nutrition survey in 2002 (Ministry of Health NZ, 2003). Given that education has been shown to be beneficial in reducing the prevalence of IDA and increasing iron intake in students, this high prevalence of ID and IDA within the New Zealand

adolescent female population supports the need for iron education to be provided. Specific topics such as symptoms of iron deficiency and ways to increase iron intake may aid in the effectiveness of treatment and prevention of ID and IDA.

A limitation of this study was that most participants were from secondary schools instead of intermediate and composite schools. Therefore, this study is more representative of the education provided in secondary schools. This is also reflected in the age of students taught, with most participants reporting that they taught 13 and 14-year-olds, with fewer reporting that they taught 11 and 12-year-olds. In the future, it would be beneficial to ensure a more representative sample of intermediate and composite school teachers is included in our study. However, despite fewer participants from intermediate and composite schools, these teachers were 6.85 times more likely to report not teaching iron education than secondary teachers. This shows that minimal iron-specific education is provided in these settings.

Another limitation of this study is that the results relied on staff perspective and were interpreted as representative of the school they taught in. This could therefore mean that even though they might not provide iron education, another person that teaches the same subject in their school might and vice versa. However, the researcher attempted to account for this within the survey design by asking participants if they knew of any other staff in their school that provided iron education. It is not likely that this was a major confounding factor in the results, with the results suggesting that school differences and curriculum interpretations between schools are the most significant contributors to differences in provision of iron education.

Therefore, this study's findings support the hypothesis for evidence of limited education regarding iron requirements and losses for females aged 11-14 in New Zealand intermediate and secondary schools. The findings also support the hypothesis that there are limited iron education resources for staff and students in these schools. Results may suggest that changes to the New Zealand health school curriculum be considered to allow for the inclusion of iron education in a subject that is compulsory for students to take.

3.5 Conclusion

In conclusion, this study found that there is limited iron education for 11-14-year-old females in New Zealand intermediate and secondary schools. Only half of the participants

(48%) reported that iron education is included in their curriculum. Health and PE teachers are just over five times more likely to report not providing iron education than nutrition and food technology teachers. Furthermore, the provision of iron education also appeared to be affected by the type of school the participants taught at, with intermediate and composite school teachers being approximately seven times more likely to report not providing iron education than secondary school teachers. The primary reasons for not including iron education were lack of time, followed by iron education being too specific.

Our findings also indicate a lack of iron education resources available for staff and students in intermediate and secondary schools throughout New Zealand. Despite this, most participants indicated that they would find iron education resources useful. Information sheets, in-person activities, videos, and websites were the most suggested ideas for potential resources.

Chapter 4 Conclusions-Recommendations

4.1 Achievement of Aims and Objectives

The research aimed to investigate the current level of iron education provided to 11-14-year-old females within New Zealand intermediate and secondary schools.

The results of this study suggest that the level of iron education provided in New Zealand schools needs to be more consistent. Due to the wide variance in school curriculums across the country (Ministry of Education NZ, 2015), only 48% of health, PE and nutrition teachers participating in our study provided iron education within the subject they taught. The primary barrier to the provision of iron education by teachers was the limited time teachers had within the subjects of health, PE, and nutrition to cover this content. The second barrier noted by teachers was the high specificity of iron education for the subject area they taught. Furthermore, when asked to score the level of iron education provided within their school, the median response from teachers was 2/10. Cumulatively these results support our hypothesis that there is limited iron education provided to 11-14-year-old females in New Zealand intermediate and secondary schools. These results suggest an opportunity for alterations of the health curriculum to ensure that iron education is included.

Despite the above findings, 80% of our participants believe that iron education is important for female adolescents and should be included in the curriculum. In comparison, 16% reported maybe, and only 4% reported either no or unsure. This result aligns with previous research, which suggests that education can positively influence individuals' knowledge, beliefs, and behaviours toward nutrition, including iron (Hong & Hwang, 2003; Khani Jeihooni et al., 2021). Furthermore, schools have been shown to be an effective setting for delivering nutrition education interventions (Wilson et al., 2018). However, there may be other reasons for teachers not providing iron education, such as not having the background knowledge to be able to provide this education. Results from this study suggest that the topics covered under iron education if provided, reflected the current knowledge/understanding of the participants.

Only 29.2% of our participants reported having access to these resources, despite 77.6% reporting that they would use iron education resources if they were available. These results support our hypothesis that there would be evidence of limited resources available to staff

to use for iron education. This highlights the potential for new iron education resources to be developed to support the curriculum, and may encourage more health, PE, and nutrition teachers to include iron education within their curriculum.

4.2 Strengths

To our knowledge, this was the first study in New Zealand that investigated the current level of iron education provided to 11-14-year-old females in New Zealand intermediate and secondary schools.

One of the study's strengths was the delivery method via an online questionnaire. The online platform enabled a broad reach of health, PE, and nutrition teachers from around New Zealand, increasing the validity of the results as they are representative of schools nationwide.

Another strength of the study was analysing the correlation between the provision of iron education against the subject the participants taught and the type of school they taught at. This enabled us to see the trend in what subject iron education is more likely to be included in, informing future recommendations for curriculum inclusion and research.

A final strength of the study is that staff perspective on the importance of iron education was sought alongside their provision of iron education. This data may be used to construct practical recommendations for staff, resource providers, and curriculum development.

4.3 Limitations

Most participants were nutrition teachers, with fewer health and PE teachers participating in the study. Furthermore, most participants were from secondary schools as opposed to intermediate and composite schools. This selection bias is a limitation, as our sample was more representative of secondary schools around New Zealand, with limited ability to apply these findings to the intermediate curriculum.

Another limitation is that we did not state at the beginning of the questionnaire that the questions related specifically to their classes with 11-14-year-old females. As such, there is a risk that where iron education was provided, it may be outside the 11-14-year-old curriculum but in the curriculum for older students. While staff that taught this age group of

females was specifically recruited to participate, the results may need to be considered with caution as they may not specifically apply to 11-14-year-old females.

The study was based on the participants' perspectives, and these were interpreted as representative of the school where they were currently teaching. There is potential participant bias within these responses, as they depend on the participants' beliefs and teaching practices. Within New Zealand, the curriculum is open to interpretation (Ministry of Education NZ, 2015), and, therefore, may not apply to other teachers within their school and subject. It should be noted that we did not ask about the gender of the participants. This is a limitation, as there is potential for females to have a stronger belief that iron education is important than males, particularly as the study focuses on female students and given females are over-represented within the IDA statistics (Abbas et al., 2021; Abu-Baker et al., 2021; Coad & Pedley, 2014). It would have been beneficial to include this in the demographic questions so that any potential gender biases could be considered when analysing results.

The current study did not ask about general nutrition education in health and PE and whether it is provided within their curriculum. This would have been beneficial, as it would have highlighted whether there was a potential opportunity for iron education to be included under the topic of nutrition within health and PE.

A further limitation of this study was that the questionnaire did not investigate the characteristics of the schools that the participants worked in. For example, it would have been beneficial to know the specific school that the participants worked at so that characteristics of the school could have been investigated (whether the school was public or private, the decile rating of the school, region in which the school was located withing New Zealand). This would have also allowed us to take into consideration how many people from each school participated, as there may have been multiple staff from one school who completed our questionnaire, therefore making the sample less representative. However, this question was not included as it would have affected the anonymity of the questionnaire and further ethical considerations would need to be taken into consideration. Therefore, to overcome this, we could have potentially asked specific questions about the characteristics of their school without asking for a direct name (public/private, region, decile rating etc).

This would have given us an idea as to how representative our sample was of schools around New Zealand.

One final limitation of this study is that we did not ask whether the staff felt confident providing iron education to their students themselves. This would have been beneficial as it would have assisted in providing informed recommendations as to whether staff require iron education so that they have the knowledge to support their teaching of this topic. Alternatively, this data could have been used to suggest that an external body specialising in iron education would be better suited for this curriculum delivery.

4.4 Recommendations and Future Directions for Research

Given that approximately half of the participants in our study reported that they do not provide iron education, despite believing it is important, it is evident that there is an inconsistency in iron education provided in schools around New Zealand. Future research should be directed at the impact of limited iron education on students aged 11-14 and their iron status within New Zealand.

- Education has been shown to be effective in influencing knowledge, attitudes, and behaviour toward nutrition (Hong & Hwang, 2003; Khani Jeihooni et al., 2021); therefore, a review of the health curriculum topics and consistency may be required. Research may examine the effectiveness of consistent iron education in the nutrition or health curriculum on student knowledge, attitudes, and behaviours towards their nutrition.
- The development of iron education resources should be considered. Based on the results of this study, a focus on resources such as videos, information sheets, online resources/websites, and in-person activities would be beneficial options. Research may seek to validate the effectiveness of these resources on students' knowledge and behaviors.
- Following the development of new resources, research on the utilisation of iron education resources or identification of the most utilised resource would be beneficial to determine if they help to increase iron education in New Zealand schools.

- Potential education for Health, PE and nutrition teachers around the country would be a possible way to create more consistency to include iron education within the health curriculum. This would give these teachers the necessary background knowledge to be confident in providing iron education to their students.
- Future research may consider reviewing students' iron deficiency status to identify any association with knowledge, behaviours, and education provided through the school curriculum. This will provide objective data that may be used to quantify the impact of iron education provided to students.
- Future research may also consider a cap on the number of participants within each characteristic to ensure a more representative sample. For example, 25 participants from secondary schools, and 25 from intermediate or composite schools. As well as 25 that teach nutrition/food technology and 25 that teach health/PE.

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Appendices

Appendix A – Participant Recruitment Poster

Appendix B – Participant Information sheet

MASSEY UNIVERSITY
COLLEGE OF HEALTH
TE KURA HAUORA TANGATA

SCHOOL OF SPORT, EXERCISE AND NUTRITION

Questionnaire on Iron Education in New Zealand Intermediate and Secondary Schools

INFORMATION SHEET

Invitation to participate

Kia Ora, my name is Jerushah Keightley, and I am a Master of Science (Nutrition and Dietetics) student at Massey University. Alongside my classmate and co-researcher Renee Jansen, I am undertaking a research project to investigate the level of iron and female health education currently provided to teenage girls (11-14 years) in New Zealand schools on behalf of Beef and Lamb New Zealand Inc. I would like to invite you to participate in the research project.

Please read the information sheet provided here in full before deciding whether or not to participate. If you wish to complete the project after reading the information contained within this information sheet, then a link to the questionnaire will be made available to you via email or through a QR code that you can scan.

For further details or questions about this study, please contact the main researcher

Jerushah Keightley
Master of Science in Nutrition and Dietetics Student
Massey University, Albany
Email: j.keightley@massey.ac.nz

Why is this research important?

Iron is responsible for transporting oxygen around the body and plays an important role in brain function, physical performance, immunity, growth and development in young children and adolescents. An adequate iron intake is important for young teenage girls to ensure optimal growth during rapid body changes and development from 10-14 years old. In addition, girls of this age group will also be getting their first menstrual cycle bleed, and as a result of both of iron demanding proceses, their iron requirements are increased. However, despite their increased iron needs, the last New Zealand National Children's Nutrition Survey published in 2002, suggested that girls aged 11-14 years were at a 44% higher risk of not having enough dietary iron which could increase their risk of developing iron deficiency.

This study has been designed to help us collect data on the national education and educational resources provided to teenage girls aged 11-14 years on their iron requirements. The overall aim of this project is to determine the current education that is provided on iron requirements for girls within this age range. This will be used to help us develop educational resources that can aid in delivering this information to this age group of girls throughout New Zealand.

Who are we looking for?

As part of this project, we are looking to recruit 50 staff throughout New Zealand to participate in an online questionnaire. To take part in this study you should:

- Be either a health teacher, a nutrition teacher, a form teacher, a school principal, or a school nurse.
- Work in an intermediate or secondary school in New Zealand.
- Teach or have contact with 11-14-year-old girls.

What will you be asked to do?

As a participant, you will have access to a secure link or QR code that will take you to an online questionnaire. The questionnaire should take you no more than 15 minutes to complete and has three parts that involve both open and closed questions. The first part includes general questions, about the age group that you teach/have contact with, and what subject you teach. The second part will include questions about your personal view of what iron and female health education is provided within the school. The final section will be about what resources you have/know of that are available to aid iron education in your school. Each staff member who completes the survey will receive a $50 koha in the form of a voucher.

Data Management

At the end of the survey, you will be directed to a separate question through a secure link which will ask you to select which voucher (supermarket voucher, or petrol voucher) you would prefer. We ask that you provide us with your email address so that we can send the voucher to you. Email addresses will be stored separately from the survey results in a secure and password-locked folder only accessible to the researchers. This is to ensure your protection and privacy and to ensure participant anonymity is maintained when analysing the results.

A summary of the project findings will be available to all schools that have participated in this study. This can be requested by the school or participants and will be sent via email.

Participant's Rights

You are not obligated to accept this invitation and it is completely voluntary. Prior to the commencement of the survey, all participants will be asked to provide informed online consent. Following the attainment of consent the full survey will be made available for you to complete. Should you choose to participate, you have the right to:

- Withdraw from the study at anytime
- Decline to answer any particular question.
- Ask any questions about the study at any point during your participation.
- Have access to a summary of the findings at the end of this study.

Project Contacts

If you have any further questions or concerns about the project, please do not hesitate to contact any of the research team listed below:

- Jerushah Keightley (main researcher): jkeight@massey.ac.nz
- Renee Jansen (secondary researcher): r.jansen1@massey.ac.nz
- Pamela von Hurst (main supervisor): P.R.vonHurst@massey.ac.nz
- Claire Badenhorst (secondary supervisor): C.Badenhorst@massey.ac.nz

Low-Risk Ethics Approval Statement

This project has been evaluated by peer review and judged to be low risk. Consequently, it has not been reviewed by one of the University's Human Ethics Committees. The researchers named in this document are responsible for the ethical conduct of this research. If you have any concerns about the conduct of this research that you want to raise with someone other than the researchers, please contact Professor Craig Johnson, Director (Research Ethics), email humanethics@massey.ac.nz.

Thank you for considering participation in this study.

If you wish to continue, please click on the link below or scan the QR code to view the survey: https://massey.au1.qualtrics.com/jfe/form/SV_ehV8GFAdzN6y9Dw

Appendix C – Low Risk Ethics Approval

Kia ora,

Link to the application

HoU Review Group

Ethics Notification Number: 4000025289

Title: A Situational Analysis of Iron Education in New Zealand Intermediate and Secondary Schools

Thank you for your notification which you have assessed as low risk.

Your project has been recorded in our database for inclusion in the Annual Report of the Massey University Human Ethics Committee.

The low risk notification for this project is valid for a maximum of three years.

Please notify me if situations subsequently occur which cause you to reconsider your initial ethical analysis that it is safe to proceed without approval by one of the University's Human Ethics Committees.

Please note that travel undertaken by students must be approved by the supervisor and the relevant Pro Vice-Chancellor and be in accordance with the Policy and Procedures for Course-Related Student Travel Overseas. In addition, the supervisor must advise the University's Insurance Officer.

A reminder to include the following statement on all public documents:

"This project has been evaluated by peer review and judged to be low risk. Consequently, it has not been reviewed by one of the University's Human Ethics Committees. The researcher(s) named in this document are responsible for the ethical conduct of this research.

If you have any concerns about the conduct of this research that you want to raise with someone other than the researcher(s), please contact Professor Craig Johnson, Director (Research Ethics), email humanethics@massey.ac.nz."

Please note that if a sponsoring organisation, funding authority or a journal in which you wish to publish require evidence of committee approval (with an approval number), you will have to complete the application form again answering yes to the publication question to provide more information to go before one of the University's Human Ethics Committees. You should also note that such an approval can only be provided prior to the commencement of the research.

You are reminded that staff researchers and supervisors are fully responsible for ensuring that the information in the low risk notification has met the requirements and guidelines for submission of a low risk notification.

If you wish to print an official copy of this letter:

1. Please login to the RIMS system (https://rme.massey.ac.nz).
2. In the Ethics menu, select Ethics Applications.
3. Using the Advanced search with appropriate criteria to find only this application.
4. With the application on the Results tab, select Reports from the toolbar.
5. Select the "Human Ethics - Low Risk Notification Letter" link, this will open the report viewer.
6. Select the application code from the Report Parameters dropdown and submit. You can then select an export option from the top toolbar (Print, Save).

Yours sincerely

Professor Craig Johnson

Chair, Human Ethics Chairs' Committee and

Director (Research Ethics)

Appendix D – Copy of Questionnaire and Recruitment Materials

Questionnaire on Dietary Iron Education in Schools

Q1. Compulsory Consent Question:

Kia Ora,

As detailed in the information sheet that was sent with this link, you have been invited to participate in a research study that aims to investigate the level of iron and female health education currently provided to teenage girls (11-14 years) in New Zealand schools on behalf of Beef and Lamb New Zealand Inc. Your participation in this study will involve completing a ~15 minutes questionnaire.

To take part in this study you should:
- Be either a health teacher, a nutrition teacher, a form teacher, a school principal, or a school nurse.
- Work in an intermediate or secondary school in New Zealand.
- Teach or have contact with 11-14-year-old girls.

The questionnaire should take you no more than 15 minutes to complete and has three parts that involve both open and closed questions. The first part includes general questions, about the age group that you teach/have contact with, and what area of the school you work in. The second part will include questions about your personal view of what iron and female health education is provided within the school, and the final section will be about what resources you have/know of that are available to aid iron education in your school.

You are not obligated to accept this invitation and it is completely voluntary. By clicking consent below, you acknowledge that:
- Your participation in this study is voluntary
- You are aware that you may withdraw from the study at any time for any reason.
- You are aware that you may decline to answer any particular question.

If you have any questions before continuing with this questionnaire, please contact the primary researcher Jerushah Keightley via email: jkeight@massey.ac.nz

Please read the following before continuing on with the questionnaire:

I have read and understood the Information Sheet that was sent with the link to this survey. Any questions I had have been answered to my satisfaction, and I understand that I may ask further questions at any time. I have been given sufficient time to consider whether to participate in this study and I understand participation is voluntary and that I may withdraw from the study at any time. I am also aware of my right to decline to answer any particular question in this questionnaire.

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

- ○ I consent, begin questionnaire
- ○ I do not consent, I do not wish to participate

Q2. Do you work at an intermediate or secondary school?

- ○ Intermediate
- ○ Secondary
- ○ Composite (intermediate and secondary combined)
- ○ Neither

Q3. What age range do you primarily teach or have teaching contact with? Please select all that apply.

- ☐ 11 year olds
- ☐ 12 year olds
- ☐ 13 year olds
- ☐ 14 years olds
- ☐ None of these

Q4. What subject do you teach? Please select all that apply

- ☐ Food and Nutrition / Home Economics
- ☐ Food Technology
- ☐ Health
- ☐ P.E.
- ☐ Other (please specify):

_____

Q5. Do you yourself have any knowledge on any of the following? Please select all that apply.

- ☐ The main functions of iron in the body
- ☐ The consequences of not getting enough iron in your diet
- ☐ The importance or iron intake for females when they have their period
- ☐ The difference between haem iron and non-haem iron
- ☐ Foods that are good sources of iron
- ☐ Vegetarian foods that are a good source of iron
- ☐ Foods/nutrients that increase iron absorption (eg. vitamin c)
- ☐ Food/ nutrients that decrease iron absorptions (eg. tea and coffee)
- ☐ The importance of iron for female athletes

Q6. Do any of your female students present with the symptoms of iron deficiency including; fatigue, lethargy, pale skin, headaches/dizziness/light-headedness, or constantly cold compared to peers?

- ○ Yes
- ○ No
- ○ Maybe
- ○ Unsure

Q7. As part of the subjects that you teach do you cover any education topics related to nutritional iron?

- ○ No
- ○ Yes

Skip To: Q9 If As part of the subjects that you teach do you cover any education topics related to nutritional i... = Yes

Q8. If no, why do you think it is not covered? Can you please provide details here?

_____

_____

_____

_____

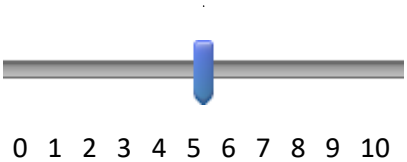
_____

Skip To: Q10 If Condition: If no, why do you think it ... Is Displayed. Skip To: Please rank on a scale of 0 to 10 wha....

Q9. If yes, what is included in this education provided to students that you teach? Please select all that apply.

- ☐ The main functions of iron in the body
- ☐ The consequences of not getting enough iron in your diet
- ☐ The importance or iron intake for females when they have their period
- ☐ The difference between haem iron and non-haem iron
- ☐ Foods that are good sources of iron
- ☐ Vegetarian foods that are a good source of iron
- ☐ Foods/nutrients that increase iron absorption (eg. vitamin c)
- ☐ Food/ drinks/ nutrients that decrease iron absorptions (eg. calcium, tea and coffee)
- ☐ The importance of iron for female athletes
- ☐ Other, please specify _____

Q10. Please rank on a scale of 0 to 10 what level of iron education/information you believe is provided within your school. 0 being no iron education is provided and 10 being thorough iron education is provided.



Q11. Do you know of any other staff members that may be providing students within your school with some education/information on nutritional iron and iron status?

- ○ Yes: what subject/s do they teach and what information on iron do they present to their students? _____
- ○ No

Q12. Is nutritional iron education/information provided to sports teams/young athletes in your school?

- ○ Yes
- ○ No
- ○ Unsure

Skip To: Q15 If Is nutritional iron education/information provided to sports teams/young athletes in your school? = No

Skip To: Q15 If Is nutritional iron education/information provided to sports teams/young athletes in your school? = Unsure

Q13. If yes, what sort of education is provided to these sports teams?

_____

_____

_____

_____

_____

Q14. Who provides this education to sports teams?

_____

_____

_____

_____

_____

Q15. Do you believe that education/information about nutritional iron intake and iron status is important for female adolescents as they enter into puberty and that it should be included in the school curriculum?

- ○ Yes
- ○ No
- ○ Maybe
- ○ Unsure

Q16. What subject do you think education/information about nutritional iron and iron status should be included in?

_____

_____

_____

_____

_____

Q17. Do you cover education on female health, changes during pregnancy, the menstrual cycle, or periods?

- ○ Yes: please briefly explain what sort of education is provided on each topic _____
- ○ No: please briefly explain why _____
- ○ Unsure

Q18. Do you have students approaching you, asking for information about their menstrual cycle, periods and/or changes occurring with puberty?

- ○ Yes: can you please specify _____
- ○ No
- ○ Prefer not to say

Q19. Do you cover education on changes females may experience in puberty?

- ○ Yes: please briefly explain what sort of education is provided _____
- ○ No: please briefly explain why _____
- ○ Unsure

Q20. Do you know of any educational resources on nutritional iron and iron status that are available to you to use in your teaching?

- ○ No
- ○ Yes: what are they? _____

Q21. If schools were provided with trusted educational resources on nutritional iron and iron status, would you use them?

- ○ Yes
- ○ No
- ○ Maybe
- ○ Unsure

Q22. What kinds of educational resources would you find beneficial for yourself and your students?

_____

_____

_____

_____

_____